International Engineering Journal For Research & Development

Vol.4
Special Issue

E-ISSN NO:-2349-0721

Impact factor : 6.03

ANALYSIS AND TESTING OF COMPOSITE MONO LEAF SPRING

Mr. Rohit Mohan
Suryawanshi
M.Tech Second Year Student
AMGOI , Wathar
rohit.suryawanshi64@gmail.com

Dr. A.A. Miraje
Associate Professor
PVPIT, Budhgaon
aamiraje.mitcoe@gmail.com

Mr. Suraj Sunil Jadhav
M.Tech Second Year Student
AMGOI, Wathar
surajjadhav93@gmail.com

Abstract—

The main use of Leaf springs is in suspension system to absorb shock loads in automobiles like light motor vehicles, heavy duty trucks and in rail systems. It carries, brake torque, driving torque,lateral loads in addition to shock absorbing. The advantage of leaf spring over helical spring is that the ends of the spring may be guided along a definite path as it deflects to act as a structural member in addition to energy absorbing device. The suspension leaf spring is one of the potential items for weight reduction in automobiles unsprung weight. The main aim of our project is to study and analyze the leaf spring of Bolero Vehicle which is made up of Steel and combination of steel and epoxy material. The 3 D model of leaf spring was drawn with the help of CATIA software. The experimental testing was carried using FFT Analyser. The analysis was carried out with the help of ANSYS software. The comparative analysis was carried out between the Analytical and experimental results. After making the comparative analysis result and conclusion was drawn.

Keywords—Leaf Spring, Steel, Epoxy, ANSYS,FFT Analyzer

Introduction

A leaf spring is a simple form of spring commonly used for the suspension in wheeled vehicles..

In most typical configuration arc shape is taken by spring with length of steel spring is of rectangular crosswise. For attracting purpose loops of spring are given at the both spring ends. On middle of the arc there is the location of the shaft. For terribly significant vehicles, a spring may be made up usually with increasingly shorter leaves, On high of every alternative in many layers many leaves are stacked.

A spring will hooked up on to the frame at each finishes. Spring also hooked up directly at one end with the opposite finish hooked up through a brief swinging arm, a shackle. The function of the shackle is to elongate once compressed. The shackle is used for softer elasticity. To hold a swiveling member some springs are terminated in a concave end. Contemporary development in cars is the leaf spring. Up to the 1970 use of leaf spring on cars is very common thing in Europe and Japan. America moves to the front wheel drive after late 1970.

LITERATURE REVIEW

Shishay Amare Gebremeskel [1],has studied leaf spring to reducing weight of vehicle. E-glass/Epoxy material is used to increase the strength of part and to reducing weight of the vehicle. For such a kind of solutions researcher are attracting towards composite material. The author of this paper has designed leaf spring for only static loading condition. Cross-section of composite material is taken as similar to that of steel leaf spring. Simulation stresses and design are below materials strength properties. In this research work light weight three wheeler vehicle is selected for design. Prototype of leaf spring prepared by using Hand lay up method.

In this paper hand lay-up method is used for manufacturing the prototype by the author. Leaf Spring has the design of constant cross section.

T.N.V.Ashok Kumar et.al[2], they have given dynamic and static analysis of steel leaf spring and composite leaf spring. The Automobile business has uses composite spring instead of steel spring. The characteristics of composite material are good corrosion resistance. High strength to weight ratio is another characteristics of composite leaf spring. The main aim of this research work is to compare weight savings, frequencies, displacement and deflections of steel leaf spring and composite leaf spring. In ANSYS 10.0 results are analyzed by layer to layer. The weight of steel leaf spring is compared with composite leaf spring. Deflection and Stresses are the design constraints. Total of 27.5 % reduction in weight is obtained as compared with steel leaf spring.
Dynamic and static analysis of multi leaf composite spring and steel leaf spring are studied by the author of this paper.

