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# DESIGN AND ANALYSIS OF LEAF SPRING BY USING COMPOSITE MATERIAL

**S VENKATESH[1] SHARANKUMAR[2] G MANJUNATH[3]**
[1]Assistant professor,department of mechanical engineering, narsimha reddy engineering college,Hyderabad, India
[21]Assistant professor,department of mechanical engineering, narsimha reddy engineering college, Hyderabad, India
[31]Assistant professor,department of mechanical engineering, narsimha reddy engineering college, Hyderabad, India
*Corresponding author E-Mail ID: venkat.rs416@gmail.com

**ABSTRACT**

A leaf spring is a simple form of spring, commonly used for the suspension in wheeled vehicles. Leaf Springs are long and narrow plates attached to the frame of a trailer that rest above or below the trailes axle. There are mono leaf springs, or single-leaf springs, that consist of simply one plate of spring steel. These are usually thick in the middle and taper out toward the end, and they don't typically offer too much strength and suspension for towed vehicles. Drivers looking to tow heavier loads typically use multi leaf springs, which consist of several leaf springs of varying length stacked on top of each other. The shorter the leaf spring, the closer to the bottom it will be, giving it the same semielliptical shape a single leaf spring gets from being thicker in the middle Springs will fail from fatigue caused by the repeated flexing of the spring .The aim of the project is to design and model a leaf spring according to the loads applied. Presently used material for leaf spring is forged steel. In this project we are going to design leaf spring for the materials Mild Steel and composite material Glass Carbon by varying reinforcement angle. We are going to check the strength variations while changing reinforcement angle. For validating this design we are conducting FEA Structural Analysis is done on the leaf spring by using two different materials Mild Steel and Glass Carbon. Modal and fatigue Analysis is also done. Creo software is used for modeling and ANSYS is used for analysis.

***Keywords:*** CREO ANSYS

## 1. INTRODUCTION

Leaf springs are mainly used in suspension systems to absorb shock loads in automobiles like light motor vehicles, heavy duty trucks and in rail systems. It carries lateral loads, brake torque, driving torque in addition to shock absorbingOriginally called laminated or carriage spring, a leaf spring is a simple form of spring, commonly used for the suspension in wheeled vehicles. It is also one of the oldest forms of springing, dating back to medieval times. Sometimes referred to as a semi-elliptical spring or cart

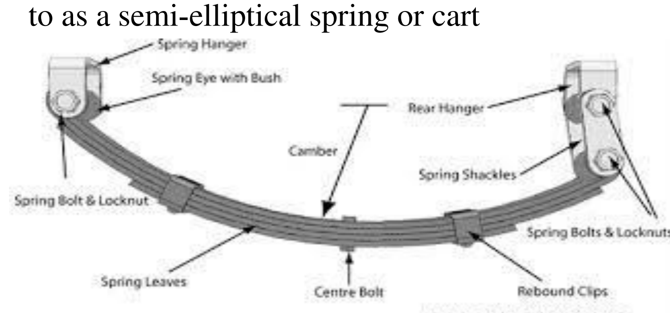


**Fig: 1.1 Leaf Spring**

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spring, it takes the form of a slender arc shaped length of spring steel of rectangular cross section. The center of the arc provides location for the axle, while tie holes called eyes are provided at either end for attaching to the vehicle body. For very heavy vehicles, a leaf spring can be made from several leaves stacked on top of each other in several layers, often with progressively shorter leaves. Leaf springs can serve locating and to some extent damping as well as springing functions. A leaf spring can either be attached directly to the frame at both ends or attached directly at one end, usually the front, with the other end attached through a shackle, a short swinging arm. The shackle takes up the tendency of the leaf spring to elongate when compressed and thus makes for softer springiness. The automotive industry is exploring composite materials for structural components construction in order to obtain the reduction of weight without decrease in vehicle quality and reliability. To conserve the natural resources and economize energy, weight reduction has been the main focus of automobile manufacturer in the present scenario. Actually, there is almost a direct proportionality between the weight of the vehicle and its fuel consumption, particularly in city driving. The advanced composite materials such as Graphite, Carbon, Kevlar and Glass with suitable resins are widely used because of their high specific strength (strength/density) and high specific modulus (modulus/density). Advanced composite materials seem ideally suited for suspension (leaf spring) applications. Their elastic properties can be tailored to increase the strength and reduce the stresses induced during application.The objective of the present work is to design the EGlass/Epoxy composite leaf spring without change in stiffness for automobile Suspension system and analyze it. This is done to achieve the following.

- To the replace conventional steel leaf springs with Eglass/Epoxy composite leaf spring without change in stiffness.
- To achieve substantial weight reduction in the suspension system by replacing steel leaf spring with composite leaf spring.

