Fabrication and testing of various sandwich composites

R. NAVEEN*,[a]

*Corresponding author
Aeronautical Engineering, Bannari Amman Institute of Technology,
Alathukombai Post Erode, India-638401
aeror.naveen@gmail.com

DOI: 10.13111/2066-8201.2019.11.1.10

Received: 26 December 2018/ Accepted: 08 February 2019/ Published: March 2019

Abstract: *Industries like aerospace, civil construction and automation uses the sandwich composites widely due to their high strength at low weight. The face sheets and core of the composites play a vital role in the properties of composites. The mechanical properties of these types of structures depend on the application and under various environmental conditions. Most of the sandwich composites will fail due to debonding and core crushing. In this research, three types of sandwich structures like bamboo, V-Board and metal type are tested and characterized for mechanical properties. The sandwich composites are tested by 3-point bending and UTM test to identify several mechanical properties like tensile strength, Young's modulus, fracture, etc. The results show that the bamboo type sandwich composites have high strength and low weight as compared to other composites.*

Key Words: *Bamboo, Sandwich, 3-point bending, V-board, core*

1. INTRODUCTION

Sandwich composites are very popular and have been widely used in several applications where the conception is an identical focus and feasible for the progress of lightweight products with stiffness.

They comprises with two skins as face sheets and a middle core which can absorb the compression load. Composite laminates and metals are commonly used for face sheets wherein the cores can be a polymer and non-polymer honeycombs.

The facings are naturally secured to the core with a bonding agent particularly adhesive resins. The facing stands maximum in-plane and flexible loads and the core describes the weight per unit deflection and shear and compressive strength.

The skin properties deal with the sandwich structural performance and also depend on the cores and the bonding agent of the core near the skins, and also depends on the dimensions.

Under several loading circumstances, properties of nonlinear material behavior & geometric nonlinearities are very important for the composite quality and various failure mechanisms are established.

The sandwich plate geometry is shown in figure 1.

[a]Assistant Professor, Aeronautical Engineering, Bannari Amman Institute of Technology, Alathukombai, Sathyamangalam, Erode, Tamilnadu, India - 638401

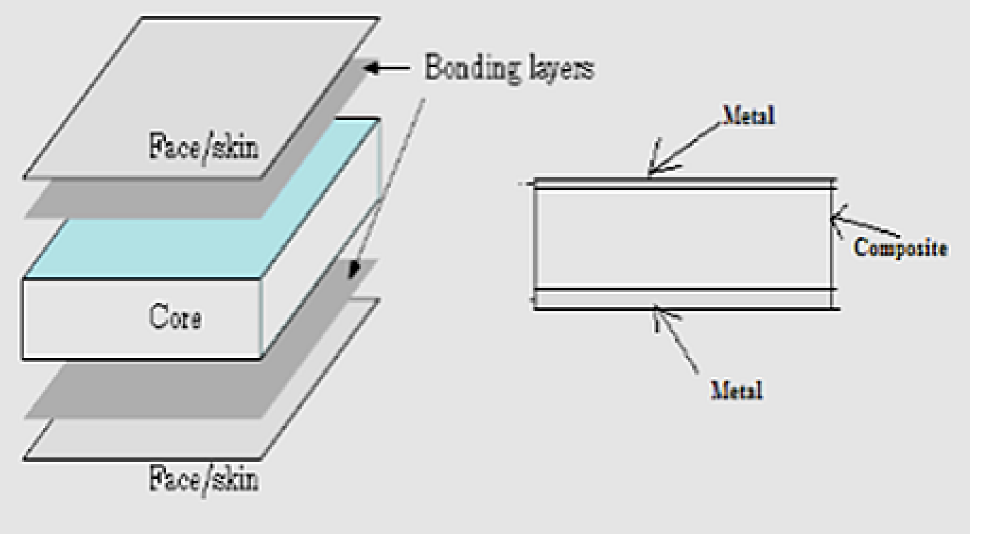

Fig. 1: Schematic Geometry of Sandwich Composite

In the last decades most of the researchers have studied the behavior of the sandwich construction; also numerous numerical, theoretical and analytical analysis are already available as formulas to define the performance of the sandwich composites, face sheets, cores under various conditions.

