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RANDOM VIBRATION ANALYSIS OF SANDWICH COMPOSITE BEAMS

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ABSTRACT
In this thesis, a sandwich composite for Semi-monocoque construction in aircraft fuselage is analyzed for its strength under different loading conditions using different materials for Stringers balsa wood, syntactic foams, and honeycombs and Carbon Fiber reinforced thermoplastics is used as skin material. 3D modeling is done in Pro/Engineer. Static, Modal and Random Vibration analysis is done on the beam using finite element analysis software Ansys.

KEYWORDS: Ansys; composite sandwich; Modal analysis; Pro/E; Random vibrational analysis; static analysis.

INTRODUCTION TO BEAM
A **beam** is a structural element that is capable of withstanding load primarily by resisting against bending. The bending force induced into the material of the beam as a result of the external loads, own weight, span and external reactions to these loads is called a bending moment.[1] Beams are characterized by their profile (shape of cross-section), their length, and their material.[2]
Beams are traditionally descriptions of building or civil engineering structural elements, but smaller structures such as truck or automobile frames, machine frames, and other mechanical or structural systems contain beam structures that are designed and analyzed in a similar fashion.[3]

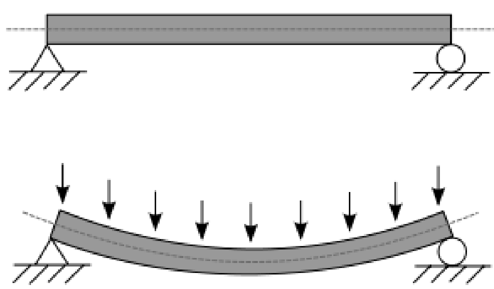

Figure 1. A statically determinate beam, bending (sagging) under a uniformly distributed load.

SANDWICH STRUCTURES
Amongst all possible design concepts in composite structures the idea of sandwich construction has become increasingly popular because of the development of manmade cellular materials as core materials.[9] Sandwich structures consist of a pair of thin strong skins faces facings or cover a thick lightweight core to separate the skins and carry loads from one skin to the other and an adhesive attachment which is capable of transmitting shear and axial loads to and from the core Fig;[4] The separation of the skins by the core increases the moment of inertia of the panel with little increase in weight producing an efficient structure for resisting bending and buckling loads Table shows illustratively the stiffness and strength advantage of sandwich panels compared to solid panels using typical beam theory with typical values for skin and core density.[5] By splitting a solid laminate down the middle and separating the two halves with a core material the result is a sandwich panel[8]. The new panel weighs little more than the laminate but its external stiffness and strength is much greater by doubling the thickness of the core material

the difference is even more striking.[6] Thus sandwich panels are popular in high performance applications where weight must be kept to a minimum for example aeronautical structures high speed marine craft and racing cars In the most weight critical applications composite materials are used for the skins cheaper alternatives such as aluminum alloy steel or plywood are also commonly used[7]. Materials used for cores include polymers, aluminum wood and composites to minimize weight these are used in the form of foams honeycombs or with a corrugated construction [10]

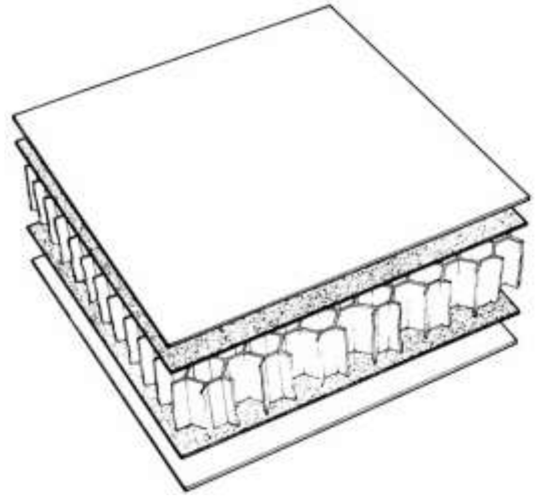

Figure 2. Sandwich construction with honeycomb core

3D Model of sandwich beam (semi monocoque)

