Finite Element Analysis and Experimental Evolution of Honeycomb Panel

Komal A. Jangavali[1], D. P. Kamble[2]

[1]PG Student, ABMSP"S APCOER Parvati, Pune-411009 Pune, Maharashtra, India

[2]Assitant Professor, ABMSP"S APCOER Parvati, Pune-411009 Pune, Maharashtra, India

Abstract: ***The honeycomb sandwich construction is one of the most valued structural engineering innovations developed by the composite industries. Honeycomb sandwich panels provides high ratio of strength to weight, high ratios of stiffness-to-weight, excellent crush strength and stiffness, high fatigue resistance and excellent moisture resistance. Sandwich panels 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. It is desired to study the mechanical behavior and energy absorption capacity of sandwich panels so as to help designer in the selection of sandwich panel as per application. Honeycomb sandwich structures are increasing being used to replace traditional materials in highly load applications. In this paper three point bending and impact test is performed on the honeycomb panel. Honeycomb panel is made up of aluminium core with FRP face sheet. Also Finite element analysis of honeycomb panel is done in the ANSYS.***

Keywords: Honeycomb structure, three point bending, impact, ANSYS

1. Introduction

Core-based sandwich panels such as honeycombs have been developed and are growing in use as new engineering materials. The out of plane impact behavior of honeycomb has attracted much attention since the honeycomb is more effective in energy absorption under out of plane impacts. There has been increasing interest in the design and development of impact resistance structures over the past decade. However, in some applications, such as using a honeycomb block as an energy absorption layer in aircraft against bird or debit"s collision, the crushing could occur along any direction of the honeycomb. Hence, the in-plane crushing behavior of a honeycomb also needs to be known besides it"s out of plane crushing behavior. Furthermore, honeycombs are used as core of sandwich panels in lightweight structures. [2]

Honeycomb material is unique core material that offers many advantages such as good mechanical properties, excellent crushing properties, low dielectric properties, low thermal conductivity coefficients, fluid control, good acoustic properties, small cross-sectional areas and large exposed area within the cells. Honeycombs are extremely efficient in stiffness to weight and strength to stiffness situations and therefore they are vastly used in sandwich structural applications. Honeycomb cores find wide applications in sandwich structures where there is primary function is to resist transverse shear loads similar to the web in I- section beam.

A typical honeycomb Panel is as shown in Fig. 1. Nearly 500 different types of honeycomb cores are present depending on cell size, cell shape and material. Most common adhesively bonded honeycomb core materials are aluminum, Nomex, fibre glass and craft paper.[1]

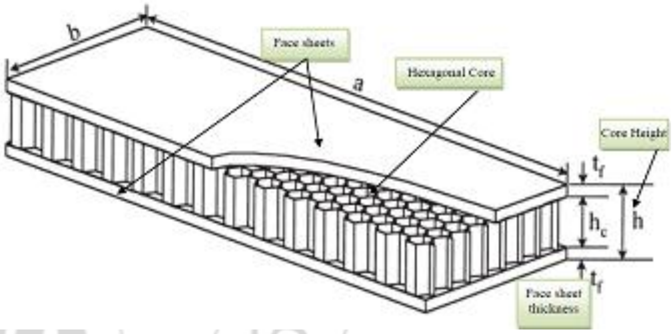

Figure 1: Honeycomb Panel

2. Literature Survey

K. Kantha Rao, included the study of bending strength of honeycomb panels. The materials used are 1) Titanium (Ti-6Al-4V), 2) 4340 High tensile steel 3) Aluminium (A 5500-H 19). It was found that titanium alloy has more strength and strength to weight ratio. It was also found that thickness of core affects the crushing strength.[3]

Dipak G. Vamja, G. G. Tejani have presented the tensile strength and bending strength analysis which was performed experimentally on aluminum honeycomb sandwich panel (Aluminum skin, polyethylene core, and resin binder material). They observed that with hexagonal composite material weight saving is 39% compared with without hexagonal composite material. [4]

Aktay et al. experimentally and numerically investigated the circular-celled honeycombs with two different cell package patterns, i.e., the square package and hexagonal package. The results show that the specific energy absorption of a circular-celled honeycombs is greater than that of single tubes.[5]

