Vibration Analysis of Composite leaf Spring

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Abstract: **Finite element analysis with full load on 3-D model of composite multi leaf spring is done using ANSYS 10 and the analytical results are compared with experimental results. Compared to steel spring, the composite leaf spring is found to have 67.35% lesser stress, 64.95% higher stiffness and 126.98% higher natural frequency than that of existing steel leaf spring. A weight reduction of 76.4% is achieved by using optimized composite leaf spring.**
Keywards:Leaf Spring, Ansys, FEM etc.

I. INTRODUCTION

1.1 Leaf Spring:

Composite materials are ideal for structural application where high strength to weight and stiffness to weight ratio are required. Aircraft and spacecraft are typical weight sensitive structures in which composite materials are cost effective. Composite materials are basically hybrid materials formed of multiple materials in order to utilize their individual structural advantages in a single structural material. The composite material then has the properties of the two materials that have been combined.

The key is the macroscopic examination of a material wherein the components can be identified by the naked eye. The advantage of composite materials is that, if well designed, they usually exhibit the best qualities of their components or constituents and often some qualities that neither constituent possesses. Some of the properties that can be improved by forming a composite material are

The objective of this dissertation is to analyze experimentally and by finite element method the mechanical behavior of leaf spring made of ductile and composite material.

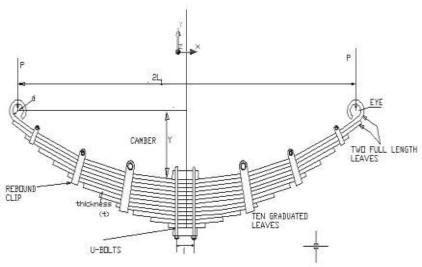


Fig. 1. Leaf spring.

Problem Definition and identification:

The present leaf spring is of Mild steel which on overloading shows bending problem. It is also found during its survey deformations induced in Mild steel springs are more. Vibrations produced by the same springs are also more which may result in failure of the spring. Also during the survey it is observed that weight of the current spring is high due to high density of mild steel which results in efficiency of vehicle.

Objectives of the work:

The suspension leaf spring is one of the potential items for weight reduction in automobiles. This project work focuses on using composite material for leaf spring of heavy vehicle for weight reduction without losing strength.

1. The objective of present dissertation is to carry out finite element analysis of composite leaf spring and experimental validation of it.
2. To study vibration characteristic of mono leaf spring.
3. To compare between steel & epoxy carbon leaf spring vibration characteristics experimentally and FEM.

Table . Stress and Deflection of existing leaf spring by Analytical Method

Sr. No.	Central load (2w) in N	Load(w) in N	Bending Stress at load w (N/mm^2)	Deflection at load w (mm)
1	1000	500	42.33	5.008
2	1500	750	63.2	7.51
3	2000	1000	84.66	10.01
4	2500	1250	105.33	12.52

II. FEM Analysis of leaf Spring

Structural Analysis of Steel Leaf Spring:

Case 1: 1000 N Loads

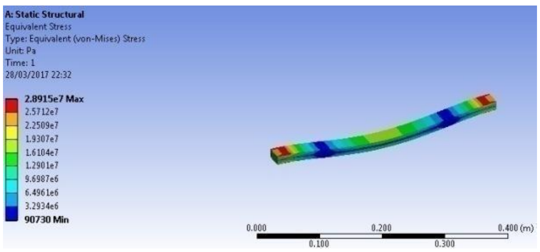


Fig. Von-Misses Stress at 1000 N

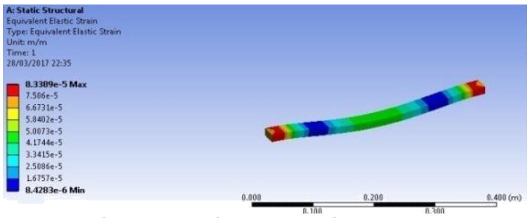


Fig. Von-Misses Strain at 1000 N

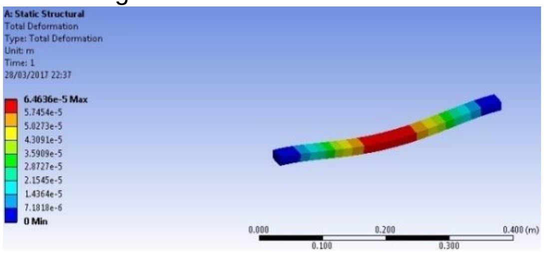


Fig.: Deformation at 1000 N

Structural Analysis of Steel Leaf Spring Table

Steel Spring	1000 N	1500N	2000N	2500N
Stress (MPa)	28.915	43.372	57.829	72.287
Strain	8.33E-5	1.25E-04	1.66E-04	1.88E-04
Deformation (mm)	6.46E-02	9.69E-02	1.29E-01	0.1616
Mass (Kg)	1.1628	1.1628	1.1628	1.1628

