Stress distribution on composite honeycomb sandwich structure for a leaf spring

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Abstract

Lightweight composite leaf spring ofhoneycomb 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 fiberby 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.

Key words: *Composite material, Natural fibers, Epoxy, Honeycomb material, Foam*

1. 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.

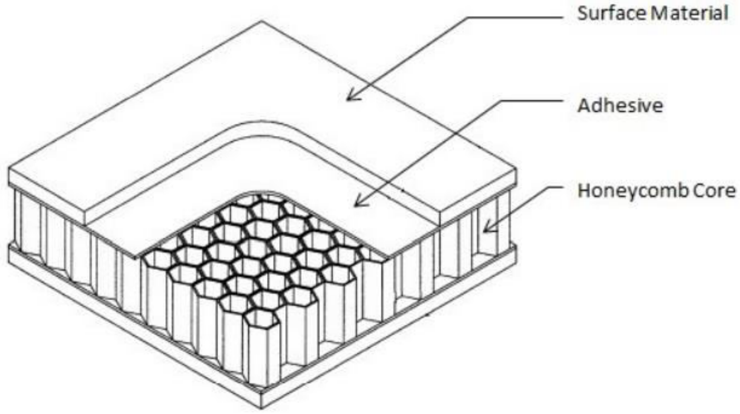


Fig 1: Layers of sandwich structure

As shown in the Figure 1, 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

2. 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

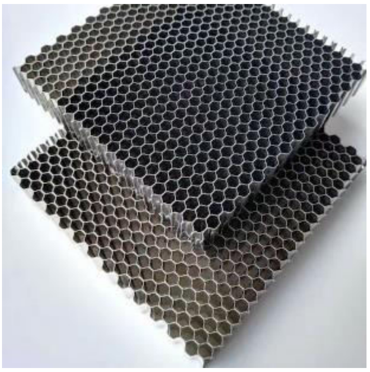
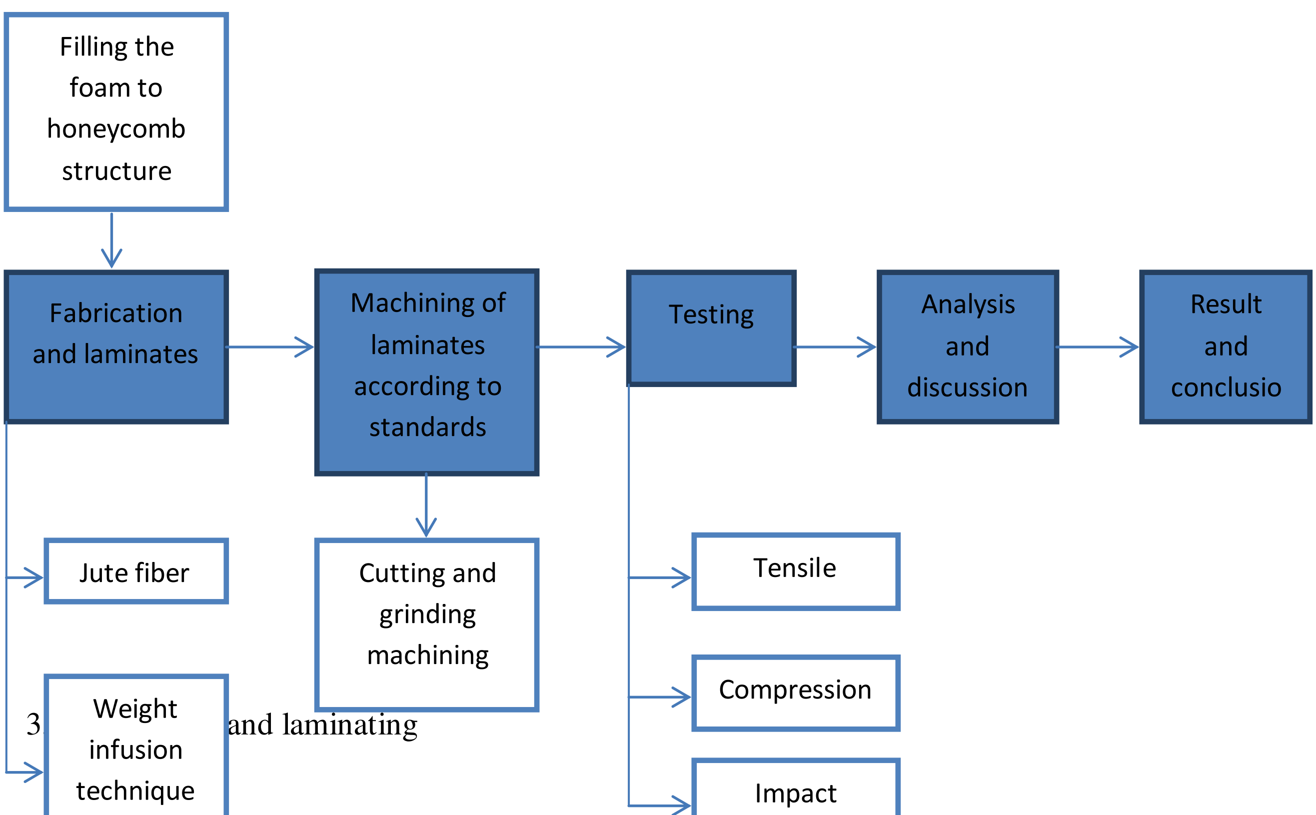