## 2 LITERATURE SURVEY

Reducing weight and increasing strength of products are high research demands in the world, composite materials are getting to be up to the mark of satisfying these demands. In this paper reducing weight of vehicles and increasing the strength of their spare parts is considered. As leaf spring contributes considerable amount of weight to the vehicle and needs to be strong enough, a single composite leaf spring is designed and it is shown that the resulting design and simulation stresses are much below the strength properties of the material satisfying the maximum stress failure criterion. From the static analysis results it is found that there is a maximum displacement of 10.16mm in the steel leaf spring and the corresponding displacements in E-glass / epoxy, graphite/epoxy, and carbon/epoxy are 15.mm, 15.75mm and 16.21mm. And all the values are below the camber length for a given uniformly distributed load 67 N/mm over the ineffective length. From the static analysis results, we see that the von-mises stress in the steel is 453.92 MPa. And the von-mises stress in Eglass/epoxy, Graphite

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/epoxy and E-glass/epoxy composite leaf spring can be suggested for replacing the steel leaf spring from stress and stiffness point of view. A comparative study has been made between steel and composite leaf spring with respect to strength and weight. Composite Mono leaf spring reduces the weight by 81.22% for E-Glass/Epoxy, 91.95% for Graphite/Epoxy, and 90.51 % for Carbon/Epoxy over conventional leaf spring.[1]

The usage of composite materials has resulted in considerable amount of weight saving when compared to conventional steel leaf spring. Taking into account the weight saving, deformation, shear stress induced and resultant frequency it is evident that composite has the most encouraging properties to act as replacement to steel The present work was aimed at modification in suspension system of the automobiles in particular or any machine by reduction of weight, which employs leaf spring, in general. This was achieved by reducing the weight of the leaf spring with the use of composite materials.Apart from being lightweight, the use of composites also ensures less noise and vibration[3]

The design and static structural analysis of steel leaf spring and composite leaf spring has been carried out. Comparison has been made between composite leaf spring with steel leaf spring having same design and same load carrying capacity. The stress and displacements have been calculated using analytically as well as using ANSYS for steel leaf spring and composite leaf spring. From the static analysis results it is found that there is a maximum displacement of 19.02 mm in the steel leaf spring and the corresponding displacements in AS4, T300, E-glass 21xk43 Gevetex and Silenka E-glass 1200tex are 341.07mm, 473.41mm, 365.38mm and 386.18mm respectively at orientation -90/90/0/90/-90. From the static analysis results, it also seen that the von-mises stress in the steel leaf spring is 219.36 MPa and in AS4, T300, E-glass 21xk43 Gevetex and Silenka E-glass 1200tex in are 182.65 MPa, 186.86 MPa and 227.97 MPa respectively at orientation -90/90/0/90/-90. All the four composite leaf springs have lower stresses than that of existing steel leaf spring. A comparative study has been made between steel and composite leaf spring with respect to strength and weight. Composite leaf spring reduces the weight by 74.82% for AS4, 72.23% for T300, 60% for E-glass 21xk43 Gevetex and 59.7% for Silenka E-glass 1200tex over steel leaf spring. The size optimization has been carried out for further mass reduction of composite leaf spring [4]

The Analyze of steel and composite leaf spring were carried analytically. Thus the steel and composite leaf spring load withstand capacity are tested at universal testing machine. The load withstand capacity of composite leaf spring is better than steel leaf spring. Thus the weights of steel and composite leaf spring are tested at electronic weight testing machine. The weight of the composite leaf spring is less than steel leaf spring. Using Ansys the total deformation equivalent stress & strain for both steel & composite materials has been found out.It is found that the composite within boron is having good material property than other materials. It is found that the boron mix composite can be used for automotive

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suspension. Which will be weight less and cost effective[5]

### 3. MODELLING OF LEAF SPRING

PTC CREO, formerly known as Pro/ENGINEER, is 3D modeling software used in mechanical engineering, design, manufacturing, and in CAD drafting service firms. It was one of the first 3D CAD modeling applications that used a rule-based parametric system. Using parameters, dimensions and features to capture the behavior of the product, it can optimize the development product as well as the design itself. The name was changed in 2010 from Pro/ENGINEER Wildfire to CREO. It was announced by the company who developed it, Parametric Technology Company (PTC), during the launch of its suite of design products that includes applications such as assembly modeling, 2D orthographic views for technical drawing, finite element analysis and more. PTC CREO says it can offer a more efficient design experience than other modeling software because of its unique features including the integration of parametric and direct modeling in one platform. The complete suite of applications spans the spectrum of product development, giving designers options to use in each step of the process. The software also has a more user friendly interface that provides a better experience for designers. It also has collaborative capacities that make it easy to share designs and make changes. There are countless benefits to using PTC CREO. We'll take a look at them in this two-part series.First up, the biggest advantage is increased productivity because of its efficient and flexible design capabilities. It was designed to be easier to use and have features that allow for design processes to move more quickly, making a designer's productivity level increase.