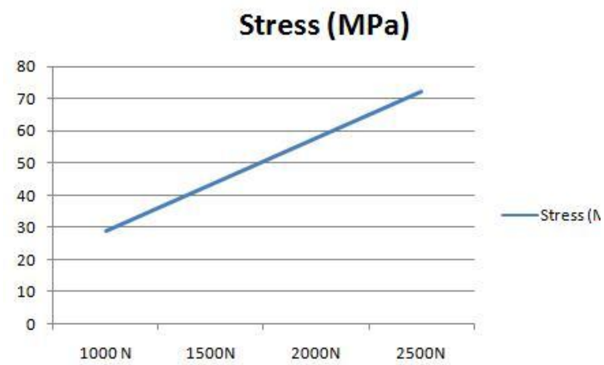


Fig.Variation of stress with load

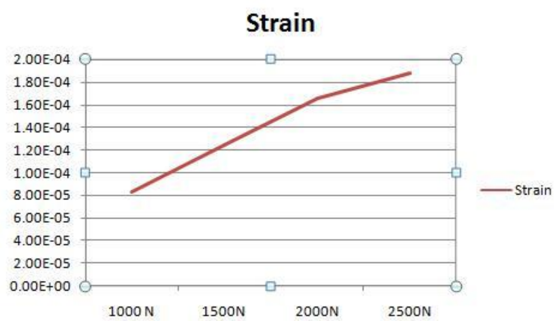


Fig.Variation of strain with load

Fig.Variation of deformation with load

Structural Analysis of Carbon Fiber Spring Composite Mono Leaf Spring:

Case 1: 1000 N Load

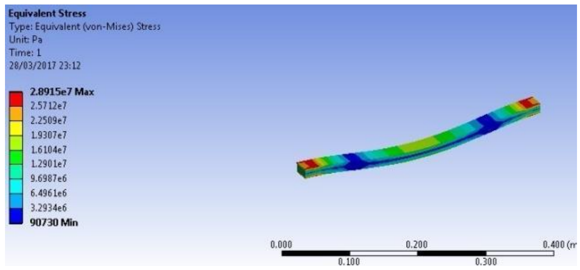


Fig. Von-Misses stress at 1000 N

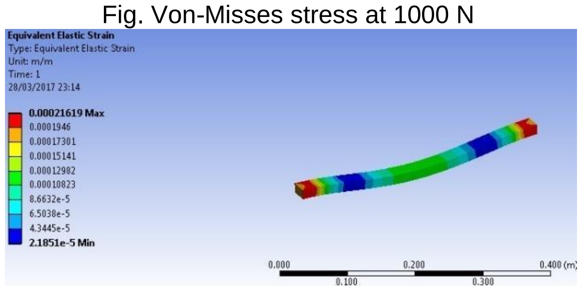


Fig .Von-Misses strain at 1000 N

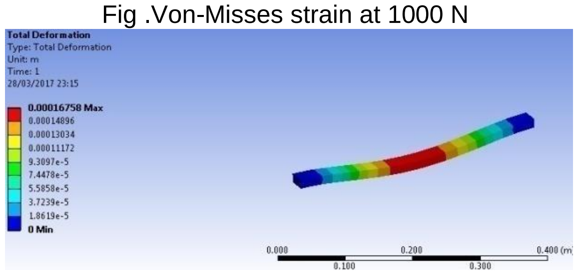


Fig .Deformation at 1000 N

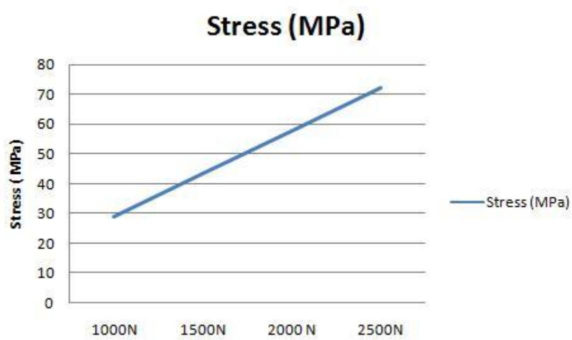


Fig.Variation of stress with load

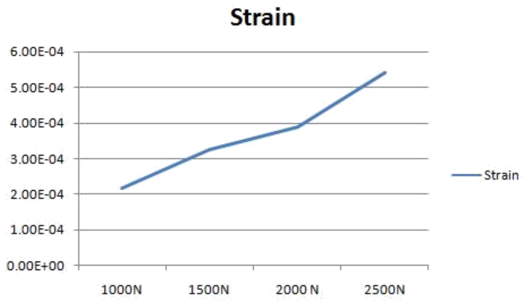


Fig.Variation of strain with load

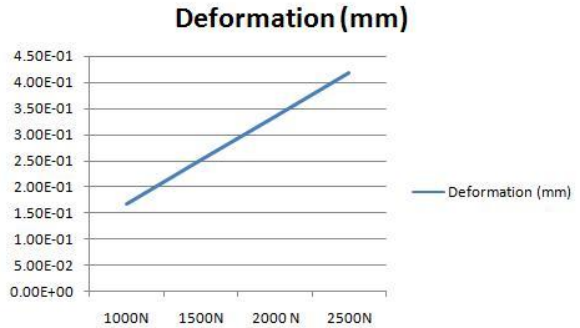


Fig.Variation of deformation with load

. Structural Analysis of E-Glass Fiber Spring Composite Mono Leaf Spring:

Case 1: 1000 N Load

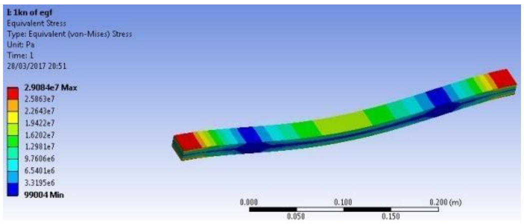


Fig.Von-Misses Stress at 1000 N

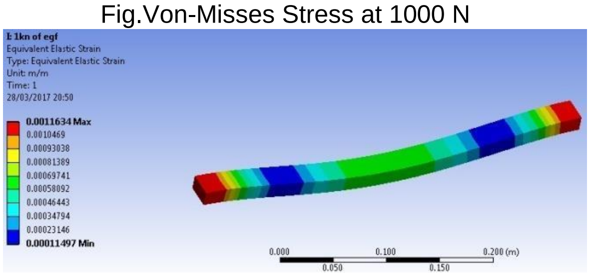


Fig. Von-Misses Strain at 1000N

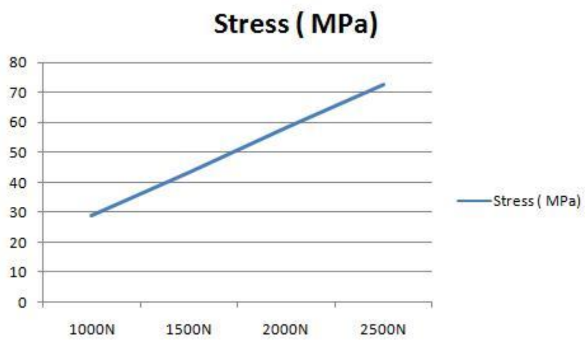


Fig. Variation of stress with load

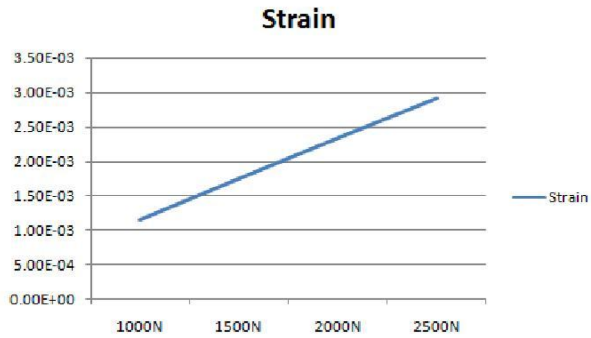


Fig.Variation of strain with load

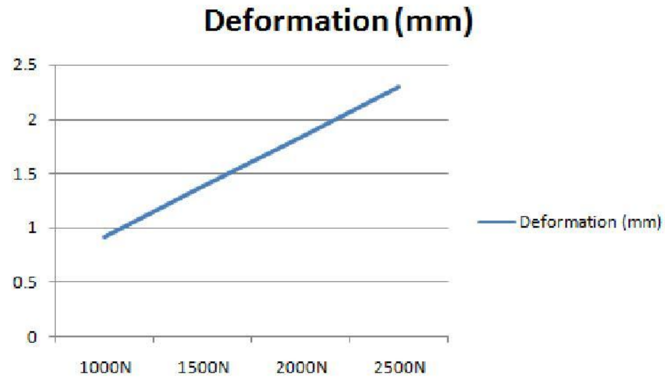


Fig.Variation of deformation with load

III.Modal Analysis

Mode shape frequency analysis of conventional leaf spring

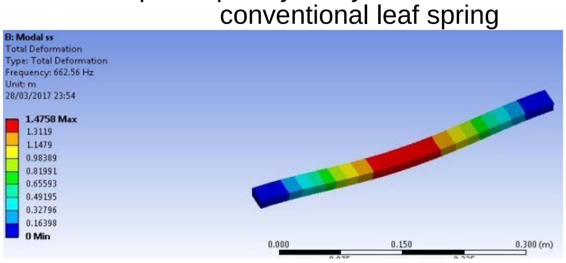


Fig . Mode 1

Mode shape frequency analysis of Carbon Fiber composite leaf spring

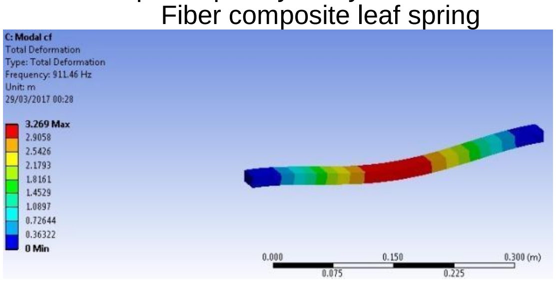


Fig.Mode 1 Mode shape frequency Analysis of E Glass fiber composite leaf spring

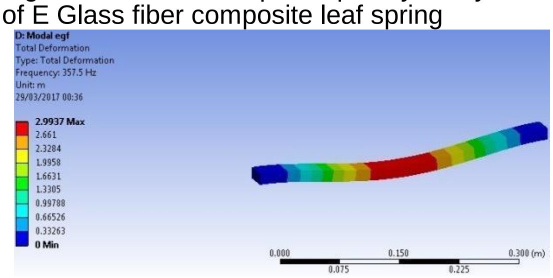
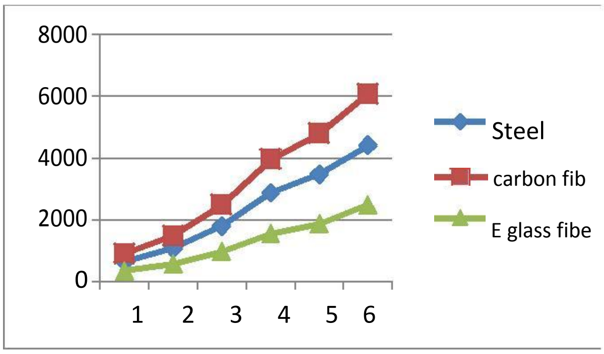


Table Modal Analysis Results Comparison

Frequency (Hz)			
Modes	Steel	carbon fiber	E glass fiber
1	662.56	911.46	357.5
2	1078.7	1483.9	584.72
3	1806.2	2484.7	975.32
4	2879.3	3960.9	1563.8
5	3490.1	4801.2	1886.3
6	4427	6090	2501



Graph Modal Analysis Results Comparison

IV. EXPERIMENTATION

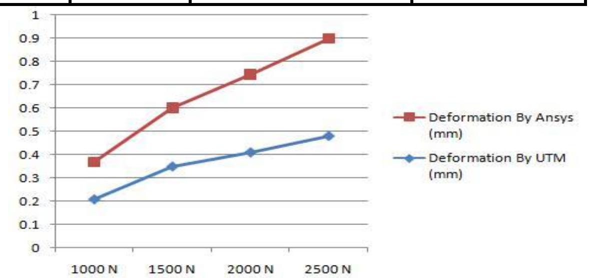
Fig Loading / deflection Experimentation of carbon fiber specimen sample rod at UTM.

