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Vibration analysis of a circular honeycomb plate and design of its support structure using fem

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Abstract

In this paper, design and analyses of honeycomb sandwich structures are investigated. Primary goal is to develop an equivalent orthotropic material model that is a good substitute for the actual honeycomb sandwich structure. By replacing the actual honeycomb structure with the orthotropic model, during the finite element analyses, substantial advantages can be obtained with regard to ease of modeling and model modification, solution time and hardware resources. To figure out the best equivalent model among the approximate analytical models that can be found in the literature, a comparison is made. First sandwich beams with different honeycomb and deck plate materials are modeled in detail. Then a set of equivalent models with the same dimensions is generated. The material properties of the equivalent models are taken from different studies performed in the literature. Every model is analyzed under the same loading and the boundary conditions. In finite element analyses, ANSYS finite element program is used. Free- free vibration analysis (natural frequency) is done on all models to determine the best material for making honeycomb sandwich structures. The results are compared to find out the best performing equivalent model. After three major analysis loops with different material combinations, decision on the equivalent model is made. However, the equivalent model can be used reliably for deflection analysis, forced vibration analysis, stiffness determination and aero-elastic analysis.
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Keywords: *Honey comb, model, sandwich, deck plate.*

1. Introduction

Aeronautical and space system always look for high strength to weight ratio for its structural components. Honeycomb structures prove to be highly effective in this aspect due to its increased directional stiffness and low elastic moduli. Honeycomb structures are widely used in space applications where the component is subjected to severe vibration and cyclic loading.

Sandwich structures are a special kind of laminated composite. Laminated composites consist of layers of at least two different materials that are bonded together. A structural sandwich consists of three elements,

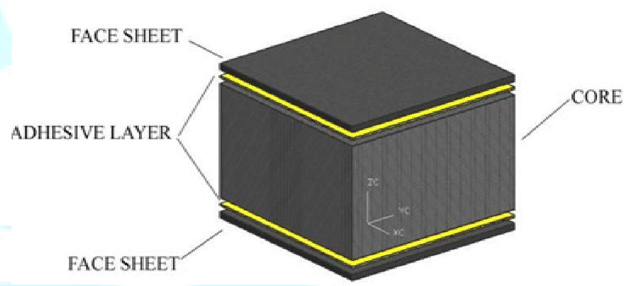

Figure: sandwich panel

The primary functions of the face sheets are to provide the required bending and in-plane shear stiffness alongside to carry the axial, bending, and in-plane shear loading. The core has several vital functions. It must be stiff enough to resist loads acting in perpendicular direction to the panels, so the distance between the upper and the lower face sheet remains fixed. Also, it must be stiff enough in shear to prevent the sliding of the face sheets over each other. If this condition is not fulfilled, the face sheets act as two independent panels and the sandwich effect is lost. In addition, the core should be stiff enough to stabilize the thin face sheets, otherwise wrinkling (local buckling) of the face sheets may occur. Role of Adhesives (or the bounding layer) in the sandwich structures is to keep the faces and the core cooperating with each other. The adhesive between the faces and the core must be able to transfer the shear forces between the faces and the core.

The adhesive must be able to carry shear and tensile stresses. It is hard to specify the demands on the joints. There are many advantages of proper use of honey comb structures. With only a small penalty in weight, the overall performance of the system may be enhanced. Visa versa is also true; great weight savings can be achieved without losing too much from the stiffness and/or strength of the system. Besides, unlike the I-beams, the face sheets are stabilized across their whole length. Rigidity is accomplished in several directions. In addition to these advantages, honeycomb structures also offer advantages like the other types of composites do. For instance, they can be used as a thermal and/or acoustical insulator while acting as a structural element. In order to design a critical component for space application we need to look into vibrational behavior in addition to other design criteria. A structure vibrates in its natural frequency just because of its inherent distribution of mass and stiffness. These vibrations become severe when any of the natural frequency coincides with the external excitation frequency. Under such circumstances the vibrational amplitude at certain locations becomes severe and it can cause failure of

