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Design of rear suspension system of car Master leaf spring by using the bump load

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Abstract: **Leaf springs are one of the oldest suspension components which are still frequently used, especially in automobile vehicles. These are used to absorb the fluctuating loads from the vehicle. Leaf spring is also known as laminated spring or carriage spring or flat spring. The main function of leaf spring is not only to support vertical load but also to isolate road induced vibrations. It is subjected to millions of load cycles leading to fatigue failure. In this connection an attempt is made to study the design and analysis of master leaf spring Suspension failure including bushes and U-bolts. Propose the improved design of leaf spring, bushes & its installation. This work is carried out on a master leaf spring used by a commercial vehicle. The finite element modelling and analysis of a master leaf spring has been carried out. The material of the leaf spring is SUP9.The FE model of the leaf spring has been generated in CATIA or Pro-E and imported in ANSYS- for finite element analysis, which are most popular CAE tools. The FE analysis of the leaf spring has been performed by discretization of the model in infinite nodes and elements and refining them under defined boundary condition. Bending stress and deflection are the target results. A comparison of both i.e. experimental and FEA results have been done to conclude.**

Keywords: **Leaf springs, suspension, automobile vehicles, vibrations, cycles leading, U-bolts.**

I. INTRODUCTION

Leaf springs are special kind of springs used in automobile suspension systems. 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 main function of leaf spring is not only to support vertical load but also to isolate road induced vibrations. It is subjected to millions of load cycles leading to fatigue failure. Static analysis determines the safe stress and corresponding pay load of the leaf spring and also to study the behaviour of structures under practical conditions.

A spring is defined as an elastic body, whose function is to distort when loaded and to recover its original shape when the load is removed. Leaf springs absorb the vehicle vibrations, shocks and bump loads (induced due to road irregularities) by means of spring deflections, so that the potential energy is stored in the leaf spring and then relieved slowly. Ability to store and absorb more amount of strain energy ensures the comfortable suspension system. Semi-elliptic leaf springs are almost universally used for suspension in light and heavy commercial vehicles. For cars also, these are widely used in rear suspension. The spring consists of a number of leaves called blades. The blades are varying in length. The blades are us usually given an initial curvature or cambered so that they will tend to straighten under the load. The leaf spring is based upon the theory of a beam of uniform strength. The lengthiest blade has eyes on its ends. This blade is called main or master leaf, the remaining blades are called graduated leaves. All the blades are bound together by means of steel straps.

The spring is mounted on the axle of the vehicle. The entire vehicle load rests on the leaf spring. The front end of the spring is connected to the frame with a simple pin joint, while the rear end of the spring is connected with a shackle. Shackle is the flexible link which connects between leaf spring rear eye and frame. When the vehicle comes across a projection on the road surface, the wheel moves up, leading to deflection of the spring. This changes the length between the spring eyes. If both the ends are fixed, the spring will not be able to accommodate this change of length. So, to accommodate this change in length shackle is provided at one end, which gives a flexible connection. The front eye of the leaf spring is constrained in all the directions, whereas rear eye is not constrained in X-direction. This rare eye is connected to the shackle. During loading the spring deflects and moves in the direction perpendicular to the load applied.

When the leaf spring deflects, the upper side of each leaf tips slides or rubs against the lower side of the leaf above it. This produces some damping which reduces spring vibrations, but since this available damping may change with time, it is preferred not to avail of the same. Moreover, it produces squeaking sound. Further if moisture is also present, such inter-leaf friction will cause fretting corrosion which decreases the fatigue.

Problem Definition:

- Today leaf spring suspension mostly used in light commercial and passenger vehicles. They failures in warranty period like spring failures/bushes failure, bolts failures. Analysis these failures and give the appropriate design suggestions to overcome these failures. The purpose of study is to design and analysis of leaf spring Suspension failure including bushes and U-bolts. Propose the improved design of leaf spring, bushes & its installation. The major objective of modal vibration analysis to find out natural frequency of leaf spring.

Finite Element Modeling:

Meshing involves division of the entire of model into small pieces called elements. This is done by meshing. It is convenient to select the free mesh because the leaf spring has sharp curves, so that shape of the object will not alter.

To mesh the leaf spring the element type must be decided first. Here, the element type is C3D8. The element edge length is taken as 2.5.Fig 1 shows the meshed model of the leaf spring.

