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Experimental Test on Sandwich Panel Composite Material

Dipak G. Vamja[1], G. G. Tejani[2]
PG Student, Dept. of Mechanical Engineering, R. K. University, Rajkot, Gujarat, India [1]
Assistant Professor, Dept. of Mechanical Engineering, R. K. University, Rajkot, Gujarat, India [2]

Abstract: Automotive industry is on the verge of development and more comforts are being incorporated in a vehicle. On other hand customers have stringent demand of fuel economy, high performance at low cost. In order to have high fuel economy the auto-motive manufacturers are induced to reduce weight. Author has selected composite material of Aluminium composite material (Aluminium skin, polyethylene core, resin binder material). Tensile strength, bending strength has been carried out on Universal Testing Machine (UTM) to optimize of mass of composite material. One can use sandwich panel composite material to optimize mass and cost of various automobile, marine, aerospace and various structures.

Keywords: Composite material, Aluminium plate, Polyethylene plate, binder material, Hexagonal structure, sandwich panel composite, Universal Testing Machine (UTM).

I. INTRODUCTION

1.1 Introduction of composite material

The word composite in the term composite material signifies that two or more materials are combined on a macroscopic scale to form a useful third material. The advantage of composite materials is that, if well designed, they usually exhibit the best qualities of their components or constituents and often some qualities that neither constituent possesses [9].

1.2 sandwich panel

Sandwich structured composites are a special class of composite materials which have become very popular due to high specific strength and bending stiffness. Low density of these materials makes them especially suitable for use in aeronautical, space and marine applications. Geometry of sandwich plate is shown in figure 1.1.

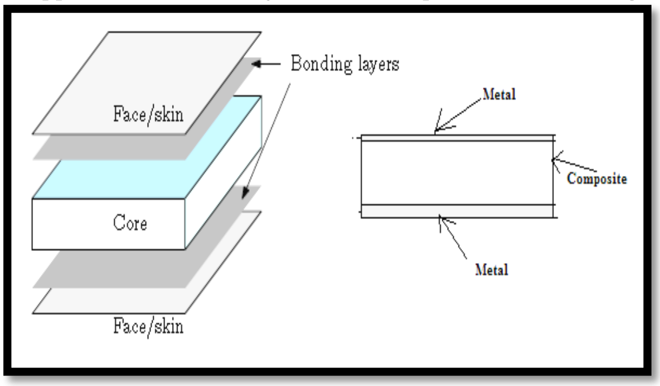

Fig. 1.1 Structure of a sandwich composite [14]

Sandwich composites primarily have two components namely, skin and core as shown in Figure 1.1. If an adhesive is used to bind skins with the core, the adhesive layer can also be considered as an additional component in the structure. The thickness of the adhesive layer is generally neglected because it is much smaller than the thickness of skins or the core. The properties of sandwich composites depend upon properties of the core and skins, their relative thickness and the bonding characteristics between them [5].

II. HONEYCOMB CORE SANDWICH PANEL

2.1 Introduction of honeycomb core

For design and construction of lightweight transportation systems such as satellites, aircraft, high-speed trains and fast ferries, structural weight saving is one of the major considerations. To meet this requirement, sandwich construction is frequently used instead of increasing material thickness. This type of construction consists of thin two facing layers separated by a core material. Potential materials for sandwich facings are aluminium alloys, high tensile steels, titanium and composites depending on the specific mission requirement. [1].

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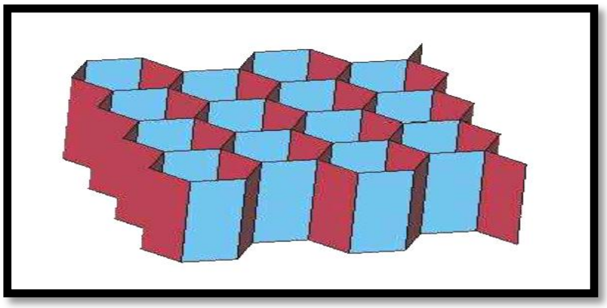

Fig. 2.1 Honeycomb core [16]

2.2 Definition of the unit cell

This unit cell is a hexagonal cell. In fact, with a hexagonal cell, it is possible to describe the entire honeycomb core. The periodicity of the structure is used here. In the second time, the unit cell is built up with one quarter of one central wall and one quarter of one inclined wall. This reduction in the size of the cell to be studied is because of the different symmetries [8].