Prof. N. D. Patil et.al [3], they have presented work regarding UTM test. To do the UTM test molded specimen rod of carbon fiber material is used. After that this specimen rod is casted. Experimental test is used to determine the values of Modules of elasticity of that material and density. These values are used for FEM analysis. UTM is used to validate experimental FEM results. The shock loads in automobiles is absorbed by leaf spring. The applications where the shock loads are applied such as Heavy duty trucks rail systems and light motor vehicles. Leaf spring also carries driving torque, brake torque lateral loads. To achieve weight reduction better manufacturing process is used. Also design optimization and better material is introduced to reduce the weight of the vehicle. Due to weight reduction fuel efficiency is increased

This paper gives information about load vs deflection testing on universal testing machine which is useful forstatic load testing of our project.

Parkhe Ravindra et.al [4], they have described design of composite leaf spring. After designing composite leaf spring analysis is done. Main issue in automobile industries is weight reduction. In this research work carbon/Epoxy composite material leaf spring is modelled with same load as that of conventional steel leaf spring. Deflections and stresses are design constraints. Varying cross-section are considered when composite leaf spring have to be modelled. ANSYS 12 is used for static analysis. Near about 22.5% weight reduction is obtained as comparison with steel leaf spring. Also composite leaf spring has less stresses as compared to steel leaf spring.

This research work includes static analysis of composite mono leaf spring.

OBJECTIVES

- To achieve increase in the breaking strength of automobile mono spring.
- To calculate mode shape and Natural bending Frequency of the mono spring.
- To carry out experimental Investigation and finite element analysis of mono spring
- To validation of experimental and FEA results.

METHODOLOGY

- Step 1: - I started the work of this project with literature survey. I gathered many research papers which are relevant to this topic. After going through these papers, I learnt about Leaf Spring.
- Step2: - After that the components which are required for my project will be decided.
- Step 3: - After deciding the components, the 3 D Model and drafting will be done with the help of CATIA software.
- Step 4: - The components will be manufactured and then assembled together.
- Step 5: - The calculations of Leaf spring will be carried out.
- Step 6: - The Experimental Testing will be carried out on UTM.

- Step 7: - The Analysis will be carried out with the help of ANSYS software.
- Step 8: - The comparative analysis will be done between experimental observations and analysis and the result and conclusion will be drawn.

DESIGN CALCULATIONS

Weight of Vehicle = 1615 Kg

Maximum Load Carrying Capacity = 535 Kg

Total Weight = 1615 + 535 = 2150 Kg

Taking F.S. = 2 & Acceleration due to gravity = g = 10 m/s2

Total Weight = W = 2150*2*10 = 43000N

Since the vehicle is 4-wheeler a single leaf spring corresponding to one of the wheels takes up ¼ th of the total weight.

F = 43000/4 = 10750 N

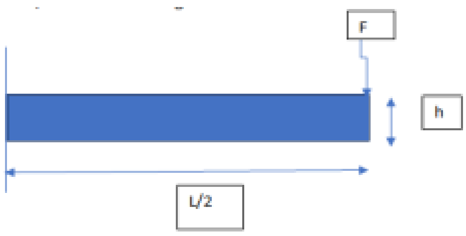
Measured data of the four-wheeler vehicle:

Leaf Span of the Load free Curved leaf spring (L') = 1016mm

Straight Length of Leaf Spring (L) = 1040mm

$\frac{C}{L'}$ = 0.089, C = 90.424mm

Where, C = Camber Length



L/2 = 520mm, F=10,750N, h =? b =?

We Know that,

For Cantilever Beam –

Maximum Stress = $\frac{W*L}{Z}$

$= \frac{F*L}{I/Y}$

$= \frac{F*L*Y}{I}$

$= \frac{F*L*h}{2*b*h3/12}$

σ max = $\frac{6*F*L}{b*h2}$ ……………………………………(1)

Maximum Deflection = $\frac{W*L3}{3*E*I}$

$= \frac{F*L3}{3*E*b*h3/12}$

$^{\delta}$ max = $\frac{4*F*L3}{E*b*h3}$…………………………..(2)

For Torsional Moment, as both ends are hinged the effective length will be considered as L = 2/3 Le

