International Journal of Scientific & Engineering Research Volume 10, Issue 5, May-2019
ISSN 2229-5518


# ANALYTICAL STUDY OF COMPOSITE SANDWICH PANELS

Siddhesh Bandekar, Ganesh Bhosale, Dipesh Gorule, Sandeep Dalvi, Prof. Sachin Solanke

Department of Mechanical Engineering, Saraswati College of Engineering, Kharghar, Navi Mumbai

**Abstract: Composite sandwich panels are used in various applications such as in racing cars, satellites, ship hulls and aircrafts etc. due to its light weight and high strength to weight ratio. Aim of this paper is to represent the strength characteristics of composite sandwich panel with aluminium honeycomb as core material and carbon fibre sheets as outer facing/skin theoretically. 3 point bending test is carried out on composite sandwich panel to determine its strength characteristics. Also, we theoretically calculated deflection and stiffness of composite sandwich panel.**

**Keywords – Composite Sandwich Panel, Aluminium Honeycomb Core, Carbon Fibre, 3 point bending test.**

## 1. INTRODUCTION

Over the last few years, the use of sandwich structures and materials has increased in various industries like aircraft, automobile and marine industry etc. because it offers various advantages in terms of weight saving, strength and high stiffness. A sandwich structure provides high strength to weight ratio. Basically, sandwich panel consist of three essential layers, two thin face sheets and one thick lightweight core material placed between two of them. These three layers are bonded together by adhesive. The core materials is normally low strength material, but its higher thickness provides the sandwich composite with high bending stiffness with overall low density. Commonly cores are made up of cellular foams, trusses and honeycomb. Among these three, honeycomb core is cheaper and provides the structure with minimal density and relatively high compression properties and shear properties.

The sandwich panel is covered by outer thin layers called as facing or skin. Facing sheets are bonded with core material with the help of adhesives. The outer skin must be thin, light weight and resistant to various environmental conditions. So, selection of right material for skin is very important as failure can result in poor performance. Also, it must be capable to hold all the layers of composite sandwich structure firmly. The adhesive should have properties like thermal resistance and corrosion resistance.

This study deals with design and testing of composite sandwich panel with aluminium honeycomb core. This panels are used in racing cars to lower the weight, increase the speed and to absorb the shocks during crash. So, we performed the three point bending test on the composite sandwich panel to understand its strength characteristics.

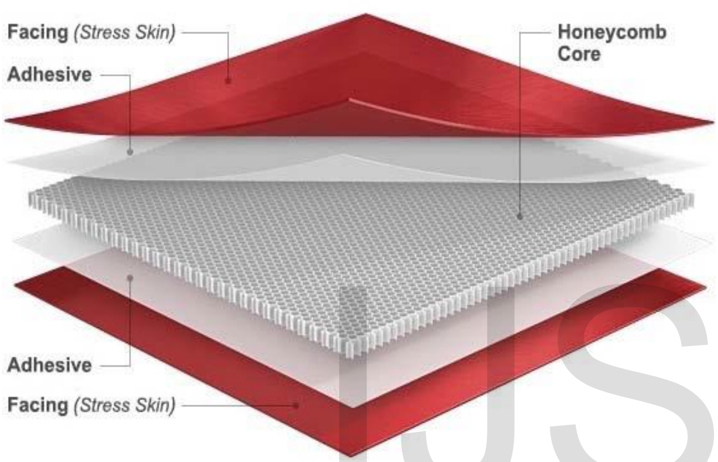


**Fig. 1 Descriptive view of a Composite Sandwich Structure**

## 2. OBJECTIVE

The main objectives of this project is

- To study different properties of core material and face sheets for their selection.
- Theoretically calculate bending stiffness, shear stiffness and deflection of the panel for different applied loads.
- To manufacture a composite sandwich panel of suitable core material and face sheet.

## 3. PROBLEM DEFINITION

- Innovative, high performance design of load bearing components is always sought in high-tech applications, such as aircrafts, spacecrafts, satellites or F1 racing cars. These structures should be as light as possible, while having having high stiffness, sufficient strength and some damage tolerance. This requires structurally efficient construction. Structural efficiency can be maximized by using the most efficient materials and optimizing the structure's geometry.
- Sandwich composite panels are the exact materials that fulfill the required conditions with minimal negatives. They have proven to be superior than many conventionally used materials in many sectors and also posses combine properties of two or more such conventional material at times. Sandwich composites have high strength to weight ratio (which results in increase of payload, provides greater range and/or reduced fuel consumption), extended operational life, lower maintenance cost (due to less corrosion, and resistance to marine boring organisms), as well as a range of integrated functions, such as thermal and sound insulation, excellent signature properties, fire safety, good energy absorption, directional properties of the face sheets enabling optimized design and production of complex and smooth hydrodynamic surfaces.