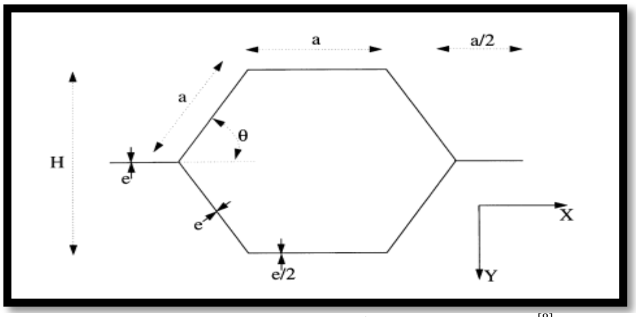

Fig. 2.2 Geometrical parameters for honeycomb core [8]

Figure 2.2 show the construction of unit cell of polyethylene sheet. As shown in figure the vertical wall thickness of hexagon is 10mm, and thickness of inclined face is 5mm, angle between two walls is 60^o, length of inclined wall and vertical is 20mm, and total height of the hexagon cell is 40mm,and thickness of the polyethylene sheet is 4mm.

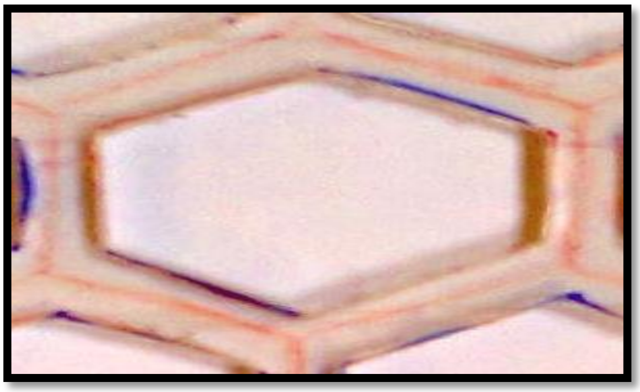

Fig. 2.3 Unit cell of polyethylene sheet

Figure 2.3 show the construction of unit cell of specimen polyethylene sheet. As shown in figure 2.3 the vertical wall thickness of hexagon is 10mm, and thickness of inclined face is 5mm, angle between two walls is 60^o, length of inclined wall and vertical is 20mm, and total height of the hexagon cell is 40mm,and thickness of the polyethylene sheet is 4mm.

III. MATERIAL SELECTION FOR SANDWICH PANEL

3.1 Aluminium composite Panel

Aluminium is a very versatile metal, touches every aspect of our lives, from aircrafts to Automobiles, from power cables to foils, aluminium can be fashioned into myriad shapes in a variety of applications and lately the building industry has caught the fancy of the versatility and Performance of the material.

Table 3.1 MATERIALS PROPERTY OF ALUMINIUM AND STEEL [15]

Properties/materials	Aluminium	Steel
Stiffness N/m	22.9×10^3	22.65×10^3
Density kg/m^3	2700	7800
Weight	Low	high
Young modulus of elasticity N/m^2	70000×10^6	210000×10^6
Shear modulus N/m^2	27000×10^6	81000×10^6
Poisson ratio	0.33	0.3
Co-efficient of thermal expansion l/K	23×10^{-3}	12×10^{-3}
Corrosion resistance	High	Low
Ductility	High	Low
Recyclability	Very good	Good
Cost	High	Low

Aluminium products are more commonly used in the construction of Buildings as composite panels in wall claddings, curtain walling, and roofing. Aluminium is an energy intensive material.

