

# Study the Effect of Core Design on Mechanical Behaviour of Honeycomb Sandwich Structures under Three Point Bending.

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**ABSTRACT:** A honeycomb core made of natural-fiber reinforced composite consisting of a epoxy resin reinforced with jute fiber is introduced. Six-mm-cell honeycomb and six-mm-diameter circular cores are manufactured using compression moulding technique. experimental tests are conducted to characterize the core response under three point bending. The flexural strength of the core are also computed via ANSYS. The results from this study suggest that jute fiber reinforced circular core has higher flexural strength as compared to hexagonal jute fibre reinforced cores.

**KEYWORDS:** Honeycomb cores, Circular cores, Mechanical characterization, Flexural strength.

## I. INTRODUCTION

Sandwich panels are used to for high-performance light weight structures [1,2]. Sandwich panels consist of two thin and stiff face-sheets and thick and light core. The face sheets provide flexural stiffness and core transmit shear between face sheets. A strong core also contribute to the flexural stiffness [3]. Typically cores are made of foams or balsa [4,5] or they are fabricated using corrugated, truss or honeycomb structures [6,7]. Corrugated cores provide unidirectional support [8,9], while honeycomb cores provide bi-directional support [1]. The most used materials in honeycomb fabrication are aluminium, polymers and composites like nomex [10]. Sandwich panels are used not only in terms of weight saving and structural performance, but also used as an effective means to reduce costs [11].

Thus there is always an interest to development of new materials and designs for low cost high performance cores.

Ji et al [12] introduced a glass-fiber reinforced-polymer corrugated core which is fabricated via the assembly of pultruded and thermoformed shapes [13]. At the same time there is also an increasing interest to substitute glass and carbon fibers by natural ones [14]. Natural fibres present some advantages when compared to their synthetic counterparts. they are cheaper, low mass per unit area, eco-friendly, recyclable and biodegradable by nature, they do not produce skin irritation, and they provide good acoustic-insulating properties [15,16]. There are developments towards the use natural fibers for the reinforcement of sandwich panels cores. In this sense, Rao et al. [17,18] introduced hollow core made of propylene with chopped sisal fiber as reinforcement.

It is introduced in this paper a honeycomb and circular core made of natural fiber reinforced with jute fabrics. The paper report the details of method of fabrication of 6 mm honeycomb and 6 mm diameter circular core, the experimental characterization of the core response under three point bending.

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## II. RELATED WORK

Y.Du fabricated various sandwich panels with PRP (paper reinforced polymer) composite skins and a resin-impregnated aramid paper honeycomb core. The effects of honeycomb core height and cell size on the flexural properties of sandwich panels were evaluated, the face sheets provide the flexural Stiffness and Strength to the panel, while the role of the core is to transmit the shear between the face sheets, a strong core also contribute to the flexural stiffness [17]. El Mahi analyzed stiffness degradation and the identification of damage mechanisms during and after fatigue tests of sandwich panels with PVC foam cores. The sandwich panels with cross-ply laminates skins made of glass fibre and epoxy resin were manufactured by vacuum moulding and subjected to three-point bending tests. The effect of core density and thickness on the damage behaviour was highlighted. It has been demonstrated that the sandwich with the higher core density, withstands a higher load and possesses greater rigidity in static tests, when compared to sandwich which has a lower core density [19]. A. Gopichand investigated load and deflection variations of Stainless steel face sheet and copper core material. Static three-point bending tests were carried out in order to investigate load and deflection variations. The gradient of deflection curve is high for lower core height and stress is low for higher value of core height [20]. Craig A. Steeves analyzed the collapse mechanisms for simply supported sandwich beams with composite faces and a PVC foam core subjected to three point bending. Depending upon the geometry of the beam and the relative properties of the constituents, collapse is by core shear, face sheet micro buckling. A failure mechanism revealed that the dominant collapse mechanism depends upon the geometry of the beam [21]. Santulli C analyzed advantages of natural fibre compared to synthetic counterparts, they are cheaper, have lower mass per unit area, ecofriendly, recyclable and bio-degradable by nature, they do not produce skin irritation and provide good acoustic-insulating properties [22].

