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STRESS DISTRIBUTION ON COMPOSITE HONEYCOMB SANDWICH STRUCTURE FOR A LEAF SPRING

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ABSTRACT

Lightweight composite leaf spring of honeycomb sandwich structures are laminated composite structures that are composed of thin stiff face sheets bonded to a thicker lightweight core in between aluminum honeycomb in that honeycomb structure filled with foam. These structures have high potential to be used in marine, aerospace, defense and civil engineering applications due to their high strength to weight ratios and energy absorption capacity. In this study, composite sandwich structures were developed with Jute fiber reinforced polymer composite face sheets and aluminum honeycomb core materials with various thicknesses. Jute fiber/epoxy composite sheets were fabricated with lamination Jute fiber by weight infusion technique. Honeycomb layers were sandwiched together filled with foam with the face sheets using a thermosetting adhesive method. Mechanical tests were carried out to determine the mechanical behavior of face sheets, cores and the composite structure. Effect of core thickness on the mechanical properties of the sandwich was investigated.

KEYWORDS: *Composite Material, Natural Fibers, Epoxy, Honeycomb Material, Foam*

Article History

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INTRODUCTION

In today's automobile industry, continuous attempts are being made to reduce the mass of the automobile as it is a proven fact that the amounts of emissions are highly influenced by the mass of the vehicle. Reduction in the total mass of the vehicle increases its fuel economy which is another important factor of the design of an automobile. While structural modifications of the components of the vehicle for reducing their mass without losing mechanical advantages is a direct way to attack the problem of mass reduction, recent developments in this issue include replacing conventional materials with the sandwich composite materials wherever possible. Because various combinations of core and skin material of the sandwich structure are possible, it is possible to achieve desirable mechanical properties such as stress, strain, stiffness, shearing and bending behavior, thermo mechanical properties of these composites' materials.

Figure 1 shows a typical sandwich structure consists of a thick, lightweight core material sandwiched between two stiff, strong and relatively thin sheets by using an adhesive between them. Common core materials include hollow structures is filled with foam to honeycomb structure, to strength the frame. It is an interesting area of research to understand the effect of various combinations and configurations of core and skin materials on mechanical properties of the composite and this has been addressed extensively in past few years. In the present study, aluminum honeycomb structure which is highly periodic in nature is used as a core and fiberglass prepreg is used as a face sheet material bonded together by a film adhesive. This material was chosen by considering factors such as strength to weight ratio, cost, availability of aluminum honeycomb panels and ability to manufacture the composite

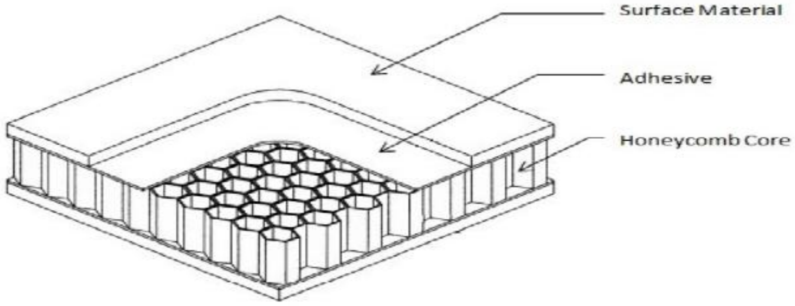


Figure 1: Layers of Sandwich Structure.

MANUFACTURING OF COMPOSITE

The various methods for creating composites, such as laminates and sandwich composites have increased the popularity of composites manufacturing. The manner in which the fiber and matrix are bonded together, which includes but is not limited to the following, may have an impact on composite production reliability or the manufacturing process.

- Matrix and fiber bonding is sufficiently improved.
- Fiber orientation
- Fraction of a volume
- Resin curing and solidification
- The structure's dimension control was developed.

There is a risk of dry areas if there is no bonding between two entries, which can lead to poor composite manufacturing. These partly dry areas can improve energy absorption capability, especially in instances when impact energy must be absorbed. The fibers provide the composites more rigidity and strength, therefore the more fibers present, the higher the volume fraction. Furthermore, cracking of composites is minimized when the fibers are uniformly distributed. When resin-rich areas are discovered, they become known as weaker parts of composites and are prone to failure. As a result, any material should be manufactured using a resin-rich technique.

