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EXPERIMENTATION & ANALYSIS OF LEAF SPRING BY USING BANANA & LINEN FIBRE REINFORCED LAMINATES

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Abstract: The experimental study of a leaf spring composed of banana fibre reinforced laminate is described in this research. This study aims to evaluate the load-bearing capacity, deformation, and stress caused by composite leaf springs to steel leaf springs. Stresses and displacements are the design restrictions. The specifications of a standard steel leaf spring automobile are measured. A composite leaf spring is designed using banana, linen, epoxy, and unidirectional laminates with the exact dimensions of a standard leaf spring. ANSYS workbench is also utilized to do static analysis on a 3D model of the standard leaf spring. The results are compared to those of a traditional structural steel leaf spring. The findings of this study reveal the leaf spring model's compact, lightweight, and efficient material for manufacture.

Keywords: Leaf spring, Banana fiber, Epoxy resin, Composite leaf spring, Linen fiber

1. INTRODUCTION

The automotive sector utilizes composite laminate technologies for the structural substance to reduce vehicle weight while maintaining vehicle performance and consistency. One of the significant primary tasks in any vehicle design is energy conservation, and weight reduction is among the highly effective energy-saving techniques because it reduces the vehicle's overall fuel consumption [1,2,3]. In wheeled vehicles, a leaf spring is widely employed for suspension. A laminated or carriage spring is a type of spring that is also known as a semi-elliptical spring or cart spring. A leaf spring is a rectangular cross-sectioned arc-shaped strand of spring steel. The axle is located in the centre of the arc, and tie holes were supplied at both ends to hold the vehicle components [4,5]. Because it contributes to 10 to 20 % of the unsprung mass in an automobile, leaf spring suspension is among the potential substance for mass reduction [6].

Automobile manufacturers have been concentrating their efforts on reducing weight. Suspension leaf springs, a potential weight-saving component in automobiles, account for 10-20% of unsprung mass, which would be defined as the weight not supported using leaf springs [8]. Leaf springs are a common type of automobile suspension. Depending on the vehicle, the leaf spring could be configured in one of two ways. In the first type, both sides of a leaf spring were connected to the vehicle's chassis; however, in a cantilevered category of leaf spring, only one side of a leaf spring is attached to the chassis, and the other side is free to move [11].

2. MATERIALS

This chapter provides a detailed description of the composite material's production and the experimental procedures carried out to characterize its mechanical properties.

2.1 MATERIAL USED

- Banana Fibre
- Linen Fibre
- Epoxy Resin
- Hardener
- OHP Sheet – Polyvinyl chloride compound

Table 1 . Properties of Banana & Linen fiber

Natural fiber	**Tensile strength (MPa)**	**Compression strength (MPa)**	**Young's modulus (GPa)**	**Specific Young's modulus**	**Failure strain(%)**
Banana	721.5	534.5	29	22	2
Linen	700	482.5	60	41	2.3

