Composite Material Reinforcement Leaf Spring of TATRA vehicle

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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 trailer's axle. There are monoleaf 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 multileaf 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 High Carbon steel. In this project we are going to design leaf spring for the materials Grey cast iron and composite material e-glass epoxy 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 S- glass epoxy. Modal Analysis is also done Pro/Engineer software is used for modeling and ANSYS is used for analysis.

1. Introduction
1.1 Suspension

Suspension is the term given to the system of springs, shock absorbers and linkages that connects a vehicle to its wheels. Suspension systems serve a dual purpose – contributing to the car's road holding/handling and braking for good active safety and driving pleasure, and keeping vehicle occupants comfortable and reasonably well isolated from road noise, bumps, and vibrations,etc. These goals are generally at odds, so the tuning of suspensions involves finding the right compromise. It is important for the suspension to keep the road wheel in contact with the road surface as much as possible, because all the forces acting on the vehicle do so through the contact patches of the tires. The suspension also protects the vehicle itself and any cargo or luggage from damage and wear. The design of front and rear suspension of a car may be different.

1.2 About leaf springs

Originally 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.

The advantages of leaf spring over helical spring are that the end of the springs may be guided along a definite path.

Sometimes referred to as a semi-elliptical spring or cart 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 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. For this reason manufacturers have experimented with mono-leaf springs.

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 a swiveling member.

There were a variety of leaf springs, usually employing the word "elliptical". "Elliptical" or "full elliptical" leaf springs referred to two circular arcs linked at their tips. This was joined to the frame at the top center of the upper arc; the bottom center was joined to the "live" suspension components, such as a solid front axle. Additional suspension components, such as trailing arms, would be needed for this design, but not for "semi-elliptical" leaf springs as used in the Hotchkiss drive. That employed the lower arc, hence its name. "Quarter-elliptic" springs often had the thickest part of the stack of leaves stuck into the rear end of the side pieces of a short ladder frame, with the free end attached to the differential, as in the Austin Seven of the 1920s. As an example of non-elliptic leaf springs, the Ford Model T had multiple leaf springs over their differentials that were curved in the shape of a yoke. As a substitute for dampers (shock absorbers), some manufacturers laid non-metallic sheets in between the metal leaves, such as wood.

3. Introduction to PRO/ENGINEER

Pro/ENGINEER Wildfire is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design while ensuring compliance with your industry and company standards. Integrated Pro/ENGINEER CAD/CAM/CAE solutions allow you to design faster than ever, while maximizing innovation and quality to ultimately create exceptional products.
Customer requirements may change and time pressures may continue to mount, but your product design needs remain the same - regardless of your project's scope, you need the powerful, easy-to-use, affordable solution that Pro/ENGINEER provides.

4. Model in PRO/ENGINEER

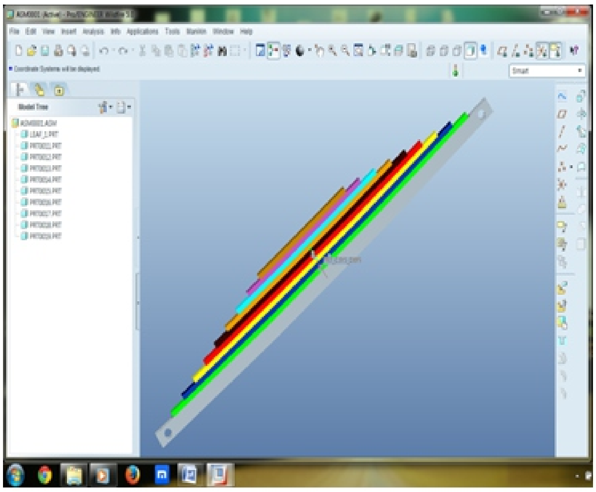

Figure-1 Leaf spring in PRO/E.

5.Introductin to ANSYS

Ansys is a general purpose finite element modeling package for numerically solving a wide variety of mechanical, electrical problems.