Part of the reason productivity can be increased is because the package offers tools for all phases of development, from the beginning stages to the hands-on creation and manufacturing. Late stage changes are common in the design process, but PTC CREO can handle it. Changes can be made that are reflected in other parts of the process. The collaborative capability of the software also makes it easier and faster to use. One of the reasons it can process information more quickly is because of the interface between MCAD and ECAD designs. Designs can be altered and highlighted between the electrical and mechanical designers working on the project.

The time saved by using PTC CREO isn't the only advantage. It has many ways of saving costs. For instance, the cost of creating a new product can be lowered because the development process is shortened due to the automation of the generation of associative manufacturing and service deliverables. PTC also offers comprehensive training on how to use the software. This can save businesses by eliminating the need to hire new employees. Their training program is available online and in-person, but materials are available to access anytime. A unique feature is that the software is available in 10 languages. PTC knows they have people from all over the world using their software, so they offer it in multiple languages so nearly anyone who wants to use it is able to do so.

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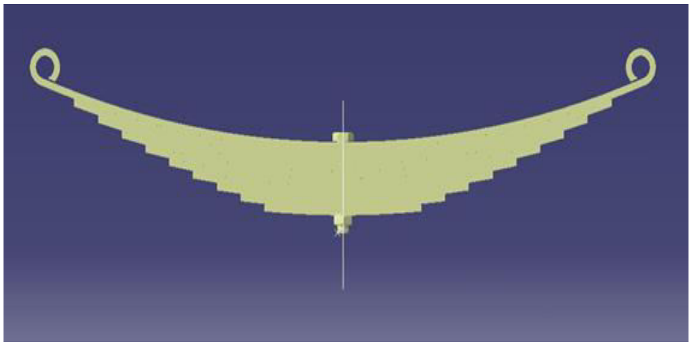


*Fig 2.1. leaf spring*

## 3.1 Material Properties of the leaf spring

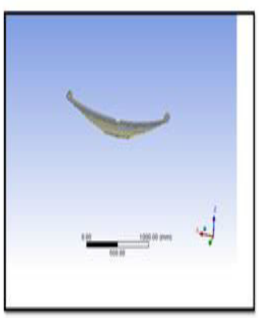
*Table 1.Material Property*

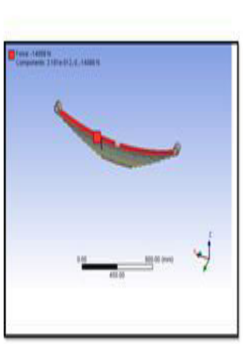
| Parameter | Mild Steel | Carbon Epoxy | S2 Glass |
|---|---|---|---|
| Density Kg/m$^3$ | 7.85g/cc | 1.60 g/cc | 2.46 g/cc |
| Young's Modulus Mpa | 215Gpa | 70.0GPa | 86.9 GPa |
| Poisson's Ratio | 0.3 | 0.3 | 0.28 |