The basics of these types of composites are defined by numerical and theoretical analysis in current works [1], [2], [3].

From the estimation of the 3-Dimensional elasticity theory built on strain conventions, displacements and stress are designed for several prototypes.

The dimensions of the sandwich construction, characterization of the constituent loading and materials situations adopt the validity of many approximations.

The composite with small deflections are behave as linear elastic assumed by most of the researchers. Any way the material type and dimensions are non-linearity's and leads to significant issue

Furthermore, to modeling composite material behavior the relative motions of the face sheet must be taken as called "multilayer build-up" theory [4], [5], [6].

A number of journals have discussed the non-linear load deflection performance of these composites [7].

There are modern concepts are existed to calculate bending and deflection at low cost composites with a line load and several conditions [8].

Many researchers are focused on the failure mechanism of simply supported sandwich structures which have a composite of face sheet and PVC as Core material using three-point bending test, [8, 9].

Failure modes and collapsing mechanism depending on the thickness and material of the core with an assumption of failure load have been studied [9].

This paper deals with the fabrication of various types of sandwich composites and identification of the composites properties by usual tensile tests and 3-point bending test. The above flowchart in figure 2 explains the flow process of the research.

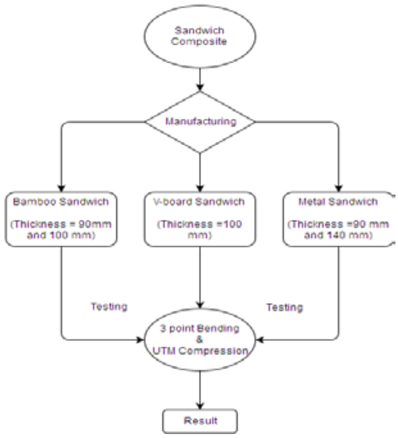

Fig. 2: Flow process

2. EXPERIMENTAL TEST

2.1 Required materials for sandwich composites

Bamboo, sheet metal and thermosetting epoxy resin and core material as polypropylene based honeycomb structure are used to fabricate the sandwich composite. The mechanical property of the sandwich composites are mentioned in table 2 in this research. The mechanical properties of face sheets and core materials are mentioned in table 1

Sandwich composites are made by various span lengths and various thicknesses for testing. To manufacture the composites, the hand layup procedure is followed. This approach refers to manual methods by which fabric layers and matrix are applied to a die.

Desired strength and stiffness are achieved by placing the fiber layers by varying the orientation. To remove the excess resin on each fabric the roller is used to squeeze out.

Table 1. Mechanical Property of Face sheet and Core

Face sheet/Core	Density (Kg/m^3)	Young's Modulus (M Pa)
Aluminium-A1100	2720	6900
Bamboo	1400	1300.1
V-board	825	1933
Honeycomb	915	1700
Polystyrene(foam)	1040	4000
Epoxy resin-DGEBA	1100	3000

2.2 Manufacture of sandwich composites

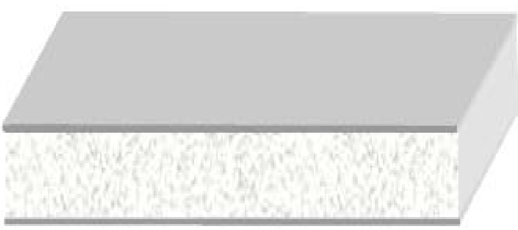

Fig. 3a: Foam type Composite

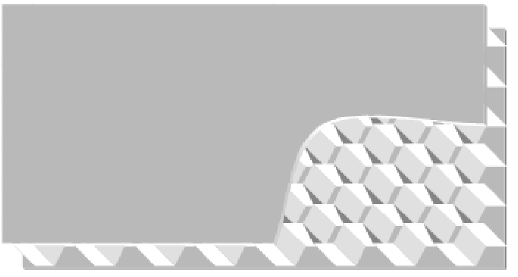

Fig. 3b: Honeycomb Type Composite

In this research, the following materials: aluminium, carbide and bamboo are used as face sheets. The polystyrene and honeycomb structure are used as core for the sandwich composite.