5.1 Types of ANSYS Process

1.Static/Dynamic structural analysis (both linear and non linear)
2.Fluid analysis
- Laminar flow
- Turbulent flow

3.Acoustic analysis
4.Electromagnetic analysis
5.Model analysis
6.Thermal analysis
- conduction
- convection
- radiation

7. Transient thermal analysis
8.Buckling analysis
9.Spectrum analysis
10.Harmonic analysis

6. Analysis in ANSYS

Pressure = 1.809 N/mm2
6.1 Structural Analysis E-Glass Epoxy

6. A. Imported model

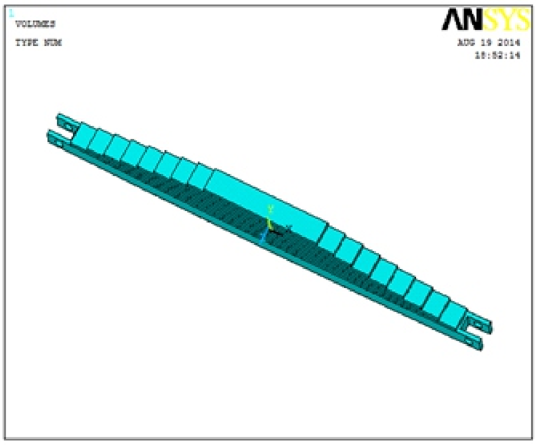

Figure. 2. Imported model from PRO/E.

6. B.Meshed model

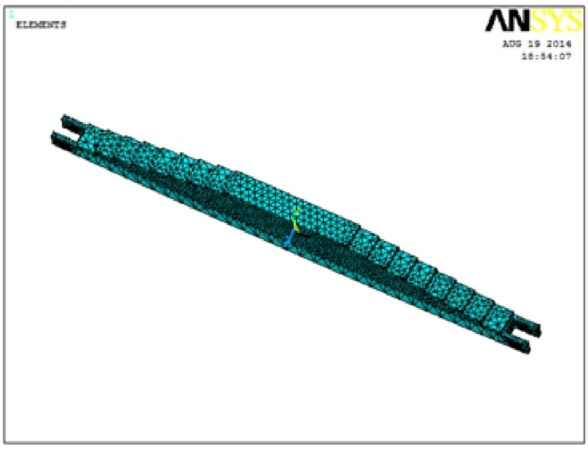

Figure. 3. Meshed model in ANSYS.

6. C.Stress = 269.403 N/mm2 (MPa)

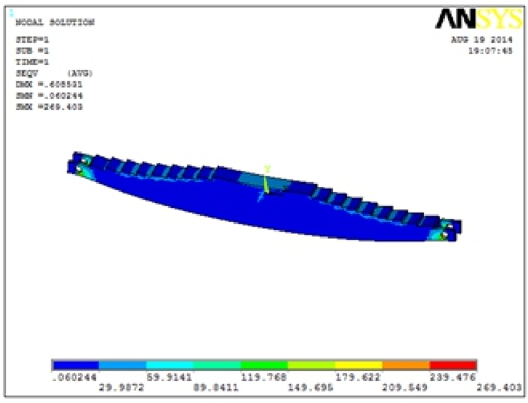

Figure. 4. Stress result in ANSYS.

6. D.Displacement = 0.608531mm

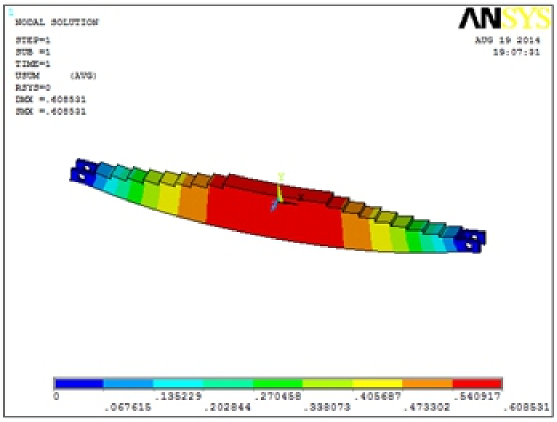

Figure. 5. Displacement result in ANSYS.

6. E. Strain = 0.001669

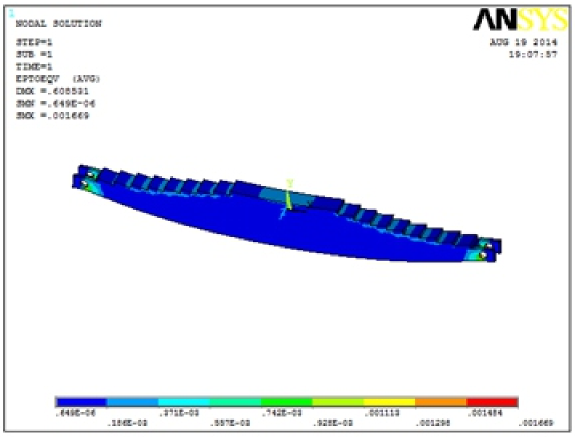

Figure. 6. Strain result in ANSYS.