3. EXPERIMENTAL METHODOLOGY

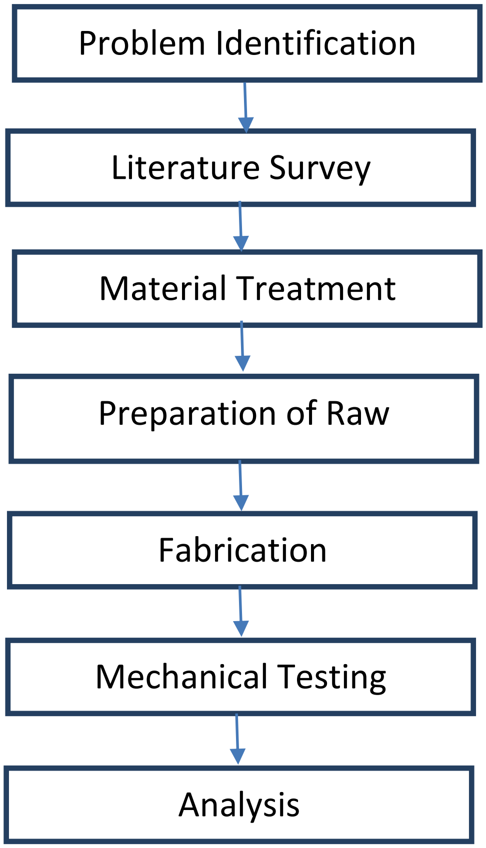

Fig 3: Flow chart of work methodology

Fig 1: Linen fiber

Fig 2: Banana fiber

3.1 MATERIALS

Steel 65Si7, the most common type of spring steel used in vehicle leaf springs, Epoxy and Banana, and linen are the four materials used in this investigation. In addition, banana fibre is mixed with epoxy in this study to form a unique composite material that can lower the weight and cost of leaf springs.

Hybrid composite specimens were constructed by hand-laying up woven linen and banana fibre with epoxy resin to prepare composite specimens. These specimens were prepared to utilize the procedure. A mould made of mild steel is used to manufacture the composite specimen. Wax has been applied to the inside of the mould so that the sample may be removed easily.

The banana and linen fibre fabrics are first trimmed to the desired size so that they may be layered on the template during manufacturing. Then, as a matrix, epoxy LY556 resin with a density of 1.14 to 1.19 g/cm3 was blended with hardener HY951 with a density of 0.97-0.99 g/cm^3 in a 10:1 weight ratio.

To achieve a smooth surface finish, two OHP sheets are employed at the top as well as the bottom of a mould. A brush and roller are employed to impregnate fibre materials and avoid air entrapment. Fiber textiles are layered in the mould with a polymer layer in between until the specimen thickness is reached. A brush and roller were employed to impregnate fibre mats and avoid air entrapment.[14]