By solving Equation 1 & 2 we get,

h = 2/3 * $\frac{\sigma\ max*L2}{E*^{\delta} max}$ *3/2

h = $\frac{\sigma\ max*L2}{E*^{\delta}max}$

σ max = 473MPa, $^{\delta}$ max = 105mm

h = 23mm

From equation 1 we get,

b = $\frac{6*F*L/2}{\sigma\ max*h2}$

b = 134mm

Bending Stress Calculations (σb):

σb = $\frac{M*y}{I}$

Where, M = Bending Moment

Y = h/2

I = Moment of Inertia

M = $\frac{F*L}{2}$ = 5590 Nm

I = $\frac{b*h3}{12}$ = 1.36*10-7 m4

Y = h/2 = 23/2 = 11.5mm = 11.5*10-3 m

By putting all the values in equation of bending stress we get,

σb = 472.68*10^6 N/m2

DESIGN

The long form of the CAD is Computer-aided design. It is used to aid in the optimization of a design, modification, creation, or analysis. The use of software is to improve the quality of design. Through documentation improve communications is also the use of CAD. Another uses of the CAD are improvement design quality, increase the productivity of the designer, creating database for manufacturing. CAD has output in the form of machining. Also electronic files for print were output of CAD.

Curves and figures are designed by using CAD software. CAD design solids in three-dimensional (3D) space. Two-dimensional (2D) space is also designed with the help of CAD.

Architectural design, aerospace industries, automotive, and shipbuilding are the applications of the CAD Software.

Fig. 1 CATIA model

Actual epoxy leaf spring

ANSYS

The method which is used to solve the Physics, Engineering and mathematical problems is called as finite element method. Heat transfer, fluid flow electromagnetic potential, mass transport and structural analysis are the typical areas of finite element analysis. Analytical solutions of this problems is solution of partial differential equation for boundary value problems. Finite element is a concept where large problems divided into small and simpler parts. Simple equations are used model the finite elements. After that models the entire problem with the help of assembling into a larger system of equations. Studying or analyzing a phenomenon by using Finite Element Method is called as finite element analysis.

Properties of Outline Row 4: Structural Steel

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	7850	kg m^-3
4	Isotropic Secant Coefficient of Thermal Expansion		
5	Coefficient of Thermal Expansion	1.2E-05	C^-1
6	Isotropic Elasticity		
7	Derive from	Young's Modu...	
8	Young's Modulus	2E+11	Pa
9	Poisson's Ratio	0.3	
10	Bulk Modulus	1.6667E+11	Pa
11	Shear Modulus	7.6923E+10	Pa

Fig.No.Structural Steel Material Properties

Properties of Outline Row 4: EPOXY MATERIAL

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	1.8E-09	tonne mm^-3
4	Isotropic Elasticity		
5	Derive from	Young's Modulu...	
6	Young's Modulus	54000	MPa
7	Poisson's Ratio	0.25	
8	Bulk Modulus	36000	MPa
9	Shear Modulus	21600	MPa

Fig. 3 EpoxyMaterial Properties

MESH

Meshing of ANSYS is intelligent, high-performance, general-purpose and automated product. Accurate mesh is produced with the help of ANSYS for efficient solutions and Multi-physics. For specific analysis mesh is well suited. For all parts in a model with single mouse click mesh is generated. To obtain fine tune of meshing Full controls over the options are available to obtain fine tune of meshing. For this expert users are available. Mesh generation time is reduced by using power of parallel processing.

.

Statistics	
Nodes	26703
Elements	4545

Fig.No.4Meshing of steel leaf spring

Statistics	
Nodes	111042
Elements	22747

Fig. 5 Meshing of epoxy leaf spring

Boundary Condition

Known value is set for an associated load or displacement for the model is called as boundary condition. Either displacement or load you can set for particular node.

Pressure, temperature and force are included in FEA. These are the main types of loading in the FEA. It can be applied to edges, surfaces, nodes, points. It can also applied on elements offset from a feature.