3.2 Polyethylene Sheet

CD case made from general purpose polystyrene (GPPS) and high impact polystyrene (HIPS) Disposable polystyrene razor. Polystyrene (PS) is economical, and is used for producing plastic model assembly kits, CD, "jewel" cases, license plate frames, and many other objects where a fairly rigid, economical plastic is desired. Production methods include thermoforming and injection moulding.

Table 3.2 MATERIALS PROPERTY OF POLYETHYLENE CORE [15]

Mechanical Property	Units	General Purpose Polystyrene
Tensile strength	MN/m^2	34.5-48.3
Elongation at break	%	20-30
Modulus in tension	MN/m^2	2000-3000
Impact strength	J/m	37-59
Flexural strength	MN/m^2	48.3-75.8
Deflection	in	0.15-0.35
Hardness	Rockwell scale	M45-M60

3.3 Binder materials and its property

The choice of a resin system for use in any component depends on a number of its characteristics, with the following probably being the most important for most com- posited structures [9].

Resin use in sandwich panel is Epoxy resins because two important mechanical properties of resin system are tensile strength and stiffness. Epoxy based laminates tend to show very good fatigue resistance when compared with both polyester and vinyl ester, this being one of the main reasons for their use in aircraft structures.

IV. EXPERIMENTAL SET-UP FOR TENSILE TEST AND RESULT

4.1 Tensile test of composite material

Two type of shape consider for tensile test, without hexagonal construction of inner core material simple or solid polyethylene sheet or plate is used, and with hexagonal construction hexagonal shape of polyethylene composite plate were used.

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Table 4.1 SAMPLE SIZE AND MASS FOR TENSILE TEST

Material	**Structure**	**Size**	**Weight**
Polyethylene	Simple	Length=84mm Height=133.5mm Width=6mm	135.6gm
Polyethylene	Hexagon	Length=84mm Height=133.5mm Width=6mm	82.4gm

Size of composite material is same for both without hexagonal composite material and with hexagonal composite material shown in table 4.1, and the structure of inner core material is different like without hexagon shape. In hexagonal composite material we get **39.23%** reduction of weight.

