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DESIGN AND ANALYSIS OF COMPOSITE MONO LEAF SPRING FOR WEIGHT REDUCTION IN LIGHT COMMERCIAL VEHICLES

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ABSTRACT

To control shock loads in light vehicles, heavy trucks and in some automobile vehicles leaf springs was mainly used. The difference of leaf spring done with helical spring which is the structural member to energy gripping device. For the natural source's conservation, manufacturing companies are trying to decrease the weight of the vehicles in upcoming years. In this work leaf spring of Coir Fiber Reinforced Composite with that of E-glass fiber for Light commercial vehicle was designed by using SOLIDWORKS modelling software. And the structural analysis was carried out in ANSYS simulation software for the structural deformation. Results and the values were compared between the conventional leaf spring with the Coir Fiber Reinforced composite leaf spring.

KEYWORDS: Natural Fibers, Coir, Leaf Spring, Composites.

1. INTRODUCTION

In the present situation, the weight reduction has one of the main focuses in automobile manufacturing companies. Automobile companies are showing interest in decreasing the weight of the vehicle by replacing the steel by composite for increasing the fuel economy and performance. The Natural composites is the superior change for the GFRC for the low cost, low weight compared to steel, moreover the natural fiber materials are Biodegradable, high strain energy and high strength to weight ratio compared to the conventional steel spring.

For the natural source's conservation, manufacturing companies are trying to decrease the weight of the vehicles in upcoming years. Weight deduction can be done by the implementation of different material and manufacturing processes. The leaf spring is one of the important aspects for weight deduction in automobiles for unsparing weight.

Fiber reinforced polymer springs also have good fatigue, resistance and durability. But the weight deduction of the leaf spring is attained not only by better material replacement by better design optimization. Weight reduction is the main aim for automobile manufacturing companies in the future scope. The replacement of conventional steel spring can provide 90% weight reduction. Finally, the composite leaf spring has less stress compared to conventional leaf spring. All these will result in fuel saving which will make countries energy independent because fuel saved is fuel produced.

2. Problem Identification

Based on analysis of literature survey it is found that most of research work is done on

- Leaf spring weight reduction with concentration on dynamic materials.
- Most of researchers have taken the composite as associate solely various rather than the other grade of steel or natural fibre strengthened composites.
- Some researchers have targeted on application of natural fibre strengthened composites for spring.

3. OBJECTIVES

- The present work is to design and analyze standard steel spring with E-glass/Epoxy and Coir/Epoxy composite spring while not amendment in stiffness.
- To achieve proper weight reduction within the mechanical system by exchange steel spring with composite spring.
- Comparison are created between composite leaf spring with that of steel leaf spring having same design and load carrying capacity.

4. SELECTION OF MATERIALS

The material analyzed for leaf springs is typically a plain steel having 0.92 to 1.00% carbon. The layer leaves are heat treated when the forming method. The warm treatment of steel spring product greater strength and so larger load capability, greater vary of deflection and higher fatigue properties. Carbon/Graphite fibers: Their benefits include high strength and modulus, less constant of heat expansion and more fatigue strength. Graphite, when used alone has low impact resistance. Its drawbacks include high value, low impact resistance and high electrical conductivity.

4.1 Glass Fibers

The main advantage of Glass fiber over others is its low cost. It has high strength, high chemical resistance and good insulating properties. The disadvantages square measure low coefficient of elasticity weak adhesion to polymers, less fatigue strength and more density, that improve spring weight and size. Also crack detection becomes difficult.

4.2 Coir Fiber

Coir fibers are found center of the exhausting, internal shell and thus the outer layer of a coconut. The individual fiber cells are slender and hollow, with thick walls product of polyose. They're pale once are reduced, but in future become hardened and previous as a layer of chemical compound is left on their walls. Every cell is regarding 1.1 millimeter (0.04 in) length and 11 to 21 μm in diameter. Fibers are typically 11 to 31 cms length. The types of coir colors are brown and white. Brown coir are extracted from completely ripened coconuts is hard, high strength and has more abrasion resistance.

Table 1: Selection of materials.