## 4. MATERIAL SELECTION

In composite sandwich panel, unlimited variety of materials and panel permutations can be used. Different types of material combinations can be used to prepare composite panels that are designated for specific tasks such as high strength, stiffness, long durability, weight saving and aesthetic design etc. The main criteria for selection of material were:

1) Strength: The main reason for using composite sandwich panel over conventional material is to improve the overall strength.
2) Stiffness: The composite sandwich panel provides high stiffness because the core material has low shear modulus which helps it to sustain fatigue failure during bending and shear forces.
3) Weight: Weight of structure can be a crucial criteria at times. Weight of the composite sandwich panel becomes less than that of conventional materials because of the use of low density core material which is complimented by a light weight facing.

By considering the above mentioned criteria, following materials were selected:

**Core** – Aluminium Honeycomb

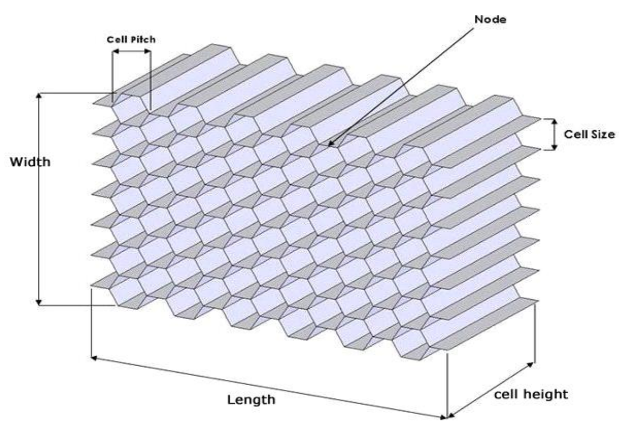


**Fig. 2 Honeycomb Structure**

The geometry of honeycomb allows the utilization of material used to reach minimum weight and minimum cost. Aluminium honeycomb is light weight, recyclable material with goo mechanical properties such as high stiffness, fire resistance, shear and corrosion resistance. It can be used for crash absorption for kinetic energy.

**Facing** – Carbon Fibre

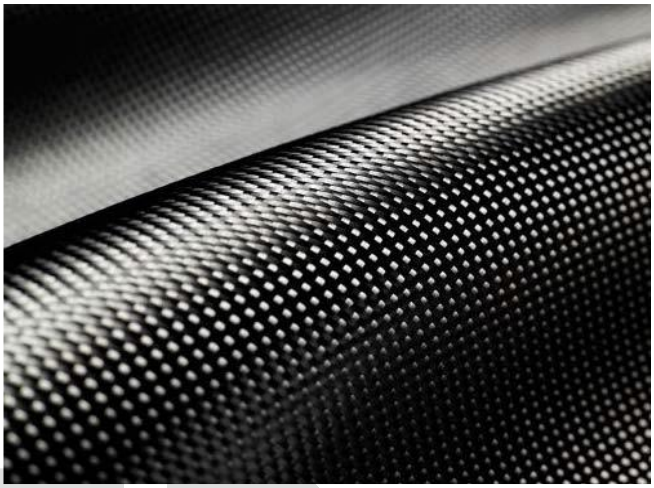

**Fig. 3 Carbon Fibre Sheet**

Carbon is woven into a textile material and resin such as epoxy is applied and allowed to cure. This resulting material is very strong and it has the best strength to weight for all construction material. Caron fibre have high tensile strength to strain and abrasion which is useful in automobiles where high speed is required.