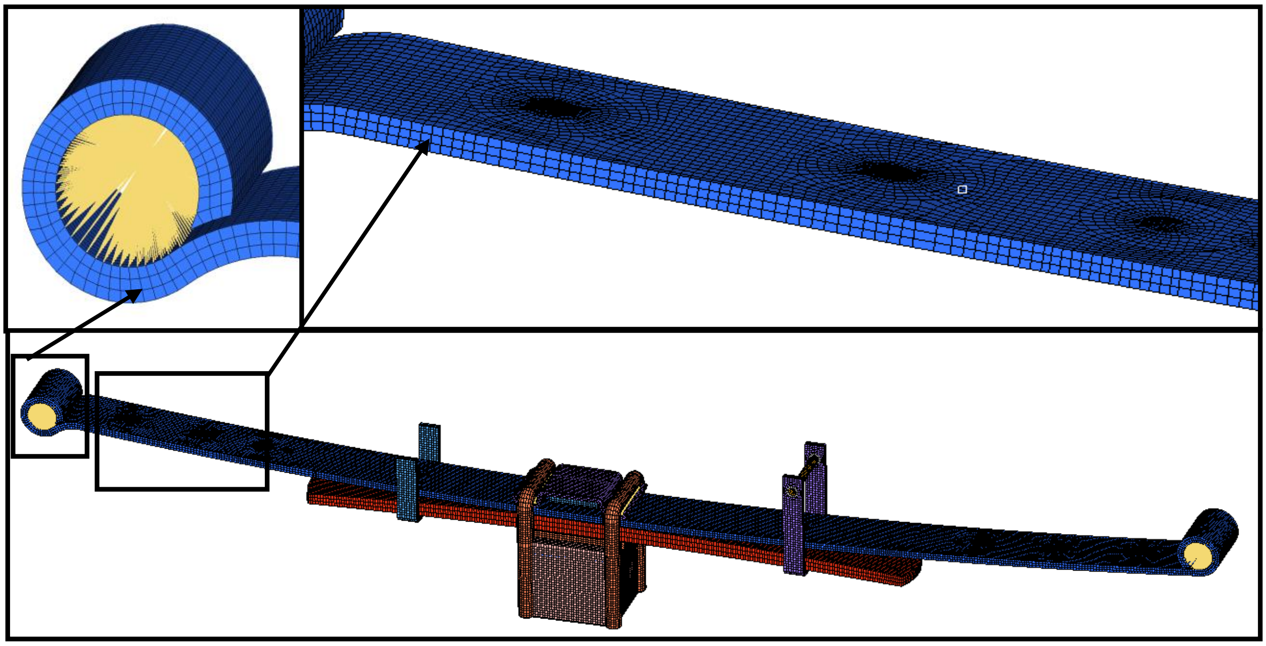

Figure 1

At Connection points the rigid elements are used for connections. As shown in the figure 0.

Total Element Count is as follows:

Type of Element	Count
Hexa (C3D8)	129478
Penta (C3D6)	2056
RBE2 (Kincoup)	9
Total	131543

Material Properties:

The following are the material properties of the given leaf spring:

Material = Manganese Silicon Steel,

Young's Modulus E = 2.1E5 N/mm2,

Density ρ = 7.86E-6 kg/mm3,

Poisson's ratio = 0.3 and

Yield stress = 1680 N/mm2.

Boundary Conditions:

The leaf spring is mounted on the axle of the automobile; the frame of the vehicle is connected to the ends of the leaf spring. The ends of the leaf spring are formed in the shape of an eye. The front eye of the leaf spring is coupled directly with a pin to the frame so that the eye can rotate freely about the pin but no translation is occurred. The rear eye of the spring is connected to the shackle which is a flexible link; the other end of the shackle is connected to the frame of the vehicle. The rear eyes of the leaf spring have the flexibility to slide along the X-direction when load applied on the spring and also it can rotate about the pin. The link oscillates during load applied and removed. Therefore the nodes of rear eye of the leaf spring are constrained in all translational degrees of freedom, and constrained the two rotational degrees of freedom. So the front eye is constrained as UX, UY, UZ, ROTX, ROTY and the nodes of the rear eye are constrained as UY, UZ, ROTX, ROTY. Figure 4 shows the boundary conditions of the leaf spring.