## III. MATERIALS AND EXPERIMENTAL METHODS

This Chapter provides details of the materials used in the study, fabrication method of the core structures and the characterization techniques.

### Core fabrication

The matrix material was prepared using the general-purpose Epoxy resin Epoxy resin LY556 (Common name: Bisphenol A Diglycidyl Ether Polymer) provided by IISU, ISRO Unit, India. Methylene diamine was used as hardener. The reinforcement materials studied are commercially available jute fibre.

The honeycomb cores were manufactured by compression molding under appropriate conditions at laboratory scale using molds with fixed hexagonal and circular inserts

### Mould with fixed inserts

The moulds and the inserts with the shape of the cells were kept in place by fixing them to the bottom plate. The mold dimensions were 120 mm in length, 60 mm in width and 10 mm in height, and it contained 32 array of 6 mm hexagonal and 6 mm diameter circular cell cores inserts. The clearance between the inserts, and thus the cores wall thickness, were  $t = 2.022 \pm 0.100$  mm. To prepare the fiber-reinforced honeycomb cores, the jute fibre were placed between the inserts following a zigzag pattern. The epoxy resin with hardener was poured into the mold at 20°C. The mould was put in hydraulic press touching the mould upper plate and the temperature was set at 100°C for 1 h and pressure 2 bar. The temperature was then increased to 140°C and kept mould at that temperature for 3 h. After 3h, the hydraulic press monitor was closed and the mould was kept in press till it attained room temperature. The core sample was then removed from mould.

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Figure-1 (a) shows orientation of jute fibres between hexagonal inserts for fabrication of jute fibre reinforced hexagonal core and Figure 1 (b) shows the orientation of jute fibres between circular inserts for fabrication of jute fibre reinforced circular core.



1(a)



1(b)

Fig.1 Orientation of jute fibres (a) In hexagonal inserts (b) In Circular inserts .

Figure-2 (a) shows the specimen prepared of jute fibre reinforced hexagonal core and figure-2 (b) shows the specimen of Jute fiber reinforced circular core after curing and removed from mould. Optical microscope was used in order to measure the cell wall thickness of the samples. The wall thickness was found to be with in range  $t=2.022 \pm 0.100$  mm .



2 (a)



2 (b)

Fig.-2 Specimen prepared (a) jute fibre reinforced hexagonal core (b) jute fibre reinforced circular core

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## IV. CHARACTERIZATION OF CORE

The mechanical characterization of the honeycombs comprised the tests to evaluate the flexural strength.

Flexural test was performed according to the ASTM: D790 standard using an Instron 4467 machine with crosshead speed of 1.2 mm/min and a span  $S = 100$  mm to determine the flexural strength of the composites.

Figure-3 shows the Specimens position under loading in 3-point bending apparatus. At least five specimens of each honeycomb core structure (core thickness  $t=2.022 \pm 0.100$  mm) were tested using the Instron 4467 universal test machine.



Fig.3 flexural test specimen under loading.

Figure-4 shows the flexural stress-strain response of the circular and hexagonal core under three point. Stress values increases linearly in both cases. Maximum stress occurs at the mid span in three point bending configuration.