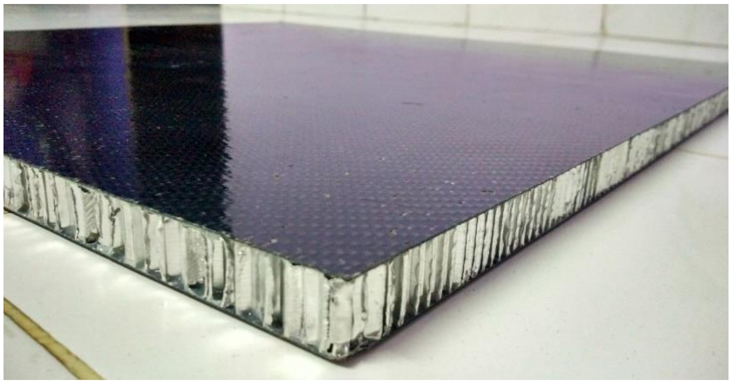

**Fig. 4 Composite Sandwich Panel**

## 5. THEORETICAL ANALYSIS OF THE SANDWICH PANELS

The sandwich structure is been provided by two supports at each ends of the beam with a point load being acted upon the panel at its center as shown in Fig 4.

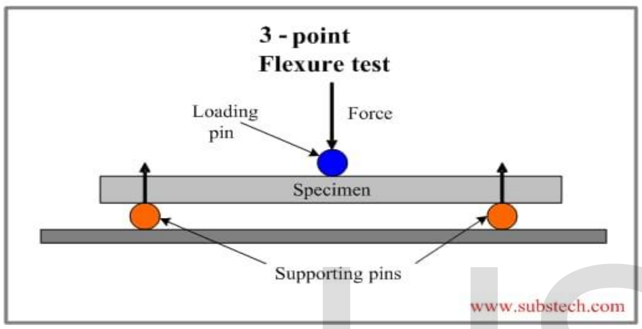


**Fig. 5 3-Point Bending Test Setup**

Due to this application of the point load at the center, the panel tends to bend which causes the lower skin to go under compression while the upper skin is subjected to tension. The point load creates bending moment which is highest at the center and nil at the edges. It also creates shear forces whose variation is indicated in Fig 5.

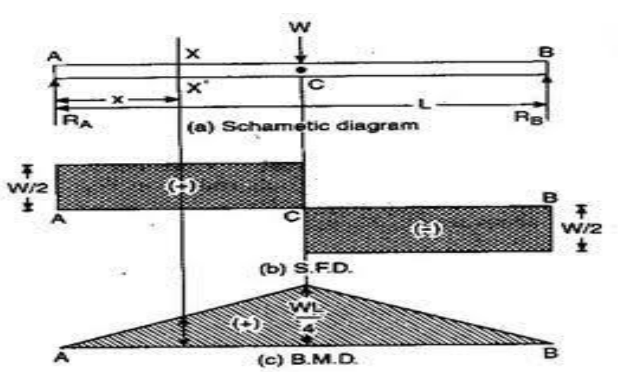


**Fig. 6 SFD and BMD diagram for a Simply Supported Beam**

To calculate the deflection at the mid-span of the beam, following formula is used

$$\delta = ( Wl^3/48E_fI_f ) + ( Wl/4A_cG_{ca} )$$

Where,

$\delta$ = Deflection in the panel

W = Force applied

l = Length between the two supports

$E_f$ = Young's Modulus of facing

$I_f$ = Area moment of inertia of the facing

$A_c$ = Cross sectional area of the core

$G_{ca}$ = Modulus of rigidity of core

The first term on the right hand side of the equation accounts for the bending effect itself while the second term on the right side is a result of the shear effect.

## 6. THEORETICAL CALCULATIONS

The calculations were done by varying the applied loads for a particular thickness of the panel and then calculating the deflection, bending stiffness and shear stiffness for the respective loads. Graphs are plotted for the same. Then, the thickness of the panel is varied and same procedure is been followed.

The main data of the panel that remains same throughout the calculations are:

1) Length (l) =17.71inches
2) Young's modulus ($E_f$) = $34*10^6$ psi

3) Breadth (b) = 10.8267 inches
4) Height of core ($h_c$) = 0.70866 inches
5) Cross sectional area of core ($A_c$) = b*h = 7.66 inch$^2$
6) Shear modulus of core along the length ($G_{cl}$) = 22000 psi
7) Shear modulus of core along the width ($G_{cw}$) = 10000 psi
8) Average shear modulus of core ($G_{ca}$) = ($G_{cl}$ + $G_{cw}$)/2 = 16000 psi