7. Material Properties
7. A. High Carbon Steel

Young's Modulus(MPa)	235000
Poisson's ratio	0.313
Density (g/cc)	8.26

Table.1.Material properties of Steel.

7. B. Grey Cast Iron

Young's Modulus(MPa)	162000
Poisson's ratio	0.330
Density (g/cc)	7.34

Table.2.Material properties of Grey cast Iron.

7. C. E-Glass Epoxy

Young's Modulus(MPa)	85000
Poisson's ratio	0.21
Density (g/cc)	1.90

TableTable.3.Material properties of E-Glass Epoxy.

8.Model Analysis
8.1 A. Mode – 1 = 0.132726

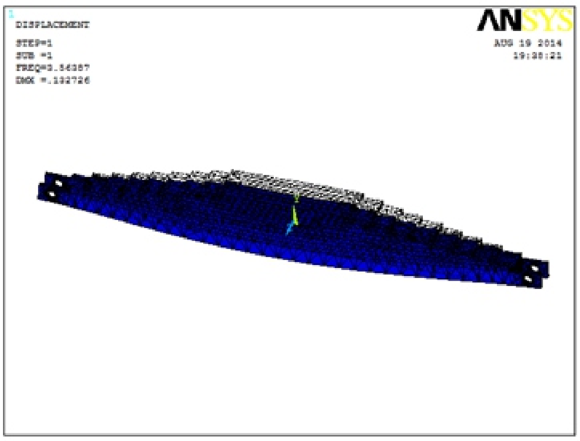

Figure. 7. Mode 1 Displacement Result.

8.2 B. Mode – 2 = 0.106651

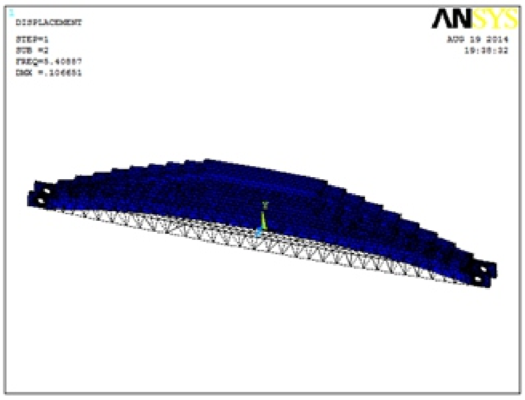

Figure. 8. Mode 2 Displacement Result.

8.3 C. Mode – 3 = 0.199286

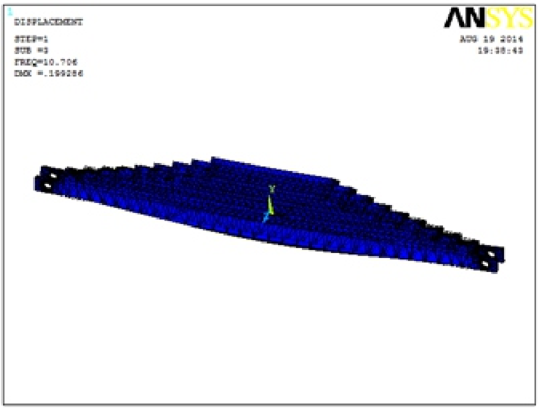

Figure. 9. Mode 3 Displacement Result.

8.4 D. Mode – 4 = 0.132157

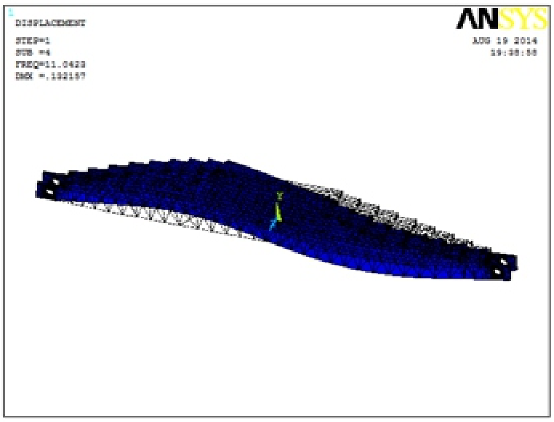

Figure. 10. Mode 4 Displacement Result.