The Various Phases of Composite Manufacturing Are Listed Below

Phase 1: Individual constituents and the matrix are present in thermoset resins in liquid form and thermoplastic resins in granular form.

Phase 2: This step includes the mixing of fibers and resins, which results in the formation of composites.

Phase 3: The laminates formed in phase two are stacked together in orientation in this stage, resulting in sufficient strength and stiffness for the various types of applications.

Phase 4: This is where the final product is made.

The following phases listed above, on the other hand, can be achieved through a variety of manufacturing processes.

MATERIALS

The raw materials that are used and the fabrication process that is been carried out is been elaborated in this section. Materials used are:

- Natural fiber(Jute, Banana)
- Honeycomb material(Paper and aluminium)
- Polyurethane foam(50Kg/m^3 and 60 Kg/m^3)
- Epoxy



Figure 2: Aluminum Honeycomb, Figure 3: Paper Honeycomb & Figure 4: Jute Fibers.


Figure 5: Polyurethane Foam & Figure 6: Epoxy and Hardener.

METHODOLOGY

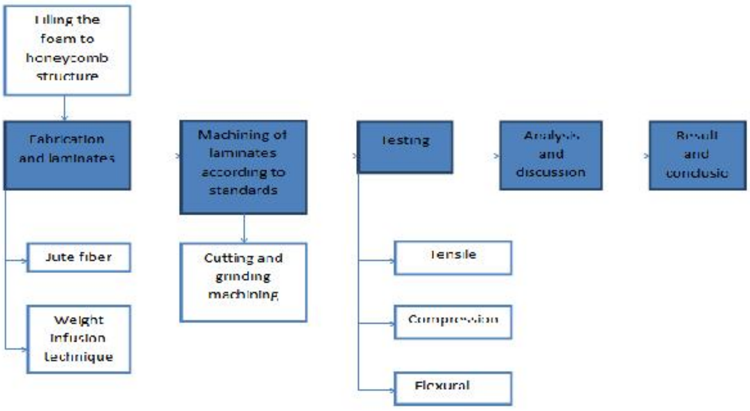


Figure 7.

Fabrication and Laminating

Step 1

Figure 8: Honeycomb Paper & Figure 9: Honeycomb Aluminum
Figure 8 & 9: Spreading of Honeycomb Material.

Step 2

Figure 10: Mixing of Polyol and Isocyanate & Figure 11: Poring of Mixed Liquid Foam.

Step 3

Figure 12: Liquid Foam in Solidifying & Figure 13: Removing of Excess of Foam and Filing .

Machining According to the Standards

Figure 14: Machining the Component According to the Standards.

Specification of the Sample Specimen

Table 1

Sl. No	Specimen Name	Fiber Used	Honeycomb Material	Density of the Foam(Kg/m^3)
1	P1J	Jute	Paper	50
2	P2J	Jute	Paper	60
3	P1B	Banana	Paper	50
4	P2B	Banana	Paper	60
5	A1J	Jute	Aluminium	50
6	A2J	Jute	Aluminium	60
7	A1B	Banana	Aluminium	50
8	A2B	Banana	Aluminium	60

Testing of Sample

Figure 15 & 16 shows as per the ASTM D3039 standard, the specimens are made for the tensile test. Tensile, compression, bending tests are conducted as per the standards. Tensile test was carried out in TUE-C-400 UTM machine. Specimen was machined as per the standard dimension i.e., 350mm length, 24mm thick and 30mm width. UTM test arrangement for tensile test and compression test.

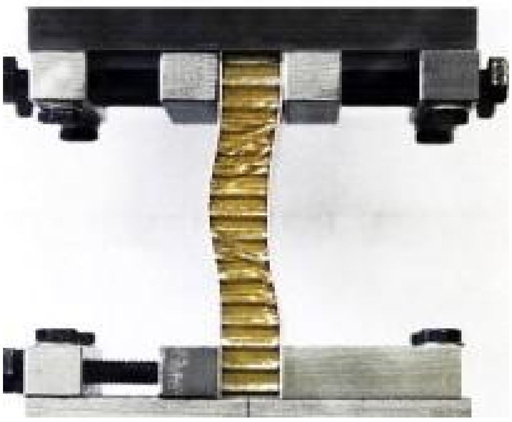



Figure 15: Tensile Test & Figure 16: Compression Test.