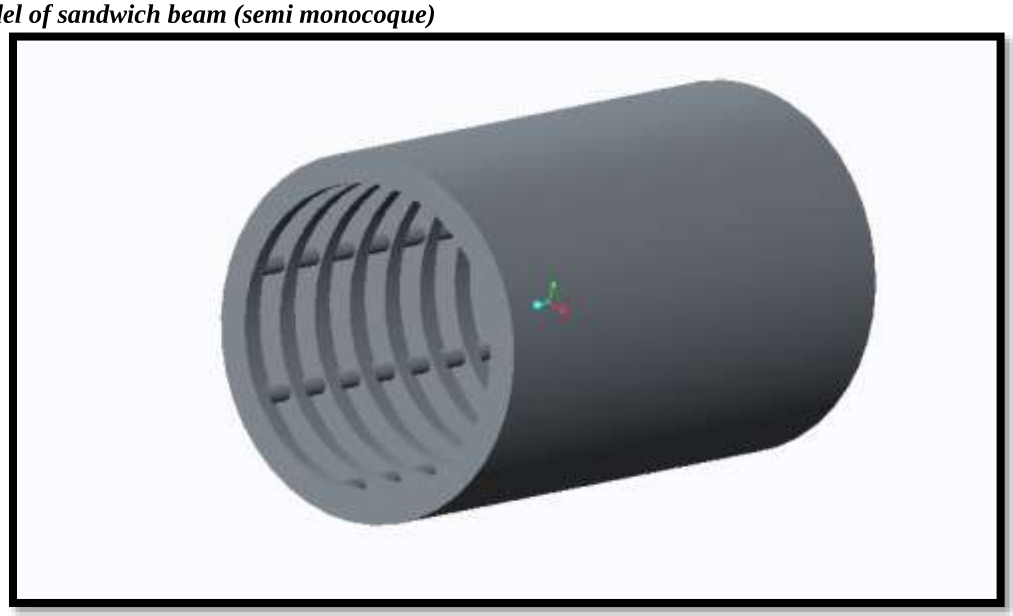

Figure 3. 3D Model of sandwich beam (semi monocoque)

MATERIAL PROPERTIES

SKIN MATERIAL PROPERTIES OF CARBON FIBER REIN FORCED THERMO-PLASTICS

Density : 1430 kg/m^3
Young's modulus : 133000Mpa
Poisson's ratio : 0.39

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STRINGERS MATERIAL PROPERTIES OF HONEY COMB

Density	:	2900kg/m^3
Young's modulus	:	165000Mpa
Poisson's ratio	:	0.25

STRUCTURAL ANALYSIS OF SANSDWICH BEAM (SEMI-MONOCOQUE)

