



International Journal of Emerging Technologies in Computational and Applied Sciences (IJETCAS)

www.iasir.net

Vibration response analysis of honeycomb sandwich panel with varying Core Height

Harish R¹, Ramesh S Sharma²

^{1,2} Department of Mechanical Engineering, R.V.College of Engineering, Bangalore, India.

Abstract— The purpose of this paper is to find out the effect of the core height on the fundamental natural frequency of aluminium honeycomb sandwich panels by both experimentally and by finite element method. Experimental modal testing was conducted on specimen by using traditional “strike method” for three boundary conditions viz. C-F-F-F, C-F-C-F. The modal characteristics of specimens are obtained by studying its impulse response. Specimens are subjected to impulse through a hard tipped hammer which is provided with a force transducer and the response are measured through the accelerometer. Computer aided FFT analyser is used to extract the modal parameters with the aid of software by using the input obtained from accelerometer and hard tipped hammer.

Keywords: Honeycomb, modal testing, frequency, Core height

I. Introduction

Honeycomb panels are advanced sandwich elements consisting of low modulus lightweight cellular (honeycomb) core sandwiched between high modulus, high strength face sheets. The assembly maximizes stiffness-to-weight ratio and bending strength-to weight ratio, resulting in a panel structure that is particularly effective at carrying both in plane and out-of-plane loads. The face sheet and the honeycomb core can be either metallic or made from fiber reinforced plastic composite material. The honeycomb sandwich structures have been widely applied in aerospace industry due to their excellent properties such as high stiffness-to weight, high strength-to weight, low thermal conductivity and good sound insulating capacity. Vibration frequencies and mode shape of honeycomb sandwich panels with various structural parameters were studied using computational and experimental methods. Two computational models were used to predict the mode shapes and frequencies of honeycomb sandwich panels. In the first model, honeycomb core was assumed to be quasi-orthotropic; in the second model, plate elements were used for honeycomb cell walls to reflect the geometric nature of hexagonal cells. The quantitative effect of the anisotropic core on the vibration properties of the sandwich panels was studied, and the mode shape and frequencies were presented [1]. In the parameter identification of aluminium honeycomb sandwich panels, an orthotropic Timoshenko beam model has been used, and the elastic constant and the modal damping ratios so as to minimize the error between the experimental and analytical result have been determined. Two optimization problems based on the natural frequencies and the accelerances are effective for the parameter identification honeycomb sandwich panels. The elastic constants can be easily identified by the experimental and analytical natural frequencies [2]. In comparative studies of free flexural vibration of honeycomb panels using three different plate theories. Numerical results indicate that the classical and improved plate theories are not adequate for the flexural vibration analysis of honeycomb panel [3]. The frequency dependence of damping was analysed for honeycomb sandwich plate. The case of CFFF plate had been studied and the effect of cell size, material nature and dumping coefficient are highlighted. The result obtained in this paper are hopeful and show that geometry and the type of material have an effect on the value of the honeycomb plate modal frequencies [4]. Within a sandwich structure in many cases the effect of a honeycomb core is not only to maintain the distance between the faceskins, but it also contributes to the overall inplane stiffnesses. In this work closed form description is given for the effective inplane core stiffnesses including the thickness effect. Based on an approximate representation for the displacement field within the core cell walls, the effective core stiffnesses are derived by energetical considerations [5].

II. EXPERIMENTAL TECHNIQUES

A. Specimen Details

In this work face sheet and core are made up of aluminium material was used. By keeping the face sheet thickness constant around 1 mm and cell size at 8 mm. Effective dimension of the specimen was kept constant at 160 mm × 160 mm for different boundary condition.

TABLE I (GEOMETRIC DETAILS OF SPECIMENS)

Face sheet & core material	Specimen dimension in mm	Face sheet thickness in mm	Core height in mm	Specimen height in mm
Aluminium	160×160	1	8	20
Aluminium	160×160	1	18	10

B. Experimental Setup

The modal characteristic of the specimen are obtained by studying its impulse response. Fixture was used to obtain different boundary condition. Traditional strike method is used to excite the specimen. By applying an impact force by the hammer to the plate, the hammer piezoelectric generates a corresponding voltage which has a sensitivity of 22 mV/N. The voltage is calibrated to force. Response is measured by an accelerometer which consists of frame, a mass, a piezoelectric element. Vibrating the mass in the accelerometer generates the electrical current in the piezoelectric element. The corresponding voltage of the piezoelectric element is calibrated to acceleration. The signal from the accelerometer and the impact hammer are transferred to computer aided fft analyser to extract the modal parameters with the aid of software.