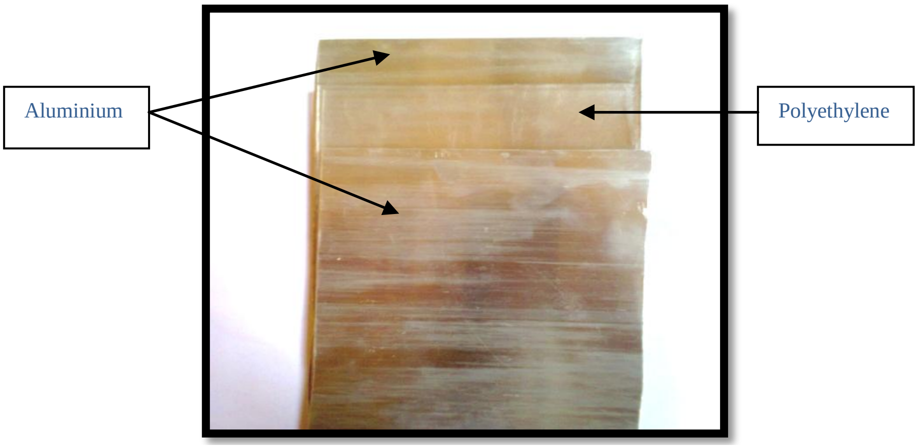

Fig. 4.1 Composite material without hexagon

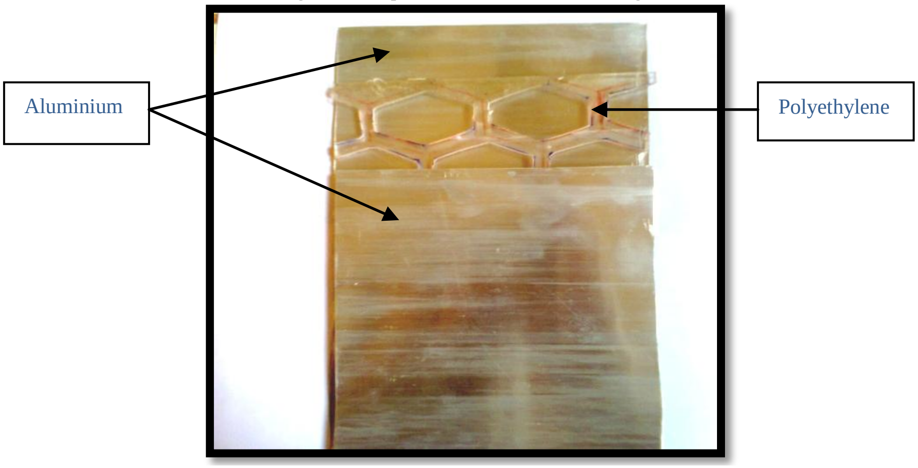

Fig. 4.2 Composite material with hexagon

Figure 4.1 shows composite material used for tensile test is without hexagonal structure and figure 4.2 shows composite materials used for tensile test is with hexagonal structure.

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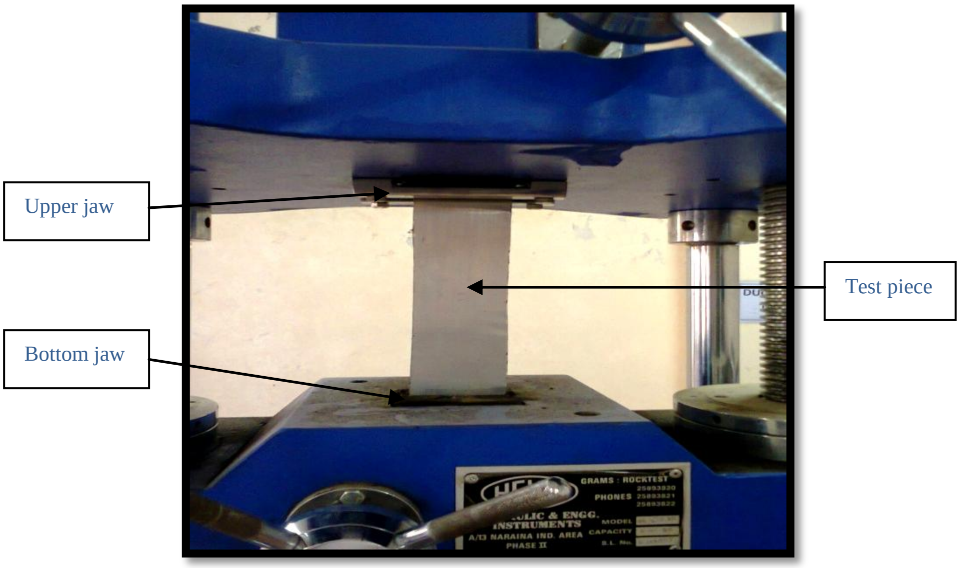

Fig. 4.3 Experimental set-up for tensile test

Figure 4.3 shows tensile set-up fix the test piece of composite in between jaws of the universal testing machine Tensile stress capacity, all results and graph is generated in UTM.

4.2 Tensile test of composite material

Tensile test of composite material without hexagon structure

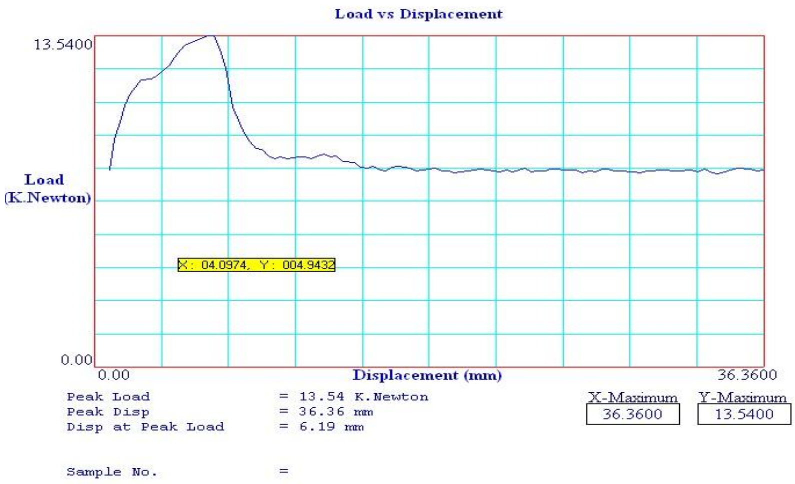

Fig. 4.4 Tensile result generated by UTM (composite material without hexagon)

