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Dynamic Analysis of Honeycomb Sandwich Laminated Composite Plate using ANSYS

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ABSTRACT

A structural sandwich is a peculiar form of a laminated composite comprising of a combination of distinct materials which are bonded together to use effectively the properties of each separate component to the structural advantage of the whole assembly. Two thin, rigid and quite strong faces in the framework are partitioned by a thick, light and weaker core. The faces are attached adhesively to the core to ensure effective load transfer between the components. Owing to the core structure, such composites are differentiated by their stiffness. Despite the thickness of the core, sandwich composites are characterized by their light structure and a good flexural strength. These composites possess unique structure, which provides it a good thermal insulator properties. Sandwich composites finds a wide range of application in aeronautics, transportation such as road vehicles, ships, winds, marine and civil engineering. The Laminated sandwiched composite pate is preferred over simple laminated composite plate due to their great ability to essentially decrease weight while maintaining optimum mechanical performance. This weight reduction provides a large number of benefits which includes higher payloads, increased range and comparatively less fuel consumption. The Present study is done to study and investigate the Sandwich composite Panel which is formed by laminating composite sheets with Aluminium Honeycomb core and Dynamic Analysis is done to study its behaviour by computing natural frequency and corresponding deflection. Triangular, Square and Hexagonal cell for the honeycomb will be used to find the best shape under dynamic loading. Further, the effect of hexagonal cell parameter will be studied in order to find optimum parameters in ANSYS 18.1 Software.

Keywords:-Sandwich, Laminate, Honeycomb, flexural, Dynamic, Composite

1. INTRODUCTION

In the case of modern engineering materials included in aeronautical materials, apart from strength properties, low weight of the final element is a vital aspect. One of the major driving factors referring towards sandwich composites is that they provide much reduced weight mechanical characteristics than traditional monolithic products such as steel which makes it very popular towards aeronautics, construction engineering, transportation and marine applications [1]. Sandwich composite materials also allow users to manufacture their loading demands with extreme accuracy. Due to the broad spectrum of mechanical characteristics it offers, the core is one of the main variable in a sandwich composite. The weaker material generally forms the core of the sandwich structure which is sandwiched in between the strong mechanical property material i.e. the facings. The facings are relatively thin but possess higher strength and stiffness while the core is relatively thick but light weighted and possess adequate stiffness in the normal direction to the faceplate. The constituents of a simple sandwich structure in such a way that core material is bonded to the face plates with the help of either adhesive materials or mechanical fasteners such that they can behave as a single load bearing member [2]. The main concept of the sandwich panel is that exterior surfaces transfer loads caused by bending (flexural load and compression), while the core transfers load due to shearing.

Sandwich composite materials are a kind of anisotropic materials which means that their strength properties changes with the load applied. Using this knowledge of anisotropy, it is possible to obtain applications depends on needs which would show specific properties in desired directions. [3]

The sandwich composite structures used for any application is subjected to vibrations. We know that every structure has defined by its own frequency when frequency caused by external force coincides with natural frequency of the structure than condition of resonance occurs [4]. As a result, large deformation in the structure leads to sudden failure of the system. So there is a great need to study the vibration analysis of composite structure sandwiched with different honeycombs.

M.A. Salam et al. (2013) [5] focused on the different configuration of sandwich beams to study the effect of its basic elements such as face and core material and their thickness on the static and dynamic behaviour of these beams such as sandwich beams with single core with cores and with pre crack which gives a clear cut solution that the optimum select on for the sandwich beam parameters depends on its required application.

Pushparaj pingulkar et al (2016) [6] used the different matrix hybridization and various stacking sequence to compute the changes observed in natural frequency and mode shape of cantilever glass fiber reinforced polymer composites and carbon fiber reinforced polymer composites under varying fiber volume fraction thoroughly. In this specific research, the laminates in question have a layup of 8 lamina with a plate aspect ratio of 2and a variable fiber volume fraction of 0.3,0.4,0.5and 0.6.The natural frequency and mode shapes are evaluated and then validated with the results available from the past literature. The results shows a great interconnection between the two results.The findings show that the hybridization a nd direction of the outermost coating heavily infl uences the natural frequencies of the composite l aminated sheets.