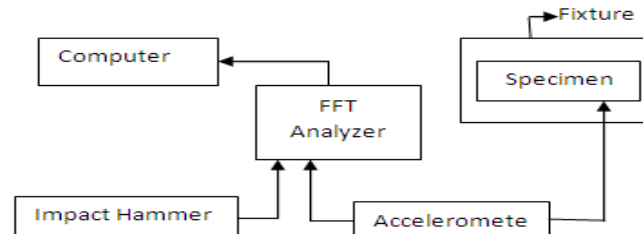


Fig. 1 Experimental setup

Initial 25 grid points are marked on the specimens that are placed at equal distance. Then similar type of modal is created in the post-processing software so that mode shape of the specimen can be captured properly. Position of accelerometer and starting point of excitation was inputted to the software. After initial excitation accelerometer position remains same but the position of excitation changes in the increment of one. After all the initial setup in the post-processing software then Accelerometer is attached to specimen using petro wax. Position of accelerometer should be such that it would record all the responses. Specimen is triggered at each grid point and recorded the response with the help of accelerometer to obtain the mode shape. At each point it is triggered five times and taken the average of that so that effect of any external effect would be neutralized.

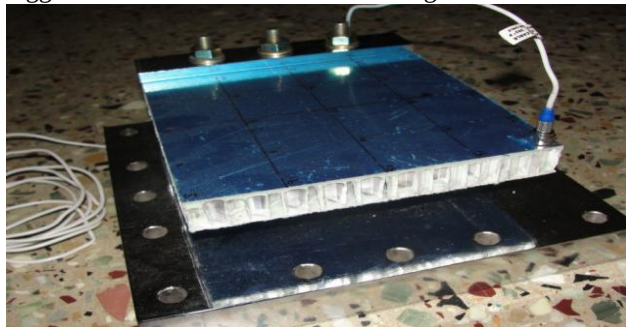


Fig. 3 Experimental setup for C-F-C-F condition,



Fig. 2 Experimental setup for C-F-F-F condition

C. Finite elemental analysis of honeycomb sandwich plate

The finite elemental model of honeycomb sandwich panel is modelled in ansys. The element employed is solid 186 for honeycomb core and honeycomb face sheet.

For aluminium face sheet, the elastic modulus is 70GPa and the Poisson ratio is 0.33. The mass density of the surface layer is 2700 kg/m³ and for core of cell size 8 it is 175 kg/m³.

In order to analyse the honeycomb sandwich plate, firstly, the equivalent parameters is obtained by using the Sandwich theory in this theory only the honeycomb core is equalized. It is assumed that the core can resist the transverse shear deformation and has some in-plane stiffness. For the hexagon honeycomb core, the equivalent elastic parameter can be found by using the formula given below.