Fig: 1Aluminum honeycomb Fig: 2 Paper honeycomb Fig: 3 jute fiber


Fig: 4 Polyurethane foam Fig: 5 epoxy and hardener

3. Methodology



3 and laminating

Step1


Fig: 6 Honeycomb Paper Fig: 7 Honeycomb Aliminium

Fig 6 and 7 Spreading of honeycomb material

Step 2


Fig: 8 Mixing Of Polyol and isocyanate Fig: 9 Poring of Mixed Liquid Foam

Step 3


Fig: 10 Liquid foam in solidifying Fig: 11 Removing of excess of foam and filing

Volume: 05 Issue: 06 | June - 2021 ISSN: 2582-3930

3.2 Machining according to the standards

Fig: 12 Machining the component according to the standards

Specification of the specimen

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

4. Testing

4.1 **Tensile test**

Fig: 13

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 is as shown in Fig.

4.2 Compressive strength

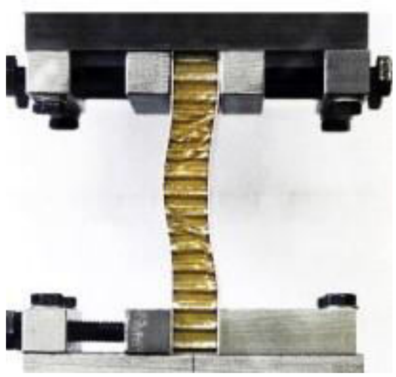


Fig:14

ASTM C365 standard was used to conduct compression test and the dimensions are 350mm length, 24mm thickness and 30mm width. Compression test was carried out in TUE-C-400 UTM machine.