Mohamed-Quejdi Belarbi *et al.*(2016) [7] proposed a model to study the free vibration behaviour of multi layer sandwich plates. Several examples of laminated composite and sandwich plate with different material combinations, aspect ratios, number of layers, boundary conditions, geometry and ply orientation are considered for analysis. 2 different ply orientation are taken for analysis which are $[0/90/0]_S$ and $[45/-45/45]_S$ and the effect of honeycomb core is studied.

Kapania et al. 2008 [8] investigated sandwich panel with square honeycomb core using the finite element approach applied for the plate theories using ABAQUS. A constitutive equivalent continuum model is obtained instead of the detailed model of honeycomb core using strain energy approach. The comparison between higher-order shear deformation theory model and continuum model show an error of 7.6%, the homogenized model may be used for sufficient accuracy and precision in place of a detailed model.

We can design the sandwich composite structure by taking optimum values of the parameters such as cell shape, cell edge ratio and cell angle of the honeycomb core.

In the present work, dynamic analysis of a sandwich plate is carried out to determine natural frequency and deformation based on 6 different modes for triangular, square and hexagonal honeycombs. Further, the effect of varying cell parameters of hexagonal honeycomb on natural frequency and deformation is studied through modal analysis in ANSYS 18.1 version is done.

2. Specimen and procedure

The work specimen used in the analysis is modeled as a square sandwich plate having dimensions 50 mm× 50 mm by gluing face material (epoxy-carbon) to honeycomb core material as Aluminium with an adhesive or mechanical fastener. The upper faceplate used in the current analysis is a laminate of epoxy-carbon which is unidirectional consisting of 4 laminate having configuration of $[-45/0/90/45]_S$ whereas the lower faceplate used is the similar symmetric laminate of same material and similar configuration. Fig 1 reflects the simple geometry of a hexagonal honeycomb and Table 1 provides the basic mechanical properties of the work specimen used.

Then, the work specimen is subjected to modal analysis for three different shapes of honeycombs such as triangular, square and hexagonal for clamped-clamped boundary condition. Further the effect of varying cell parameters on the modal parameters such as natural frequency and deformation are also examined.

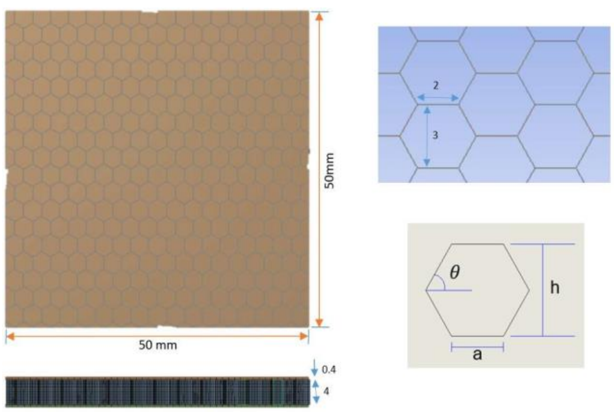

Fig 1. Geometry and cell shape of specimen used

Table 1. Mechanical properties of material used

Epoxy carbon		Aluminium alloy	
Property name	Property value	Property name	Property value
E_1(GPa)	121	E(GPa)	71
E_2(GPa)	8.6	μ	0.33
E_3(GPa)	8.6	K(GPa)	69.608
μ_{12}(GPa)	0.27	G(GPa)	26.692
μ_{23}(GPa)	0.4_{11}	Y_1(MPa)	280
μ_{13}(GPa)	0.27	Y_2(MPa)	280
G_{12}(GPa)	4.7		
G_{23}(GPa)	3.1		
G_{13}(GPa)	4.7		

3. Results and Discussion

3.1. Effect of different cell shapes in clamped configuration

Triangular, square, and hexagonal cell shaped honeycomb core have been used in clamped - clamped configuration and subjected to modal analysis. The following figures show the comparison of different cell shape honeycomb cores in terms of natural frequency and deformation.