Testing Results

Average Tensile Strength

The tensile strength of the various specimens is as shown in Table 2. It is been observed from the table that the jute reinforced, aluminum honeycombed core with polyurethane foam of density 60Kg/m^3(A2J) is having a dominated tensile strength when compared other specimens. It has been observed that the average tensile strength of the specimen A2J is 12.21 MPa and the average tensile strength of various sandwich composites is tabulated as shown in Figure 16 We found that the specimen A2J exhibited a better tensile strength when compared to other specimens. The poor tensile strength was observed in the P1B specimen.

Table 2

Specimen Name	Average Tensile Strength(MPa)
P1J	9.22
P2J	10.01
P1B	6.79
P2B	7.01
A1J	11.98
A2J	12.21
A1B	8.77
A2B	9.11

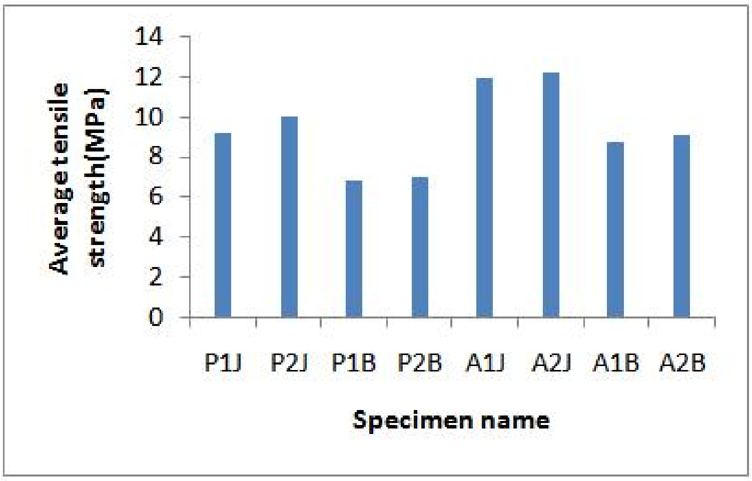


Figure 17

Average Compression Strength

Table 3 shows the average compressive strength of the sandwich composite materials. It is been observed that the sandwich composite with aluminum core material exhibited better compressive strength which is filled with foam of density 60Kg/m^3 and reinforced using jute fiber(A2J).It was also observed that aluminum core embedded composite material exhibited better compressive strength when compared to that of the paper embedded core material. Figure 17 shows the evidence that A2J specimen exhibits the better compressive strength i.e. 21.07 MPa and specimen P1B exhibits lowest compressive strength of all the other specimens i.e. 15.65MPa.

Table 3

Specimen Name	Average Compressive Strength(MPa)
P1J	18.25
P2J	19.07
P1B	15.65
P2B	16.31
A1J	19.93
A2J	21.07
A1B	17.43
A2B	18.19

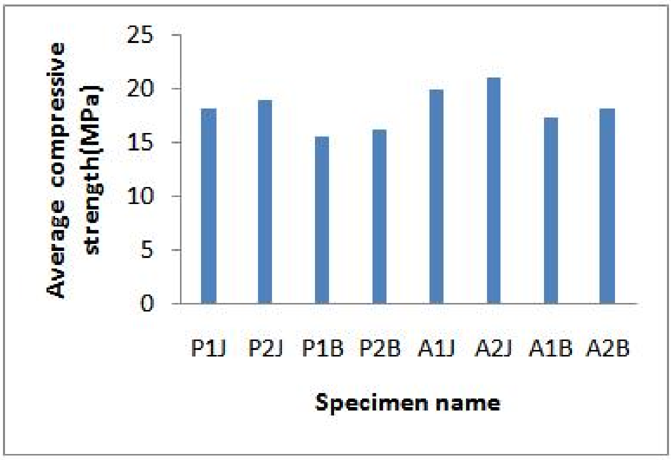


Figure 18.