Materials	Young's Modulus	Poisson's ratio	Tensile strength	Density
Steel	190-210 Mpa	0.27-0.30	572.3 Mpa	1000 kg/m^3
E-glass /Epoxy	24000 Mpa	0.3	205 Mpa	1520 kg/m^3
Coir/ E-glass/ Epoxy	21000 Mpa	0.21	184 Mpa	1470 kg/m^3

5. Design Experiment

The introduction of composites is useful in designing a good suspension system with good ride quality by achieving without much high in cost and low in quality and reliability. In this design of leaf springs, strain energy is the most important factor. The relation for the strain energy is obtained as

$$U = \sigma^2 / \rho E$$

Where s is the strength,

r is the density and E is the Young's Modulus of the spring material .It can be easily observed that material having lower modulus and density will have a greater specific strain energy capacity.

Table 2: Specification of leaf spring.

Total length of the leaf spring	1042 mm
From half- the arc length between the axle seat and the front eye	498 mm
Thickness of the leaf spring	6 mm
Width of the leaf spring	65 mm

5.1. Introduction of Finite Element Software

The Basic conception in FEA is the body could be splited into smaller parts of finite dimensions referred to as "Finite Elements". The first body is then thought of as Associate in nursing assemblage of those parts linked at a finite variety of joints referred to as nodes or nodal Points. Straightforward functions square measure chosen to approximate the displacements over every finite component. Such assumed functions square measure referred to as "shape functions. This will represent the displacement inside the part with that of the nodes of the part. Numerically, the body to be verified is splited into a fine mesh sized part. Inside every part, the variation of displacement is assumed to be determined by easy polynomial form functions and nodal displacements. Equations of strains and stresses were proposed in the form of irrelevant nodal displacements. From this, the equations of equilibrium are assembled in a very matrix type which might be simply be programmed and resolved in package.

5.2. Solid Modeling

In the present work, multi-leaf steel spring and mono-composite leaf spring are modeled. For modeling the steel spring, the dimensions of a conventional leaf spring of a light weight commercial vehicle are chosen. Since the leaf spring is symmetrical about the neutral axis only half of the leaf spring is modeled by considering it as a cantilever beam and a uniformly distributed load is applied over the ineffective length of the leaf spring in the upward direction.

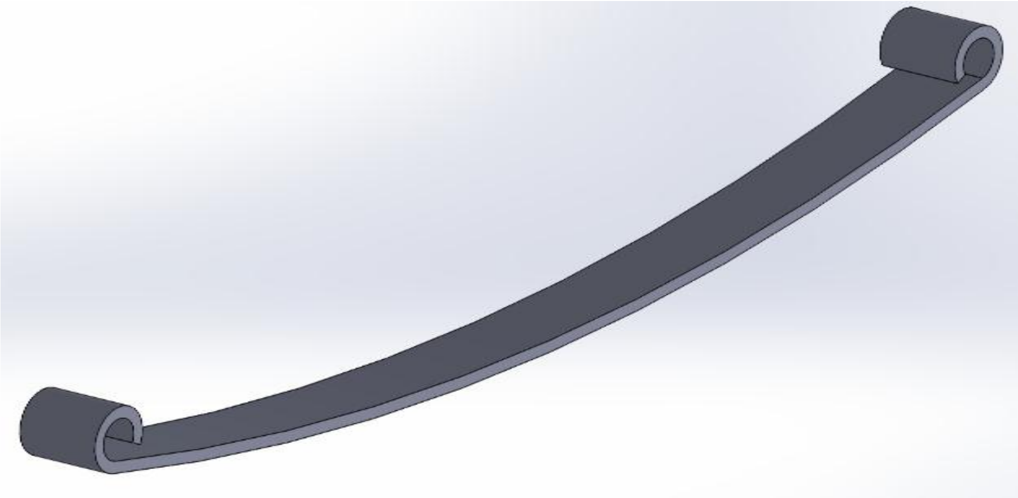

Figure 1: Solid modeling of leaf spring done in Solidworks.

