FLEXURAL ANALYSIS OF SANDWICH PANEL WITH CORE AS JUTE FIBRE REINFORCED POLYMER COMPOSITE

[1]*Pritesh Kailas Patil, [2]*Pritam Tanaji Mane, [3]*Shashikant Tiwari, [4]*G. Venkatachalam.

*School of Mechanical and Building Science,
VIT University,
Vellore-632014, India.

ABSTRACT

Natural Fibre- reinforced polymer matrix composite materials has gain importance by virtue of their light weight. An attempt is made within this study to fabricate sandwich panel with jute fibre reinforced polymer composite as core and also Aluminium as face sheet. Flexural analysis of fabricated sandwich panel is furthermore performed. The hybrid polymer matrix, present in the core, is prepared by blending general purpose resin and cashew nut shell liquid (CNSL). The core thickness, fibre volume and the fibre length are varied and its effect on the flexural behaviour is examined. INSTRON machine is used to carry out the three point bending test, to study its flexural behaviour. Utilizing the ANOVA method, the impact of distinctive parameters on the flexural stress is examined, and a regression equation has been obtained exhibiting the influence of the parameters.

Keywords: Sandwich Panel, Polymer matrix composite, Jute fibre, General purpose Resin, CNSL, Flexural test.

INTRODUCTION

Polymer matrix composite are enhancing more consideration in designing practical application on account of its ease of access as well as simplicity of manufacturing as compared to various strands. A Sandwich Structured composite is a distinguished class of composite material that is fabricated by incorporating two thin but yet all the more hardened skin to a light weight still a thick core. Due to this approach, it allows to have superior mechanical performance at insignificant weight. Multilayered composites are essential structural elements in weight susceptible aviation application, in which high-quality to weight as well as durability to-weight proportion are preferred. The core material is normally of low toughness material, however its increased thickness delivers the sandwich composite with higher bending stiffness with effective lower density. The high durability of a sandwich panel is accomplished under flexural load employed on the panel: core normally takes the shear load and so creates a separation between the skin which takes the in-plane stresses, one skin in tension, the other in compression. Jute is an elongated, sophisticated, glossy vegetable fibre, which can be spun into coarse, solid threads. Jute fibre are derived from solely of the plant material cellulose and lignin. It falls into bast fibre (fibre gathered from bast, the phloem of the plant now and then referred to as skin). It is usually known as raw jute in industry sector. This jute fibre reinforced composites are effortlessly disposable and biodegradable. Fig.1 shows general layout of sandwich panel.

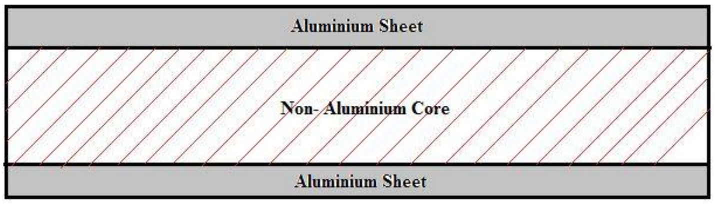


Fig.1 Sandwich Panel

METHODOLOGY

MATERIALS: The fibre used for the fabrication of composite is jute. The jute and the electric casing for the mold has been provided by the School of Mechanical and Building Science, VIT University. The general purpose resin, CNSL, has been provided by Herenba Instruments & Engineers, Chennai. Some Physical properties of jute as shown in the following table 1.

Table.1 Physical Properties of Jute Fibre

Type	Value
Fibre length	1.5 - 3.65 m
Density	1.46 gm/cc
Elongation	1 to 1.8% at the break
Specific Gravity	1.5
Initial modulus	16 to 31 N/tex

FABRICATION METHOD: The Hybrid polymer matrix is formed by making use of the fibre, jute, as a strengthening material of core, for the sandwich panel. The jute in addition, quite well named as bast fibre, is extracted from the innermost bast tissues of the plant stem which is utilized in producing of rope like material, mattresses and so forth. A jute fibre of diameter 0.65mm is used for fabrication. The measurements of the specimen for the flexural stress test is implemented in accordance to the ASTM standard –ASTM C393. The length of the specimen taken= 96 mm (constant), width= 22 mm (constant),. Hand lay-up technique is employed for preparing the specimens. There are actually three parameters varying mainly- Core Thickness (X mm), Fibre Volume (Y %), and even Fibre Length (Z mm). The specimens are fabricated based upon the **Taguchi's Design of Experiment**, an overall of 9 samples with a combination of the above three variables.

