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Modal Analysis Of Honeycomb Sandwich Panel

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Abstract—The geometry consists of a thick core surrounded by two thin facing layers, and core shape is the regular hexagon. It is designed to be a weight critical structure. Top and bottom are rectangle plates which are bonded to the core of the panel. The individual effect of various dimensions like cell side, cell height, honeycomb core sheet thickness and face sheet thickness on the strength, and weight of the sandwich panel are contributing to the structural efficiency of the panel. Depending on mission requirements material is chosen like aluminum alloys, high tensile steel, titanium alloys are used. In this paper, computational validation of modal analysis of a honeycomb sandwich panel is performed and different materials are tested. Usually, skin required to protect the vehicle frame ex: airframe in Aerospace which is the primary structure of the vehicle they avoid debris and support structural for mechanical and aerodynamic loads. So the need for the special study on these panels is necessary for efficient operation, Therefore, the panel is validated on vibrations effect for safe operation. Results of the study show that the panel is found to be vibrationally capable for the desired mission.

Keywords—Honeycomb sandwich panel; modal analysis;

I. INTRODUCTION

A typical honeycomb sandwich panel consists of two thin and stiff facing materials bonded to a thick and lightweight thin-walled core with in-plane two-dimension periodic cellular structure. A sandwich-structured composite is a special class of composite materials that is fabricated by attaching two thin but stiff skins to a lightweight but thick core. The core material is normally low strength material, but its higher thickness provides the sandwich composite with high bending stiffness with overall low density. Harish R et al. has studied the effect of core height on the fundamental natural frequency of honeycomb sandwich panel and found that as the core height increases frequency also increases [1]. Anju Mohanan et al. has performed the dynamic and buckling analysis and concluded that natural frequency and mode shapes are sensitive to the presence of damage to the structure but less sensitive in identifying the damage location and its size [2].Rajesh Arjunan has performed the vibroacoustic analysis experimentally and computationally on the honeycomb composite fuselage and concluded that good agreement is achieved [3]. A Boudjemai et al. has made a comparison between simulated and experimental results of modal analysis of honeycomb sandwich panels and developed an equivalent model whose results are accepted with good accuracy and also leads to the reduction in cost and the time of analysis [4]. Sourabha S Havaldar et al. has done the modal analysis experimentally (Strike technique) and numerically on FRP honeycomb core with different cell sizes under two different boundary conditions viz. C-F-F-F and C-F-C-F. He concludes that for the facings and the core the fundamental frequencies are quite close to the experimentally determined values [5]. Amit kumar Jha has performed the modal analysis on simply supported aluminum core sandwich panel and concluded that there was a good agreement of FEA and analytical results [6]. K R Pradeep et al. has performed the modal analysis of honeycomb sandwich panel containing the debonds and proposed the modal strain energy change ratio (MSECR) as an indicator of damage [7]. Jarmil Vlach et al. has compared the modal analysis of honeycomb sandwich panels by experimental method, first order shear deformation theory and Reddy's third-order shear deformation theory [8]. Donghuan Liu et al. has performed the modal analysis on a three-dimensional honeycomb sandwich panel and presented an equivalent laminated plate model and shown a good agreement in results [9]. The present paper aims at analyzing the modal analysis of single core and multi-core honeycomb sandwich panel with three different materials like structural steel, aluminum alloy, and titanium alloy.

II. MATERIALS

The materials selected for the analysis of modal analysis are structural steel, aluminum alloy and titanium alloy. The structural steel is steel construction material, a profile, formed with a specific shape or cross section and certain standards of chemical composition and mechanical properties. Structural steel shape, size, composition, strength, storage, etc., is regulated in most industrialized countries.

Aluminum alloys are alloys in which aluminum (Al) is the predominant metal. The typical alloying elements are copper, magnesium, manganese, silicon, tin and zinc. Alloys composed mostly of aluminum have been very important in aerospace manufacturing since the introduction of metal skinned aircraft. Titanium alloys are metals that contain a mixture of titanium and other chemical elements. Such alloys have very high tensile strength and toughness (even at extreme temperatures).

They are light in weight, have extraordinary corrosion resistance and the ability to withstand extreme temperatures. However, the high cost of both raw materials and processing limit their use to military applications, aircraft, spacecraft, medical devices, highly stressed components such as connecting rods on expensive sports cars and some premium sports equipment and consumer electronics.