CONDITION 1- PRESSURE (14Psi)
MATERIAL - HONEY COMB

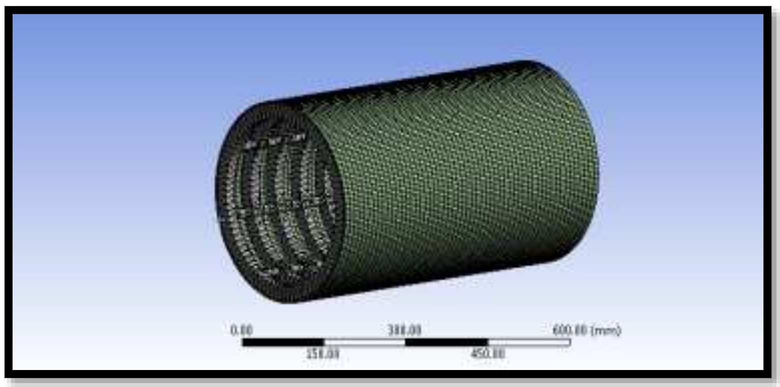


Figure 4. Meshed Model

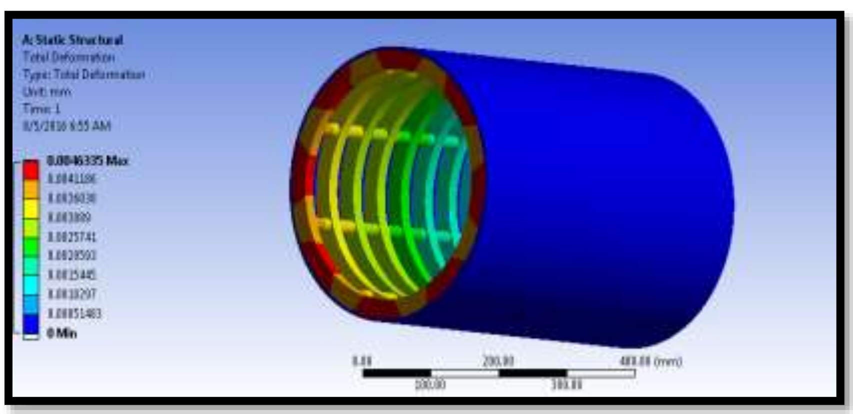


Figure 5. Total Deformation

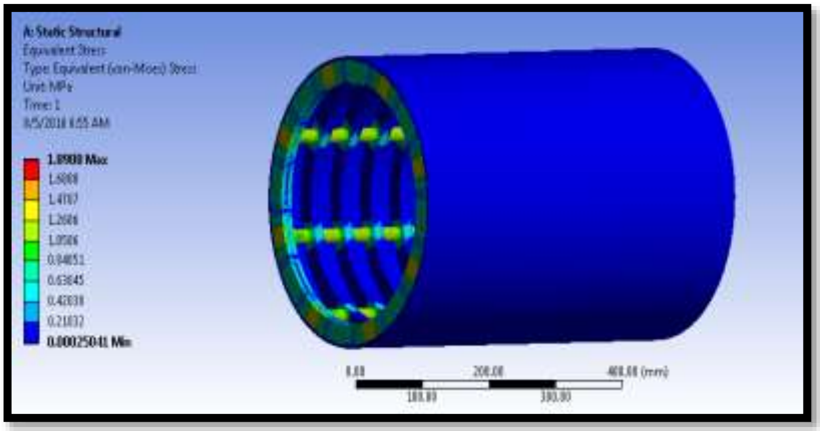


Figure 6. Equivalent Stress

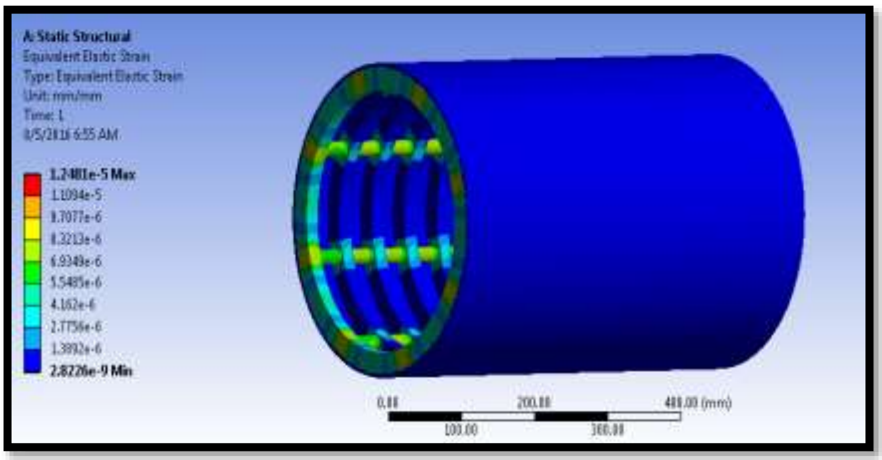


Figure 7. Equivalent Strain

MODAL ANALYSIS OF SANDWICH BEAM (SEMI-MONOCOQUE)