The X parameter is taken as 2, 3, 4 mm respectively. The Y parameter is taken ass 3, 6, 9 % respectively. The Z parameter is taken as 96, 32, 16 mm respectively. Mold is prepared by using an electrical PVC packaging with width of 22 mm. The measurement of the mold is 96 mm x 22 mm x (fluctuating thickness). Molding clay is utilized on each side to maintain the fibre straight along the length. The hybrid polymer matrix solution is made by blending together a general purpose resin with cashew nut shell liquid (CNSL is constant of 25 % of the total volume throughout the samples) with little amount of catalyst and the last hardener with very small percentage. After that a couple of Aluminium sheet as Face sheet are taken of dimension, 96 mm x 22 mm x 1.65 mm, are introduced, while the core is sandwich between this face sheet with adhesive material. Fig.2 shows the mold preparation. Fig.3 shows the sandwich specimen.

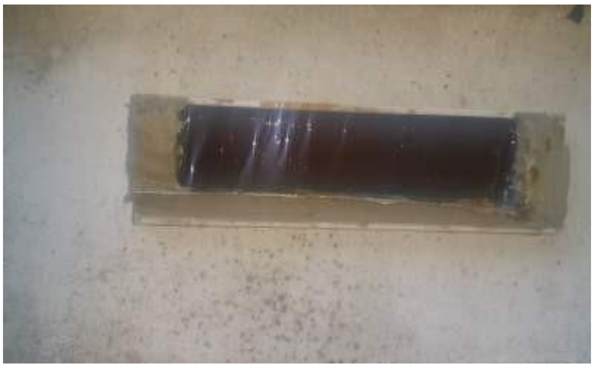


Fig.2 Mold preparation

Fig.3 Sandwich specimen

MECHANICAL TESTING OF SANDWICH PANELS:

A flexural test is performed making the use of an INSTRON testing machine on 9 samples and thus their stress and modulus values are obtained. Three point bending test is conducted on these samples. A constant strain rate of 2 mm/min is applied while the specimen is monitored to have deformation under the action of applied load up to the point of its failure. Fig.4 shows the specimen loaded on machine and ready for the test. Fig.5 sows the failure of the specimen at maximum load.

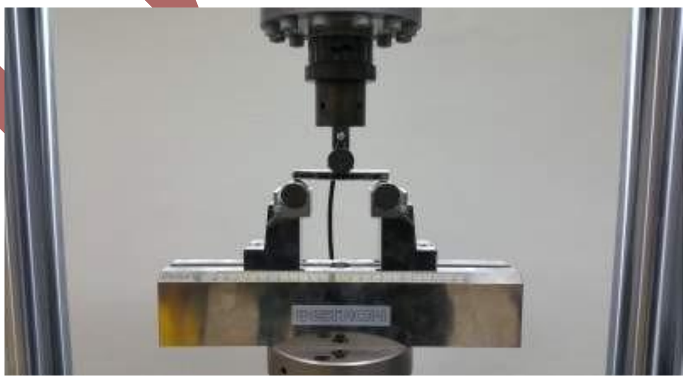


Fig.4 Test of specimen loaded on machine

Fig.5 Failure of the component at maximum load

RESULTS AND DISCUSSIONS

Flexural test is performed by making use of INSTRON machine and the results in terms of outcome of maximum flexural stress as well as modulus of each and every sample for maximum load are obtained. The following table.2 gives the result. Overall Nine iterations are performed ass determined from the DOE by using Taguchi's L9 Orthogonal arrangement.

Sample no.	*Core Thickness (X mm)*	*Fibre Volume (Y %)*	*Fibre length (Z mm)*	*Flexural Stress (MPa)*	*Modulus (MPa)*
1	2	3	96	84.28398	5694.20949
2	2	6	32	138.90907	9746.03288
3	2	9	16	116.54005	7324.00312
4	3	3	32	118.71996	9319.43909
5	3	6	16	80.45705	5657.25004
6	3	9	96	148.24951	11631.99268
7	4	3	16	58.98146	3245.62387
8	4	6	96	99.56944	3812.80423