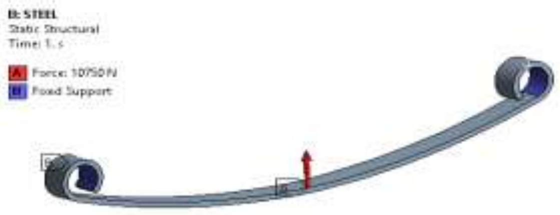


Fig.No.6 boundary condition of steel leaf spring

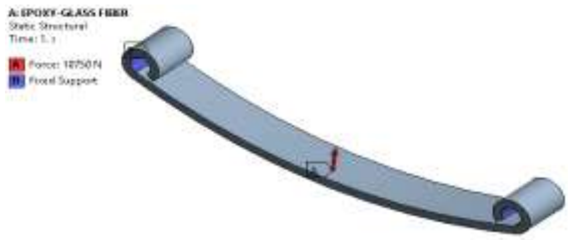


Fig.7 Boundary condition of epoxy leaf spring

Total Deformation

General terms in the finite element method are directional deformation & total deformation. This is independent upon the software which is used for analysis. . Directional deformation: Displacement of the system is put as user defined direction or particular axis. Total deformation: All directional displacements of the systems vector sum is nothing but total deformation.

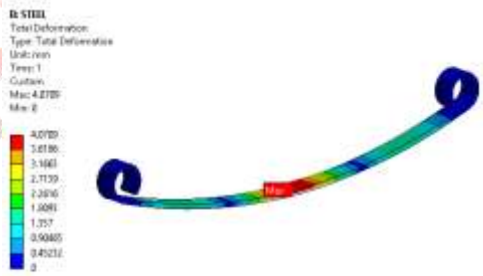


Fig.No.8Steel Spring Total Deformation

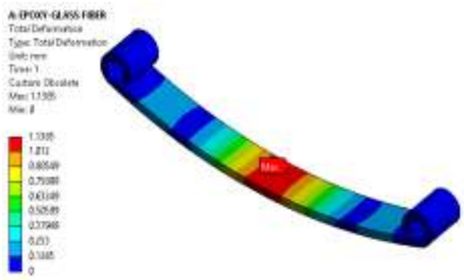


Fig. 9 Epoxy leaf springTotal deformation

Equivalent Stress

The equation by which principal stresses and

equivalent stresses are related is given as:

$$\sigma_e=\left[\frac{(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2}{2}\right]^{1/2}$$

Any arbitrary three-dimensional stress state which represented as a single positive stress value is allowed by Equivalent stress so it is used for design work. Yielding in a ductile material is predicted by equivalent stress.

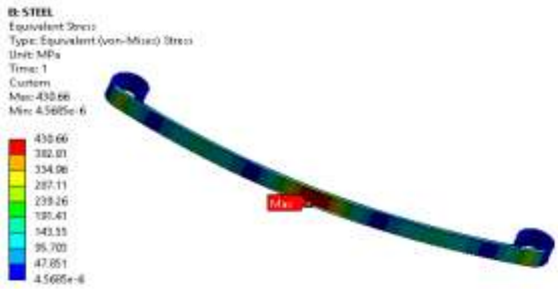


Fig. 10 Steel leaf spring Equivalent stress

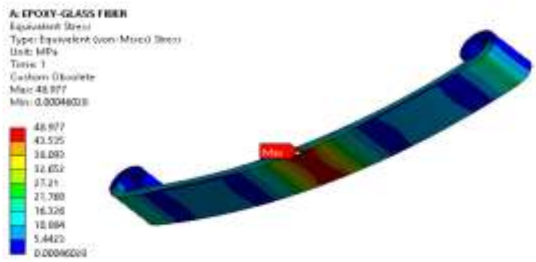


Fig. 11 Epoxy leaf spring Equivalent stress

Model analysis:

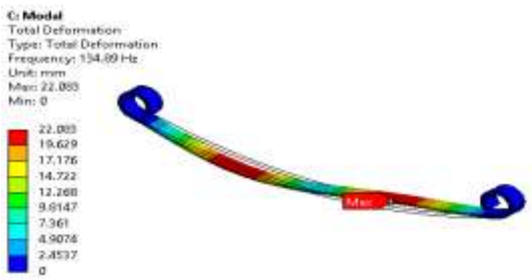


Fig. 12Natural frequency of steel leaf spring at mode 1

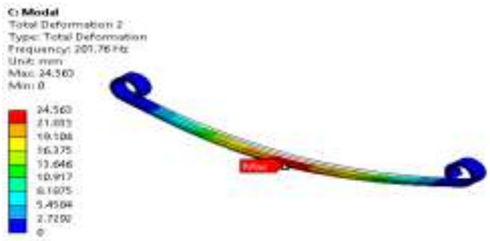


Fig. 13Natural frequency of steel leaf spring at mode 2

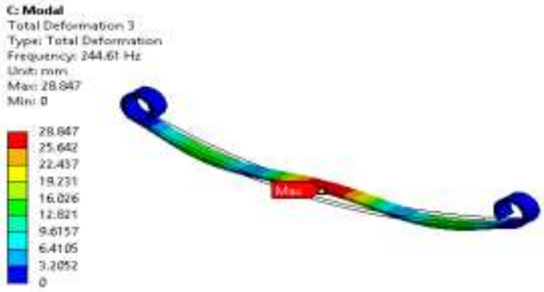


Fig. 14 Natural frequency of steel leaf spring at mode 3

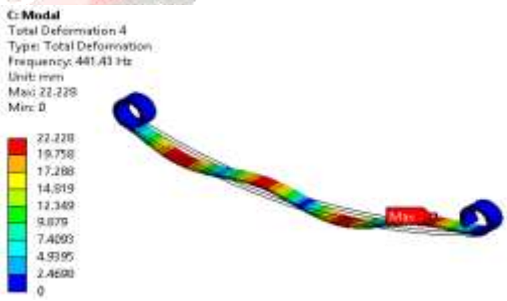


Fig. 15Natural frequency of steel leaf spring at mode 4

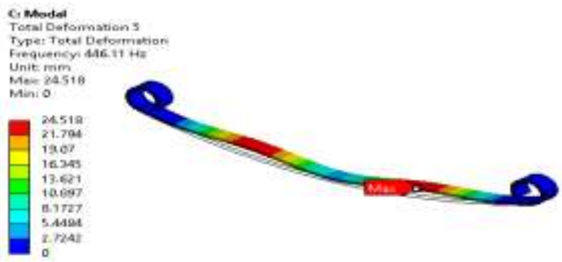


Fig. 16 Natural frequency of steel leaf spring at mode 5

MODAL ANALYSIS OF EPOXY LEAF SPRING

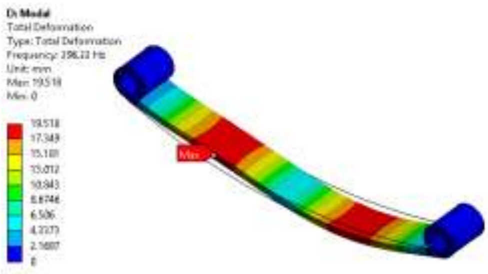


Fig. 17Natural frequency of epoxy leaf spring at mode 1

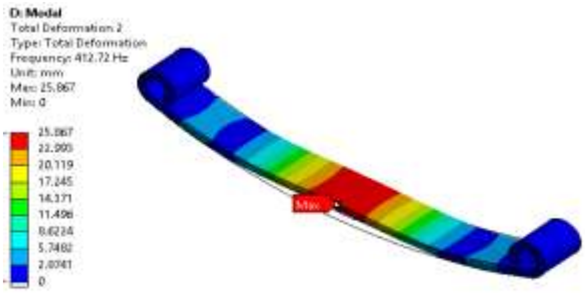


Fig. 18 Natural frequency of epoxy leaf spring at mode 2

Fig. 19 Natural frequency of epoxy leaf spring at mode 3

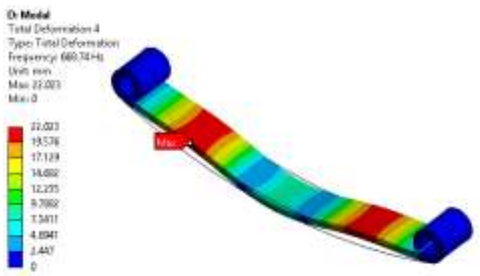


Fig. 20 Natural frequency of epoxy leaf spring at mode 4

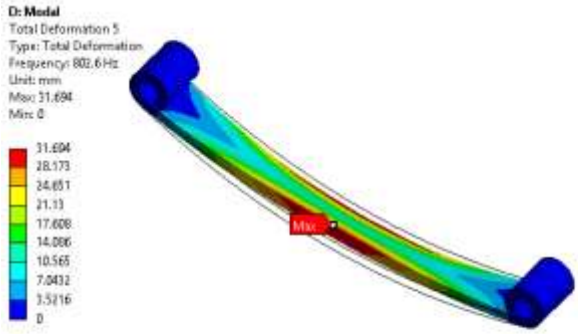


Fig. 20 Natural frequency of epoxy leaf spring at mode 5

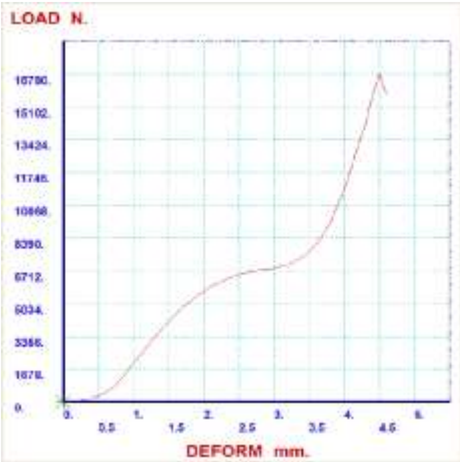
EXPERIMENTAL RESULTS

Specification of UTM

1	Max Capacity	400KN
2	Measuring range	0-400KN
3	Least Count	0.04KN
4	Clearance for Tensile Test	50-700 mm
5	Clearance for Compression Test	0- 700 mm
6	Clearance Between column	500 mm
7	Ram stroke	200 mm
8	Power supply	3Phase, 440Volts, 50 cycle. A.C
9	Overall dimension of machine (L*W*H)	2100*800*2060
10	Weight	2300Kg

Experimental testing photo