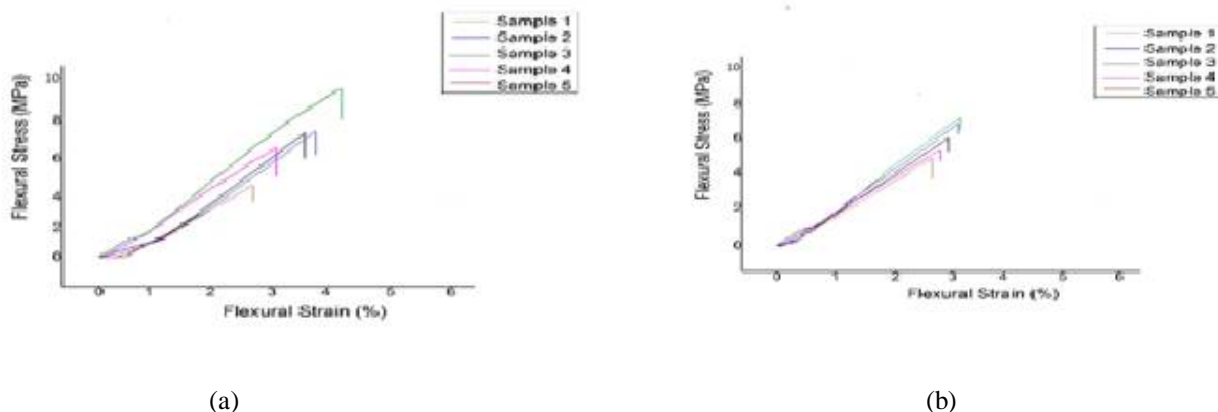


Fig.4. Flexural Stress-Strain response under UTM of (a) Circular core (b) Hexagonal core

Table-1 shows the comparative flexural strength of jute fibre reinforced circular and hexagonal core, average flexural strength of the circular core and hexagonal core were found to be 7 MPa and 5.48 MPa respectively. The loading in the bending test consists of tension, compression and shear forces. The core was tested along the fiber direction and

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they generally experienced brittle failure on the tensile surface. The fracture starts at the middle of the specimen because of the maximum bending moment. By observing the samples after flexural testing it was seen that fiber rupture occurred in the middle section of tensile surface.

Sample S.No.	Jute fibre reinforced circular core		Jute fibre reinforced hexagonal core		Specimen behavior
	Flexural Strength (MPa)	Flexural strain[%]	Flexural Strength (MPa)	Flexural strain[%]	
1	9.23	4.17	7.03	3.19	Yield
2	7.10	3.22	6.16	3.10	Yield
3	6.52	3.01	6.03	2.96	Yield
4	6.43	2.65	6.10	2.48	Yield
5	5.85	2.47	5.06	2.13	Yield
Mean	7.00	3.10	5.48	2.77	
S.D.	1.09	0.59	0.58	0.72	

Table-1 Comparative flexural strength of Jute fiber reinforced circular and hexagonal core.

## V. EXPERIMENTAL RESULTS

Fig.5 shows the flexural strength analysis of jute fiber reinforced circular and hexagonal core under three point bending via ANSYS software. jute fiber reinforced circular core has higher flexural strength as compared to jute fiber reinforced hexagonal core.

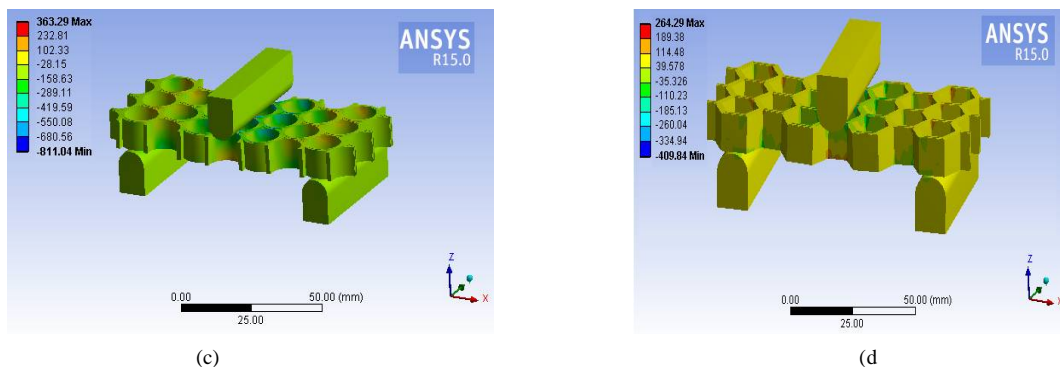


Fig.5 Flexural strength analysis by ANSYS (c) Circular core (d) Hexagonal core

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## VI. CONCLUSION

This chapter presents the summary of the work and the conclusion drawn. The results from this study suggest that jute fibre reinforced circular core exhibit higher flexural strength as compared to jute fibre reinforced hexagonal core. These results were verified by ANSYS software.

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