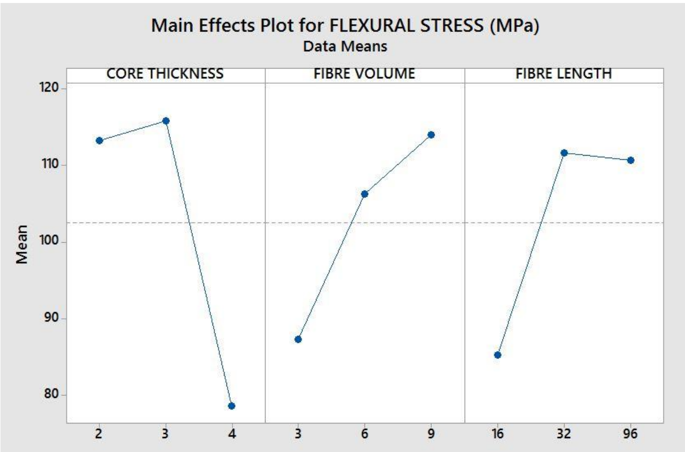
9	4	9	32	77.35299	2966.8094

Table no.2

From the above table, we can say that for Average core thickness, maximum fibre volume and maximum fibre length we get the maximum Flexural stress and Modulus.

ANOVA ANALYSIS

The ANOVA evaluation is conducted to determine the impact of the parameters taken into consideration on the flexural stress of the sandwich panel. The MINITAB software package is utilized for the same. Fig.6 displays the main effect plot of the Maximum Flexural stress by varying the three parameters.



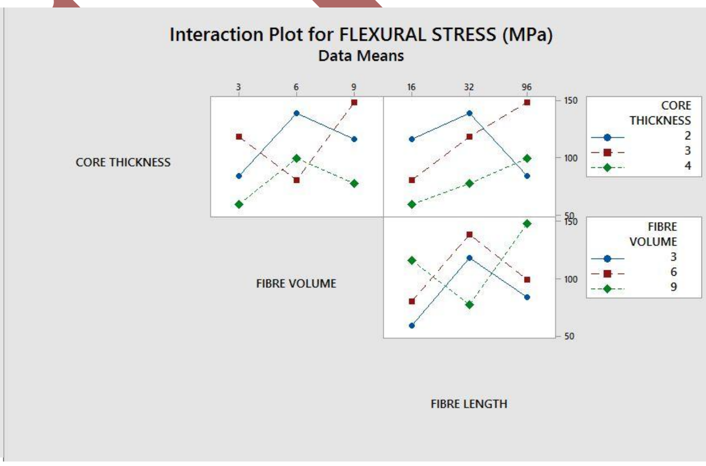


Fig.6 Main Effect plot Fig.7 Interaction plot

Study on influence of various parameters on Flexural stress

The main effects plot, presented in the fig.6, for the maximum flexural stress shows that the increase in fibre volume exhibits higher flexural stress, but the increase in core thickness upto 3mm increases the stress but after reduces the flexural stress. For the case of Fibre length, flexural stress increases linearly. Fig.7 gives the Interaction plot between the three parameters for response as flexural stress.

Influence of Fibre Length and Core Thickness on Flexural stress.

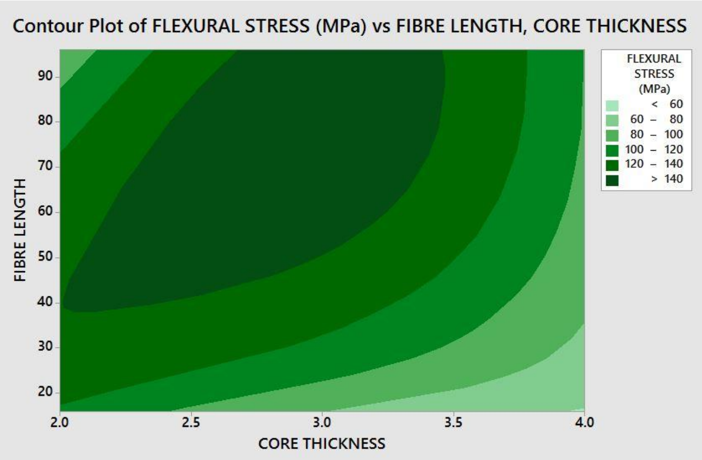


Fig.8 represents the contour plot of Fibre length Vs core thickness and flexural stress as the response factor. Now according to the contour plot, when the Fibre length is around 16 -20 mm and the core thickness is around 4mm, we get the least stress value less than 60 which is shown by light green colour. Now when the Fibre length is around 96mm and the core thickness is around 3mm we get the maximum stress developed in it which is greater than 140 MPa.