A.M.S. Hamouda (2007) suggested that the maximum load carrying capacity and energy absorbing of the metal tubes were higher than composite tubes. However, the specific energy of the composite tubes was about four times higher than the specific energy of the metal tubes. [6]

Harish R, Ramesh S Sharma (2013) investigated the effect of the core height on the fundamental natural frequency of aluminum honeycomb sandwich panels by both experimentally and by finite element method . It is proved that increase in core height increases natural frequency of sandwich panel.[7]

Javad MARZBANRAD, mehdimehdi khan , ashcan saeedi pour(2009) He had investigated energy absorption values of Square, circular, and elliptic tubes of steel and aluminum by carrying out finite element simulation It was found that the ellipse cross section had more energy absorption than the two others. Moreover, the amount of energy absorption will be greater with increasing thickness for smaller section tubes. However, the square section and then the circular section of the steel tube absorbed energy per weight more than the elliptic section of the aluminum tube, respectively.[8]

Jhaver and Tippur (2010) investigated the compression behavior of syntactic foam filled aluminum honeycomb composite. They used three syntactic foams with different volume fractions of micro balloons. Uniaxial compression tests were carried out under quasi-static conditions. They have found that filling aluminum honeycomb by syntactic foam can improve elastic modulus and plateau stress values by 26-31% and 36-39% when compared to the syntactic foam with the same volume fraction of micro balloons.[9]

Yin et al.(2011)suggested that if tubes filled with hexagonal honeycombs, the energy absorption capacity will be enhanced.[10]

NizamYob, K. A. Ismail, M. A. Rojan, Mohd Zaid Othman & Ahmad Mujahid Ahmad Zaidi (2015) investigated that Circular tube gives the best crushing performance higher than the square tube. Energy absorbed by the circular tube is twice more than the square tube.[11]

Doa‟aFadhel Mohammed(2015)experimentally and numerically investigated different core angles (60°, 90°, 120°)of hexagonal honeycomb are made and submitted to free vibration by ANSYS. It was found that Stiffness increase with increasing skin thickness [12]

In this paper the three point bending and vertical drop impact test is performed on honeycomb panel. Honeycomb panel is made up of the aluminimum core with FRP face sheet

3. Experimental

The facing material used for the panel is FRP with aluminum core. The dimensions of the honeycomb sandwich panel are cell size is 6.35 mm, cell wall thickness is 0.07 mm, Height of the core is 8 mm ,face sheet thickness 1 mm and total thickness of sandwich is taken 10 mm.

A. Three point Bending Test

As mentioned in ASTM C393 standard the test specimen are made rectangular in cross section. The thickness of the specimen is selected as 10 mm. The width of the specimen is taken as 25 mm which is maintained as twice the total thickness. The length of the specimen is taken as 200 mm where 40 mm is total unsupported length and span length is 160 mm.

Experimentally three point bending test was performed on the Machine 5982 INSTRON .Experimentally the critical load found was 547 N and deformation found was 8 mm. Test setup for three point bending is as shown in fig.2

Theoretically critical load (P_o) is calculated by,

$$P_o = C\frac{bh^2\sigma_{fo}}{a}\left\{1-\left(\frac{h_c}{h}\right)^2\right\}$$

Where, $C = \frac{C_1}{C_1+C_2}$,

$$C_1 = \frac{a^3}{48E_f I_f}$$

$$C_2 = \frac{a}{4\times A_c \times G_{ca}}$$

$$I_f = \frac{b\left(h^3 - h_c{}^3\right)}{12}$$

$$P_o = 0.993 \times \frac{25\times 10^2 \times 100}{160}\left\{1-\left(\frac{8}{10}\right)^2\right\}$$