5. Testing results

5.1 Average tensile strength

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

Table 2

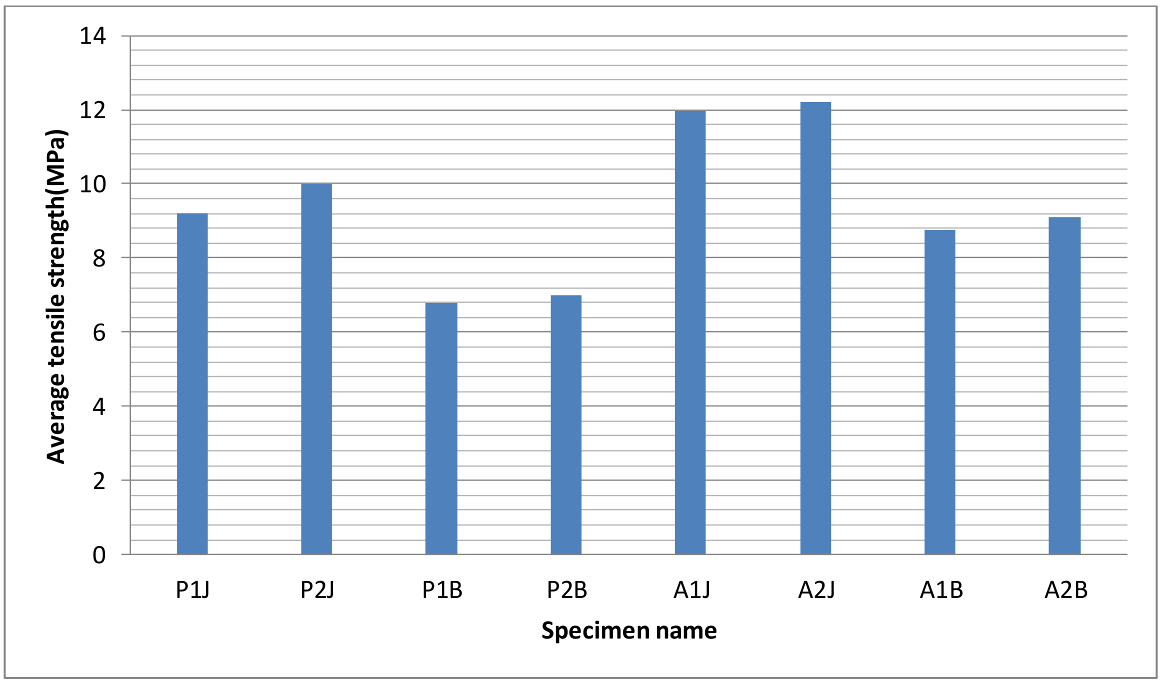


Fig:15

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 12.21MPa and The averagetensile strength of various sandwich composites is tabulated as shown in Fig:15We 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.

5.2 Average Compression Strength

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

Table 3

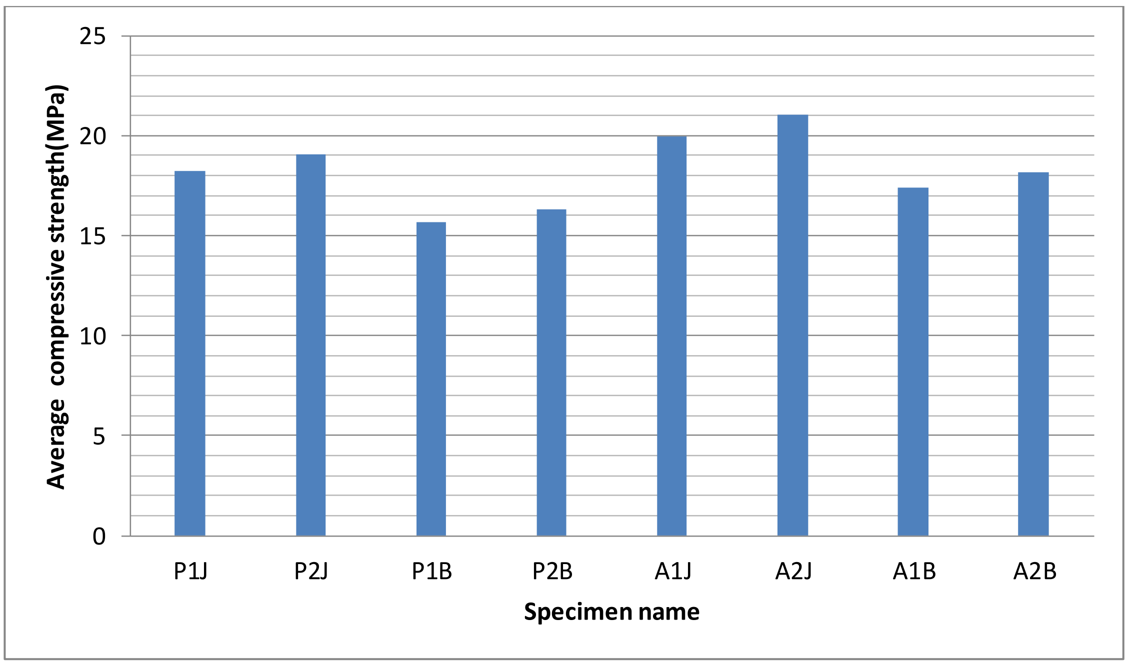


Fig:16

Table 3 shows the average compressive strength of the sandwich composite materials. It is been observed that the sandwich composite with aluminium 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 aluminium core embedded composite material exhibited better compressive strength when compared to that of the paper embedded core material.Fig: 16 shows the evidence that A2J specimen exhibits the better compressive strength i.e. 21.07MPa and specimen P1B exhibits lowest compressive strength of all the other specimens i.e. 15.65MPa.

Conclusions

The comparison of the mechanical properties of sandwich composites embedded using paper and aluminium honeycomb material with different foam densities filled in it was done. Two types of fibers namely jute and banana fibers were used in the work and the following conclusions are indicated based on the results obtained.

1. Composites are made by sandwiching 2 different honeycomb materials which are filled with polyurethane foam of 2 different densities. Thus prepared core material was sandwiched between 2 layers of natural fibers namely Jute and banana fibers. Typical hand lay-up method was used for the fabrication process.
2. From tensile test, it is concluded that the specimen embedded with jute fiber showcased better tensile strength when compared to that of the banana fiber embedded composites. Specifically aluminium honeycomb material with foam density 60Kg/m^3 (A2J) required maximum load for breaking.
3. Compressive test proved that jute embedded sandwich composites had better compressive strength than banana embedded sandwich composite material. It is also seen that with the increase in the foam density there was slight increase in the compressive strength of the material

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