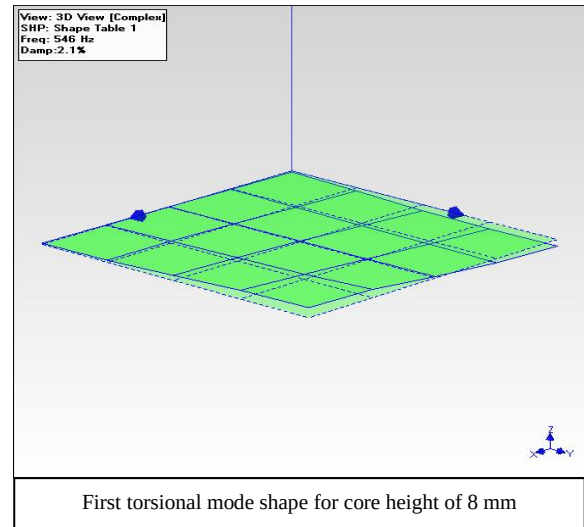
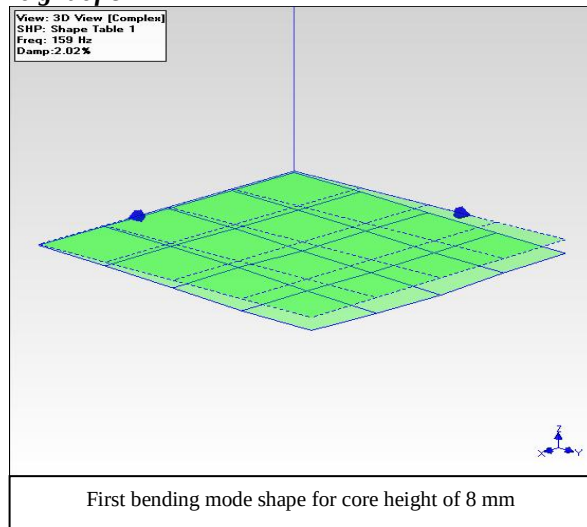
$$E_x = \frac{4}{\sqrt{3}} \left(\frac{t}{l} \right)^3 E_s, E_y = \frac{4}{\sqrt{3}} \left(\frac{t}{l} \right)^3 E_s, E_z = \left(\frac{t}{l} \right) E_s, G_{yz} = \frac{\sqrt{3}}{2} \gamma \frac{t}{l} G_s, G_{xy} = \frac{\sqrt{3}}{2} \gamma \left(\frac{t}{l} \right)^3 E_s, G_{xz} = \frac{\gamma}{\sqrt{3}} \frac{t}{l} G_s$$

Where E,G are the engineering constants of the material of the core; l,t are the length and thickness of the honeycomb cell; γ is the technology corrected coefficient whose value is about 0.4 and 0.6. For E=70GPa, G=26GPa, t=0.2mm, cell size=8mm, l=4.618mm, $\rho = 175 \frac{\text{kg}}{\text{m}^3}$

D. Result and Discussion

Tables given below shows the experimental and ANSYS result obtained for different boundary condition of honeycomb sandwich panel for core height of 8 mm and 12 mm. It is clear that the frequency increases with the increase in thickness of the core for bending and torsional modes.

Experimental result for C-F-F-F condition for core height of 8mm



Experimental result for C-F-F-F condition for core height of 18mm

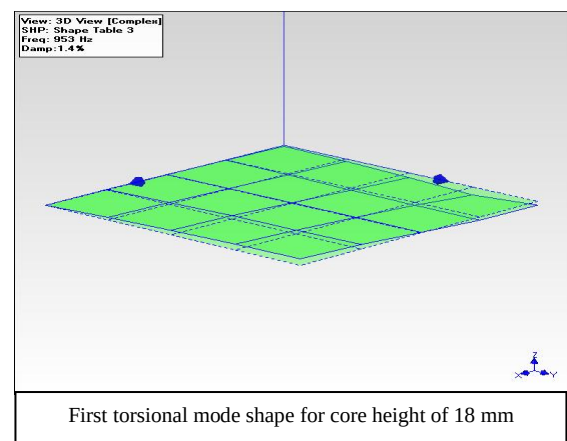
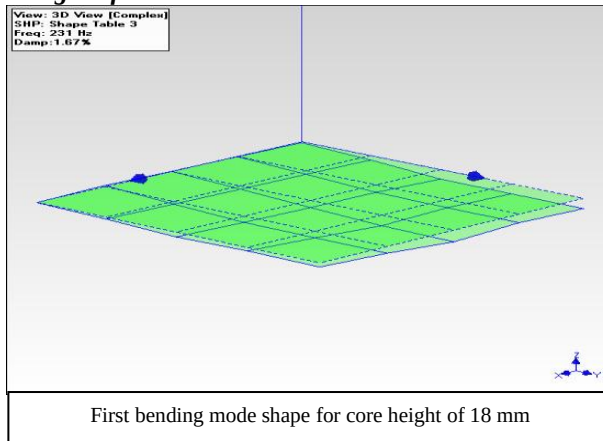


TABLE II
ELASTIC PROPERTIES OF HONEYCOMB SANDWICH CORE

Properties	Elastic modulus E_x	Elastic modulus E_y	Elastic modulus E_z	Shear modulus in plane G_{xy}	Shear modulus in plane G_{yz}	Shear modulus in plane G_{xz}	Poisson ratio in plane μ_{xy}
values	13.13 MPa	13.13MPa	3030 MPa	0.307 MPa	487.85 MPa	325.05 MPa	.33