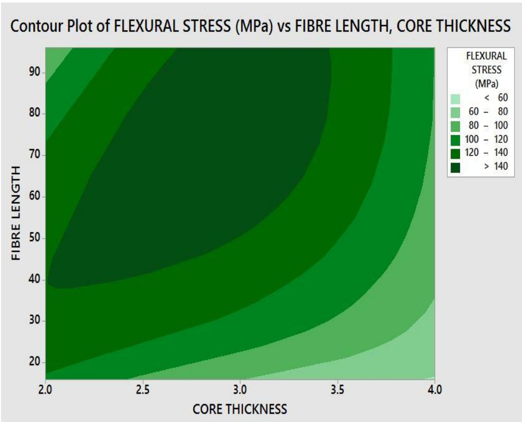


Fig.8

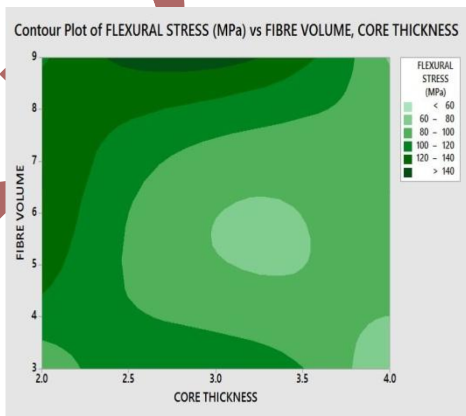


Fig.9

Influence of Fibre Volume and Core Thickness on Flexural stress.

Fig.9 represents the contour plot of Fibre volume Vs core thickness and flexural stress as the response factor. Now according to the contour plot, when the Fibre volume is around 3% and the core thickness is around 4mm, we get the least stress value less than 60 which is shown by light green colour. Now when the Fibre volume is around 9% and the core thickness is around 2.5-3mm we get the maximum stress developed in it which is greater than 140 MPa.

Influence of Fibre Volume and Fibre Length on Flexural stress.

Fig.10 represents the contour plot of Fibre volume Vs Fibre length and flexural stress as the response factor. Now according to the contour plot, when the Fibre volume is around 3% and the fibre length is around 20mm and also when the Fibre volume is around 9% and the fibre length is around 50mm, we get the least stress value less than 60 which is shown by light green colour.

Now when the Fibre volume is around 5-6% and the fibre length is around 50- 60 mm we get the maximum stress developed in it which is greater than 140 MPa.

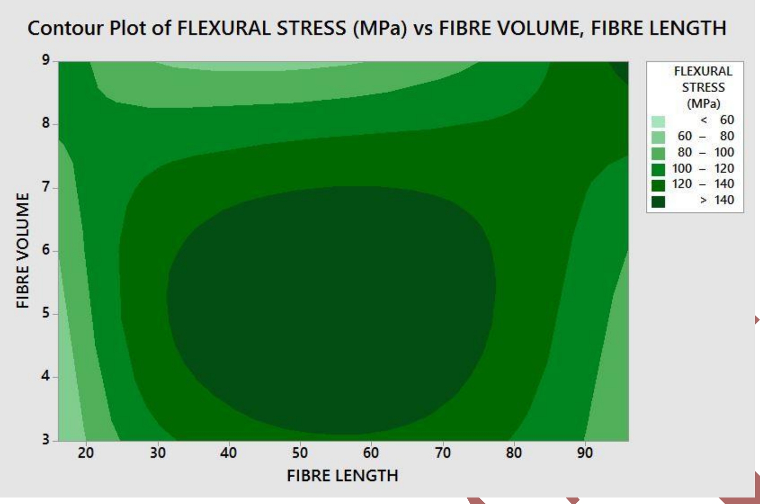


Fig.10

Regression Equation

Regression Equation are obtained via ANOVA analysis in MINITAB software with which we can find the approximate flexural stress, modulus of the composite with core thickness, fibre volume and fibre length. Now from this equation, one can get flexural stress value and modulus for any value of parameters considered in this work. It also gives the level of influence of different parameters on flexural stress and modulus.

Flexural Stress (MPa) = 117.1 - 17.3 X + 4.45 Y + 0.222 Z ……… (1)

Modulus (MPa) = 11111 - 2123 X + 203 Y + 13.3 Z……….. (2)

Where, X= Core Thickness (mm),
Y= Fibre Volume (%),
Z= Fibre Length (mm)

CONCLUSION

An attempt is made to fabricate sandwich panels of jute fibre hybrid polymer matrix, according to the Taguchic's Design of Experiment, Flexural stress is evaluated at various combinations and best results are obtained using ANOVA technique. This natural fibre hybrid polymer matrix can replace many synthetic resin composite sandwich panels considering the recyclability and cost factors.

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