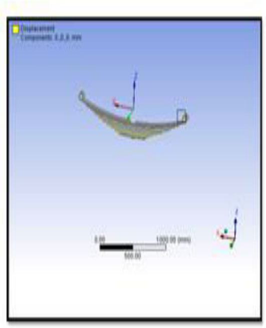
## 4. RESULTS AND DISCUSSION

### 4.1 STRUCTURAL ANALYSIS

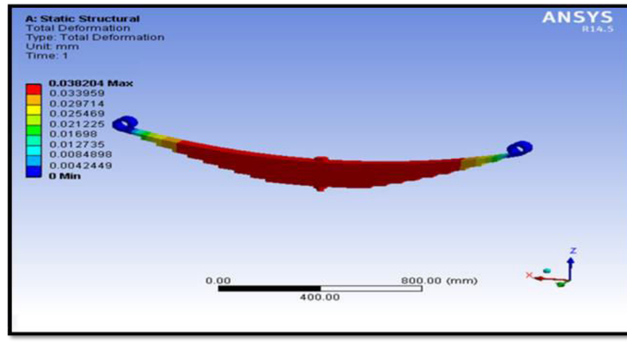
### 4.1.1 MILD STEEL



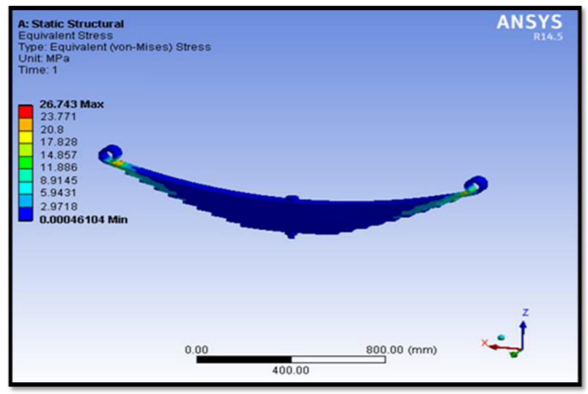




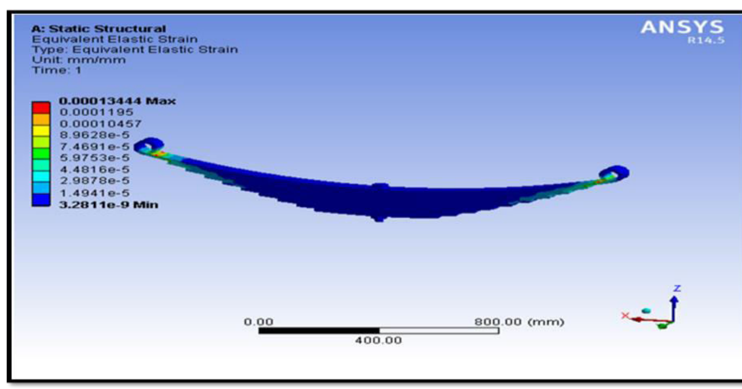
**Total deformation**



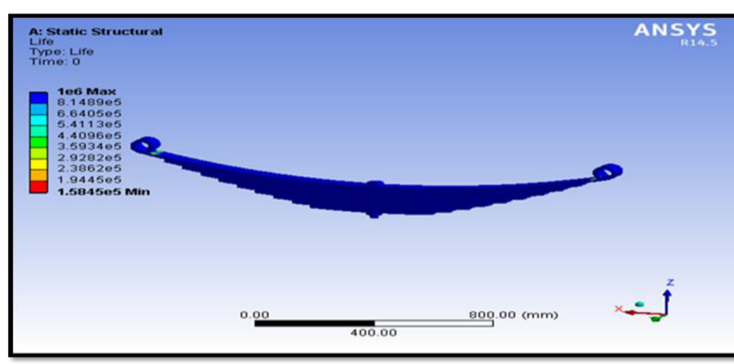

**VON-MISES STRESS**




**VON-MISES STRAIN**




**Life**



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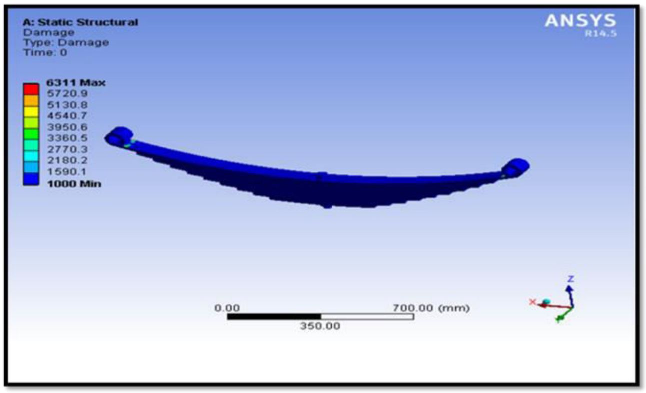
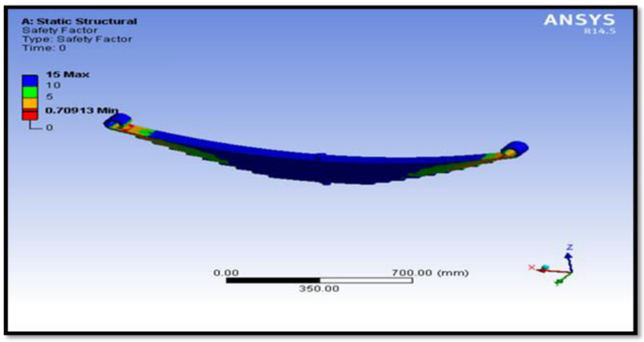
### Damage