TABLE III
COMPARISON BETWEEN EXPERIMENTAL AND ANSYS RESULT FOR CANTILEVER CONDITION

Core height	First bending Frequency in Hz			First Torsional Frequency in Hz		
	Experimental	ANSYS	Difference	Experimental	ANSYS	Difference
8 mm	159	167	5.03	546	586	7.32
18 mm	231	249	7.79	953	1005	5.45

TABLE IV
COMPARISON BETWEEN EXPERIMENTAL AND ANSYS RESULT FOR BOTH END FIXED CONDITION

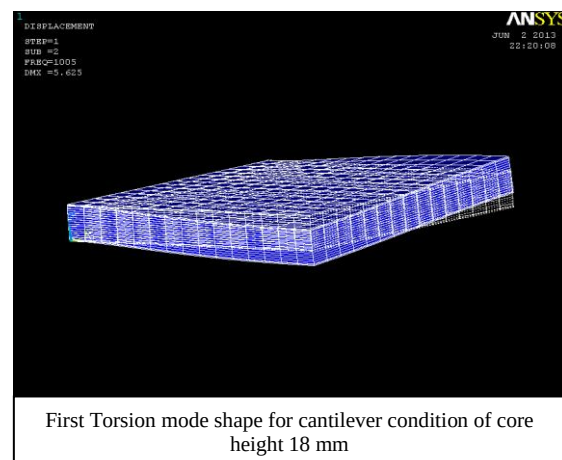
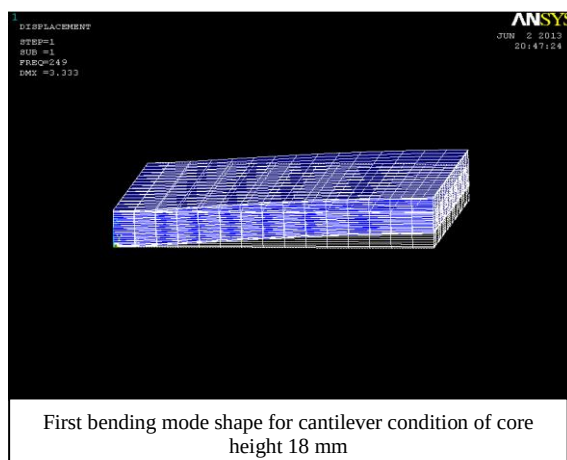
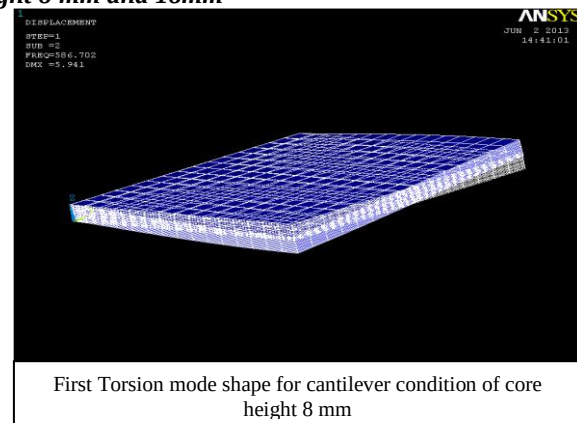
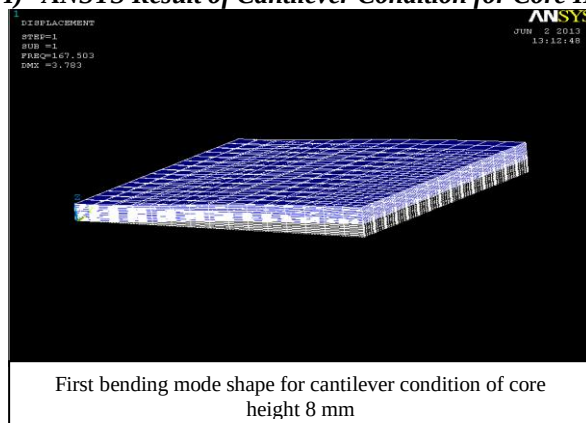
Core height	First bending frequency in Hz			First Torsional frequency in Hz		
	Experimental	ANSYS	Difference	Experimental	ANSYS	Difference
8 mm	760	829	9.07	1060	1182	11.50
18 mm	1400	1573	12.32	1650	1812	9.8