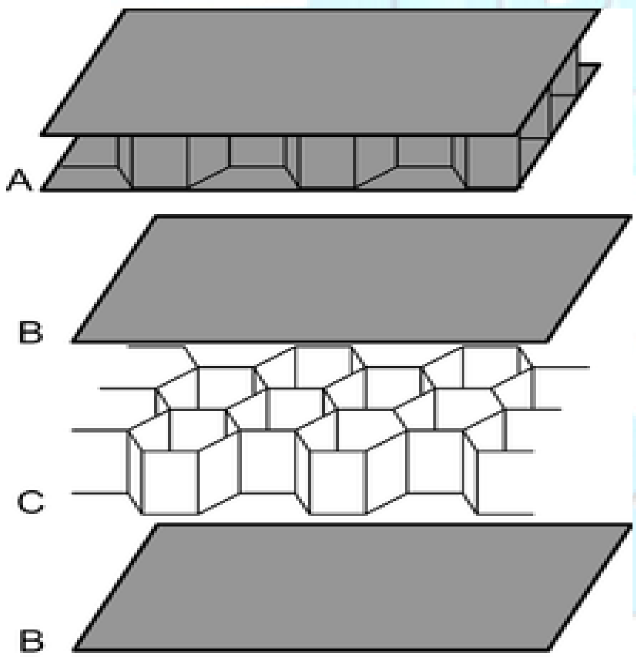

Fig1. Diagram of an assembled composite sandwich (A), and its constituent face sheets or skins (B) and honeycomb core (C)

the component. Vibration analysis basically deals with analyzing its fundamental and other frequencies and corresponding mode shapes. By doing such analysis we will get an idea about the number of frequencies fall within the operational frequency range. Corrective measures are taken based on such frequency analysis.

2.Design and finite element analysis of honeycomb sandwich structures

A honey comb sandwich structure having hexagonal shaped core with 2 face sheets placed in the top and bottom of core. The package used for model the honey comb plate is ANSYS

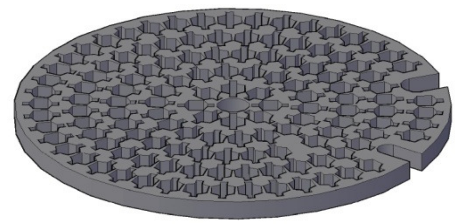

Fig3: Honeycomb Structure

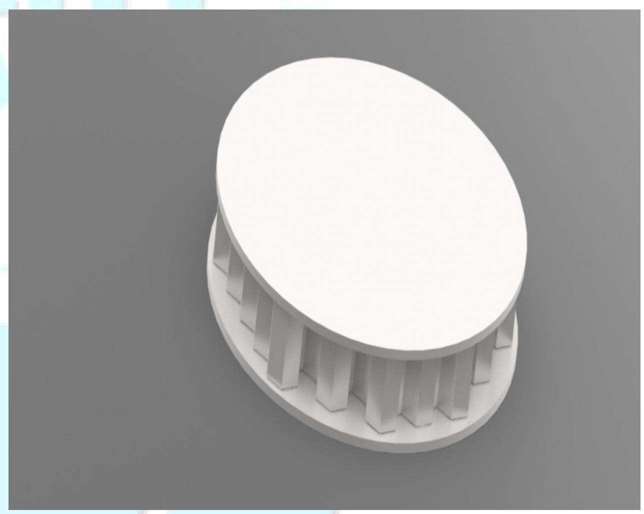

Fig 4: Honeycomb Sandwich Model

The above honeycomb plates are modeled in Solid works and import it to ANSYS. Import the plate in ANSYS and mesh the plate using the SHELL 181 element. SHELL 181 elements is the element used for sandwich plates. It is a layered shell element Also it has model analysis capabilities.SHELL181 is suitable for analyzing thin to thick shell structures. It is a 4 node element with six degrees of freedom at each node: translations in the x, y and z directions and rotations about the x, y and z axes. (If the membrane option is used the element has translational degrees of freedom only.)The degenerate triangular option should only be used as a filler element in mesh generation.SHELL181 is well suited for linear large rotation and or large strain non linear applications. Change in shell thickness is accounted for in nonlinear analysis. In the element domain both full and reduced integration schemes are supported.SHELL181 may be used for layered applications for modeling laminated composite shells is governed by the first order shear deformation theory (usually referred to as Mindlin-Reissner shell theory). SHELL181 can be used instead of SHELL43 for many problems that have convergence difficulty with SHELL43 The honeycomb plate modeled using SHELL181 element the top and bottom face sheets are modeled as isotropic and the core layer will be modeled as orthotropic. Aluminum is the face sheet material. So the properties like elastic modulus, density shear modulus for aluminum is given as real constants for face sheets. The core material is orthotropic material. So the 9 real constants 3 young's modulus, 3 Poisson's ratios and 3 shear modulus are found out using the equation from literature survey. These 9 values are given as the real constants for the core material.

Table 1.properties of selected materials

Material	**density** (g/cm 3)	**poisson's ratio**	**young's modulus**
Aluminum 5056	2.64	0.33	71
Fiber glass	2.55	0.22	80
Stainless Steel 316	7.99	0.275	193

structure consists of top plate, bottom plate and a unit honey comb cell. The unit structure is modeled and subjected to free-free vibration analysis to determine its natural frequencies and mode shapes. The force applied on the structure is 50N. analysis was done by taking following material combinations

Case 1:deck plates- stainless steel 316,hc structure - aluminum 5056

Case 2:deck plates - stainless steel 316 hc structure - stainless steel 316

Case 3:deck plates- stainless steel 316,hc structure-fiber glass or fiber reinforced plastic or e- glass

.