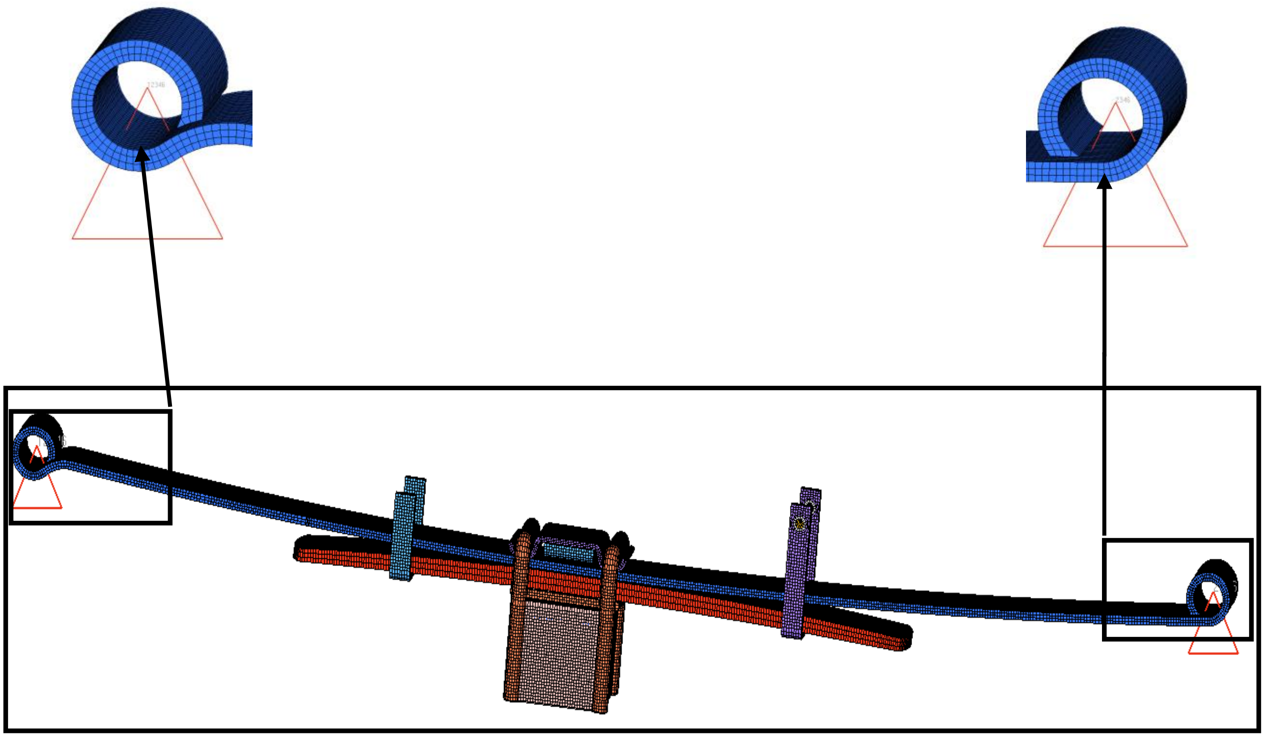

Figure 2

Loads Applied:

The load is distributed equally by all the nodes associated with the center bolt. The load is applied along Fy direction as shown in Figure 4. To apply load, it is necessary to select the circumference of the bolt hole and consequently the nodes associated with it. It is necessary to observe the number of nodes associated with the circumference of the bolt hole, because the applied load need to divide with the number of nodes associated with the circumference of the center bolt.