The fibre weight fraction is kept constant at 40%. The mould is now inserted into the compression moulding machine. The mould is subjected to 70 kgf of pressure and allowed to settle for approximately 24 h at room temperature.

CAD model designs for mono leaf springs using conventional as well as composite materials are developed in CATIA V5 R20, which includes unique tools for producing common surfaces that are then transformed into solid models. In addition, the measurements of a leaf spring from a TATA ACE car were utilized for modelling the mono leaf spring.

3.2 ANSYS

ANSYS-based finite element analysis meshing has been the process of discretizing an item into tiny components known as elements. Piecewise approximation is another name for it. The leaf spring model is constructed here with a 10mm brick mesh element size.

Table 2. Leaf spring dimensions

Specification	**Values**
Leaf spring length	1000
Both end Width	50
an axle seat height of the arc	120
Center width	45
Closed eye diameter	50
Center thickness	30
Both end thickness	10

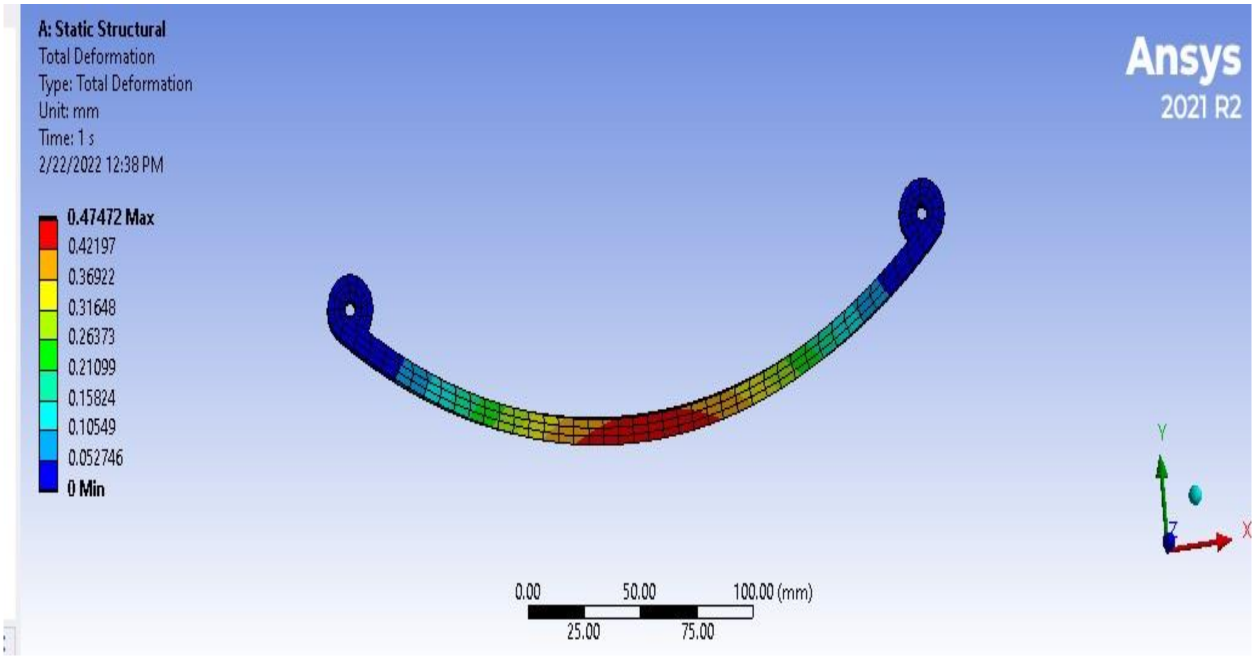
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Fig 4. ANSYS Total Deformation