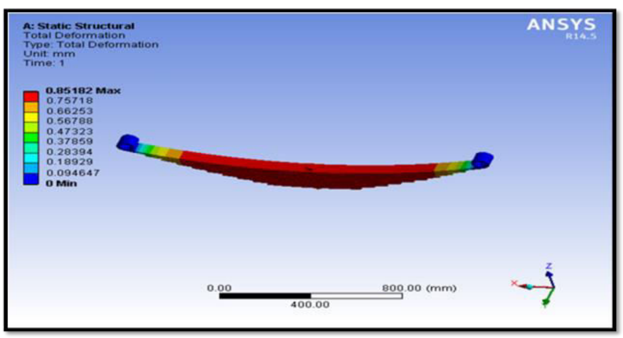



### Factor Of Safety

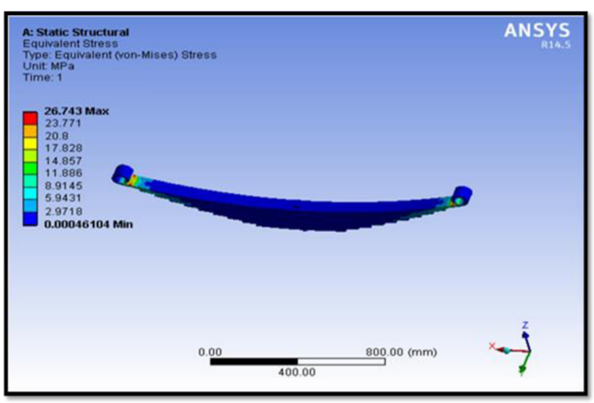



### 4.1.2 CARBON EPOXY

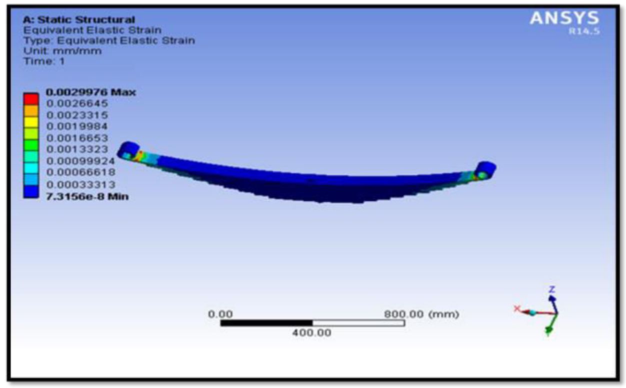
### Total deformation



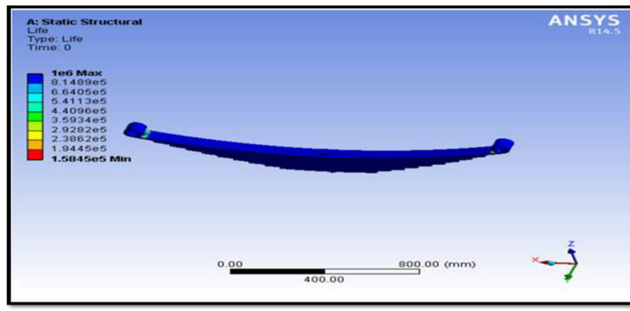

### VON-MISES STRESS



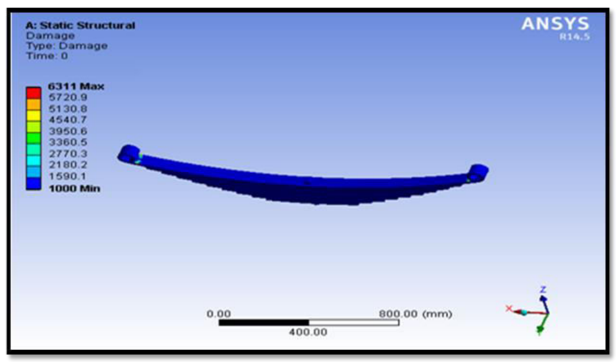

### VON-MISES STRAIN



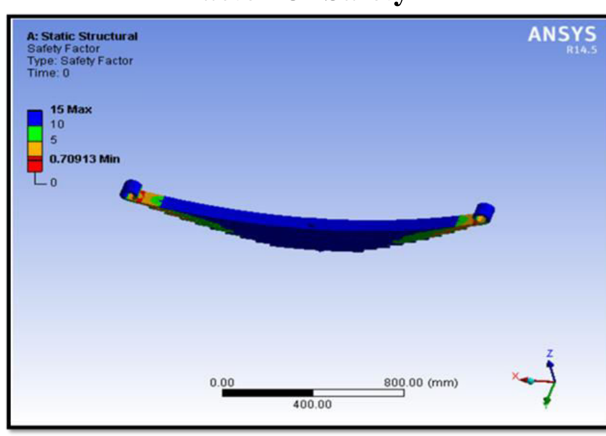

### Life




### Damage




### Factor Of Safety



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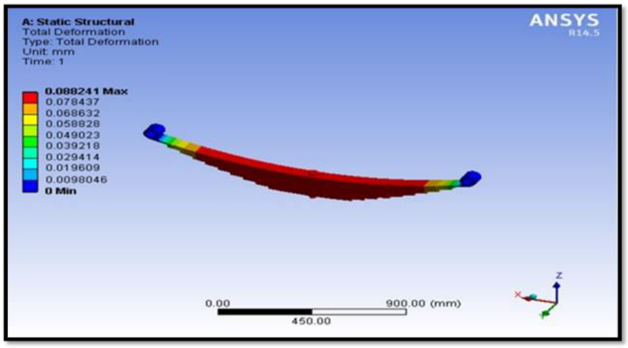
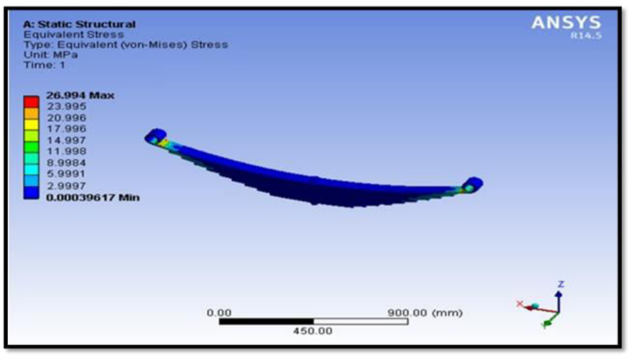