Tensile test of composite material without hexagon structure

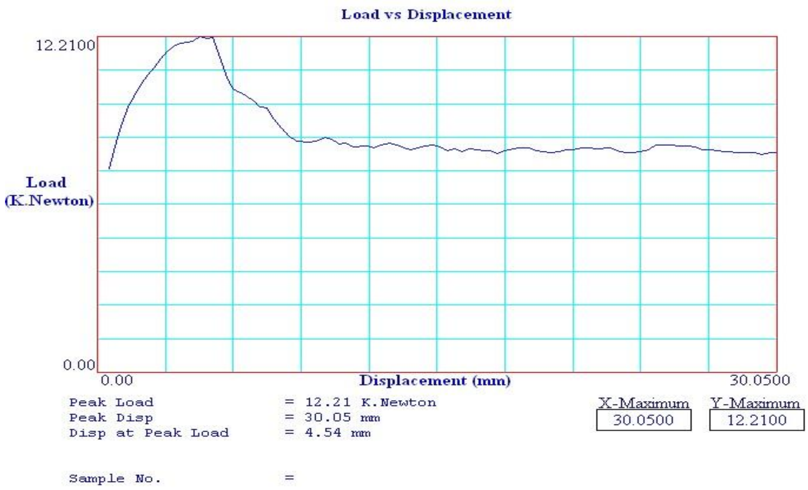

Fig. 4.5 Tensile result generated by UTM (composite material with hexagon)

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Result of tensile test with hexagon structure is shown on figure 4.5. Figure shows composite material with hexagon structure is break at 12.21 KN, and displacement at maximum load is 4.54 mm. Peak load and displacement is highlight in result table of tensile of composite material with hexagon.

Comparison of tensile test with hexagon and without hexagon structure

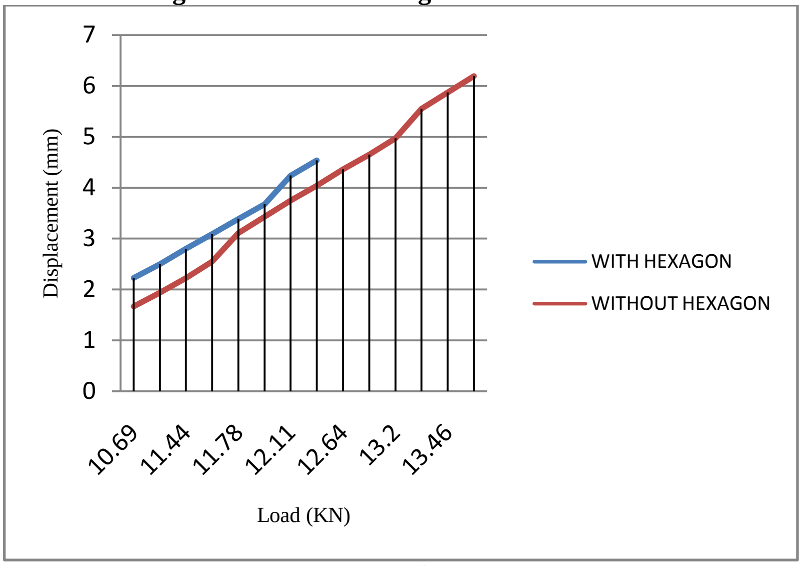

Fig. 4.6 Comparison of tensile test result

Figure 4.6 shows displacement verses load graph is shown, as shown in figure peak load 13.54 KN indicate the tensile test result of sandwich panel composite material without hexagonal structure, and 12.21 KN indicate the tensile result of sandwich panel composite material with hexagonal.