**TABLE 1**

**Variation of Mechanical Properties w.r.t. changing panel thickness and varying loads**

| **Sr. No.** | **Thickness (inches)** | **Moment of Inertia (inch$^4$) I = $b(h^3-h_c^3)/12$** | **Bending Stiffness $K_b$ = E*I (lbs-inch$^2$)** | **Shear Stiffness $K_s$= $(5G_{ca}*A)/6$ (lbs-inch$^2$)** | **Load (lbs)** | **Deflection $\delta = (Wl^3/48E_fI_f) + (Wl/4A_cG_{ca})$ (inch)** |
|---|---|---|---|---|---|---|
| 1. | 0.7244 | 0.3429 | 11658600 | 103936 | 224.8 | 0.04297 |
| | | | | | 449.6 | 0.08594 |
| | | | | | 674.4 | 0.1289 |
| | | | | | 899.2 | 0.1718 |
| | | | | | 1124 | 0.2148 |
| | | | | | 1318 | 0.2576 |
| | | | | | 1579 | 0.3018 |
| | | | | | 1798.4 | 0.3437 |
| 2. | 0.7401 | 0.3657 | 12433800 | 105380 | 224.8 | 0.02519 |
| | | | | | 449.6 | 0.05039 |
| | | | | | 674.4 | 0.07555 |
| | | | | | 899.2 | 0.1007 |
| | | | | | 1124 | 0.1259 |
| | | | | | 1318 | 0.1511 |
| | | | | | 1579 | 0.1770 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | 1798.4 | 0.2015 |
| 3. | 0.7559 | 0.3896 | 13246400 | 108266.67 | 224.8 | 0.01926 |
| | | | | | 449.6 | 0.03852 |
| | | | | | 674.4 | 0.05779 |
| | | | | | 899.2 | 0.07705 |
| | | | | | 1124 | 0.09632 |
| | | | | | 1318 | 0.1155 |
| | | | | | 1579 | 0.1353 |
| | | | | | 1798.4 | 0.1541 |
| 4. | 0.7716 | 0.4144 | 14089600 | 109709.33 | 224.8 | 0.0163 |
| | | | | | 449.6 | 0.0326 |
| | | | | | 674.4 | 0.0489 |
| | | | | | 899.2 | 0.0652 |
| | | | | | 1124 | 0.0815 |
| | | | | | 1318 | 0.0977 |
| | | | | | 1579 | 0.1145 |
| | | | | | 1798.4 | 0.1305 |
| 5. | 0.7874 | 0.4404 | 14973600 | 112597.33 | 224.8 | 0.01453 |
| | | | | | 449.6 | 0.02905 |
| | | | | | 674.4 | 0.0435 |
| | | | | | 899.2 | 0.05812 |
| | | | | | 1124 | 0.07264 |
| | | | | | 1318 | 0.08712 |
| | | | | | 1579 | 0.1021 |
| | | | | | 1798.4 | 0.1162 |