Result of UTM



FFT analysis

For any given sequence, many transforms are being usedto find this property of FFT. Time and memory management are the two major issues of FFT analysis. For calculating FFT and Autocorrelation of any given sequencetwo different algorithms are written. With respect to thetimemanagements and memorycomparison is done between the two algorithms and the better one is pointed. Considering thememory andtime as the only main constraintcomparison between the two algorithms is written. Time is takenin finding the fundamental frequency by the two transforms. While using the two algorithms the memory consumed is also checked. Based on these aspects algorithm isselectedwhich has better results.

DEWE-43 Universal Data Acquisition Instrument

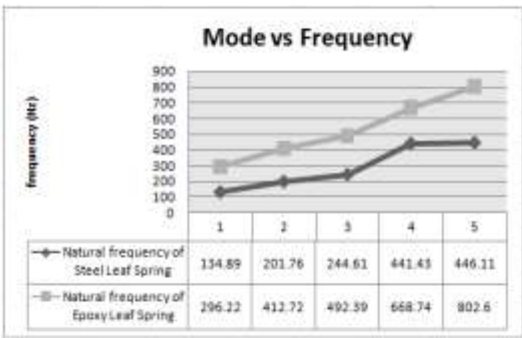
When connected to the high speed USB 2.0 interface of any computer the DEWE-43 becomes a powerful measurement instrument for analog, digital, counter and CAN-bus data capture. Eight simultaneous analog inputs sample data at up to 204.8 kS/s and in combination with DEWETRON Modular Smart Interface modules (MSI) a wide range of sensors are supported Voltage Acceleration Pressure Force Temperature Sound Position RPM Torque Frequency Velocity And more The included DEWESoft application software adds powerful measurement and analysis capability, turning the DEWE-43 into a dedicated recorder, scope or FFT analyzer.