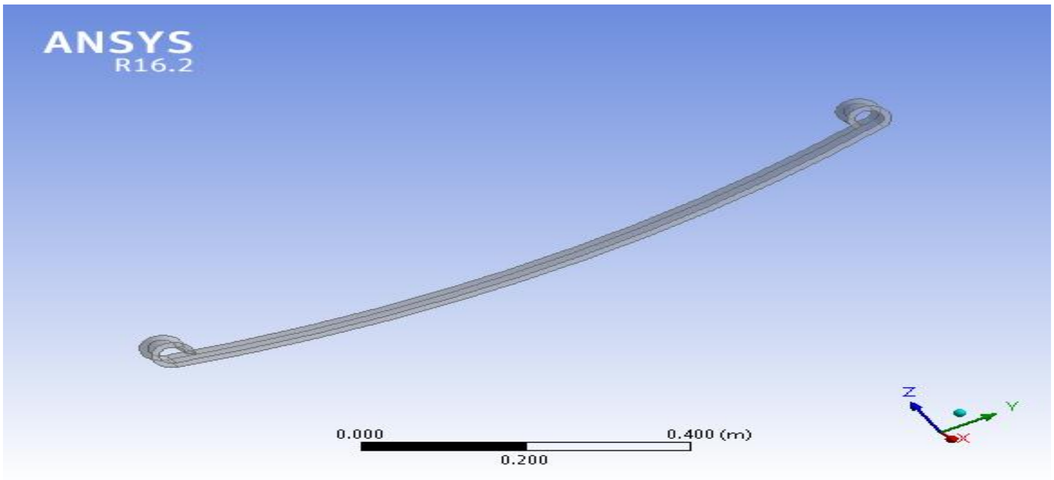

Figure 2: Modeling Exported to ANSYS.

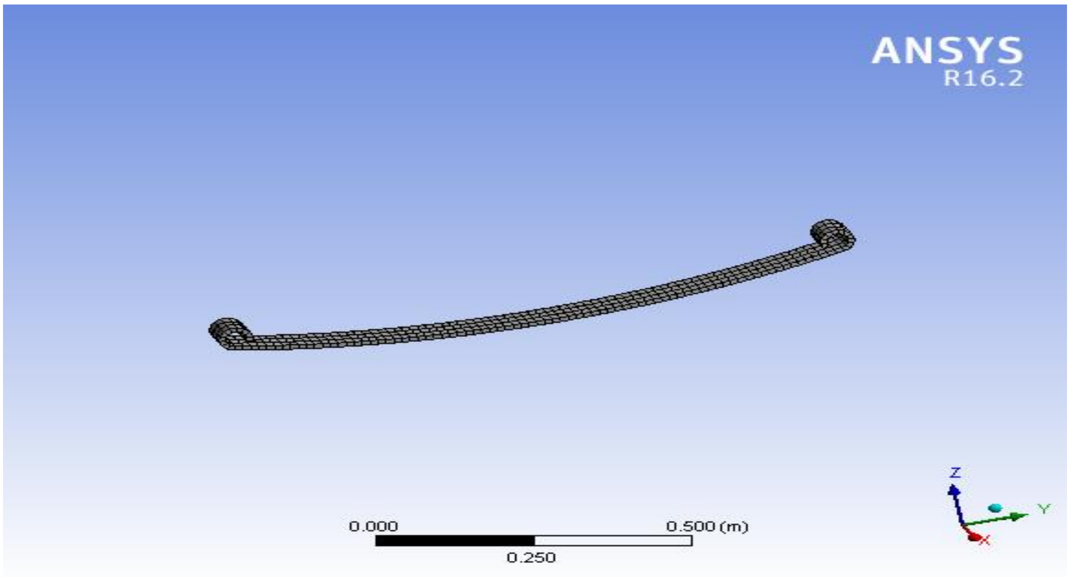

Figure 3: Mesh Model.

5.3. Specific Design Data

Here total weight and parts of Mahindra light commercial vehicle are chosen.

Gross vehicle weight = 2155 kg

Unstrung weight = 2500 kg

Total sprung weight = 1920 kg

Taking factor of safety (FS) = 1.4

Acceleration due to gravity (g) = 10 m/s²

There for; Total Weight (W) = 1920*10*1.4 = 26741 N

Hence the vehicle is four wheeler, a mono leaf spring according to each of the wheels acts one third of the total weight.

