iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** III **Month of publication:** March 2023

DOI: https://doi.org/10.22214/ijraset.2023.49583

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue III Mar 2023- Available at www.ijraset.com

Design and Analysis of Leaf Spring Using Ansys

Snehal S. Besekar[1], Prof. Pranav R. Pimpalkar[2], Dr. Vinod S. Gorantiwar[3]
[1]*M. Tech. Student (CAD/CAM) at Shri Sai College of Engineering& Technology Bhadrawati, Chandrapur, Maharashtra, India*
[2]*Prof.at Shri Sai College of Engineering & Technology Bhadrawati, Chandrapur, Maharashtra, India*
[3]*Principalat Shri Sai College of Engineering& Technology Bhadrawati, Chandrapur, Maharashtra, India*

Abstract: The leaf springs are different spring styles used for automotive suspension systems. In addition to the use of energy absorption equipment, the ends of the spring can be pointed in a certain direction as it deflects as a structural function. Not primarily supporting vertical loads but isolating road-induced vibration is the principal feature of leaf spring. The present research aims at studying the safe load of the leaf spring, showing how easily an easy, safe driving speed is achieved. A standard TATA-407 light commercial vehicle leaf spring configuration is chosen. Finite element analysis for safe stresses and pay loads has been done. Conventional materials and alternative materials in spring construction used in the present work have been studied. Computer aided designing (CAD) is being widely used in different industries for product testing and manufacturing, this paper consist of design and analysis of leaf spring using ANSYS 19.2. Static structural tool has been used of ANSYS. Leaf springs are used in heavy load vehicle where load is much larger than in passenger vehicles, they are used in vehicles which are limited to varying cycles stress to millions thus eventually leads to failure of fatigue. High elastic material springs are used which possess maximum strength and fatigue effects. Weight reduction is one of the major concern while designing a vehicle as it helps in design optimization and fuel economy's three layer composite leaf spring with full length leave. E-glass/Epoxy composite material has been used and is compared with conventional steel leaf spring. After conducting various tests it is found that e-glass/epoxymaterial is better in strength and lighter in weight as contrast with conventional steel leaf spring.

I. INTRODUCTION

Increasing competition and innovation in automobile sector tends to modify the existing products or replace old products by new and advanced material products. A suspension system of vehicle is also an area where these innovations are carried out regularly. Suspension system consists of a spring and a damper. The energy of road shock causes the spring to oscillate. These oscillations are restricted to a reasonable level by the damper, which is more commonly called as shock absorber.

The primary objectives of the suspension system are:
1) To prevent the road shocks from being transmitted to the vehicles.
2) To safeguard the occupants from road shocks.
3) To preserve the stability of the vehicle in pitching or rolling, while in motion.

More efforts are taken in order to increase the comfort of user. Thus, it becomes necessary to use a good suspension springs which fulfills all the above objectives thoroughly. Further, the appropriate balance of comfort riding qualities and economy in manufacturing of spring is also becoming an obvious necessity.
The springs are placed between the road wheels and the body. When the wheel comes across a bump on the road, it rises and deflects the spring, thereby storing energy therein. On releasing, due to the elasticity of the spring material it rebounds thereby expanding the stored energy.
In this way the spring starts vibrating and with amplitude decreasing gradually on account of internal friction of the spring material and friction of the suspension joints, till vibrations die down.

A. Types Of Suspension Springs
1) Steel Springs
a) Leaf Spring
b) Tapered Leaf Spring
c) Coil Spring
d) Torsion Bar

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue III Mar 2023- Available at www.ijraset.com

2) Rubber Springs
e) o Compression Spring
f) o Compression – shear spring
g) o Steel – reinforced spring
h) o Progressive spring
i) o Face shear spring
j) o Torsional shear spring
3) Plastic Spring
4) Air Spring
5) Hydraulic spring.