### 4.1.3 S2 GLASS

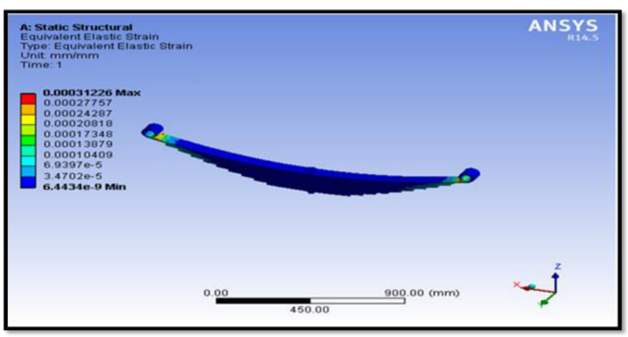
**Total deformation**



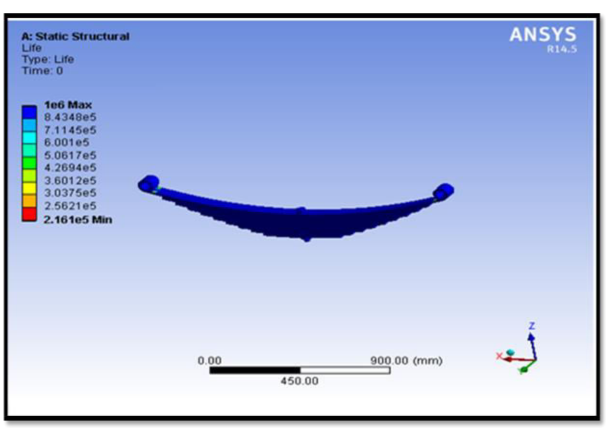

**VON-MISES STRESS**



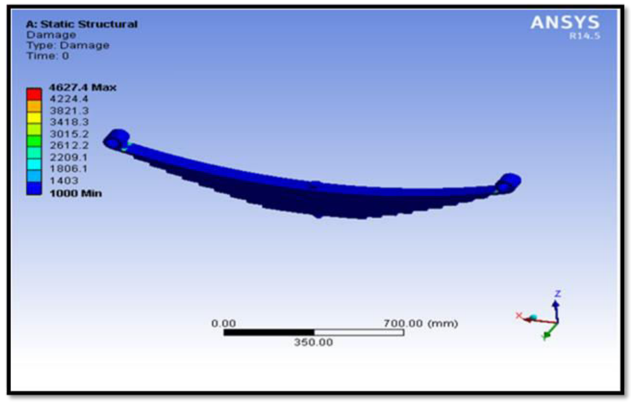

**VON-MISES STRAIN**



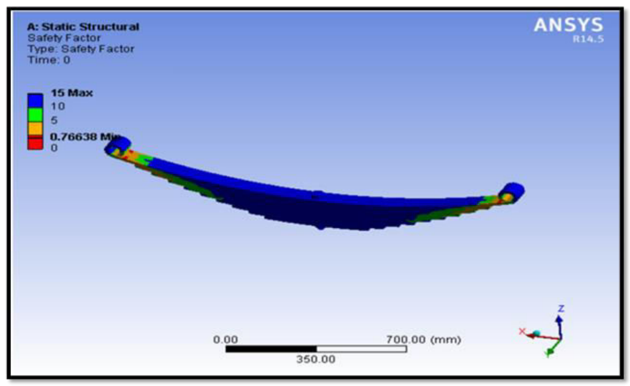

**Life**




**Damage**




**Factor of Safety**




STRUCTURAL ANALYSIS

| | Mild steel | Carbon epoxy | S2 glass |
|---|---|---|---|
| Deformation (mm) | 0.038204 | 0.85182 | 0.088241 |
| STRESS ($N/mm^2$) | 26.743 | 26.743 | 26.944 |
| STRAIN | 0.00013444 | 0.0029976 | 0.00031226 |