CAD MODELS OF COMPOSITE HONEYCOMB SANDWICH STRUCTURE LEAF SPRING

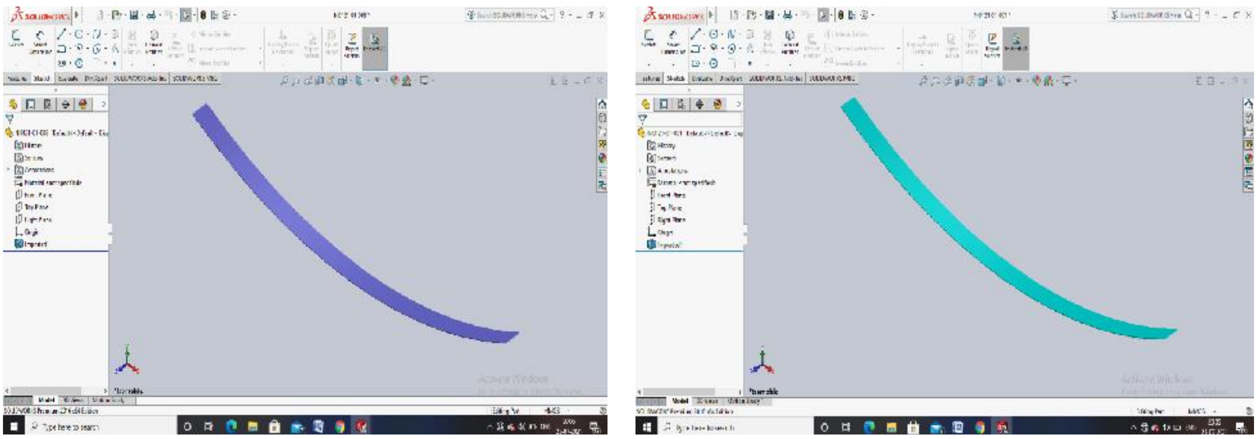
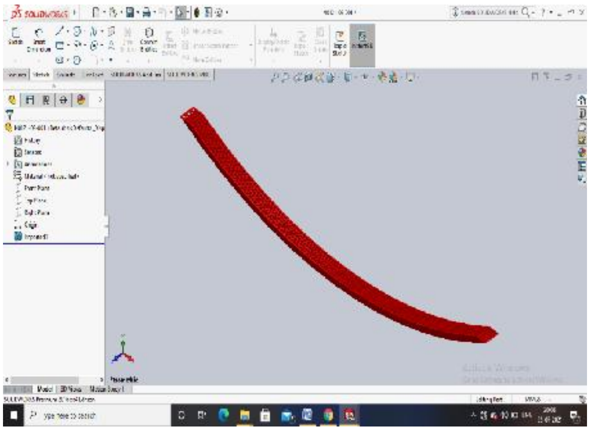


Figure 19: Upper Face Sheet & Figure 20: Lower Face Sheet.



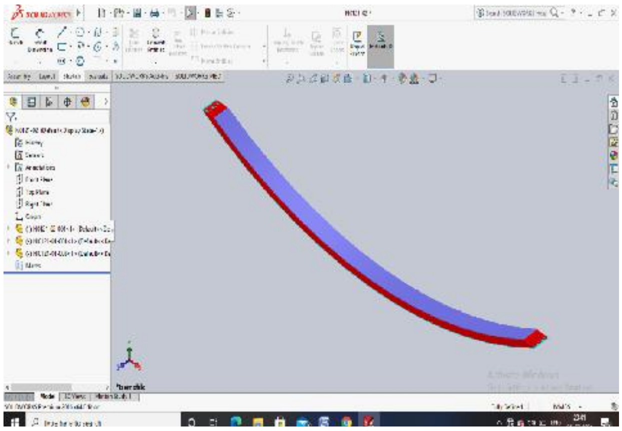
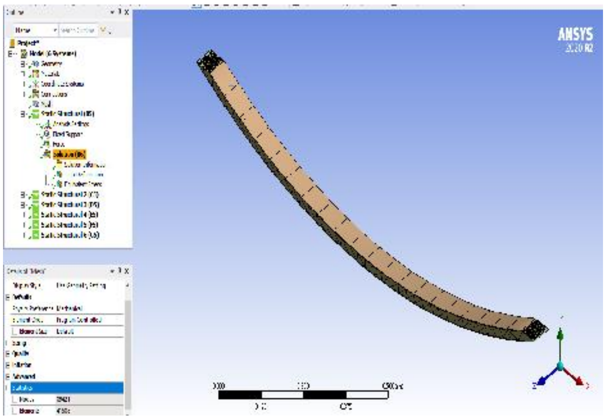


Figure 21: Middle Layer of Aluminum Honeycomb & Figure 22: Assembly of Leaf Spring