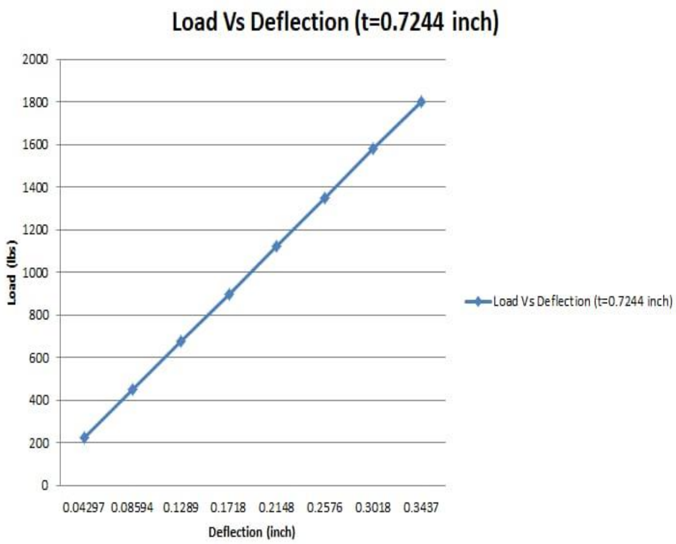


**Fig. 7 Load vs Deflection for 0.7244 inch thickness**

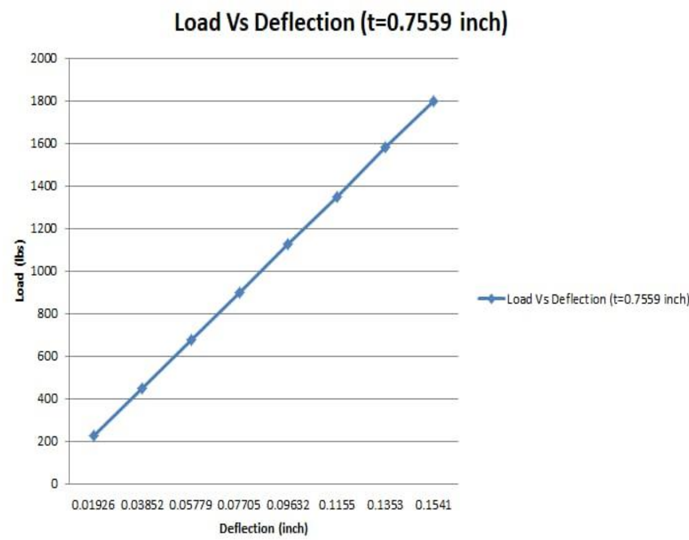


**Fig. 9 Load vs Deflection for 0.7559 inch thickness**

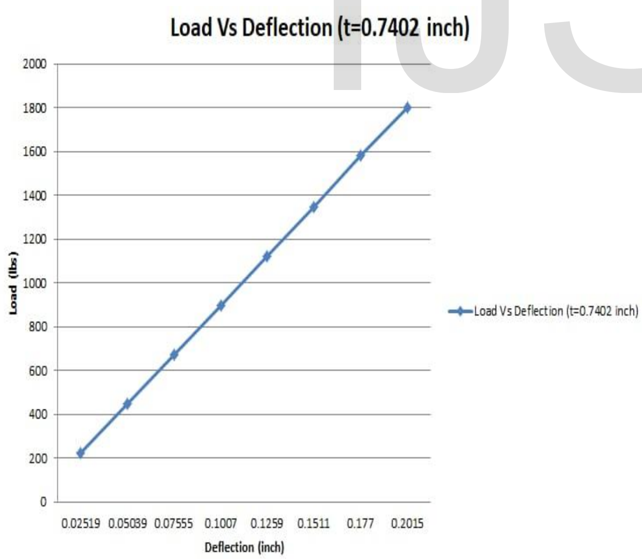


**Fig. 8 Load vs Deflection for 0.7402 inch thickness**

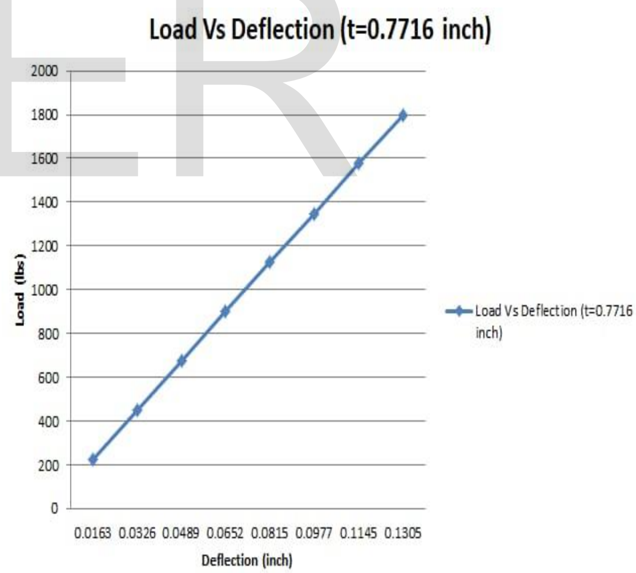


**Fig. 10 Load vs Deflection for 0.7716 inch thickness**

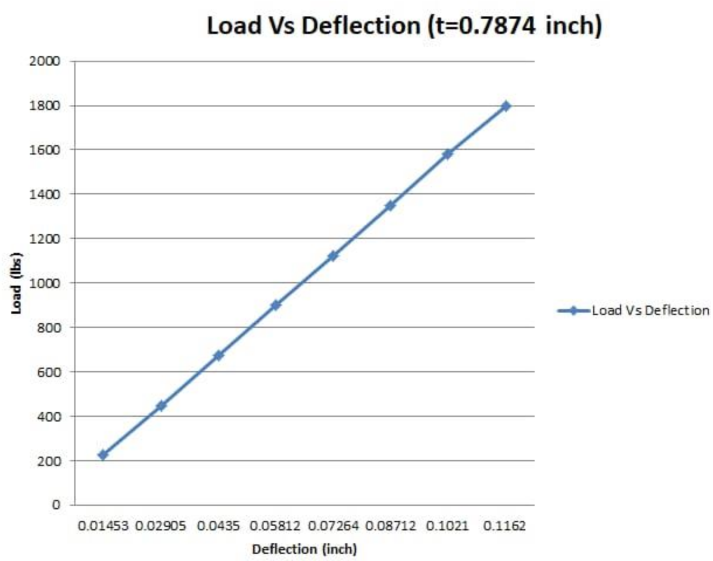


**Fig. 11 Load vs Deflection for 0.7874 inch thickness**

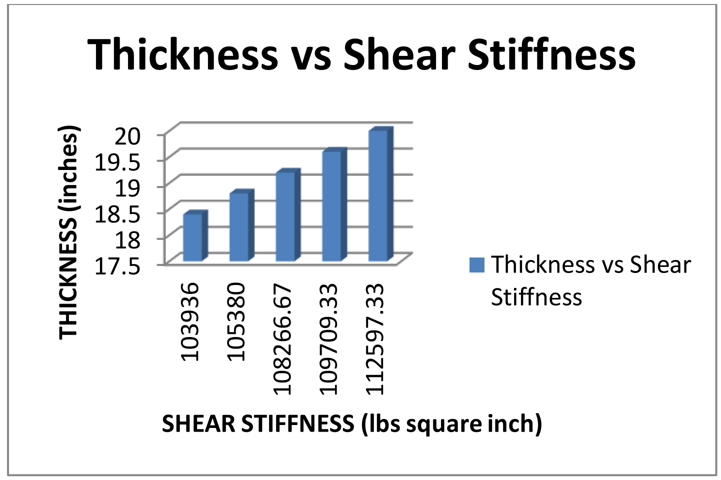


**Fig. 13 Variation of Shear Stiffness with Panel Thickness**

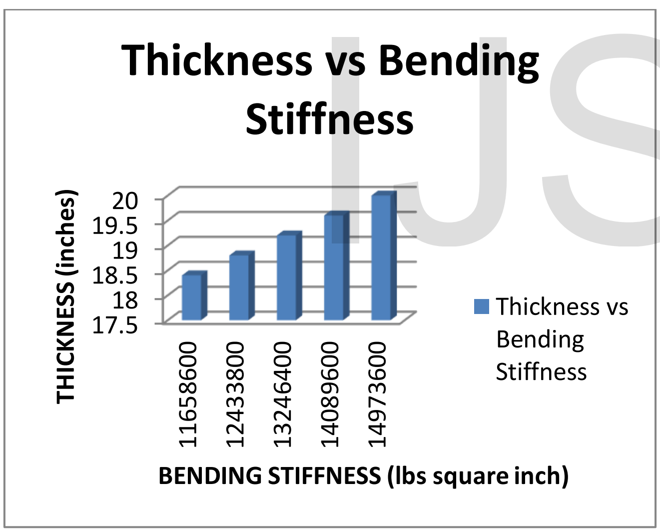


**Fig. 12 Variation of Bending Stiffness with Panel Thickness**



## 7. CONCLUSION

3 Point Bending Test was conducted theoretically and experimentally on composite sandwich panel with aluminium honeycomb as core and carbon fibre as facing material. It is observed that, this composite sandwich panel has enhanced strength properties than that of the conventional materials. From 3 Point Bending Test on composite sandwich panel varying the thickness of facing material, it was observed that, with an increase in facing thickness, the deflection occurring in the panel is reduced which results in increase of strength and durability.

## 8. REFERENCES

[1] K.Kantha Rao and K. Jayathirtha Rao,"Bending Behavior of Aluminium Honeycomb Sandwich Panels", ISSN: 2249-8958, Vol-1, Issue-4, April 2012.

[2] G.R. Rayjade and G.V. Seshagiri Rao," Study of Composite sandwich structure and bending characteristics", Vol-5, no. 2, pp 797-802, 2015.

[3] Ksenia Jegrova," Composite honeycomb cores", pp 1-43, 2014.

[4] Jeom Kee Paik and Anil K. Thayamballi," The strength characteristics of aluminium honeycomb sandwich panels", pp 205-231, 1999.

[5] Achilles Petras," Design of sandwich structures", pp 1-12, 1999.