FATIGUE ANALYSIS

| | Mild steel | Carbon epoxy | S2 glass |
|---|---|---|---|
| Life | 1e6 | 1e6 | 1e6 |
| Damage | 6311 | 6311 | 4627.4 |
| Safety factor | 15 | 15 | 15 |

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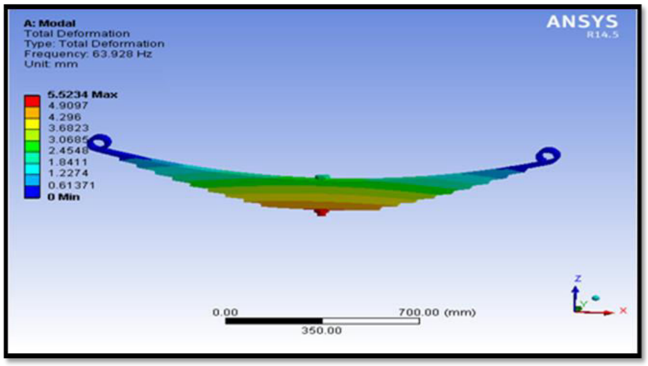
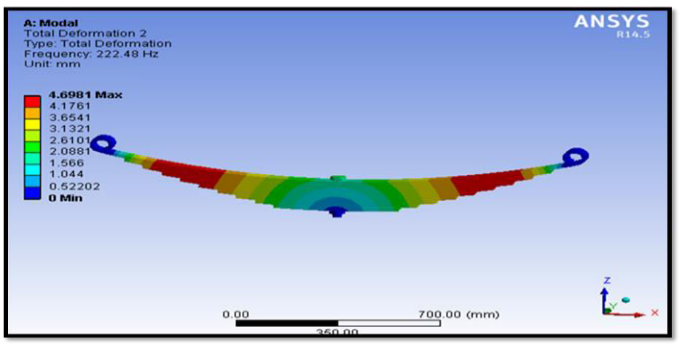
### 4.2 MODEL ANALYSIS

#### 4.2.1 MILD STEEL

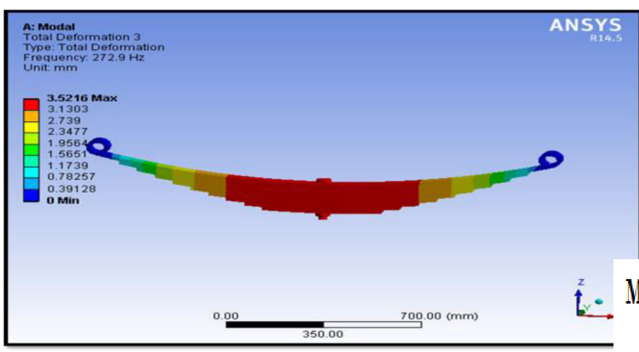
**Mode1**




**Mode2**




**Mode3**

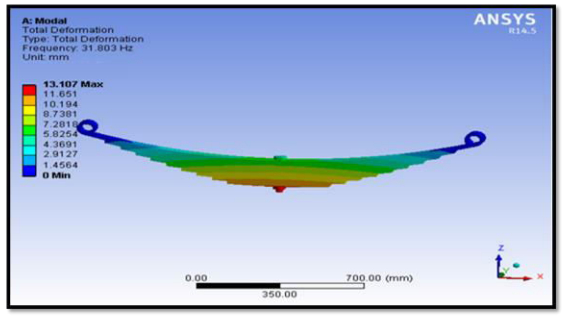



MODEL ANALYSIS MILD STEEL

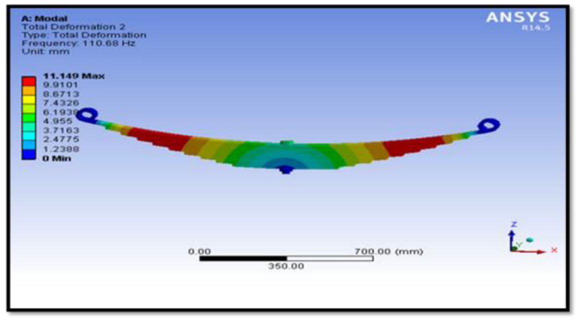
| | Model | Mode2 | Mode3 |
|---|---|---|---|
| deformation | 5.5234 | 4.6981 | 3.5216 |
| Frequency(Hz) | 63.928 | 222.48 | 272.9 |