TABLE V
COMPARISON BETWEEN EXPERIMENTAL AND ANSYS RESULT FOR ALL SIDE FIXED CONDITION

Core height	First bending frequency in Hz			First Torsional frequency in Hz		
	Experimental	ANSYS	Difference	Experimental	ANSYS	Difference
8 mm	1560	1704	9.23	2418	2651	9.5
18 mm	2250	2454	9.0	3018	3311	9.63

$$\text{Difference} = \frac{f_{\text{Experimental}} - f_{\text{ANSYS}}}{f_{\text{Experimental}}} \times 100$$

I) ANSYS Result of Cantilever Condition for Core Height 8 mm and 18mm



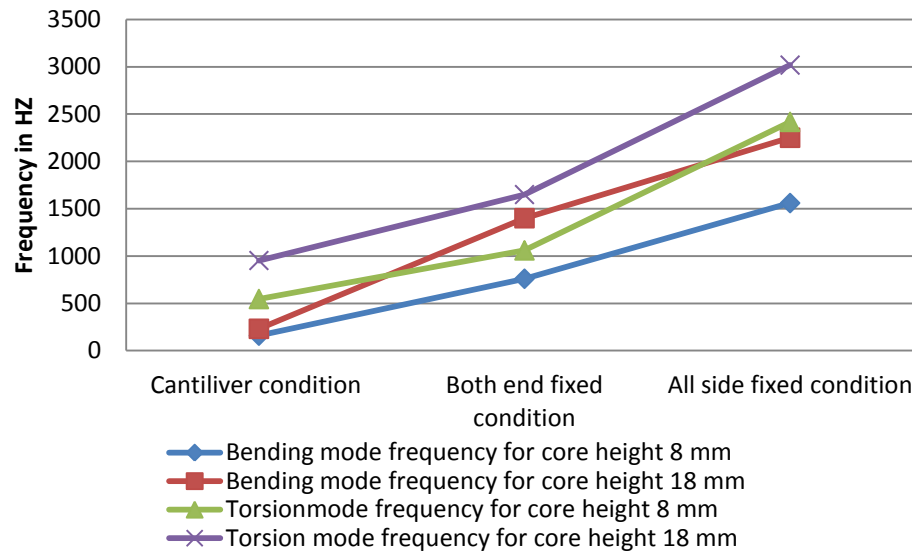


Fig. 12 variation of frequency for different boundary condition

III. CONCLUSION

Effect of core height on fundamental natural frequency of honeycomb sandwich panel is studied. It is found that effect of core height has large influence on fundamental natural frequency of honeycomb sandwich panel. As core height increases frequency also increases.

ACKNOWLEDGMENT

Authors thankfully acknowledge the Management, Principal and Head of the Department of Mechanical Engineering, R V College of Engineering for their constant encouragement and support in carrying out this work.

REFERENCES

1. The Q.L. Liu and Y. Zhao, "Role of Anisotropic Core in Vibration Properties of Honeycomb Sandwich Panels" *Journal of Thermoplastic Composite Materials*, Vol.15, No.1, 2002, pp.944-952
2. T. Saitoa, R. D. Parberyb, S. Kawnoa, "Parameter Identification for Aluminium Honeycomb Sandwich Panels based on Orthotropic Timoshenko Beam Theory", *Journal of Sound and Vibration*, Volume 208, Issue 2, 27 November 1997, Pages 271-287.
3. S. D. Yu, W. L. Cleghorn, "Free Flexural vibration analysis of symmetric honeycomb panels", *Journal of Sound and Vibration*, Volume 284, Issue 1-2, pages 189-204, 06/2005.
4. A. Boudjemai, M.H. Bouanane, Mankour, R. Amri, H. Salem, B. Chouchaoui, "MDA of Hexagonal Honeycomb Plates used for Space Application", *World Academy of Science, Engineering and technology* 66 2012.
5. Wilifried Becker, "Closed form Analysis of the Thickness Effect of Regular Honeycomb Core Material", *Composite Structure* 48 (2000) 67-70.
6. Modal testing: theory and practice, D J Ewins , research studies press ltd. New York .
7. M. K. Neilsen, "Continuum Representations of Cellular Solis," DOET Technical Report No. Sand-93-1287, Washington DC,1933