$$P_o = 558.56\ \text{N}$$

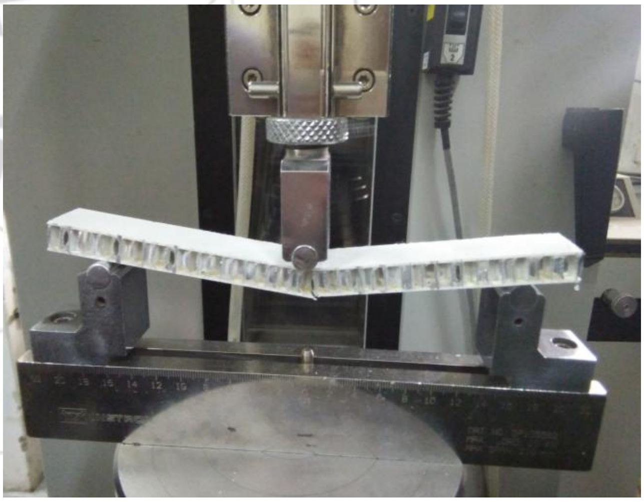

Figure 2: Experimental setup for three point bending

B. Vertical Drop Weight Impact Test

Impact test is conducted to find out maximum force which can be sustained by specimen. Simultaneously puncture force after impact, Peak energy, Deformation at Peak Force, Total deformation are obtained. According to ASTM C393 standard specimen size taken for impact test is taken as 100 mm ×150 mm. Input parameter for impact testing machine is energy in joule. Lowest value of input energy is 5 Joule and maximum value obtained for complete puncture of specimen is 15 Joule. For 15 J input energy the deformation found was 10 mm.

4. Analysis

CAD Model of honeycomb panel is done in the Creo 2. Then this model is imported to ANSYS for performing the analysis. The dimensions for bending specimen are 160 mm × 25 mm and its thickness is 10 mm.

A) Total Deformation of honeycomb Panel under Bending :

Fig 3 shows the deformation of Honeycomb Panel under the application of 10 mm Deformation. The maximum load is found at center is 513 N.

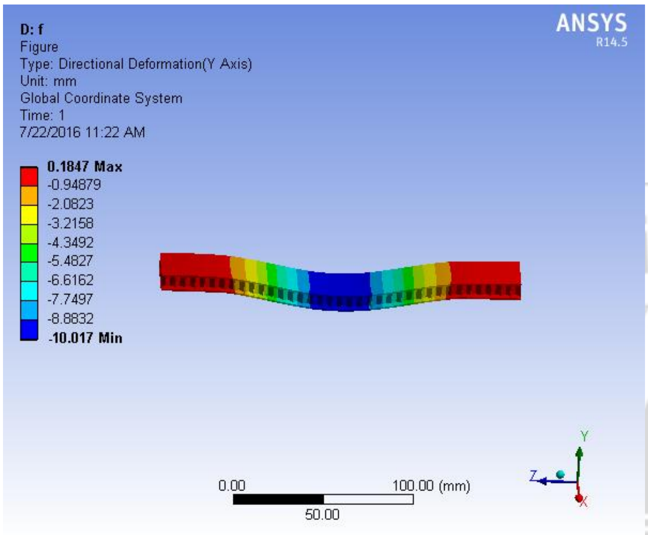

Figure 3: Deformation of panel under bending

B) Stress induced in honeycomb Panel under Bending :

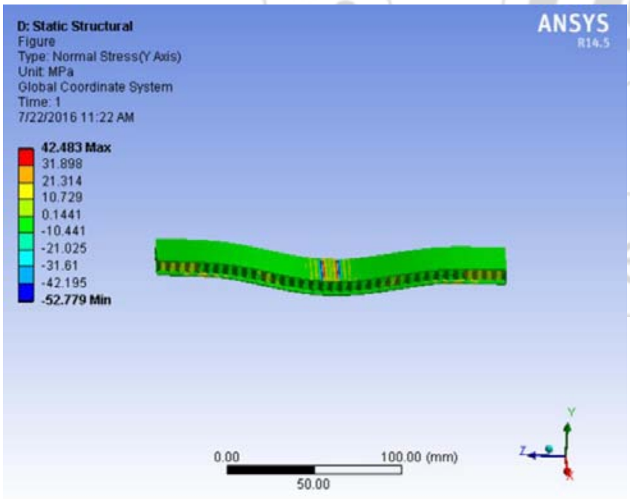

Figure 4: Stress of panel under bending

Fig. 4 shows the stresses induced in panel. The maximum stress found was 42.48 MPa. Maximum stress was found at center.