B. *Description Of Steel Leaf Spring*

Here we are going to discuss only about Steel Leaf Springs as our study is based on it. Leaf springs are almost universally used for suspension in light and heavy commercial vehicles. An advantage of a leaf spring over a helical spring is that the end of the leaf spring may be guided along a definite path. Semi – Elliptic Spring 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 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. While the interleaf friction provides a damping action, it is not well controlled and results in stiction in the motion of the suspension. 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. Some springs terminated in a concave end, called a spoon end (seldom used now), to carry swiveling member. For heavy vehicles, they have the advantage of spreading the load more widely over the vehicle's chassis, whereas coil springs transfer it to a single point. Unlike coil springs, leaf springs also locate the rear axle, eliminating the need fortrailing arms and a Pan hard rod, thereby saving cost and weight in a simple live axle rear suspension.

Fig. 1.1: Image of a parabolic semi – elliptic leaf spring

A more modern implementation is the parabolic leaf spring. This design is characterized by fewer leaves whose thickness varies from centre to ends following a parabolic curve. In this design, inter-leaf friction is unwanted, and therefore there is only contact between the springs at the ends and at the center where the axle is connected. Spacers prevent contact at other points. Aside from a weight saving, the main advantage of parabolic springs is their greater flexibility, which translates into vehicle ride quality that approaches that of coil springs.

II. AIM AND OBJECTIVE OF RESEARCH

The multi-leaves spring was studied using finite element techniques, with seven leaves used for heavy industrial vehicles. Analysis is performed on the stress distribution and deflection characteristics in ANSYS 14.0 workbench. Each model is dynamically analyzed for four different materials with the same charge conditions. The purpose of this research is to improve the collection of leaf spring materials. In Ansys, a static analysis is conducted in selected dimensions for this spring simulation and ANSYS14.0 for selected architecture parameters. To reach the main study goal, the obtained findings are compared graphically.

III. REVIEW CRITERIA

This journal uses double-blind review process, which means that both the reviewer (s) and author (s) identities concealed from the reviewers, and vice versa, throughout the review process. All submitted manuscripts are reviewed bythree reviewer one from India and rest two from overseas. There should be proper comments of the reviewers for the purpose of acceptance/ rejection. There should be minimum 01 to 02 week time window for it.

IV. FINITE ELEMENT ANALYSIS

The experimental bridge structure Truss has been studied using ANSYS, a software product combined with commonly used engineering simulations, which provides a full group of products covering the entire spectrum of physics, allowing the use of almost many engineering replicas that are needed by the design process. The software package utilizes its tools position a virtual product by a stringent test process, for example by measuring a beam for a considerable object below completely different loading condition. In a fast, safe way and with a large number of different contact algorithms, the ANSYS can perform advanced engineering analyses, mainly on loading times and non-linear materials. In this research, she investigates under static loading conditions under distinct modeling of the Truss bridge structure.

V. METHODOLOGY OF RESEARCH

The methodology of solution is chosen once the mathematical models are ready. A qualitative or quantitative dimension maybe considered for the mathematical formulation of the problem. Mathematical formulations of the question are tested in qualitative analysis without clear resolution in qualitative analyses. Quantitative analytical methods, on the other hand, may be classified as theoretical, physical and computational methods. FEM research is usually performed in order to load the leaf spring statically.

VI. MATERIAL SELECTION FOR LEAF SPRING

Structural steel is the main material for the leaf spring. This article has contrasted the result of structural steel, nickel

Material Specifications

Leaf's Specifications

Sr. No.	Parameters	Values
1	No. of Master Leaves (nf)	2
2	No. of Graduated leaves (ng)	7
3	Breadth (b)	70 mm
4	Thickness (t)	13 mm
5	Span (2L)	860 mm
6	Diameter of Eye	O.D. = 55mm I.D. = 29 mm
7	Camber	150 mm
8	Diameter of Centre Bolt	10 mm
9	Length of Master Leaf	1100 mm
10	Length of Second Leaf	900 mm
11	Length of Third Leaf	700 mm
12	Length of Fourth Leaf	550 mm
13	Length of Fifth Leaf	400 mm
14	Length of Sixth, Seventh, Eighth & Ninth Leaf	254 mm
15	Radius of Curvature	620 mm

Sr. No.	Items	Values
1	Grade	SUP 9
2	Composition	% C = 0.52 - 0.6, % Si = 0.15 – 0.35, % Mn = 0.65 – 0.95, % S =0.035, % P=0.035.
3	Young's Modulus of Elasticity	210000 N/mm²
4	Poisson's Ratio	0.266
5	Material Behaviour	Isotropic
6	Density	0.00785 Kg/cm³

VII. RESULTS AND DISCUSSIONS

The study on the behavior of the leaf spring under static conditions has been completed with all the three approaches i.e. Analytical, Experimental and FEA (Ansys). The results from each section are taken for the comparison purpose.