In order to fabricate the sandwich composite the compression moulding technique is used. The adhesives are used to bind the face sheets and core layer under compression load.

The transfer of the shear forces in-between core and facings is achieved by using the adhesive layer. The main function of the adhesive is to carry tensile and shear load.

The same process is also followed for other two composites. The foam and honeycomb types composites are shown in figures 3a, b.

2.3 Bending test

There are various factors are involved in the strength of the sandwich structure /including the materials and geometry of the composite.

The property of material involves the Young's modulus, tensile and fracture strength. Testing of the panel specimens is performed in a horizontal position using a test frame shown in Figure 4.

The load is applied to the specimens in a vertical position. The displacement of the specimen is monitored through manually.

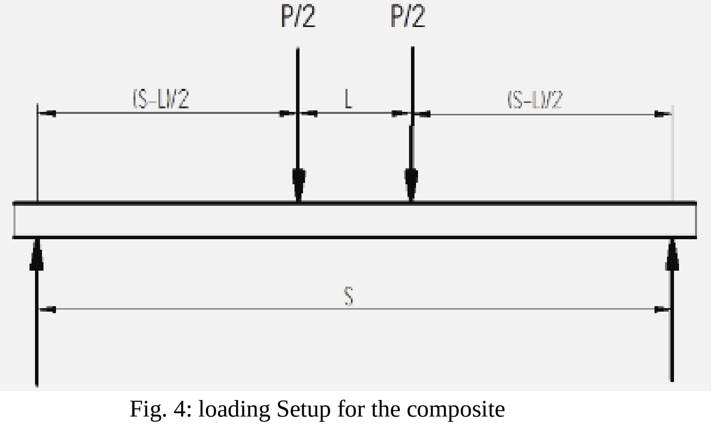

Fig. 4: loading Setup for the composite

Figures 6 to 9 below show the load-deflection curves for wall and the theoretical extremes for various span length and are shown.

The behavior of the panel components during flexural loading a gradual loss of stiffness is shown by increasing the load after an early stage of the linear path.

Fig. 5: Bending test for V-board type composite

Table 2. Details of various sandwich composites

Sandwich type	Thickness (mm)	Weight (Kg)	Density (Kg/m^3)
Metal sandwich composite	90	30.5	111
	140	33	75.7
Bamboo Sandwich	90	17.2	63.9
	60	18	100.36
V-board	100	60	75.6