8.5 E.Mode – 5 =0.128625

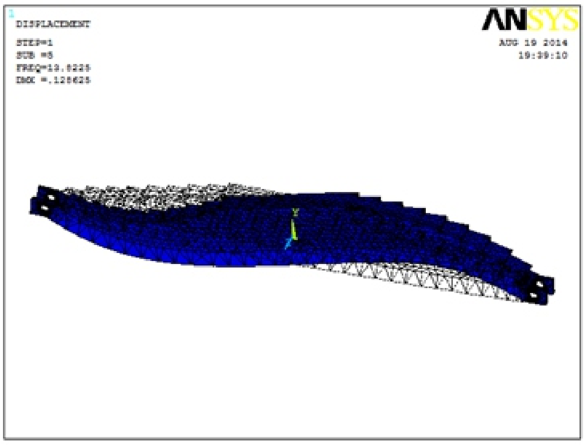

Figure. 11. Mode 5 Displacement Result.

9.Harmonic Analysis
E-Glass Epoxy
Frequency vs Displacement at Y

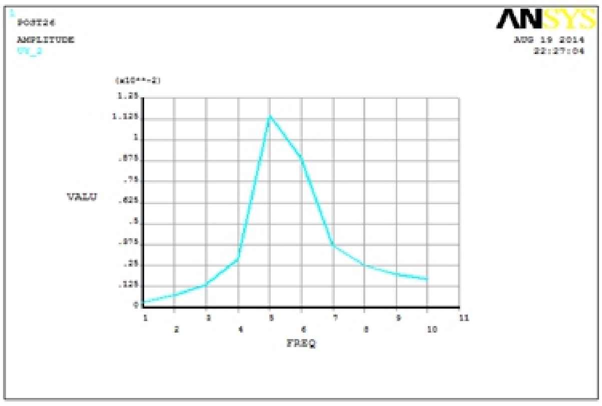

Figure. 12. Graph indicates Frequency vs Displacement at Y. Frequency vs Strain

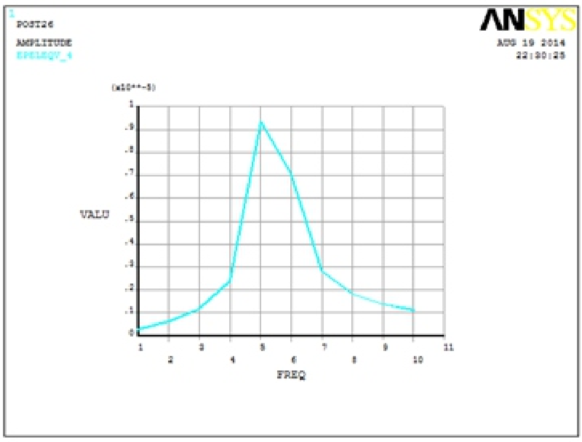

Figure. 13. Graph indicates Frequency vs Strain. Frequency vs. Stress

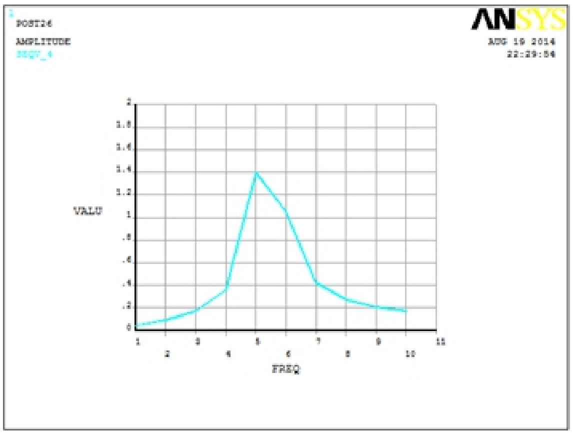

Figure. 14. Graph indicates Frequency vs. Stress.