V. EXPERIMENTAL SET-UP FOR BENDING TEST AND RESULT

5.1 Bending test of composite material

Table 5.1 SAMPLE SIZE AND MASS FOR BENDING TEST

Material	**Structure**	**Size**	**Weight**
Polyethylene	Simple	Length=225mm Height=6mm Width=105mm	133.6gm
Polyethylene	Hexagon	Length=225mm Height=6mm Width=105mm	81.4gm

Size of composite material is same shown in table 5.1, and the structure of inner core material is different like without hexagon shape. In hexagonal composite material we get **39.08%** reduction of weight.

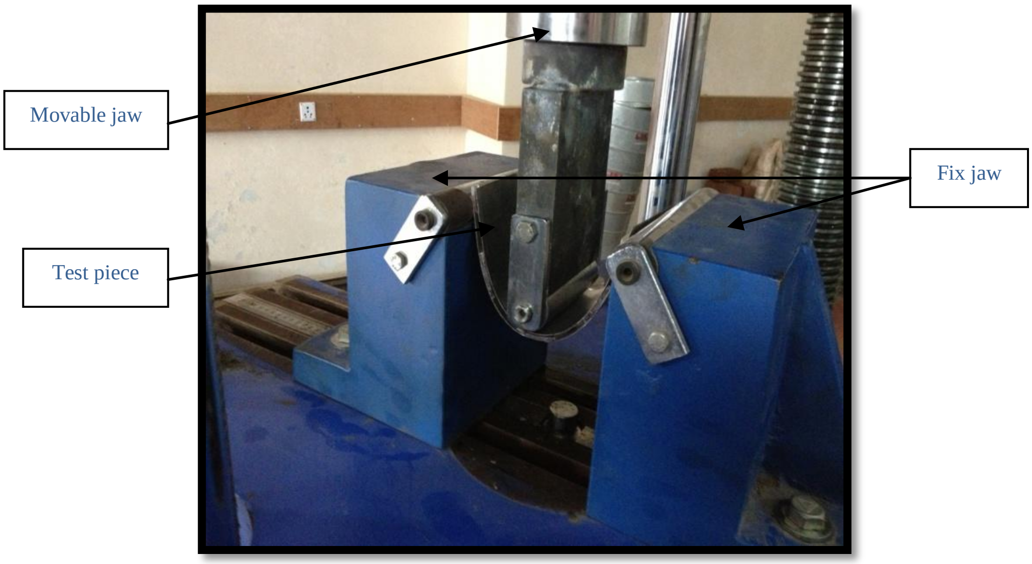

Fig. 5.1 Experimental set-up of bending test

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5.2 Bending test of composite material

There are two types of sandwich panel composite material is consider for bending test sandwich panel composite material without hexagonal structure and sandwich panel composite material with hexagonal structure of core material.

Bending test of composite material without hexagon structure

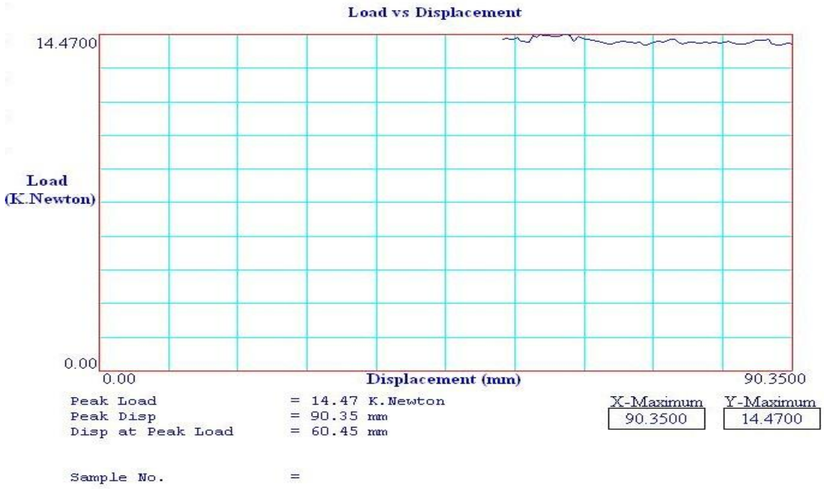

Fig. 5.2 Bending result generated by UTM (composite material without hexagon)