RESULT AND DISCUSSIONS

Results



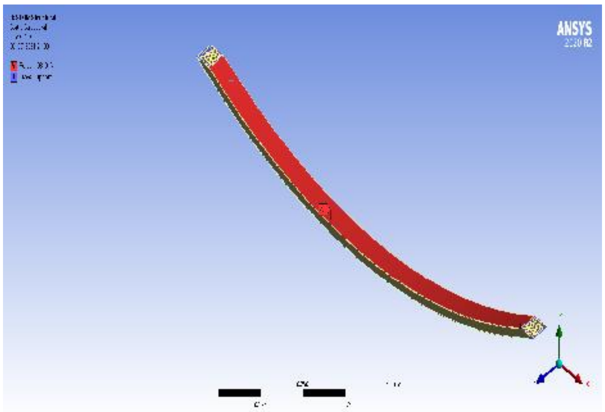
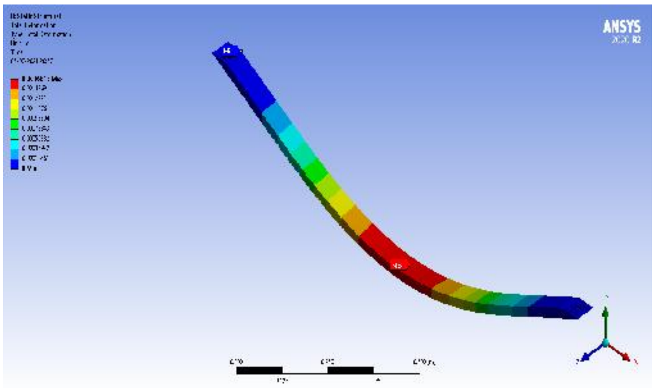


Figure 23: Meshing & Figure 24: Bounadry Condition 1000kg.



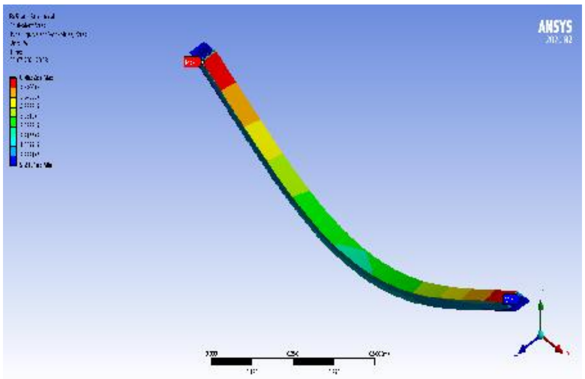
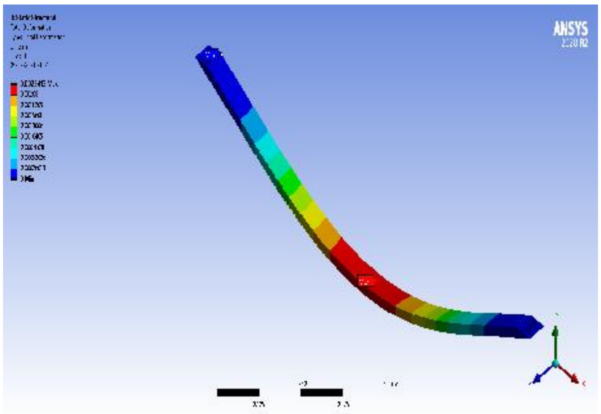


Figure 25: Deformation of Jute & Figure 26: Stress For Bounadry Condition of Jute.



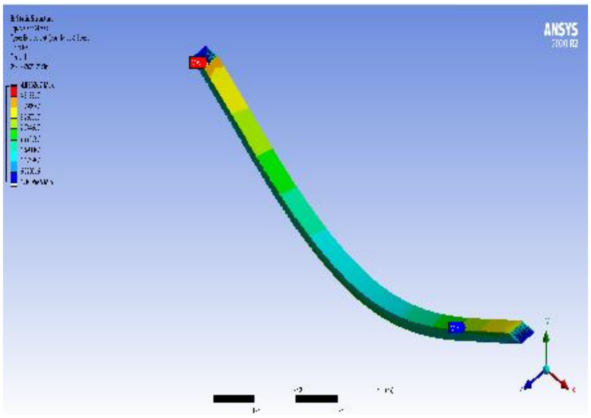


Figure 27: Deformation of Banana & Figure 28: Stress For Bounadry Condition of Banana.