F = 26741/4 = 6685 N

5.4. Loading and Boundary Conditions

Fixed Support

For the analysis of the leaf spring one of the eye ends of the spring is attached to the chassis of the commercial vehicle. Since the fixed support has some barrier to move along X and Y direction and rotation about that fixed point. So the fixed eye end part of the leaf spring is stable in all of the positions i.e. for the eye end and degrees of freedom is zero.

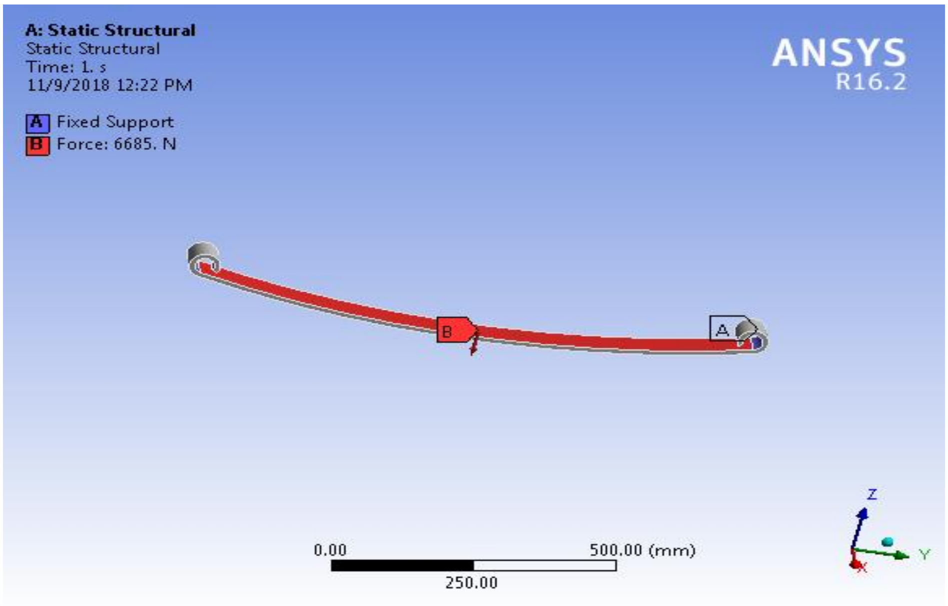

Figure 4: Load condition.

6. RESULTS AND DISCUSSION

The FEA of the leaf spring of both the materials of steel and composites are carried out.

6.1. Stress on Steel and Composite Leaf Spring

The below fig 5 and fig 6 shows the result for von-misses stresses in both the conventional and composite leaf spring.

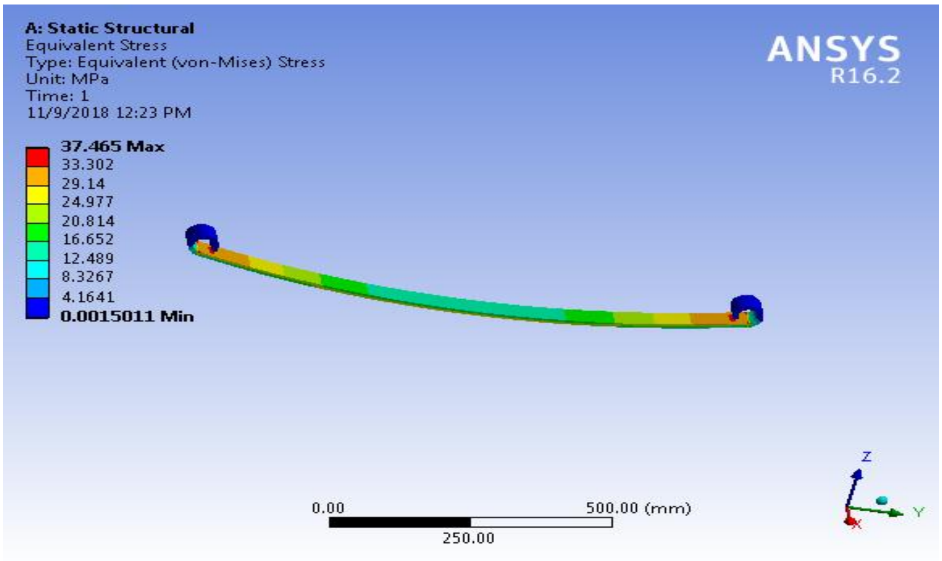

Figure 5: Von-misses Stress in Steel Leaf Spring.