3. Results

Table 2 : Case1, frequencies and deflection of honeycomb structure with deck plates

MODE NO:	FREQUENCY IN HERTZ	MAXIMUM DEFLECTION
1	5316.08	146.21
2	6245.99	229.774
3	7906.89	177.14
4	8871.1	297.753
5	9648.11	230.374

Table 2 :Case 2, frequencies and deflection of honeycomb structure with deck plates

MODE NO:	FREQUENCY IN HERTZ	MAXIMUM DEFLECTION
1	3501.3	117.62
2	4372.7	173.45
3	5494.8	124.70
4	6624.0	340.18
5	7236.0	245.04

Table 3: Case 3, frequencies and deflection of honeycomb structure with deck plates

MODE NO:	FREQUENCY IN HERTZ	MAXIMUM DEFLECTION
1	1763.5	76.71
2	2413.0	92.03
3	2863.7	75.64
4	4428.6	301.32
5	4958.5	209.54

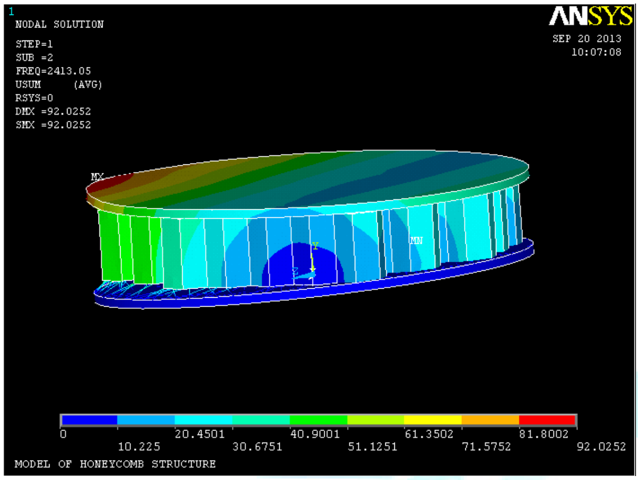

Fig 5. Frequency analysis of honeycomb structure

4 Conclusions

The honeycomb sandwich structure is modeled using SHELL 181 element and is subjected to modal analysis with three cases by changing the materials used for Deck plates and HC structure. The deck plates are modeled as solid element and mixed modeling is used for creating the sandwich structure. In free-free condition we relax all the degrees of freedom at support locations. By conducting modal analysis using different materials, first we used Al 5056 for HC and SS316 for deck plates in case 1. The structure is then exited in between 0 and 10,000 Hz. In case 1 we obtained the highest value as 9648.11 Hz. In case 2 we changed material for both HC and Deck plates to SS 316. In this case we got the maximum value as 7236 Hz. In case 3 we again changed material for HC as Fiber glass and for Deck plates as SS 316, got the highest value as 4958.5 Hz. From this we can conclude that the best material combination for Honeycomb sandwich structure is the case 3, ie HC made of Fiberglass and Deck plates made of SS 316.

5. References

1.Masters I.G., Evans K.E " models for the elastic deformation of honey combs", Composite structures ,Vol.35,1996,pp 403-422,136
2.Liu Q Zhao Y, "Effect of soft Honey comb core on flexural vibration of Sandwich Panel using Low order and High order shear Deformation Models", Journal of sandwich Structures and Materials ,Vol. 9,2007 pp 95-108
3.Abd-el- Sayed F., Burgess I. W, Jones R " A Theoretical Approach to the Deformation Of Honey comb-Based Composite Materials", Composite 1979pp 209-214
4.Grediac M., "A finite Element Study of the Transverse shear in Honey comb Cores", Int. J Solids Structures, vol.30, 1993,pp 1777-1788
5.Shi G., tong P, "Equivalent Transverse Shear stiffness of Honey comb Cores Int. J Solid Structures Vol.32 1995 pp 1383-1393
6.Kelsey S Gellatly R.A, Clark B>W " The Shear Modulus of Foil Honey comb Cores", Aircraft Engg., Vol.30 1958, pp 294-302
7.Becker W., "Closed Form Analysis of the thickness Effect of Regular Honey comb Core Material:, Composite StructuresVol.48,2000 pp 67-70
8.Zhang J., Ashby M.F.," The Out- of -Plane Properties of Honey combs" Int.J. Mech Sci., Vol.34,No.6 ,1992, pp 475-489
9.Nast E." ON Honeycomb- Type Core Moduli ", AIAA/ASME/AHS Adaptive structures Forum, Kissimmee,FL,Apr.7-10,1997, Collection of Technical Papers, Pt.2 (A97-2411205-39)