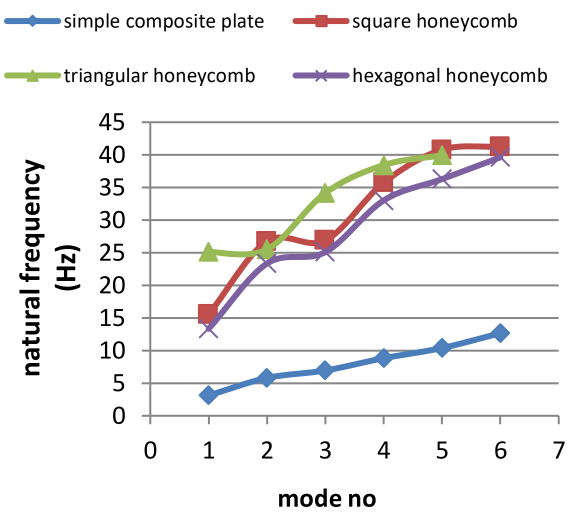

Fig.2 (a) comparison of natural frequency for different shapes of honeycombs

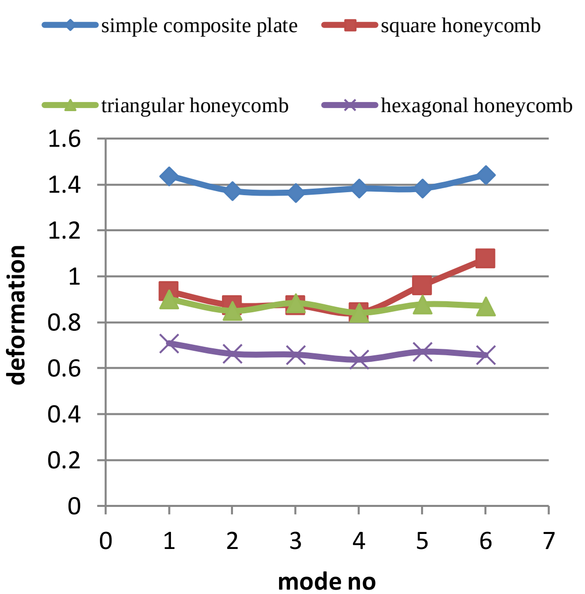

Fig.2 (b) comparison of deformation for different shapes of honeycombs

As the figure 2(a) indicates that the natural frequency of simple composite laminate of 8 layers is very less as compared to other composite material when sandwiching is done. Triangular Honeycomb gives the good result of optimum natural frequency as compared to other honeycombs indicating the structure is strongest and It is evident from the figure 2(b) that the deformation produced in simple composite plate is larger then composite structure with honeycomb.Again, the hexagonal honeycomb provides the less deformation almost same in all the 6 modes gives the best honeycomb shape as compared to square and triangular shape indicating the higher stiffness in hexagonal structure.

3.2 Effect of varying cell parameter ratio

In this part of analysis, the core used is hexagonal honeycomb .The effect of varying cell parameter i.e. edge of regular hexagon, height of the cell and cell angle is studied. Cumulatively as the ratio of these two quantities (i.e. a/h ratio). Hence we have two parameters i.e. a/h ratio and cell angle as depicted in the figure.

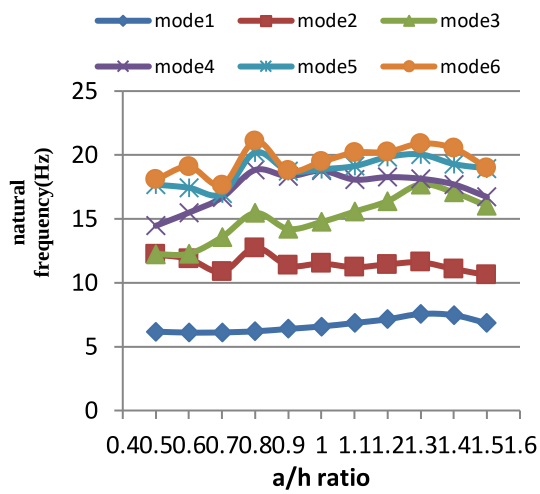

Fig 3 (a) comparision of natural frequency with variation in a/h ratio for different modes