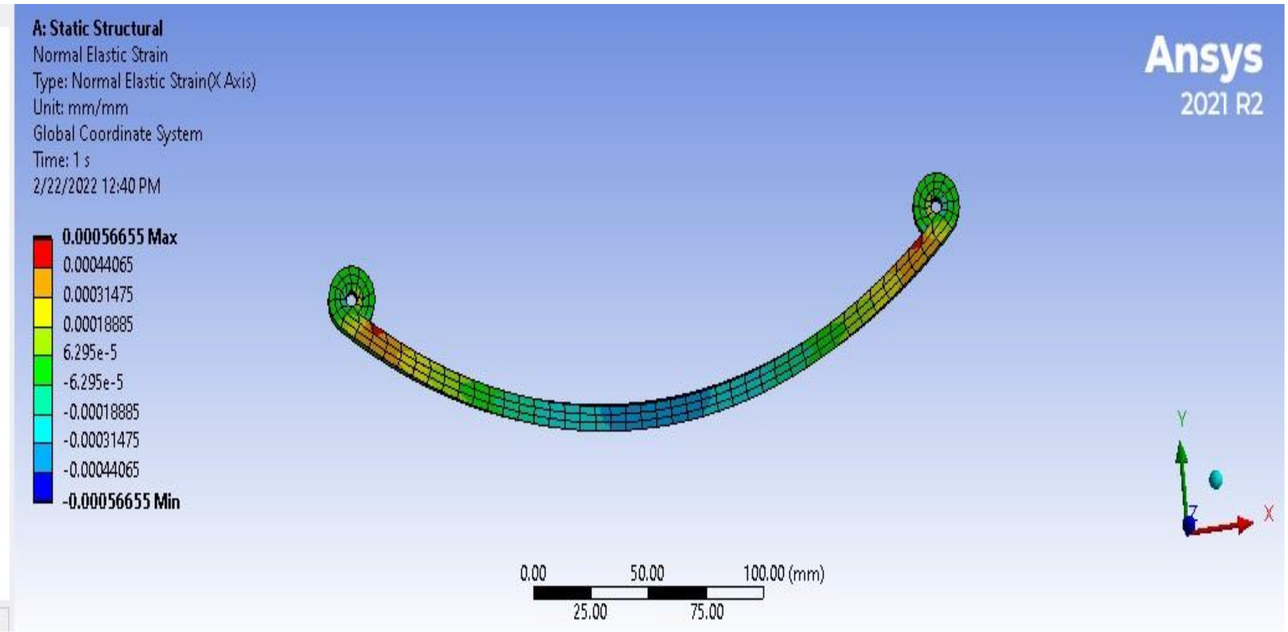


Fig 5. ANSYS Elastic Deformation

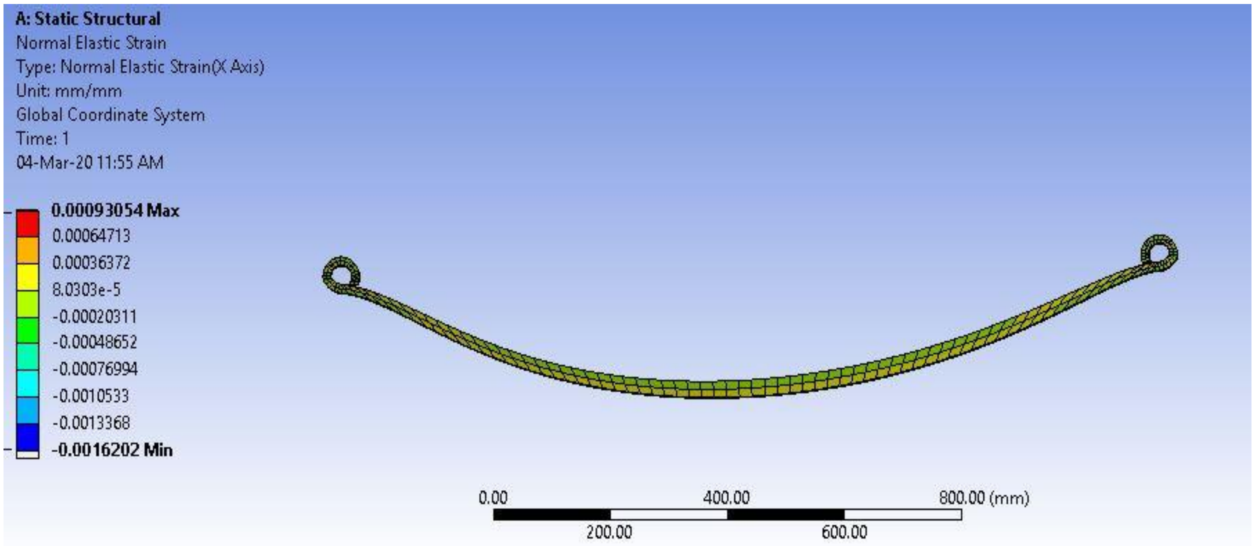


Fig 6. ANSYS Normal Elastic Strain

3.2.1. Boundary Conditions

Only the Y and Z directions of the rear end are confined, while the X direction allows translational motion. The front portion is bound in all DOF. When a leaf spring is loaded, a force is applied to its centre from the bottom up in a vertical direction. The loading capacity is between 1500 N and 5500 N. Results of the structural analysis using finite element analysis, including steel's stress (Von-Mess), deformation, and strain energy.

The stresses inside the leaf spring have all been found to be well below the permitted limits, with an excellent factor of safety when the design was examined. It was discovered that the longitudinal direction of the fibres in the laminates provided the leaf spring with good strength. It may say that its laminate leaf spring used to have the same stiffness as the steel leaf spring because the deflections of a composite leaf spring were practically equal.

4. TESTING OF SAMPLES

4.1. COMPRESSION TEST

The elastic and compressive fracture characteristics of brittle and low ductile materials must be measured using compression tests. Therefore, compression tests are being used to figure out compressive yield point, proportional limit, and elastic modulus. The ASTM D256 Flexural Strength Machine can be used to conduct the compression test.

4.2. TENSILE TEST

It's used to determine a material's strength and how far it can be strained before breaking. First, young's modulus, a measure of yield strength, is determined using this test procedure. Then, it is computed using the ASTM D 3039 M instrument.