Sl. No	Properties	Titanium alloy	Aluminium alloy	Structural steel
1	Density	4620 kg/m^3	2770 kg/m^3	7850 kg/m^3
2	Young's modulus	9.6e+10 Pa	7.1e+10 Pa	2.e+11 Pa
3	Poisson's ratio	0.36	0.33	0.30
4	Bulk modulus	1.1e+11	6.9e+10	1.6e+11
5	Shear modulus	3.5e+10 Pa	2.6e+10 Pa	7.6e+10 Pa

Table 1. Properties of the materials used in the analysis

III. MODAL ANALYSIS

Vibration is a mechanical phenomenon whereby oscillations occur about an equilibrium point. The oscillations may be periodic such as the motion of a pendulum or random such as the movement of a tire on a gravel road. Vibration is occasionally "desirable". For example, the motion of a tuning fork, the reed in a woodwind instrument or harmonica, or mobile phones or the cone of a loudspeaker is desirable vibration, necessary for the correct functioning of the various devices.

TYPE OF VIBRATIONS

Vibration can be defined as a regularly repeated movement of a physical object about a fixed point. Vibration can be classified based on various factors like

- Nature of excitation (usually the excitation will be periodic).
- Nature of displacement

Modal analysis is the study of the dynamic properties of structures under vibrational excitation. Modal analysis is the field of measuring and analyzing the dynamic response of structures and or fluids during excitation.