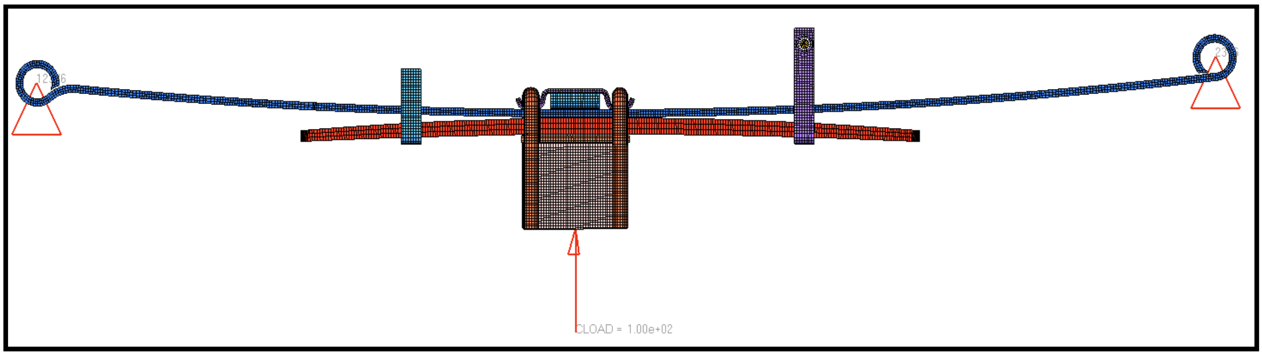

Figure 3

II. RESULTS AND DISCUSSIONS

A) Static Analysis:

The deformed and undeformed shape of the leaf spring is shown in Figure 4and 5 and the Figure 6 gives the Von-Mises stress at applied Load.