CONDITION 1- PRESSURE (14Psi)
MATERIAL - HONEY COMB

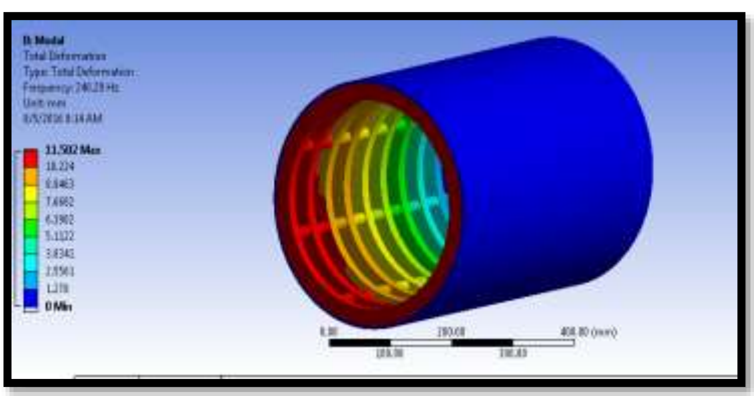


Figure 8. Total Deformation at Mode 1

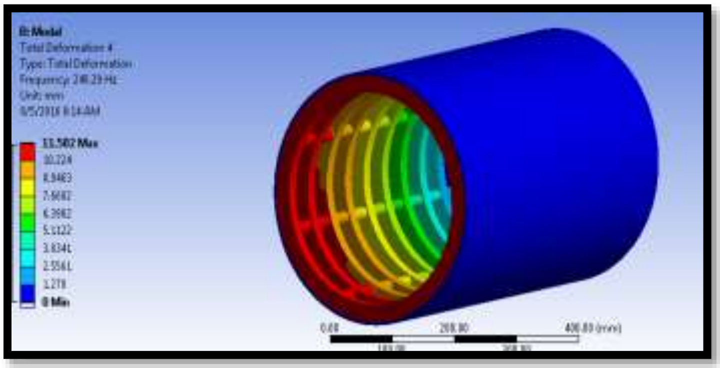


Fig – Total Deformation at Mode 2

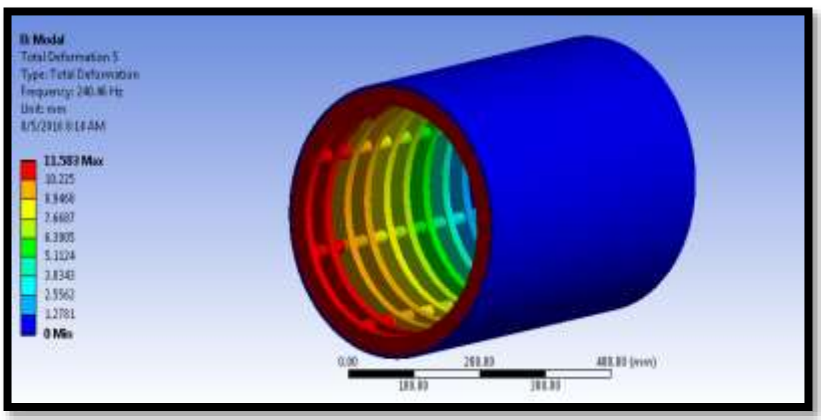


Fig – Total Deformation at Mode 3

RANDOM VIBRATIONALANALYSIS OF SANDWICH BEAM (SEMI-MONOCOQUE)

CONDITION 1- PRESSURE (14Psi)
MATERIAL - HONEY COMB

Tabular Data

	Frequency [Hz]	☑ Displacement [(mm²)/Hz]
1	159.58	48.995
2	233.57	49.068
3	487.91	49.348