Results For Jute Fiber

Table 4

Sl/no	Load (kg)	Deformation (mm)	Stress (Mpa)
1	1000	1.66	64.62
2	1200	1.99	77.54
3	1400	2.32	90.47
4	1600	2.62	103.39
5	1800	2.99	107.82
6	2000	3.32	129.24

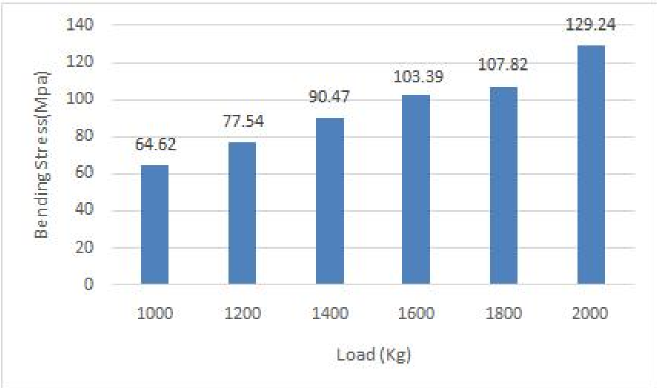


Figure 28: Load Vs Deformation.

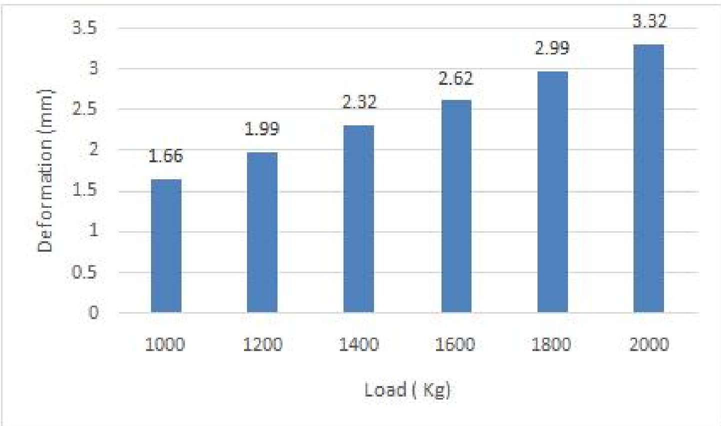


Figure 29: Load Vs Stress.

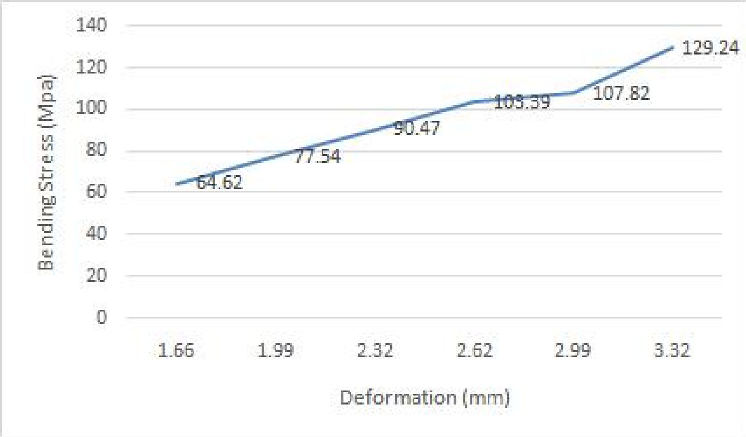


Figure 30: Deformation Vs Stress.

Results For Banana Fiber

Table 5

Sl/no	Load in (kg)	Deformation (mm)	Stress (Mpa)
1	1000	2.34	48.63
2	1200	2.8	58.03
3	1400	3.27	67.7
4	1600	3.74	77.37
5	1800	4.21	87.05
6	2000	4.68	96.72

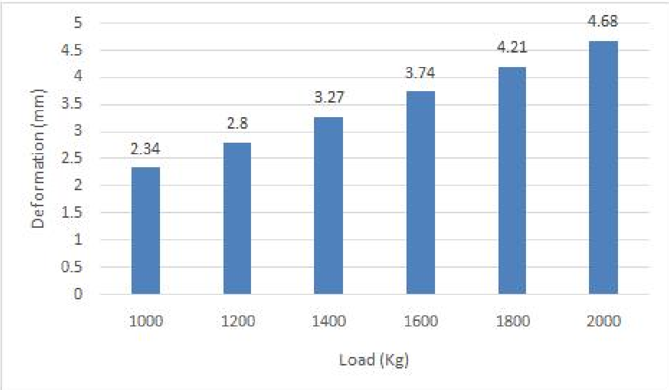


Figure 31: Load Vs Deformation.