3. RESULTS AND DISCUSSIONS

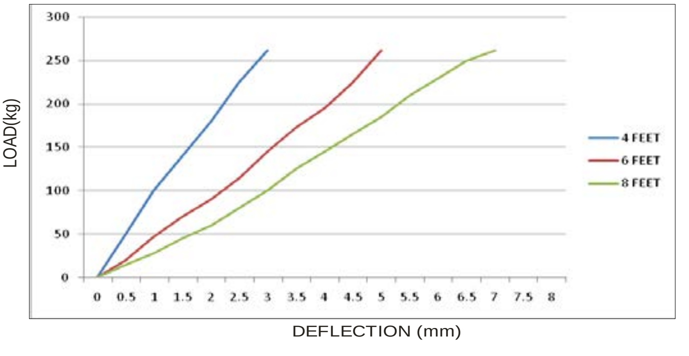

Fig. 6: Load deflection curve for metal sandwich composite-2

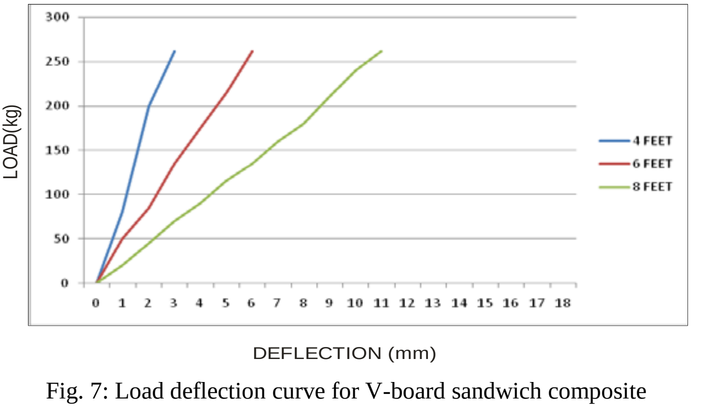

Fig. 7: Load deflection curve for V-board sandwich composite

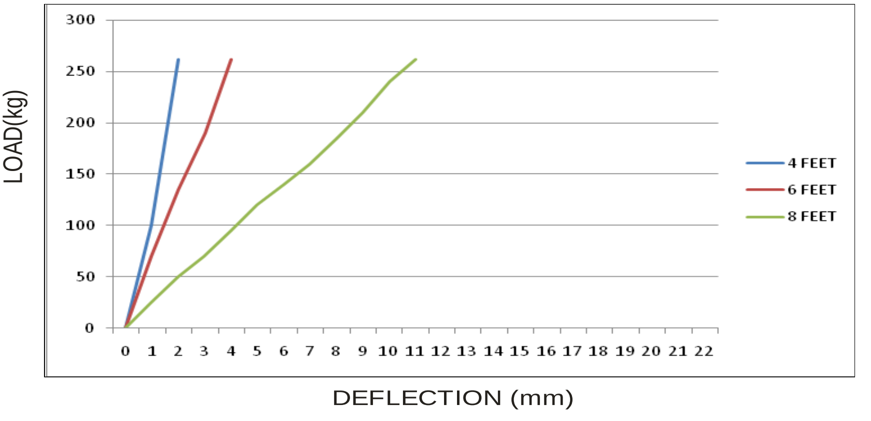

Fig. 8: Load deflection curve for Bamboo sandwich composite-1

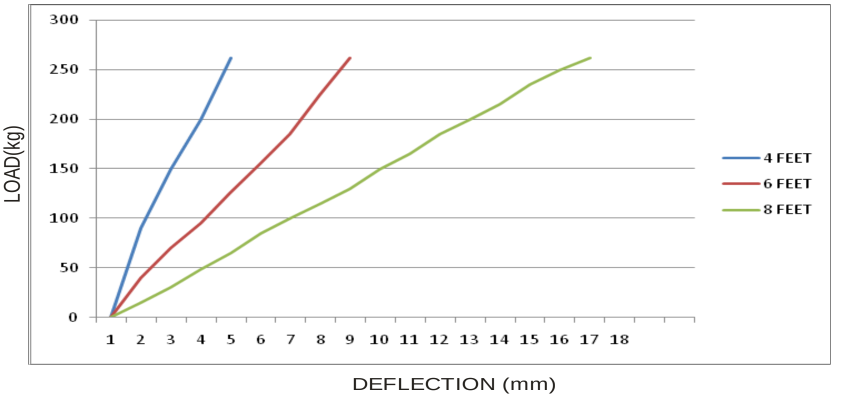

Fig. 9: Load deflection curve for Bamboo sandwich composite

From the above values, we can easily compare the various sandwich composites based on their high-density and low-density materials.

We can also determine the Young's modulus and density of each material. From the four sandwich panels, bamboo has the highest Young's modulus of elasticity.

The bamboo has a tensile strength about 40 KN/cm^2 and it is comparable to less than the tensile strength of the steel about 37 KN/cm^2.

Table 3. Load-deflection behavior of sandwich panels under flexural loading

Material Name	Maximum Flexural Load (Kg)	Young's Modulo Kg/mm^2	Density Kg/mm^3	DEFLECTION (mm) for span length (Feet)		
				4	**6**	**8**
Bamboo Sandwich Panel Thickness=90mm	262 Kg	903	63.56	2	4	11
Bamboo Sandwich Panel Thickness=60mm	262 Kg	1542	100	5	9	17
V Board Honeycomb Thickness=100mm	262kg	510	75.4	3	6	11
Metal Sandwich Panel Thickness=90mm	262kg	933	111.1	3	5	7

Metal Sandwich Panel Thickness=140mm	262kg	1584	75.7	0	2	4

4. VERIFICATION

The various types of composites were tested in the computerized universal testing machine. Results like stress vs. strain graph, load-deflection curves are plotted by using this machine. Load deflection curve for the above composites were verified by comparing the experimental results with the computerized results.