Figure 5.2 shows without hexagonal structure composite material maximum load sustain 14.47 KN. And at peak load displacement is 60.45 mm. Peak load and displacement is highlight in result table of bending of composite material without hexagon.

Bending test of composite material with hexagon structure

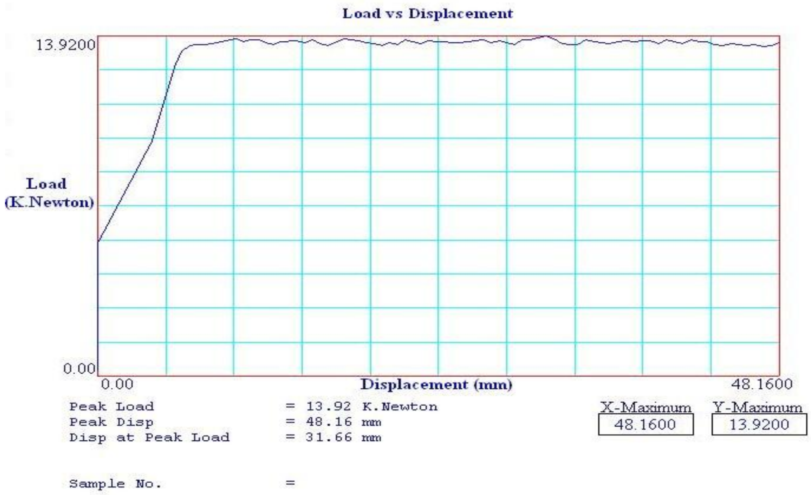

Fig. 5.3 Bending result generated by UTM (composite material with hexagon)

Figure 5.3 shows with hexagonal structure composite material maximum load sustain 13.92 KN. And at peak load displacement is 48.16 mm. Peak load and displacement is highlight in result table of bending of composite material with hexagon.

Comparison of bending test with hexagon and without hexagon structure

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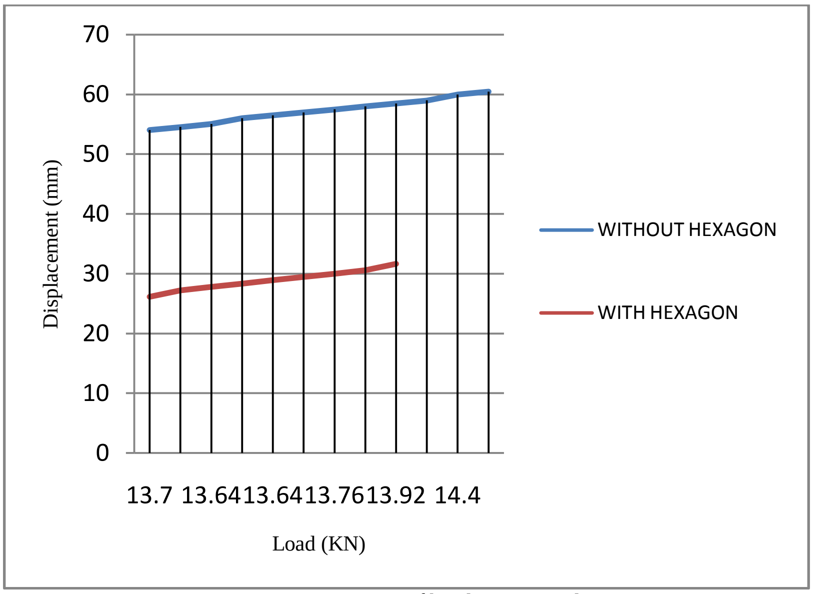

Fig. 5.4 Comparison of bending test result

Figure 5.4 shows displacement verses load graph is shown, as shown in figure 14.47 KN indicate the bending test result of sandwich panel composite material without hexagonal structure, and 13.92 KN indicate the bending result of sandwich panel composite material with hexagonal.