Firstly, the Experimental results are tabulated in comparison with analytical results.

Comparison of results:- experimental and analytical approach

Sr. No.	Load (N)	Parameters	Analytical	Experimental	Variation
1	90556	Stress (N/mm²)	1097.185	1033.53	5.80 %
		Deflection (mm)	74.31	70	5.82 %
2	76400	Stress (N/mm²)	925.66	856.35	
		Deflection (mm)	62.695	58	

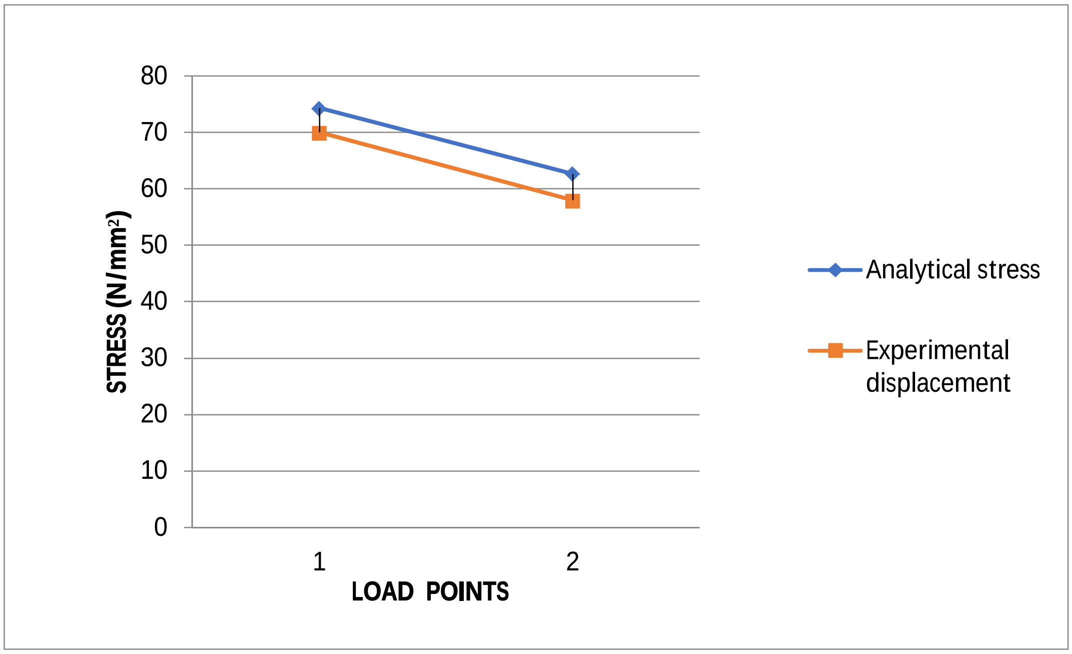

Fig. Load Vs Stress Graph for Analytical & Experimental Approach

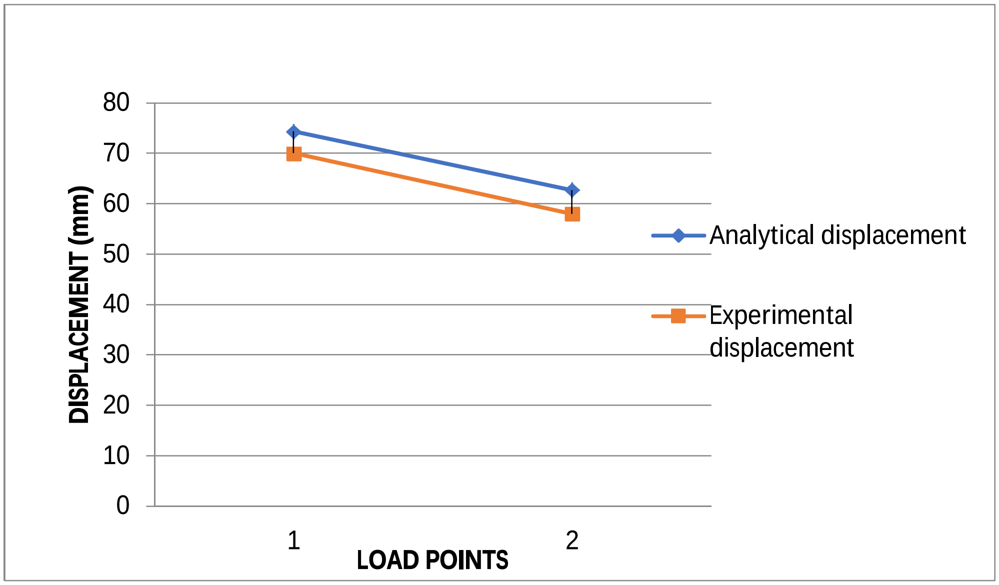

Fig.Load Vs. Displacement Graph for Analytical & Experimental Approach

Similarly, FEA analysis has been performed and the results are tabulated in comparison with analytical results.

Table : Comparison of results:- Analytical and FE approach (ANSYS)

Parameters	Analytical	ANSYS	Variation
Stress (N/mm^2)	1097.185	924.05	15.78 %
Deflection (mm)	74.31	69.4	6.64 %

Lastly, FEA results and Experimental Results are tabulated together and compared.

Table Comparison of results:- Experimental& FE approach (ANSYS)

Parameters	Experimental	ANSYS	Variation
Stress (N/mm^2)	1033.53	924.05	10.59 %
Deflection (mm)	70	69.4	0.86 %

VIII. CONCLUSION

This work involves design and analysis of a conventional leaf spring under static loading conditions. The 3D model is prepared in PRO-E and then FEA analysis is performed using ANSYS-11. From the results obtained from ANSYS, many discussions have been made and stated as follow:

1) When the leaf spring is loaded with 6.154 tonnes (90556 N) of load, a variation of 0.86% in deflection is observed among the
2) Experimental & FEA value, which proves the validation of our model and analysis.
3) At the same time bending stress for FEA solution, is decreased by 10.59 % in comparison with experimental result. This may be observed because
   - Improper Meshing of the model in Ansys