10.Layer Static AnalysisE-Glass Epoxy

10.A. Displacement = 3604.22 mm

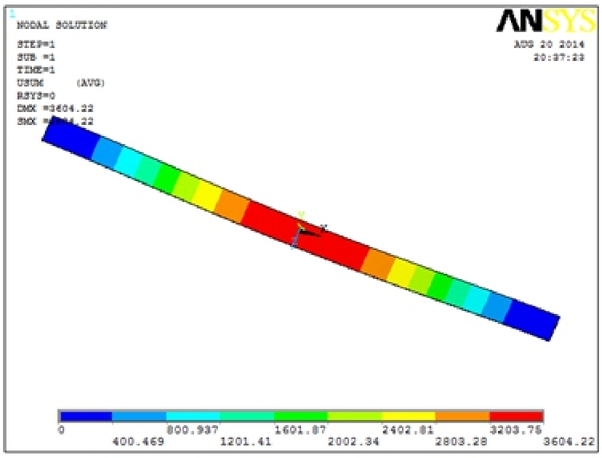

Figure. 15. Displacement result in ANSYS.

10.B. Stress = 27969.7

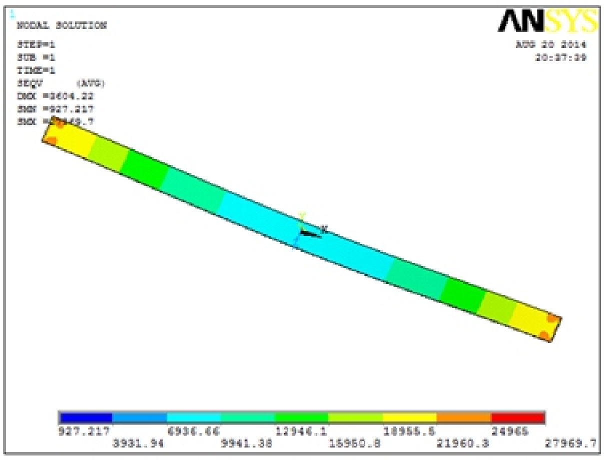

Figure. 16. Stress result in ANSYS.

10.C Strain = 0.176036

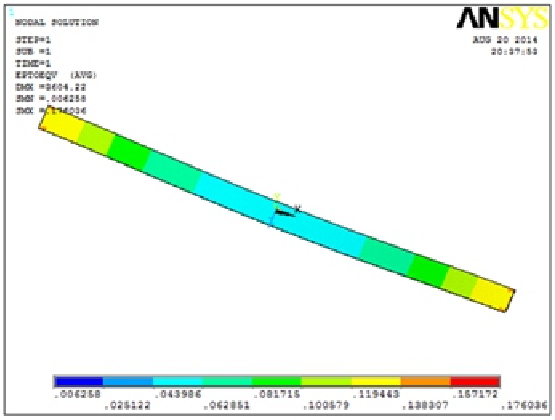

Figure. 17. Strain result in ANSYS.

11.Results

11.1. Structural Analysis

Materials	Displacement	Stress	Strain
E-Glass	0.608531	269.403	0.001669
H.C Steel	0.419292	269.905	0.001153
Grey Cast iron	1.15448	273.269	0.003222

Figure. 18. Structural Analysis Results.

11.2. Modal Analysis

Materials	Displacement 1	Displacement 2	Displacement 3	Displacement 4	Displacement 5
E-Glass	0.132726	0.106651	0.199286	0.132157	0.128625
H.C Steel	0.202982	0.163315	0.304931	0.202318	0.196914
Grey Cast iron	0.258439	0.209588	0.262638	0.389802	0.252288

Figure. 19. Modal Analysis Results.

11.3. Layer Static Analysis

Materials	Displacement	Stress	Strain
E-Glass	3604.22	27969.7	0.176036
H.C Steel	2484.15	28042.3	0.121414
Grey Cast iron	6861.62	27574.7	0.326954

Figure. 20. Layer Static Analysis Results.

12.Conclusion

In this thesis, a leaf spring is designed for TATRA 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, E glass Epoxy and Grey cast iron.

Structural and modal analysis are conducted on total assembly of leaf spring and for single leaf by using layer analysis, this analysis is done for only composites. The results show:

- The stresses in the composite leaf spring of design are much lower than that of the allowable stress.
- The strength to weight ratio is higher for composite leaf spring than conventional steel spring with similar design.
- Weight of the composite spring by using material E-Glass epoxy 5 times less than steel. For less weight of the spring mechanical efficiency will be increased.
- Harmonic Analysis Graphs also show the Frequencies of Stress, Displacement and Strain.

In this project it can be concluded that using composite S2 - Glass 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.

Future Scope: By this project result, in future we can use composite material by re pleasing steel material. But Experimental works have to done on this on this project like bending, torsion, hardness.

13. References

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