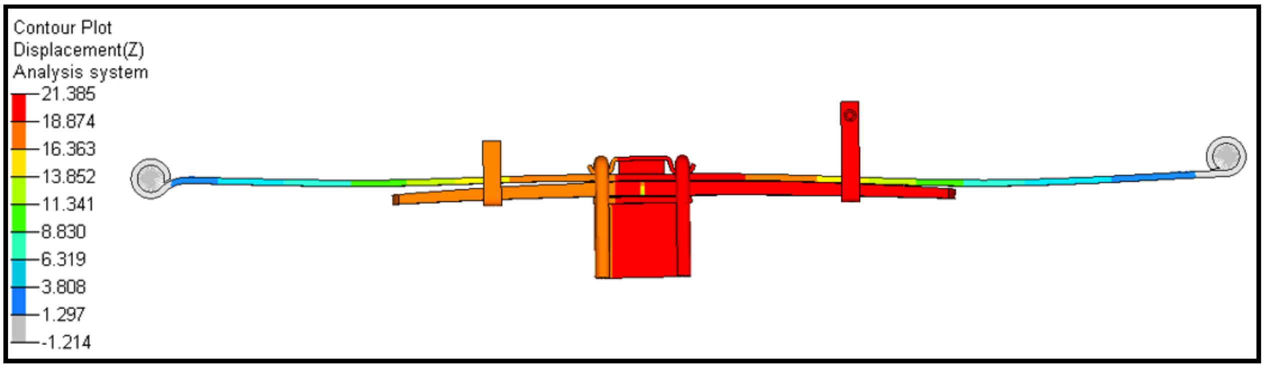

Figure 4

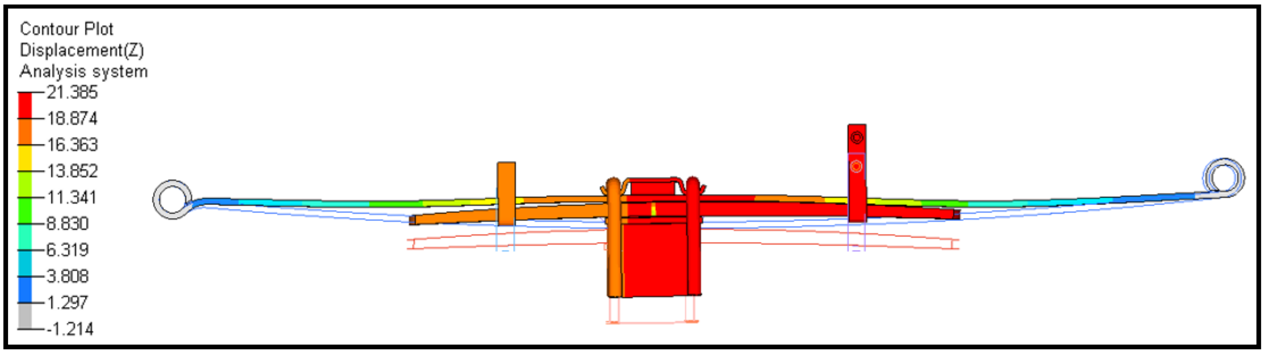

Figure 5

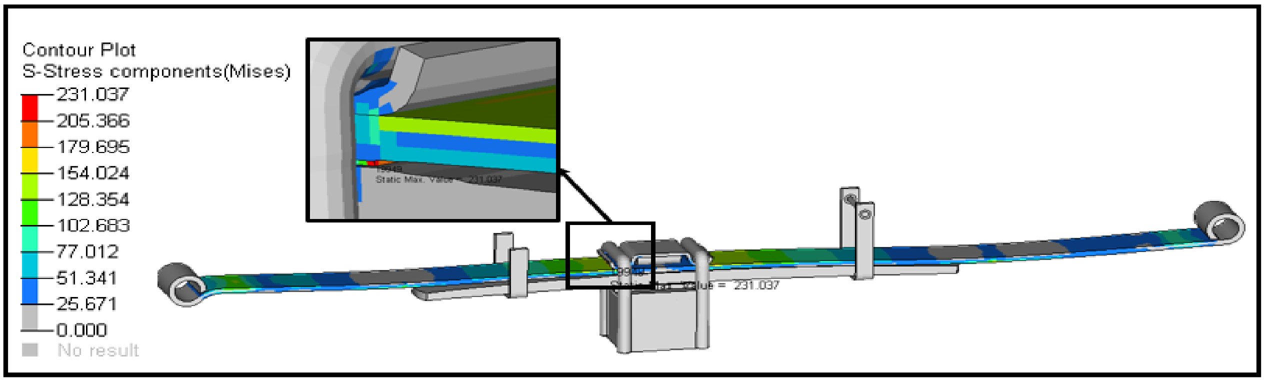

Figure 6

Results Table (Static Analysis):

Load = 100 N	Theoretical	FE Analysis	Yield Stress
Displacement (mm)	20.31	21.38	1680 Mpa
Von-misses Stress (Mpa)	244.89	231.03	--

It has been observed that from the above results that the stress and displacements are within the elastic limit.

B) Modal Analysis:

Modal analysis has been perform on the leaf spring assembly for checking the primary modes of the leaf spring assembly:

Following figures are showing the mode shapes for first 6 modes of the leaf spring assembly.