First we are attach accelerometer to the Epoxy Leaf Spring specimen .After that we are applying Impact hammer to Epoxy Leaf Spring for validation of natural frequencies.

Fig.No.21Experimental setup of FFT

FEA Result

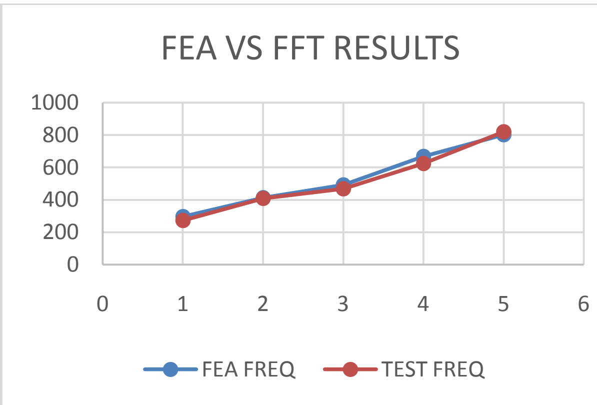
	Total deformation (mm)	Equivalent stress (MPa)
Steel Leaf Spring	4.070	430.66
Epoxy Leaf Spring	1.138	48.977



Graph 1

FEA and FFT Comparative Result

MODE NO	Natural frequency of Epoxy Leaf Spring (FEA)	Natural frequency of Epoxy Leaf Spring (Test)
1	296.22	273.43
2	412.72	410.15
3	492.39	468.75
4	668.74	625
5	802.6	820.31



Graph 2

CONCLUSION

1. Mono composite leaf spring is designed with the help of classical lamination theory. Reducing weight of the vehicle is main objective of this research work by considering constraints such as natural frequency.
2. The weight of composite leaf spring is 76.27% lower than conventional steel leaf spring with same stiffness.
3. With respect to deflection, natural frequency and weight comparative study has done among both the springs.
4. For both rough road condition and smooth condition composite leaf spring is used.
5. As deformation of composite leaf spring was lower than steel spring. It allows for greater stability and good control.

References:

- Design, Analysis, Manufacturing and Testing of Mono Composite Leaf Spring Using UD E-Glass Fiber/Epoxy BY Mr. Akshay Kumar, Mr. V. J. Shinde, Mr. S. S. Chavan
- Design, Simulation, and Prototyping of Single Composite Leaf Spring for Light Weight Vehicle By Shishay Amare Gebremeskel
- Weight Optimization of Mono Leaf Spring Used for Light Passenger Vehicle BY Atul J. Pawar Prof.S.N.Bansode
- Automobile Leaf Spring from Composite Materials BY Rajagopal D, Varun S, Manikanth M, Bysani Somasai Sriram Kumar
- Static analysis of mono leaf spring with different composite materials BY B. Raghu Kumar, R. Vijaya Prakash and N. Ramesh
- Modeling and Analysis of Carbon Fiber Epoxy Based Leaf Spring under the Static Load Condition by Using FEA BY Parkhe Ravindra, Mhaske Raman, Belkar Sanjay
- Design Optimization of Leaf Spring BY Malaga. Anil Kumar, T.N.Charyulu, Ch.Ramesh
- Modeling and Analysis of Laminated Composite Leaf Spring under the Static Load Condition by using FEA BY M. Raghavedra, Syed Altaf Hussain, V. Pandurangadu, K. PalaniKumar
- Static analysis of mono leaf spring with different composite materials BY B. Raghu Kumar, R. Vijaya Prakash and N. Ramesh
- DESIGN OF SINGLE COMPOSITE LEAF SPRING FOR LIGHT WEIGHT VEHICLE BY Achamyeleh a Kassie, R Reji Kumar and Amrut Rao