The tested pieces are shown below.

Fig. 10: Experimental test Pieces

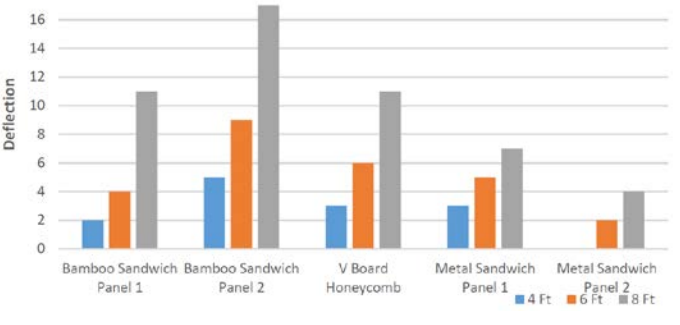

Fig 11. Defection variation of various composites

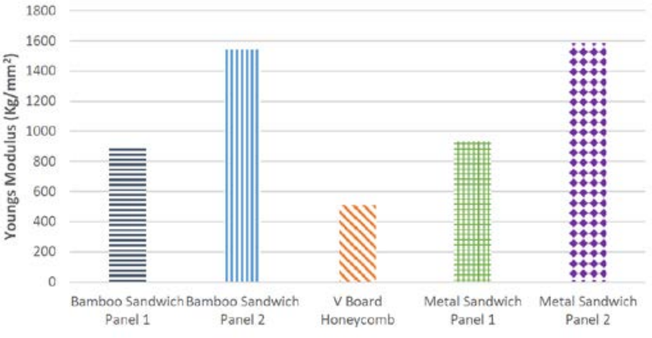

Fig 12. Young's Modulus various composites

5. CONCLUSIONS

In this paper, various types of composites are tested and verified by using UTM and the mechanical properties of the composite were determined. Based on the requirement of the application, these composites can be used. From density and Young's modulus point, the bamboo shows good strength, because the bamboo has a tensile strength about 40 KN/cm^2 and it is comparable to less than the tensile strength of the steel about 37 KN/cm^2.

ACKNOWLEDGMENT

I acknowledge Bannari Amman Institute of Technology management to carry out the research successfully.

REFERENCES

[1] D. Zenkert, An Introduction to Sandwich Construction, Engineering Materials Advisory Services, London, 1995.
[2] A. K. Noor, W. S. Burton and C. W. Bert, Computational Models for Sandwich Panels and Shells, *Applied Mechanics Reviews*, Vol. **49**, pp. 15-199, 1996.
[3] J. N. Reddy, *Mechanics of Laminated Composite Plates: Theory and Analysis*, CRC Press, Boca Raton, FL., 1997.
[4] C. T. Sun, Microstructure Theory for a Composite Beam, *J. of Appl. Mech.*, Vol. **38**, No. 4, pp. 947-954, 1971.
[5] K. Kemmochi and M. Uemura, Measurement of Stress Distribution in Sandwich Beams under Four-Point Bending, *Exper. Mech.*, Vol. **20**, pp.80-86, 1980.
[6] E. Reissner, Finite Deflections of Sandwich Plates, *J. Aeronaut. Scie.*, Vol. **15**, pp. 435-440, 1948.
[7] H.-R. Meyer-Piening, *Remarks on Higher Order Sandwich Stress and Deflection Analysis*, Proc. of the First Int. Conf. on Sandwich Constructions, ed. K.-A. Olsson & R. P. Reichard. EMAS. West Midlands, UK, pp. 107-127, 1989.
[8] C. E. Glenn, M. W. Hyer, Bending Behaviour of Low-cost Sandwich Plates, *Composites Part A Applied Science and Manufacturing*, **36** (10): pp. 1449–1465, 2005.
[9] C. A. Steeves, N. A. Fleck, Collapse Mechanisms of Sandwich Beams with Composite Faces and a Foam Core, Loaded in Three-point Bending. Part II: Experimental Investigation and Numerical Modelling, *International Journal of Mechanical Sciences*, **46** (4): pp. 585-608, 2004.