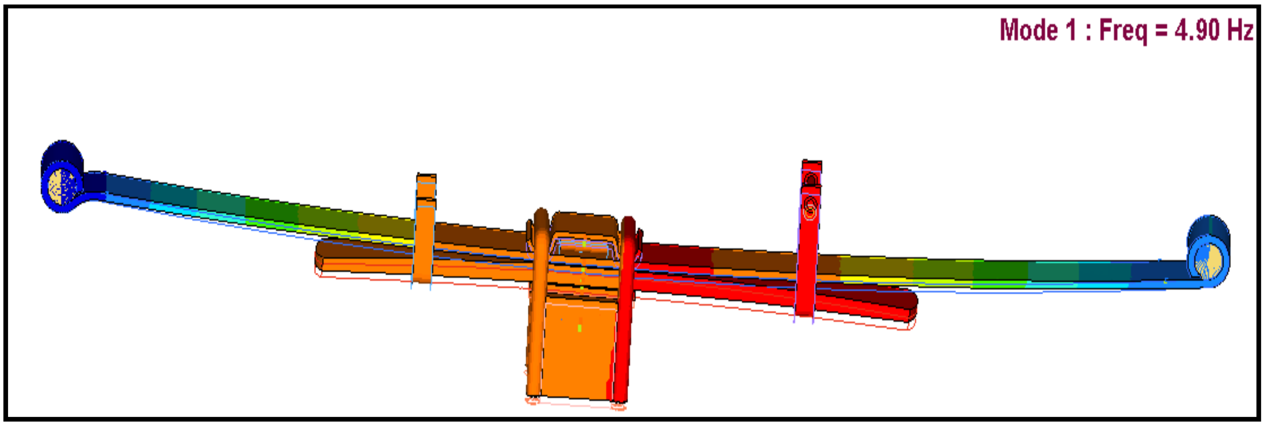

Figure 7

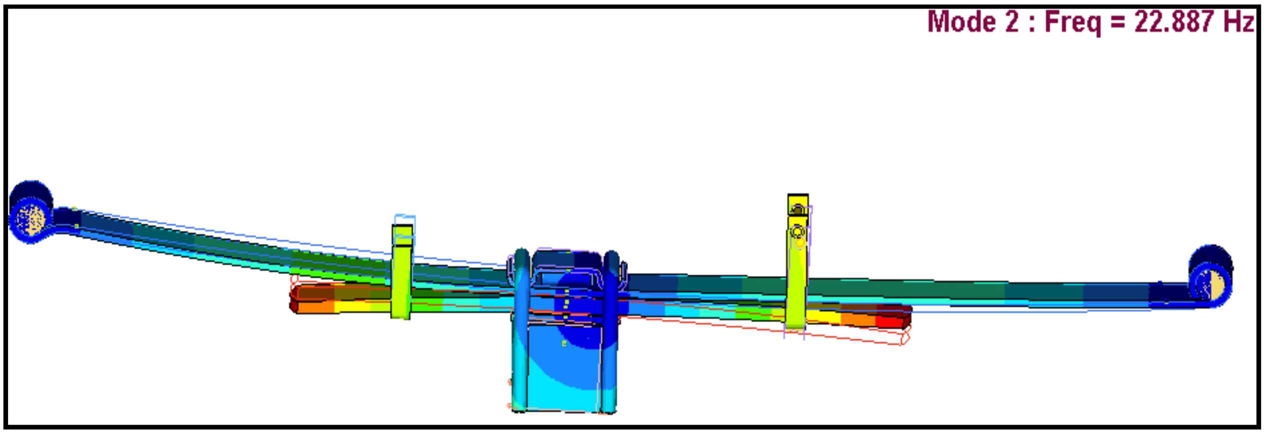

Figure 8

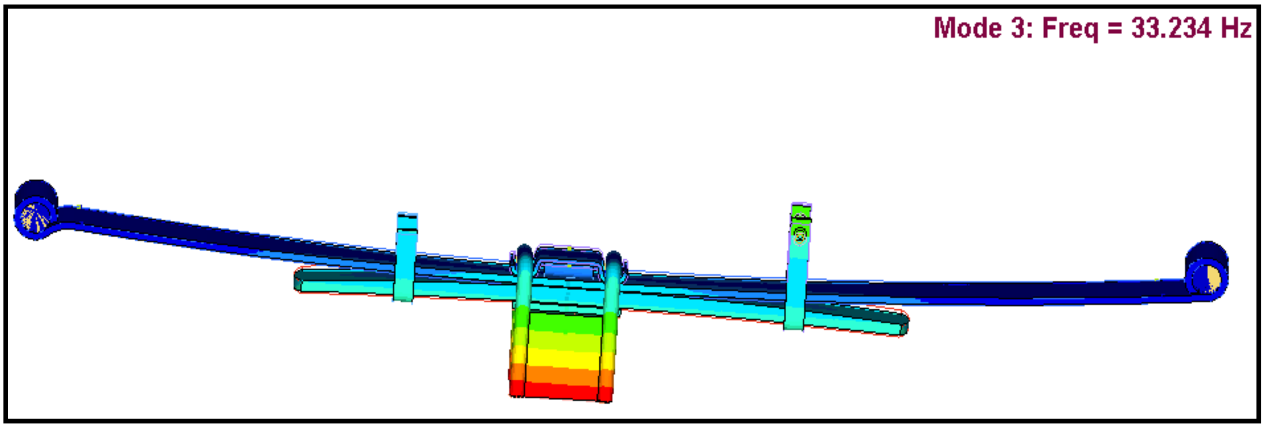

Figure 9