   - The node selected for the application of load would not be totally correct.
4) The Ansys analysis and the output image show that the spring is safe.
5) Also, at the time of experiment we found that the material will fall under plastic stage if it is loaded above 90556N.

Thus, it is concluded that when SOLID 45 mesh element is used for FEA analysis the results are closer to the Experimental results. Also, FEA tools provides a cost effective and less time consuming solution in comparison with the experimental testing but the results may vary in the specified range.

REFERENCES

Research Papers And Journals

[1] Vinkel Arora, Dr. M.L. Aggarwal, Dr. Gian Bhushan, "A Comparative Study of CAE and Experimental Results of Leaf Springs in Automotive Vehicles" - International Journal of Engineering Science and Technology (IJEST), ISSN: 0975-5462 Vol. 3 No. 9 September 2011, p.p. 6856 – 6866.

[2] J.J.Fuentes, H.J. Aguilar , J.A. Rodriguez , E.J. Herrera , "Premature fracture in automobile leaf springs Engineering Failure Analysis", P.P.648–655, 2009.

[3] G. Goudah, E. Mahdi, A.R. Abu Talib, A.S. Mokhtar and R. Yunus' "Automobile Compression Composite Elliptic Spring", International Journal of Engineering and Technology, Vol. 3, No.2, 2006, pp. 139-147.

[4] Prof. Al–Qureshi H.A "Automobile leaf springs from composite materials" Journal of Materials Processing Technology, 2001, Pages 58 – 6.

[5] Prof. N.P. Dhoshi, Prof .N.K.Ingole, Prof .U.D.GULHANE, "Analysis and Modification of Leaf Spring of Tractor Trailer Using Analytical and Finite Element Method" International Journal of Modern Engineering Research (IJMER) ISSN: 2249-6645 Vol.1, Issue.2, pp-719-722.

[6] Mahmood M Shokrieh, Davood Rezaei, "Analysis and optimization of a composite leaf spring" Journal of Composite structure 2003. Pages: 317-325.