VI. CONCLUSION

Bending test, tensile test is performed on sandwich panel composite material. Two type of inner core structure is considered for sandwich panel composite material, without hexagonal composite material, and with hexagonal composite material. And it is observed that with hexagonal composite material weight saving is **39%** compared with without hexagonal composite material.

From tensile test and bending test of composite material, tensile strength and bending strength capacity of with hexagonal composite material is less compare to without hexagonal composite material, but it can be negligible. Hence sandwich panel composite material (with hexagonal structure) is acceptable in Automobile, Aerospace, and Marine engineering.

REFERENCES

[1] K.Kantha Rao, K. Jayathirtha Rao, A.G.Sarwade, B.Madhava Varma, “Bending Behaviour of Aluminium Honey Comb Sandwich Panels”, International Journal of Engineering and Advanced Technology (IJEAT), ISSN: 2249 – 8958, 2002.

[2] G.A.O. Davies, D. Hitchings, T. Besant, A. Clarke, C. Morgan, “Compression after impact strength of composite sandwich panels”, Composites Science and Technology 69, pp 2231–2240, 2009.

[3] Vitaly Koissin, Andrey Shipsha, Vitaly Skvortsov, “Compression strength of sandwich panels with sub-interface damage in the foam core”, Composites Science and Technology 69, pp 2231–2240, 2009.

[4] Salih N. Akour, Hussein Z. Maaitah, “Effect of Core Material Stiffness on Sandwich Panel Behaviour Beyond the Yield Limit”, Proceedings of the World Congress on Engineering, 2010.

[5] X. Frank Xu, Pizhong Qiao, “Homogenized elastic properties of honeycomb sandwich with skin effect”, International Journal of Solids and Structures 39, pp 2153–2188, 2002.

[6] Kujala, P., Metsa, A. and Nallikari, M, “All steel sandwich panels for ship applications”, Helsinki University of Technology, 2000.

[7] Ji-Hyun Lim, Ki-Ju Kang, “Mechanical behaviour of sandwich panels with tetrahedral and Kagome truss cores fabricated from wires”, International Journal of Solids and Structures 43, pp 5228–5246, 2006.

[8] F. Meraghni, F. Desrumaux, M.L. Benzeggagh, “Mechanical behaviour of cellular core for structural sandwich panels”, Composites: Part A 30, pp 767–779, 1999.

[9] Bhagwan D. Agarwal, Lawrence J. Broutman, K. Chandrashekhara, “Analysis and performance of fiber composites”, ISBN: 978-81-265-3636-8, 2006.

[10] M D Banea, L F M da Silva, “Proceedings of the Institution of Mechanical Engineers”, Journal of Materials Design and Applications, 2009.

[11] M. Meo, R. Vignjevic, G. Marengo, “The response of honeycomb sandwich panels under low-velocity impact loading”, International Journal of Mechanical Sciences 47, 2005.

[12] Jeom Kee Paik, Anil K. Thayamballi, Gyu Sung Kim, “The strength characteristics of aluminium honeycomb sandwich panels”, Thin-Walled Structures 35, 1999.

[13] Robert m. Jones, “Mechanics of composite materials”, ISBN: 1-56032-712-X, 2003.

[14] Wennberg, David, “Light-Weighting Methodology in Rail Vehicle Design through Introduction of Load Carrying Sandwich Panels”, Design Department of Aeronautical and Vehicle Engineering, 2011.

[15] Mazumdar, Sanjay K, “Composite manufacturing Materials, Product, and Process Engineering”, CRC PRESS Boca Raton London New York Washington, 2000.

[16] Nikhil Gupta, “Characterization of syntactic foams and their sandwich composites Modelling and experimental approaches”, Indian Institute of Science, Bangalore, India, 2003.