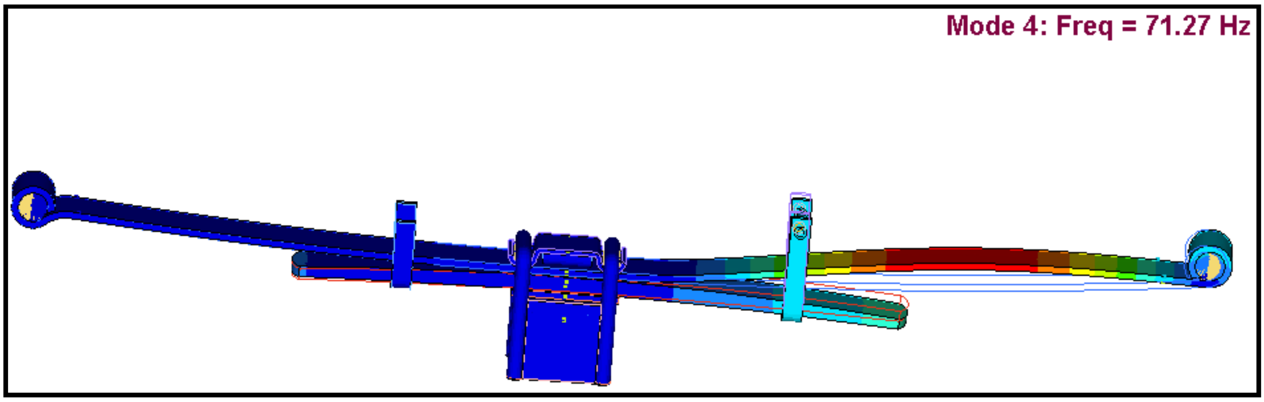

Figure 10

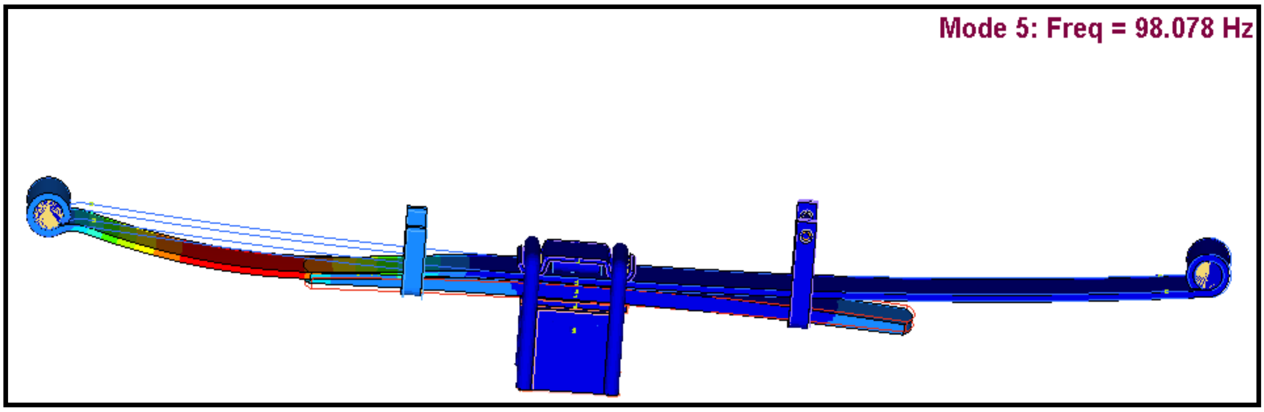

Figure 11

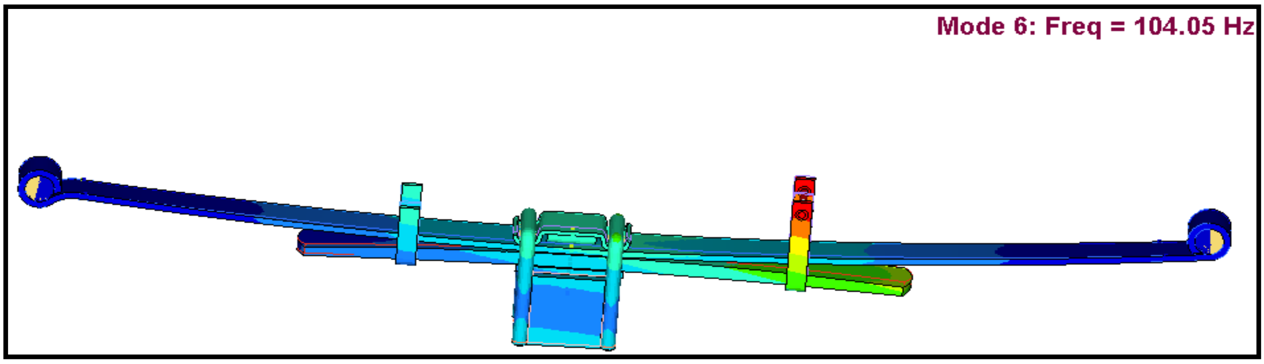

Figure 12

Results Table (Static Analysis):