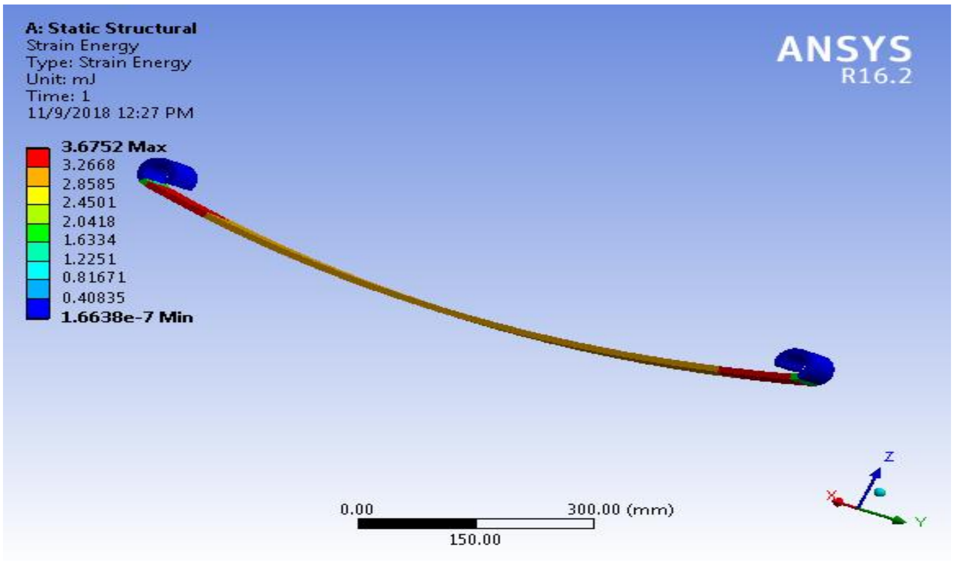

Figure 6: Von-misses Stress in Coir/E-glass/epoxy fiber-Composite.

6.2. Strain Energy on Steel and Composite Leaf Spring

The below fig 7 and fig 8 shows the result for strain in both the conventional and composite leaf spring. The results are for the vehicle load i.e. 6685N.

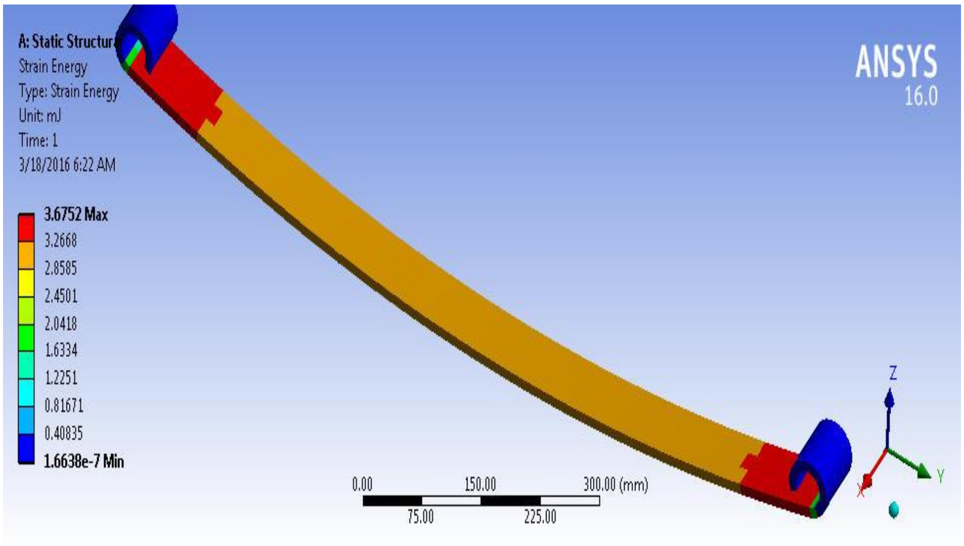

Figure 7: Strain energy in Steel.