4.3. IMPACT TEST

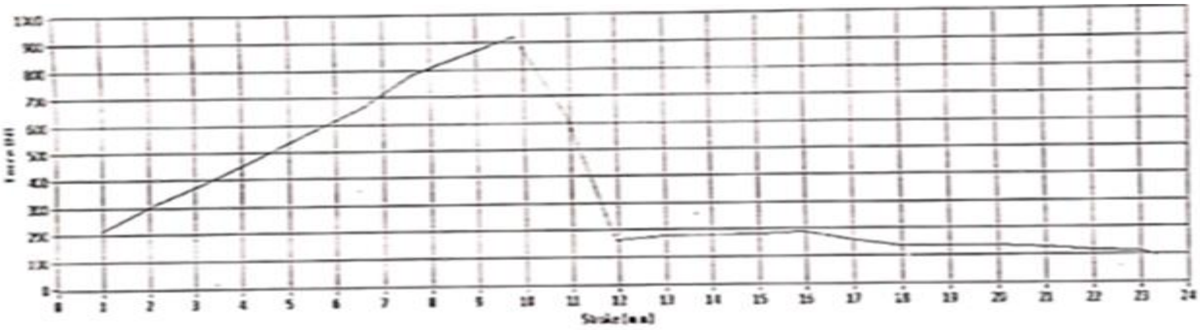
It is used to calculate how much energy the material absorbed during fracture. In addition, the material's brittleness or ductility can also be ascertained using this method. Therefore, it is possible to use ASTM D256 in the Charpy Izod impact test.

Fig 7. Compression test sample

Fig 8. Tensile test sample

5. RESULT AND CALCULATION

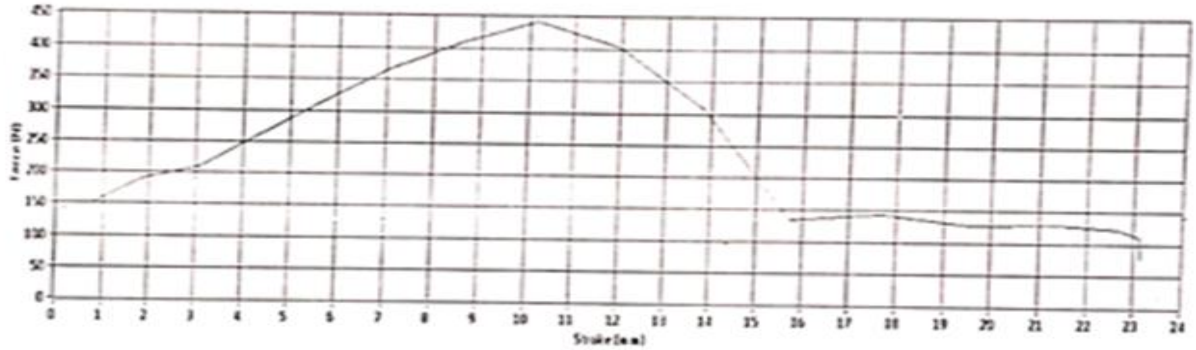
5.1. COMPRESSION TEST



Result:

Fmax -0.92KN

Fig 9. Compression Test sample 1



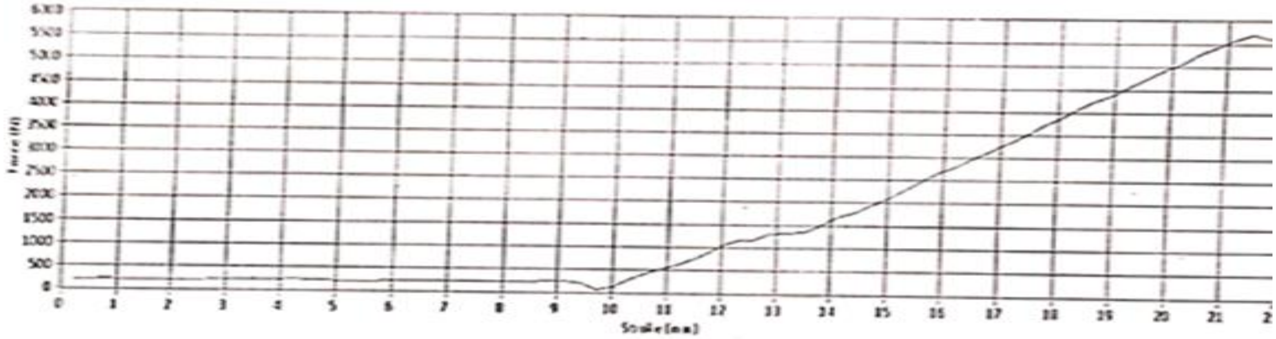
Result:

Fmax -0.44KN

Fig 10. Compression Test sample 2

It can be shown from figs. 9 and 10 that sample 1 exhibits higher compressive properties than sample 2. For sample 1, the Fmax value is 0.92 KN. Sample 1 has a maximum compressive strength of 86 MPa. Sample 2 has a compressive strength of 44 MPa.