[7] Mr. V. K. Aher, Mr. P. M. Sonawane, " Static And Fatigue Analysis Of Multi Leaf Spring Used In The Suspension System Of LCV" - International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 2, Issue 4, July-August 2012, pp.1786-179.

[8] M. Venkatesan, D. Helmen Devaraj, "Design and analysis of composite leaf spring in light vehicles" –International journal of modern engineering research, Vol. 2, Issue.1, Jan-Feb 2012, pp 213-218.

[9] C. K. Clarke, G.E. Borowski, "Evaluation of a Leaf Spring Failure"- ASM International journal, p.p. 54-63l, 2005.

[10] Peiyong Qin, Glenn Dental, and Mikhail Mesh, "Multi-Leaf Spring and Hotchkiss Suspension", ABAQUS Users' Conference, 2002.

[11] Kumar Krishan and Aggarwal M.L. , "A finite element approach for analysis of a multi leaf spring using CAE tools"- Research journal of recent sciences, vol.1(2), Feb.2012, pp92-96, ISSN 2277-2502

[12] Miravete.A, Castejon. L, Bielsa.J, Bernal.E - Analysis and Prediction of large composite Structures, 1990.

[13] M. Raghavedra, Syed Altaf Hussain, V. Pandurangadu, K. Palani Kumar, "Modeling and Analysis of Laminated Composite Leaf Spring under the Static Load Condition by using FEA", International Journal of Modern Engineering Research (IJMER), Vol.2, Issue.4, July-Aug. 2012, pp-1875-1879,ISSN: 2249-6645.

[14] Ballinger C.A. – Getting Composites into Construction, Reinforced Plastics, 1995

[15] Chowdhury, S.K., Islam, "Design and analysis of a composite mono leaf spring", Proceedings of the 5th International Conference on Engineering Research, Innovation and Education, ICERIE 2019, 25-27.

[16] Shishay Amare Gebremeskel. Design, simulations, and prototyping of single composite Leaf Spring for Light Weight Vehicles. Global Journal of Researches in Engineering Mechanical and Mechanics Engineering Volume 12, Issue 7, Version 1.0, Year 2012.

[17] Amol Bhanage and K. Padmanabhan. Design for fatigue and simulation of Glass fiber/epoxy composite automobile leaf spring. ARPN Journal of Engineering and Applied Sciences.VOL. 9, NO. 3 MARCH 2014.

[18] SORATHIYA MEHUL, DHAVAL B. SHAH, VIPUL BHOJAWALA. Analysis of composite leaf spring using FEA for light vehicle mini truck. Journal for information, knowledge and research in mechanical engineering. ISSN 0975 – 668X, NOV 12 TO OCT 13, VOLUME – 02, ISSUE – 02.

[19] D.N.Dubey, S.G.Mahakalkar. Stress Analysis of a Mono-parabolic Leaf Spring–A Review. IJMER, Vol.3, Issue.2, March-April. 2013 pp-769-772.

[20] Vinkel Arora, Dr. ML Aggarwal, Dr. Gyan Bhushan. A Comparative Study of CAE and Experimental Results of Leaf Springs in Automotive Vehicles. IJEST, Vol. 3 No. 9 September 2011.

[21] AnandKumar A. Satpute, Prof. S.S Chavan. Mono Composite Leaf Spring – Design and Testing. INDIAN JOURNAL OF APPLIED RESEARCH. Volume: 3 | Issue: 7 | July 2013.

[22] Malaga. Anil Kumar, T.N.Charyulu, Ch.Ramesh. Design Optimization of Leaf Spring. IJERA, Vol. 2, Issue 6, November- December 2012.

[23] Senthilkumar Mouleeswaran. Design, Manufacturing and Testing of Polymer Composite Multi-Leaf Spring for Light Passenger Automobiles - A Review. www.intechopen.com.

[24] M. M. Patunkar, D. R. Dolas. Modelling and Analysis of Composite Leaf Spring under the Static Load Condition by using FEA. International Journal of Mechanical & Industrial Engineering, Volume 1 Issue 1-2011

[25] R.B Charde, Dr.D.V. Bhope. Investigation of stresses in master leaf of leaf spring by FEM and its experimental verification. IJEST, Vol.4 No.02 February 2012.