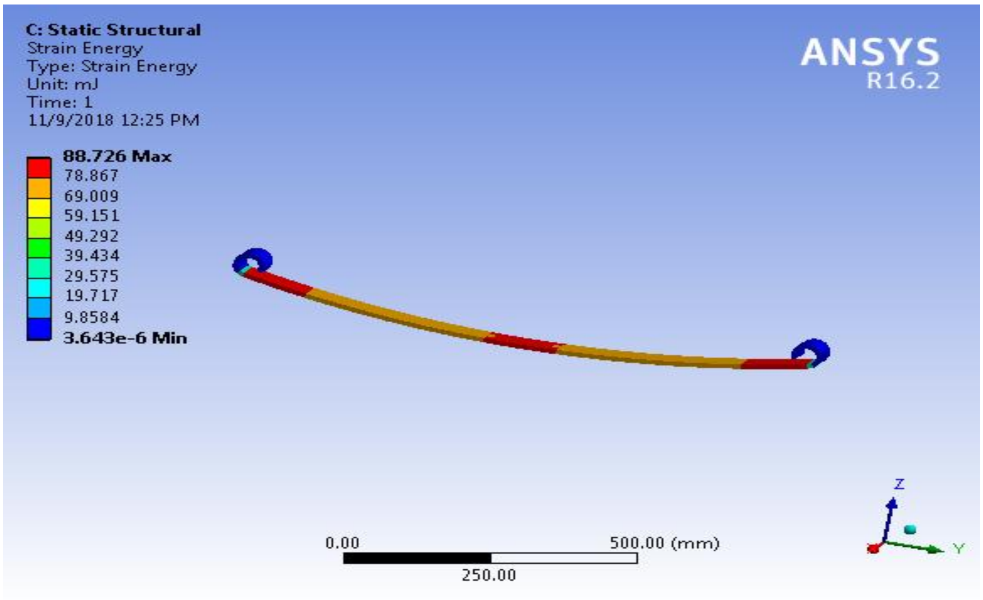

Figure 8: Strain energy in Coir/E-glass/epoxy fiber-Composite.

6.3. Comparison of Steel and Composite Leaf Spring

The following table 3 shows the clear comparison of steel and composite leaf spring in which the criteria such as weight, stress and strain values are compared.

Table 3: Comparison of steel and composite leaf spring.

Material	Mass (kg)	Von- misses Stress	Strain energy
Steel	5.4	37.465 MPa	3.67 MJ
Coir/ E-glass/ Epoxy	5.2	34.552 MPa	88.72 MJ

7. CONCLUSION

In the current work, a conventional leaf spring was improved by a coir fibre reinforced composite leaf spring for the high strength to weight ratio for the same load carriage and stiffness.

- As reducing the load and improving strength of parts are lack of development in the world, composite materials are more better to be up to the mark of satisfying all the demands. In this paper reducing weight of vehicles and increasing the strength of their spare parts is considered.
- The spring contributes significant quantity of weight to the vehicle and desires to be robust enough, a single composite spring is designed and it's shown that the ensuing design and simulation stresses are much below the strength properties of the material satisfying the utmost stress failure criterion.
- Coir/E-glass/epoxy composite leaf spring can be recommended for interchanging the steel leaf spring from stress and stiffness point of view. An equivalent research has been carried within steel and composite leaf spring in order to strength and weight. Compare to steel the epoxy having less weight, about 3.7% of weight has been reduced and the stress also reduced which will be increasing life of the leaf spring.

Totally it is clearly shown that the Natural fibre reinforced composite mono leaf spring is the healthier than of steel mono leaf spring. Therefore, it is analysed that the composite leaf spring is a desirable replacement of conventional leaf spring.

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