Figure 9. Enter frequencies and deformation values from modal analysis

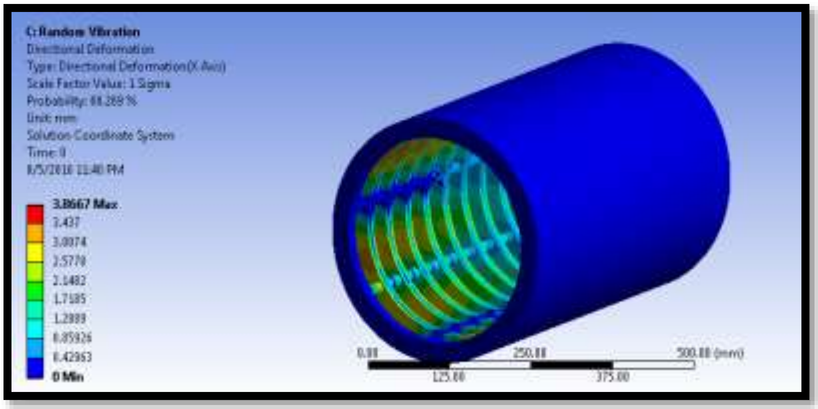


Figure 10. Directional Deformation

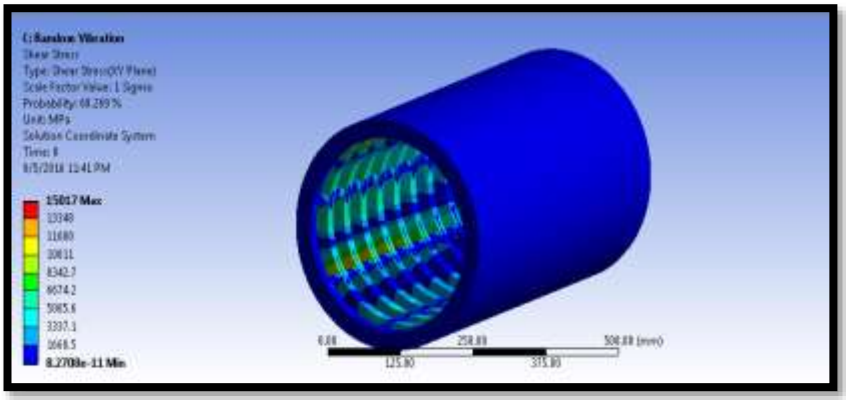


Figure 11. Fig – Shear Stress

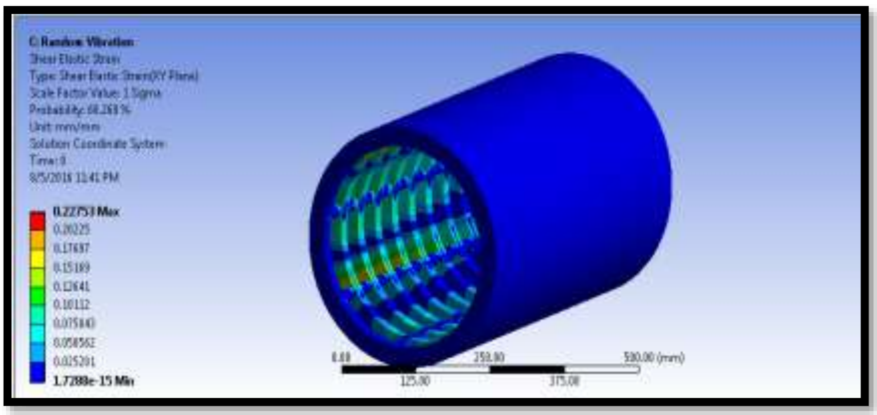


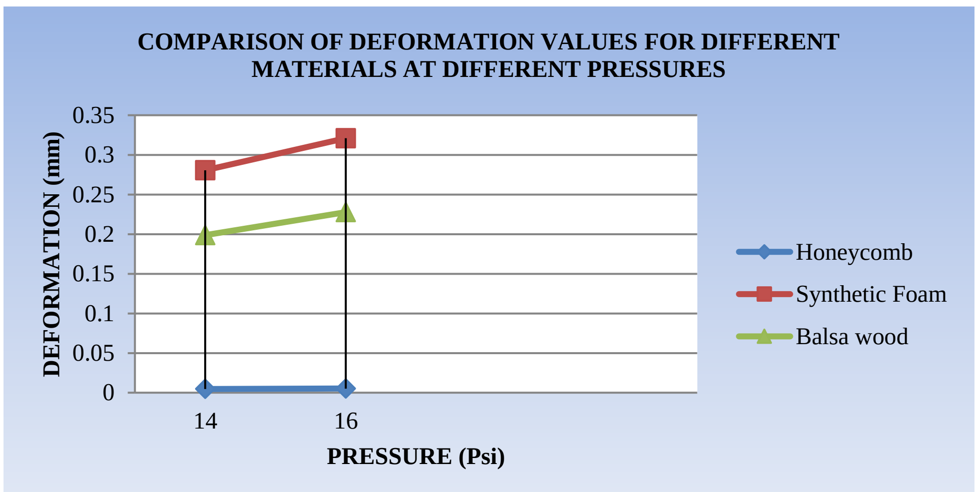
Figure 12. Shear Strain

RESULTS TABLES

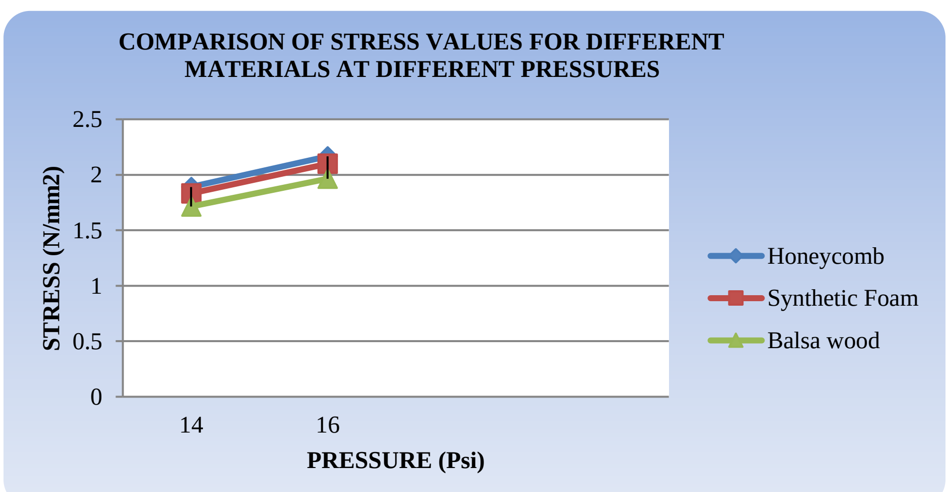
STATIC ANALYSIS

TABLE I. Static analysis

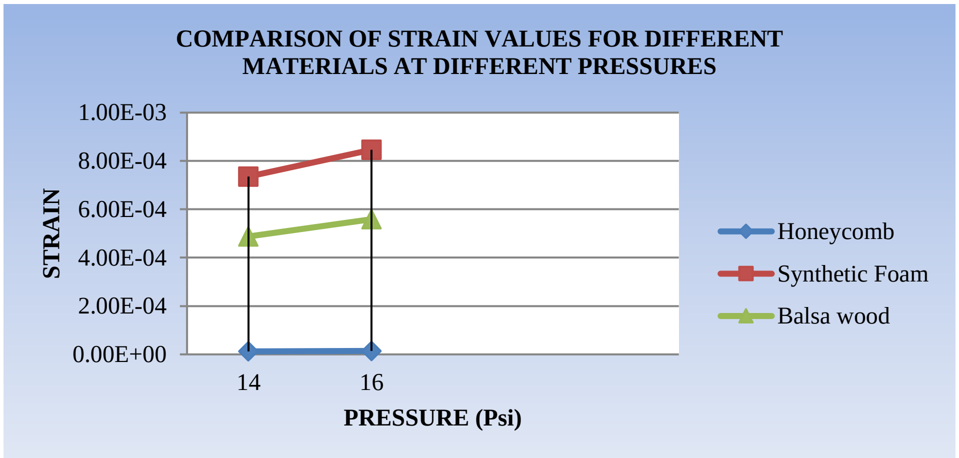
Load condition(Pressure Psi)	Material	Deformation (mm)	Stress (N/mm^2)	Strain
14	**Honeycomb**	0.0046335	1.8908	1.24e-5
	Synthetic foams	0.28059	1.8319	0.0007355
	Balsa wood	0.19874	1.7143	0.00048783
16	**Honeycomb**	0.00530	2.166	1.43e-5
	Synthetic foams	0.321	2.099	0.00084626
	Balsa wood	0.2277	1.9643	0.0005589



Graph 1. Comparison of deformation values for different materials at different pressures



Graph 2. Comparison of stress values for different materials at different pressures