5.2. TENSILE TEST

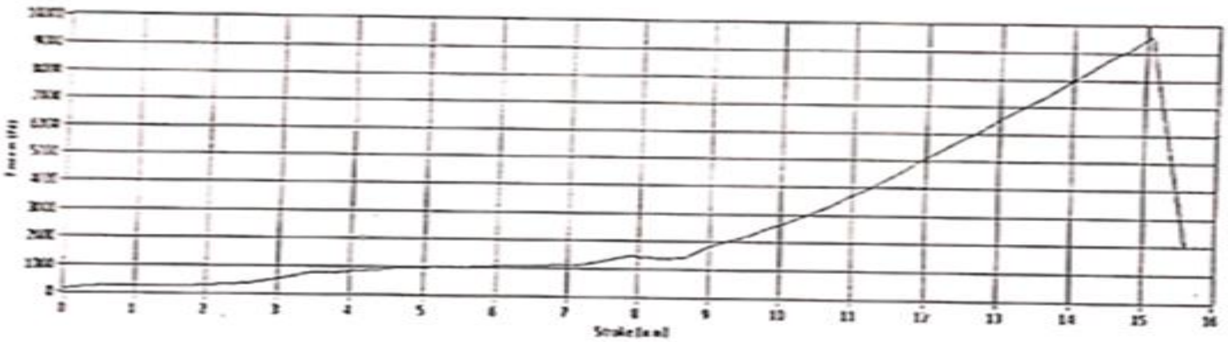


Result:

Fmax -5.71KN

UTS -67.80Mpa

Fig 11. Tensile Test sample 1



Result:

Fmax	-9.63KN
UTS	-196.26Mpa

Fig 12. Tensile Test sample 2

Sample 2 illustrates the higher tensile strength over one and the maximum stretch it can withstand before breaking in the aforementioned figs. 11 and 12. Sample 2 has a maximum tensile strength of 196.26 MPa. Sample 1 has a tensile strength of 67.80 MPa.

5.3 IMPACT TEST

Sample 2 has high impact energy, with an impact energy of around 16.80 J/m, and sample 1 has an impact value of 14.70 J/m, as seen in Table 3.

Table 3. Experimented Test Results

SAMPLE	RESIN (gram)	COMPRESSION TEST (MPa)	TENSILE TEST (KN)	IMPACT TEST (J)
1	250	86	5.71	14.70
2	250	44	9.63	16.80

6. CONCLUSION

This study compares the effectiveness of leaf springs made of steel (65Si7), Epoxy resin/Linen fibre/E-Glass, and Epoxy resin/ Banana fibre/E-Glass. Compared to standard steel leaf springs, hybrid laminate leaf springs are tested and determined to be less stress and barely noticeable increased deflection under various loading circumstances. Because it is less dense and has a lesser Young's modulus than either the Epoxy resin/ Banana fibre/E-Glass hybrid laminate can store more elastic strain energy compared to steel, E-glass/Linen/Epoxy laminate. Hybrid composite leaf springs are used to absorb energy, which results in a comfortable ride better. E-Glass/Banana/Epoxy composite materials leaf springs can replace steel leaf springs and reduce weight by 81.5 percent. The vehicle's fuel consumption is reduced when its weight is reduced.

7. FUTURE SCOPE

Plans include using various composites to reduce the issue of chip formation as well as the overall cost of the vehicle because composite leaves are less stressed, lighter, stiffer, more deflective, and stronger.

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