Load = 100 N	Theoretical	FE Analysis	Yield Stress
Displacement (mm)	20.31	21.38	1680 Mpa
Von-misses Stress (Mpa)	244.89	231.03	--

Results Table (Modal Analysis):

Frequency Table

Mode	Frequency (Hz)
1	4.9
2	22.887
3	33.234
4	71.27
5	98.08
6	104.05

III. CONCLUSIONS

The automobile chassis is mounted on the axles, not direct but with some form of springs. This is done to isolate the vehicle body from the road shocks which may be in the form of bounce, pitch, roll or sway. These tendencies give rise to an uncomfortable ride and also cause additional stress in the automobile frame and body. All the part which performs the function of isolating the automobile from the road shocks are collectively called a suspension system. Leaf spring is a device which is used in suspension system to safeguard the vehicle and the occupants. For safe and comfortable riding i.e, to prevent the road shocks from being transmitted to the vehicle components and to safeguard the occupants from road shocks it is necessary to determine the maximum safe load of a leaf spring. Therefore in the present work, leaf spring is modeled and static and Modal analysis is carried out by using ABAQUS software and it is concluded that for the given specifications of the leaf spring, it is safe for ride as the bending mode frequency is within the limit as it is less than 6 Hz. This is represented in the first mode. It is observed that the maximum stress is developed at the inner plate between master and lower leaf of the assembly, so care must be taken in design and fabrication and material selection. The selected material must have good ductility, resilience and toughness to avoid sudden fracture for providing safety and comfort to the occupants.

REFERENCES

[1] Dakshraj Kothari, Rajendra Prasad Sahu and Rajesh Satankar, “Comparison of Performance of Two Leaf Spring Steels Used For Light Passenger Vehicle” VSRD-MAP, Vol. 2 (1), 2012, 9-16.

[2] Edward Nikhil Karlus, Rakesh L. Himte, Ram Krishna Rathore, “OPTIMIZATION OF MONO PARABOLIC LEAF SPRING”, International Journal of Advances in Engineering & Technology, Mar. 2014, ISSN: 22311963, Vol. 7, Issue 1, pp. 283-291

[3] B.Vijaya Lakshmi, Satyanarayana, “STATIC AND DYNAMIC ANALYSIS ON COMPOSITE LEAF SPRING IN HEAVY VEHICLE”, International Journal of Advanced Engineering Research and Studies E -ISSN2249–8974, IJAERS/Vol. II/ Issue I/Oct.-Dec.,2012/80-84

[4] Malaga. Anil Kumar, T.N.Charyulu, Ch.Ramesh, “Design Optimization Of Leaf Spring”, International Journal of Engineering, Research and Applications (IJERA) ISSN: 2248-9622, Vol. 2, Issue 6, November- December 2012, pp.759-765.

[5] ANU RADHA , C.SAILAJA , S.PRASAD KUMAR , U.CHANDRA SHEKAR REDDY & A.SIVA KUMAR, “STRESS ANALYSIS AND MATERIAL OPTIMIZATION OF MASTER LEAF SPRINGN”. International Journal of Application or Innovation in Engineering & Management, Volume 2, Issue 10, October 2013 ISSN 2319 – 4847, Volume 2, Issue 10, October 2013, PP 324-329.

[6] G HARINATH GOWD, E VENUGOPAL GOUD, “STATIC ANALYSIS OF LEAF SPRING”, INTERNATIONAL Journal of engineering science and Technology, ISSN: 0975-5462, pp 3794-3803.

[7] V.R.Baviskar, P.L.Sarode, I.N. Wankhede, N.P.Salunke, “STATIC ANALYSIS OF MASTER LEAF SPRING”, International Journal of Research in Engineering and Technology , eISSN: 2319-1163 | pISSN: 2321-7308, Volume: 03 Special Issue: 08, NCAME-2014, June-2014, pp 9-12.

[8] SubhashChandrabose, C. Thamotharan, P. Naveenchandran and R. Anbazhagan, “Design Optimization and Analysis of a Parabolic Leaf Spring”, Middle-East Journal of Scientific Research 20 (11): 1590-1596, 2014,pp 1590-1596.