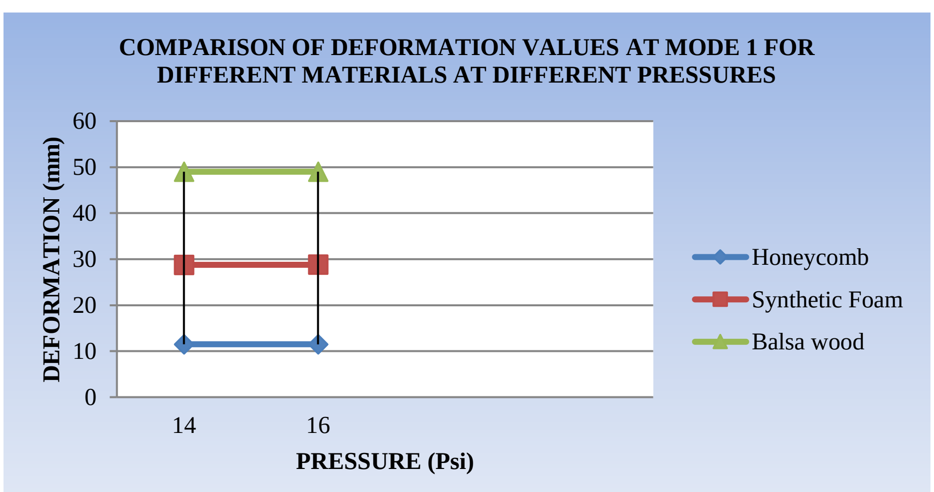


Graph 3. Comparison of strain values for different materials at different pressures

MODAL ANALYSIS

TABLE II. Model analysis

Load condition (Pressure Psi)	Material	Frequency (Hz)	Deformation 1 (mm)	Frequency (Hz)	Deformation 2 (mm)	Frequency (Hz)	Deformation 3 (mm)
14	**Honeycomb**	240.29	11.502	240.29	11.503	240.46	11.504
	Synthetic foams	77.378	28.763	112.23	28.898	236.65	29.015
	Balsa wood	159.67	48.995	233.66	49.067	488.2	49.363
16	**Honeycomb**	240.46	11.503	346.99	11.505	538.88	34.233
	Synthetic foams	77.312	28.78	112.16	28.89	236.44	29.001
	Balsa wood	159.58	49.015	233.57	49.068	487.91	49.348



Graph 4. Comparison of deformation values at mode 1 for different materials at different pressures

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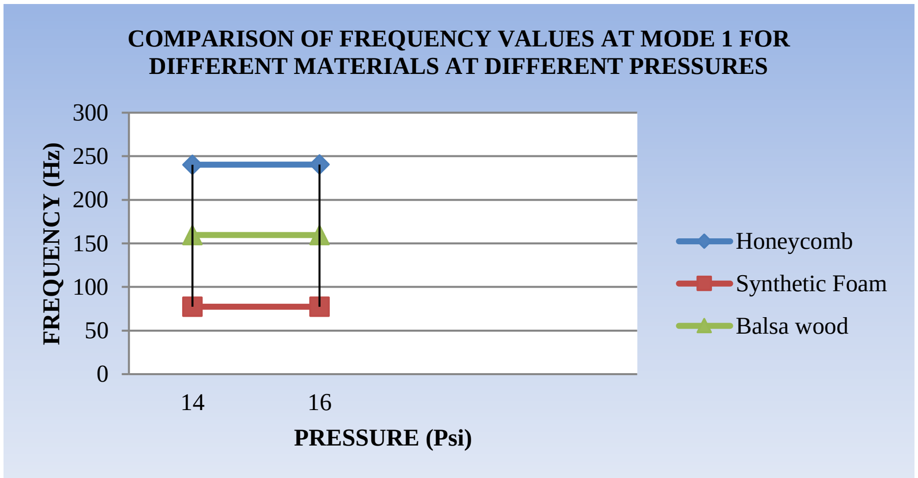
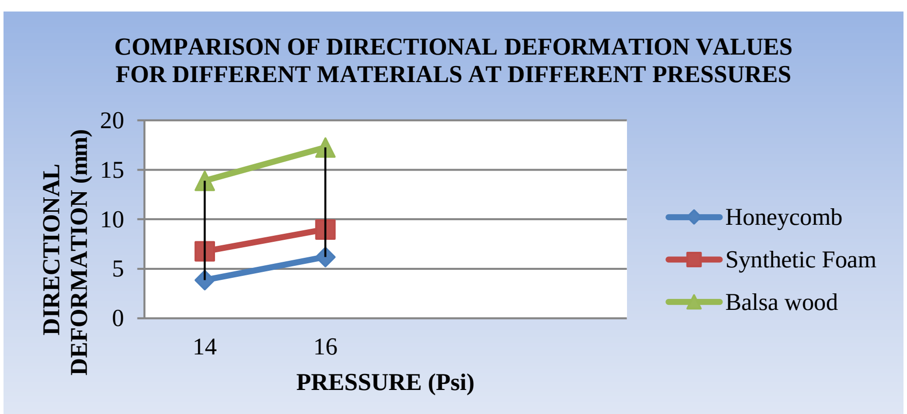