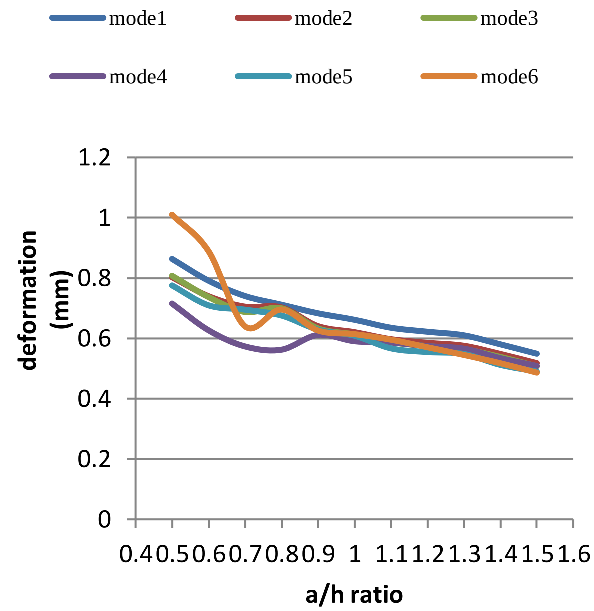

Fig.3 (b). Comparision of deformation with variation in a/h ratio for different modes

From fig 3(a) ,it is clear that All the modes give a stable and optimum a/h ratio of 1.3 which corresponds to maximum natural frequency And minimum natural frequency is achieved at a/h ratio of 0.5 which represents the instability in the honeycomb and from fig3 (b) we observe that All the modes give the same results showing that the deformation decreases with increase in a/h ratio.The maximum deformation and minimum deformation in all the 6 modes is obtained at a/h ratio of 0.5 and 1.5 respectively.

3.3 Cell angle

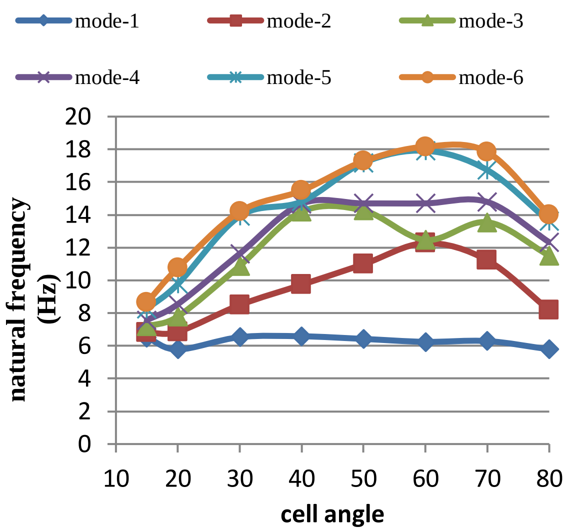

Fig. 4 (a)Comparision of Natural frequency for different modes with different cell angles

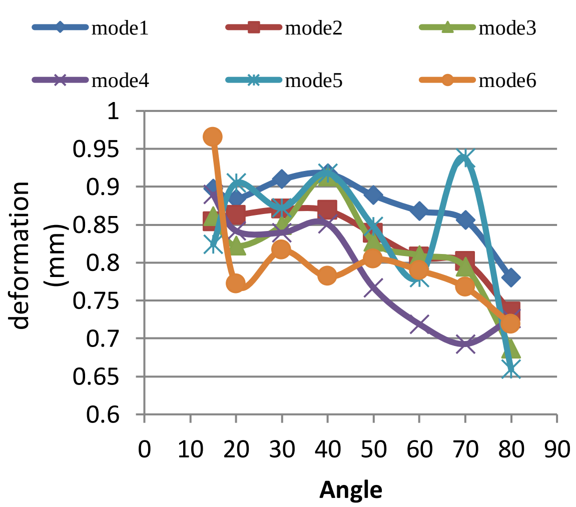

Fig.4.(b). Comparision of deformation for different modes with different angles

From figure 4(a) and 4(b), optimum cell angle of 40° is obtained for both Natural frequency and deformation indicating most stable cell angle.

Conclusion

The paper reveals that under modal analysis, triangular honeycomb core can undergo more cycles of vibrations then square and hexagonal honeycomb but when stiffness is priority, hexagonal honeycomb is best and when hexagonal parameter a/h ratio is varied, a stable and optimum a/h ratio of 1.3 is observed which corresponds to maximum natural frequency and minimum deflection. Cell angle of 40° is the optimum angle find during the analysis.

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