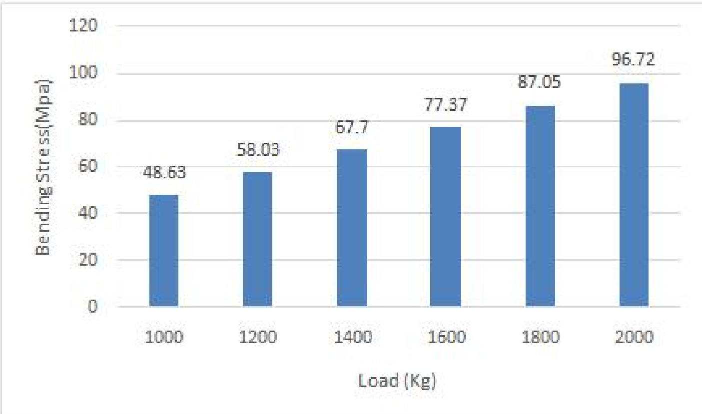


Figure 32: Load Vs Stress.

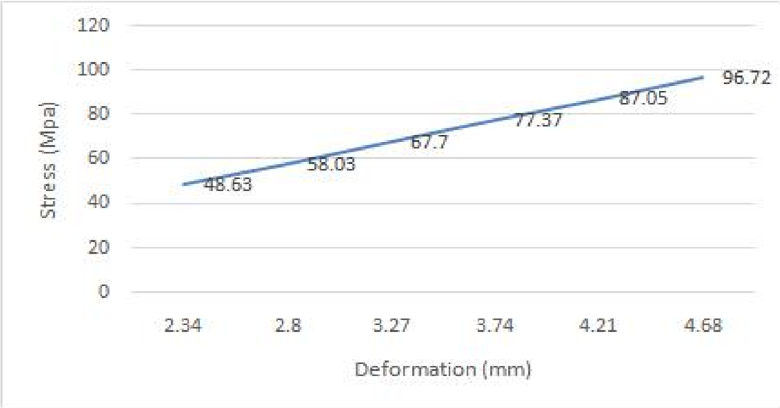


Figure 33: Deformation Vs Stress.

DISCUSSIONS

As the above discussion is for the testing specimen, after the we have analysed for the composite honeycomb sandwich structure leaf spring through Ansys for the jute fiber / Epoxy and Banana fiber / Epoxy for different load factors and we have got better results.

By considering the load of 1000 kg i.e., 9810 N we have got 6.965 mm of deformation and 392.10 Mpa for its corresponding stress for the conventional leaf spring. Similarly, the tested result for composite honeycomb sandwich structure for same load of 9810 N we have got deformation of 1.66 mm for jute and 2.34 mm for banana and 64.62 Mpa for jute and 48.63 Mpa for banana Are corresponding stress for the load of 9810 N.

CONCLUSIONS

In this research, a steel leaf spring is substituted with a composite honeycomb sandwich structured leaf spring, which has a higher strength-to-weight ratio, the same load bearing capacity, and the same rigidity as a steel leaf spring of the same specification. A mono leaf spring is made from a composite of natural fibers, such as jute fiber/Epoxy and banana fiber/Epoxy, for use in automobiles. At the static load condition, the stress and deformation of the composite leaf spring is tested among these two fibers we have achieved the better results for the jute fiber where it observes the higher stress and with the less deformation when it is compared with the banana fiber.

When the leaf spring is subjected to various types of loading and lamination thickness constraints, natural fiber will reduce its weight. The composite leaf spring reduces friction coefficient and wear rate while increasing strength and fatigue life when compared to a traditional leaf spring. Because the automobile industry demands lighter and stronger products, natural fiber is the most dominant and controlling element on the bending stiffness of the structure. Natural fiber is the most dominant and controlling element on the bending stiffness of the structure, and composite materials should be able to meet these demands

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