C) Total deformation found under Impact

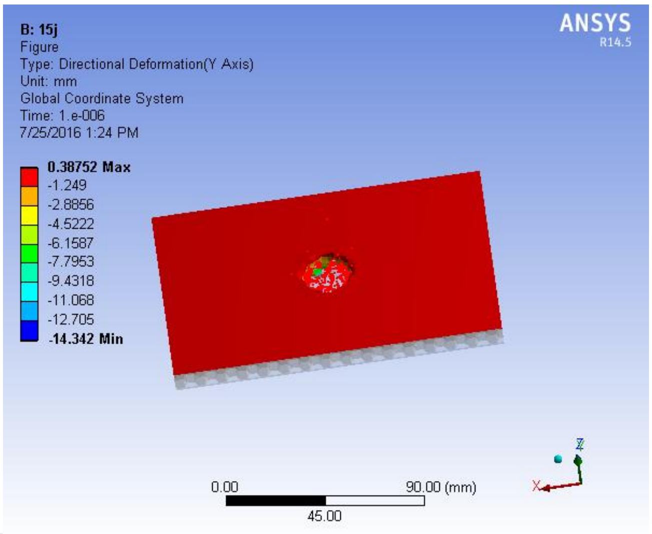

Figure 5: Deformation of panel under Impact for 15J energy

Fig 5 shows the deformation of Honeycomb Panel under the application of 15J energy. The maximum deflection is found is 14.342 mm.

5. Conclusion

In this work the experimental bending and impact test was performed on the honeycomb sandwich panel made up of aluminium core and FRP facesheet and same is validated by analysis. The critical load find in bending test theoretically is 558 N and in experimental is was found is 548 N. So, the value of critical load found experimentally is 2 % greater that the it was found theoretically. The critical load found from FEA 513 N and it was found from experimental is 547 N. So, only 5-6 % variation is found in experimental and FEA results. For the impact test the deformation found after giving the energy of 5J, 10J and 15J in experimentation is slightly greater than the deformation found in the analysis.

References

[1] Tom bitzer „honeycomb technology" hexcel corporation, CA, USA
[2] Costantino Menna , Alberto Zinno, Domenico Asprone, Andrea Prota, "Numerical assessment of the impact behavior of honeycomb sandwich Structures"
[3] K.Kantha Rao, K. Jayathirtha Rao, A.G.Sarwade, M.Sarath Chandra "Strength Analysis on Honeycomb Sandwich Panels of different Materials", ISSN: 2248-9622, Vol. 2, Issue 3, May-Jun 2012
[4] Dipak G. Vamja1, G. G. Tejani, "Experimental Test on Sandwich Panel Composite Material", ISSN: 2319-8753, Vol. 2, Issue 7, and July 2013.
[5] L. Aktay, B.H. Kroplin, A.K. Toksoy, M. Guden „Finite element and coupled finite element/smooth particle hydrodynamics modeling of the quasi-static crushing of empty and foam-filled single, bitubular and constraint hexagonal- and square-packed aluminum tubes", Materials and Design 29 (2008) 952–962

[6] A.M.S. Hamouda , Energy absorption capacities of square tubular structures , Journal of Achievements in Materials and Manufacturing Engineering , Volume 24 Issue 1

[7] Harish R. and Ramesh S. Sharma, “Vibration response analysis of honeycomb sandwich panel with varying Core Height”, IJETCAS 13-433; 2013

[8] Javad marzbanrad, Mehdi mehdikhanlo, Ashkansaeedi pour, “An energy absorption comparison of square, circular, and elliptic steel and aluminum tubes under impact loading” , Turkish J. Eng. Env. Sci.,33 (2009) .

[9] Rahul Jhaver and Hareesh Tippur, “Characterization and modeling of compression behavior of syntactic foam-filled honeycombs”, Journal of Reinforced Plastics and Composites 29(21) 3185–3196

[10] Hanfeng Yin , Guilin Wena , Shujuan Hou , Kai Chen, “Crushing analysis and multi objective crashworthiness optimization of honeycomb-filled single and bitubular polygonal tubes”, Materials and Design 32 (2011) 4449–4460

[11] Nizam Yob, K. A. Ismail, M. A. Rojan1, Mohd Zaid Othman & Ahmad Mujahid Ahmad Zaidi, “Quasi Static Axial Compression of Thin Walled Aluminum Tubes: Analysis of Flow Stress in the Analytical Models”, Modern Applied Science, ISSN 1913-1844 Vol. 10, No. 1; 2016

[12] Doa‟a Fadhel Mohammed, “Experimental and Numerical Analysis of AA3003 Honeycomb Sandwich Panel with Different Configurations”, Am. J. Sci. Ind. Res., 2015