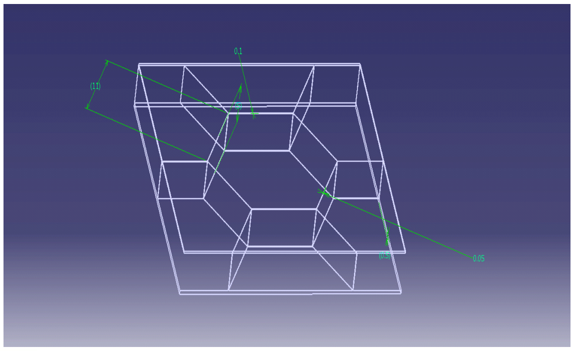

Fig. 1 Single core honeycomb panel

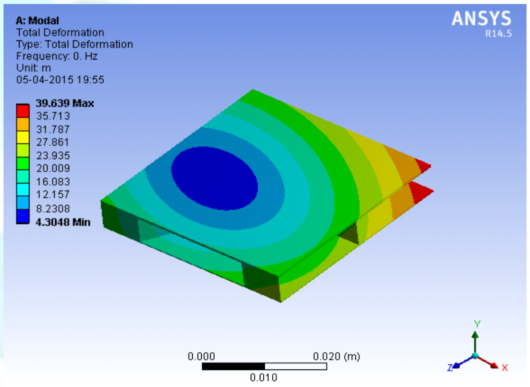

Fig. 2 Modal analysis of single core honeycomb panel

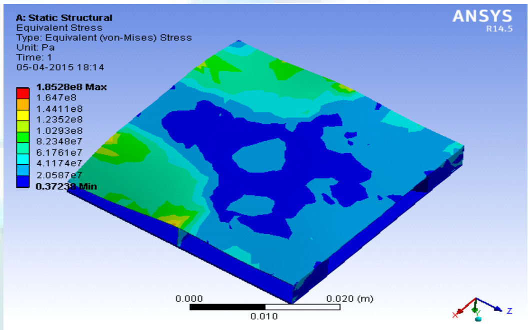

Fig.3 Modal Analysis of pre-stressed single core panel

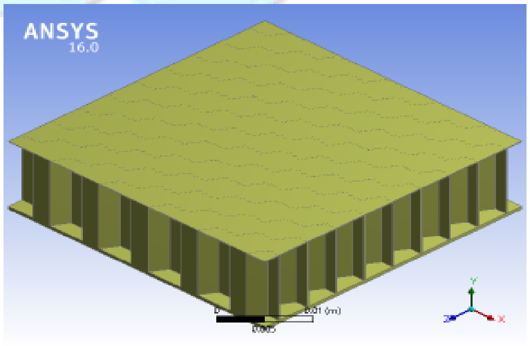

Fig. 4 Multicore honeycomb sandwich panel

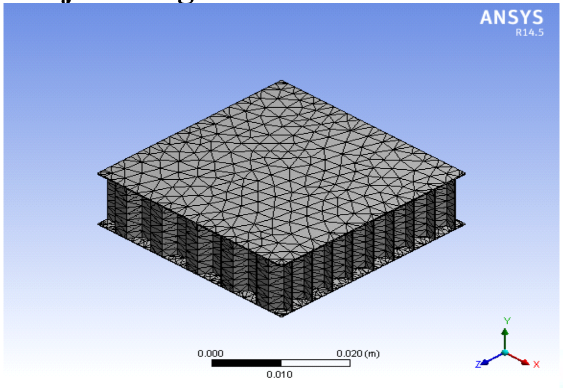

Fig. 5 Meshing of multi-core honeycomb sandwich panel

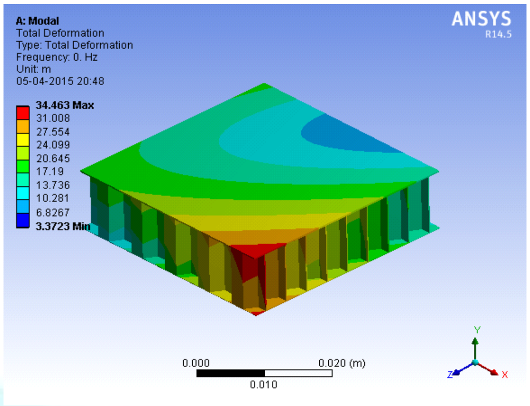

Fig.7 Modal analysis of prestressed multi-core panel

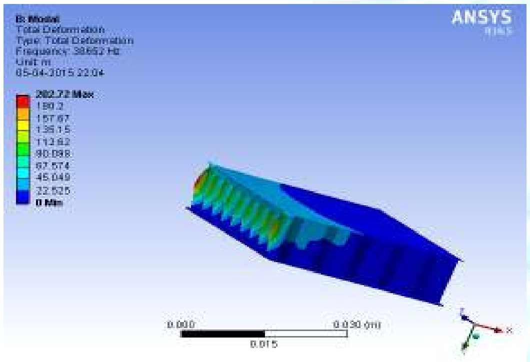

Fig. 6 Modal analysis of multi-core honeycomb panel

IV RESULTS & DISCUSSIONS

The honeycomb sandwich panel is modeled with the following dimensions. Honeycomb cell size =11mm, Honeycomb sheet thickness = 0.05mm, Honeycomb cell height = 10mm& top and bottom sheet thickness = 0.1 mm. A Modal analysis is carried out for the single core and multi-core honeycomb sandwich panels without pre-stressed and with pre-stressed in a commercially available software ANSYS Workbench. Fig.1 shows the basic dimensions of the honeycomb sandwich panel. Fig.2 & Fig.3 shows the honeycomb panel with the natural frequencies without pre-stressed and with pre-stressed of 1 MPa. Fig.4 & Fig. 5 shows the model of honeycomb with multi-core & meshing of the honeycomb respectively. Fig.6 & Fig.7 shows the modal analysis of the multi-core honeycomb sandwich panel without pre-stressed and with pre-stressed of the same pressure of 1 MPs. The results of the modal analysis are shown in Table 2 and Table 3. Modal analysis results show that the aluminum alloy frequency is less for both single core and the multi-core. The von-mises stresses for the three materials are with the material limits, which shows that the honeycomb sandwich panel can withstand the structural stresses while it is in vibrational mode.

Table 2. Modal analysis results of single core and multi-core honeycomb sandwich panels.

Mode	Frequency of the Honeycomb panel					
	Aluminum single core	Aluminium Multi core	Structural steel single core	Structural Steel Multi core	Titanium single core	Titanium Multicore
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0.0861	0.0929	0.0317	0.0861	0.04147	0.094
5	0.1326	0.1244	5.240e-2	0.1326	5.523e-2	0.108
6	0.1656	0.1750	6.168e-2	0.1656	8.937e-2	0.167

Table 3. Modal analysis results of pre-stressed single core and multi-core honeycomb sandwich panels.

	Frequency of the Honeycomb panel – pre stressed					
Mode	Aluminium single core	Aluminium Multi core	Structural steel single core	Structural Steel Multi core	Titanium single core	Titanium Multicore
1	2966.8	38652	2715.1	38787	2715.1	34597
2	3233.1	42118	2968.4	42038	2968.4	37752
3	6397.4	42405	5910.9	42516	5910.9	38190
4	6441	43811	5957.7	43675	5957.7	39555
5	7524.9	44695	6930.7	44494	6930.7	40399
6	7804	45088	7199.2	44873	7199.2	40768

V CONCLUSIONS

- The honeycomb sandwich structure is modeled and is subjected to modal analysis with three cases by changing the materials used for Deck plates and HC structure.
- The increase in thickness of core increases natural frequency.
- The increase in density of the core decreases the natural frequency of the sandwich plate.
- Theoretically, the natural frequency is inversely proportional to the density of the sandwich plate hence density increase natural frequency decreases.
- In case 1, Al5056 material is used and structure are excited in between 0 and 7804 Hz and the highest value obtained is 7804 Hz.
- In case 2, the material used is SS316 & the natural frequencies obtained are in between 0 and 0.1656 Hz. The highest value obtained is 0.1656 Hz.
- In case 3, the material used is Ti106 and the natural frequencies obtained are in between 0 and 7199.2 Hz. The highest value obtained is 7199.2 Hz. In all the three cases Al5056 resists in high frequency with similar modes.

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