Graph 5. Comparison of frequency values at mode 1 for different materials at different pressures

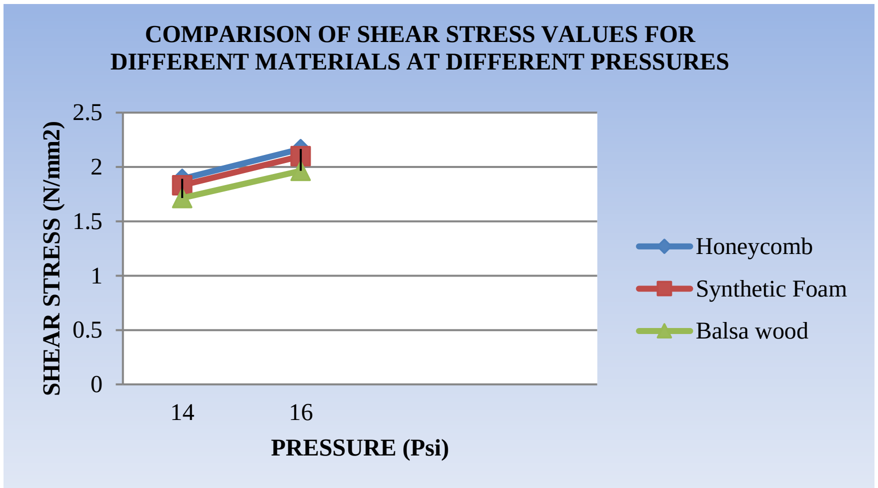
RANDOM VIBRATION ANALYSIS

TABLE III. Random vibration analysis

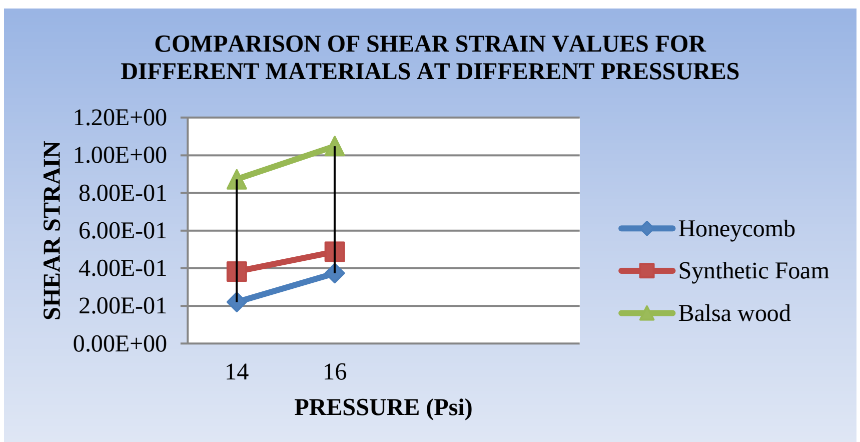
Load condition(pressure)	Material	Directional Deformation (mm)	Shear Stress (N/mm^2)	Shear Strain
14 Psi	**Honeycomb**	3.86	15017	0.22
	Synthetic foams	6.76	382.35	0.38235
	Balsa wood	13.899	1086.1	0.8724
16 Psi	**Honeycomb**	6.204	24595	0.3726
	Synthetic foams	8.99	487.28	0.48728
	Balsa wood	17.265	1303.6	1.0477



Graph 6. Comparison of directional deformation values for different materials at different pressures



Graph 7. Comparison of shear stress values for different materials at different pressures



Graph 7. Comparison of shear strain values for different materials at diffeent pressures

CONCLUSION

By observing the structural analysis results, the deformation, stress and strain values are increasing by increasing the pressure. The deformation and strain values are more when Synthetic foam is used than honeycomb and balsa wood. The stress values for all materials are less than their respective allowable strength values. The stress values are slightly more when honeycomb is used than synthetic foam and balsa wood. By observing the modal analysis results, the deformation values are less when honeycomb is used but the frequencies are more. If the frequencies are increasing, vibrations will increase. By observing the random vibration analysis results, the directional deformation and shear strain are less when honeycomb is used but the shear stress values are more. Though the stress values when honeycomb is used than synthetic foam, its strength is more, so it can be concluded that using honeycomb as stringer material is better.

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