#### 4.2.2 CARBON EPOXY

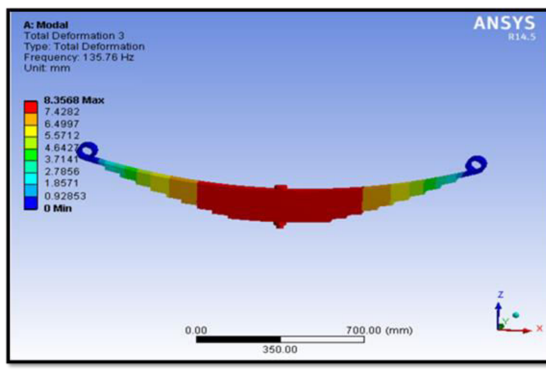
**Mode1**




**Mode2**




**Mode3**




MODEL ANALYSIS CARBON EPOXY

| | Model | Mode2 | Mode3 |
|---|---|---|---|
| deformation | 13.107 | 11.149 | 8.3568 |
| Frequency(Hz) | 31.803 | 110.68 | 135.76 |

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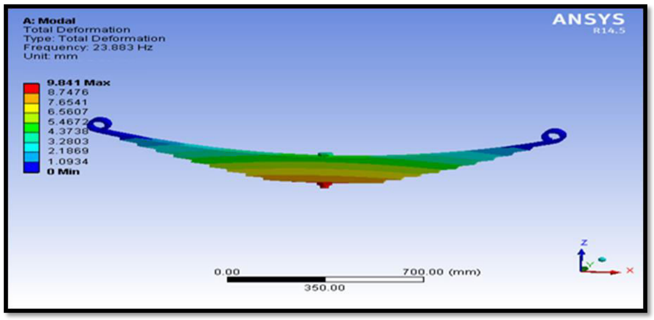
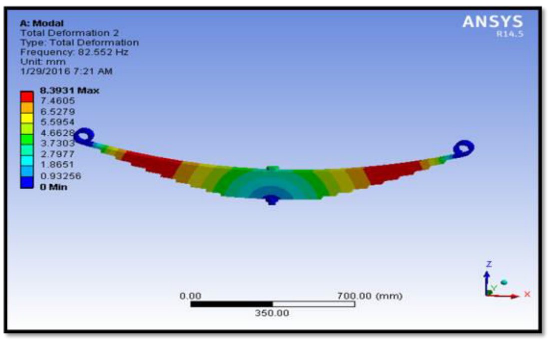
### 4.2.3 S2 GLASS

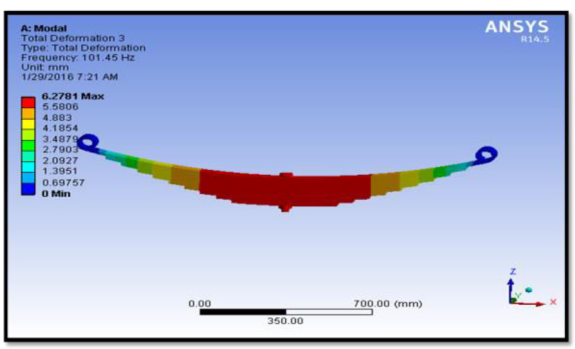
**Mode1**




**Mode2**




**Mode3**




MODEL ANALYSIS S2 GLASS

| | Mode1 | Mode2 | Mode3 |
|---|---|---|---|
| deformation | 9.841 | 8.3931 | 6.2781 |
| Frequency(Hz) | 23.883 | 82.522 | 101.45 |

## 5. CONCLUSION

In this thesis, a leaf spring is designed for Ashok Leyland Viking heavy vehicle. The data is collected from net for the specifications of the model. The leaf spring is designed for the load of 14087.5N. Theoretical calculations have been calculated for leaf spring dimensions at different cases like varying thickness, camber, span and no. of leaves by mathematical approach. In this thesis, analysis have been done by taking materials steel, carbon Epoxy. Structural and modal analysis are conducted on total assembly of leaf spring and for single leaf by using layer stacking analysis, this analysis is done for only composites. The results show:

1. The stresses in the composite leaf spring of design are much lower than that of the allowable stress.
2. The strength to weight ratio is higher for composite leaf spring than conventional steel spring with similar design.
3. Weight of the composite spring by using material S_2 Glass epoxy 5 times less than steel. For less weight of the spring mechanical efficiency will be increased.

In this project it can be concluded that using composite carbon Epoxy is advantageous. The major disadvantages of composite leaf spring are the matrix material has low chipping resistance when it is subjected to poor road environments which may break some fibers in the lower portion of the spring. This may result in a loss of capability to share flexural stiffness. But this depends on the condition of the road. In normal road condition, this type of problem will not be there. Composite leaf springs made of polymer matrix composites have high strength retention on ageing at severe environments.

The steel leaf spring width is kept constant and variation of natural frequency with leaf thickness, span, camber and numbers of leaves are studied. It is observed from the present work that the natural frequency increases with increase of camber and almost constant with number of leaves, but natural frequency decreases with increase of span. The natural frequencies of various parametric combinations are compared with the excitation frequency for different road irregularities. The values of natural frequencies and excitation frequencies are the same for both the springs as the geometric parameters of the spring are almost same except for number of leaves.

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