Loading / Deflection Experimentation of carbon fiber specimen sample rod at UTM.

Sr.No	Load (Kg)	Deflection(mm)
1	100	0.21
2	150	0.35
3	200	0.41
4	250	0.48

Table Showing comparison of experimental & FEM results of loading & deflection of carbon fiber epoxy composite material specimen rod

Sr. No	Load (N)	Deformation in mm by UTM	Deformation in mm by ANSYS
1	1000	0.21	0.16
2	1500	0.35	0.251
3	2000	0.41	0.335
4	2500	0.48	0.4184



Concluding remark:

Through comparison of experimental & FEM results of loading & deflection of carbon fiber epoxy composite material specimen rod.(sample size =15 x 25 x 395 mm).Which is simply supported at both ends 50 mm away from each end. It is investigated that results are matching

with 9% error may be due to improper inputs provide to ANSYS. But still in acceptance range.

Table Showing comparison of Experimental & FEM results of natural frequency of carbon fiber epoxy composite material specimen rod

SN	Natural Frequency by FFT analyzer in HZ	Natural Frequency by ANSYS in HZ	% difference
1	927.6	911.46	5
2	1512.3	1483.9	4.5
3	2498	2484.7	5
4	3887.2	3960.9	4
5	4869.2	4801.2	3
6	6087.4	6090	1

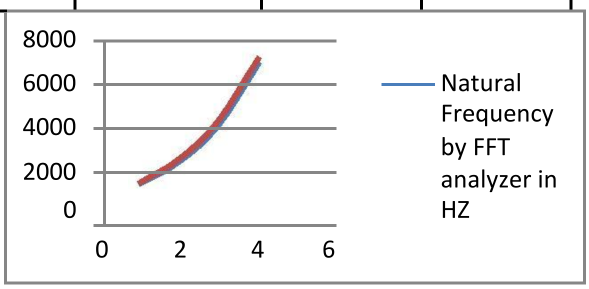


Fig.Comparative natural frequency

Concluding remark:

Through comparison of experimental & FEM results of natural frequency of carbon fiber epoxy composite material specimen rod.(sample size =15 x 25 x 395 mm). which is simply supported at both ends 50 mm away from each end. It is investigated that results are matching with 4.5% error may be due to improper inputs provided to ANSYS But still in acceptance range.

V.RESULTS AND DISCUSSION

Table Results And Discussion

Load ⟹	1000 N			1500 N		
Material ⟹	Steel Spring	Carbon Fiber	E-Glass Carbon Fiber	Steel Spring	Carbon Fiber	E-Glass Carbon Fiber
Stress (MPa)	28.915	28.915	29.084	43.372	43.372	43.626
Strain	5.83E-05	2.16E-04	1.16E-03	1.25E-04	3.24E-04	1.75E-03
Deformation (mm)	6.46E-02	1.68E-01	0.9124	9.69E-02	0.25136	1.3754
Mass (Kg)	1.1628	0.237	0.28144	1.1628	0.237	0.28144
Load ⟹	2000 N			2500 N		
Material ⟹	Steel Spring	Carbon Fiber	E-Glass Carbon Fiber	Steel Spring	Carbon Fiber	E-Glass Carbon Fiber
Stress (MPa)	57.829	57.829	58.168	72.287	72.287	72.71
Strain	1.66E-04	3.89E-04	2.33E-03	1.88E-04	5.40E-04	2.91E-03
Deformation (mm)	1.29E-01	3.35E-01	1.8339	0.1616	0.4189	2.2924
Mass (Kg)	1.1628	0.237	0.28144	1.1628	0.237	0.28144

The maximum deformations induced in Steel mono leaf spring are 6.4E-02mm, 9.69E-02, 1.29E-01, 0.1616 which is not in safe limits (1% of total span). Hence based on rigidity the design is unsafe, but if we compare deformations induced in carbon fiber for different cases it gives Minimum deformations. If we compare corresponding deformations with E-glass fiber which has more deformation. Therefore carbon fiber has good strength. The equivalent stress induced for three materials is almost same i.e.28.924 Mpa, 29.003 Mpa, 28.924 Mpa which is less than the allowable stress (380Mpa).Hence the design is safe based on strength. Corresponding weight of each lift are shown in above table. From the above table it is clear that carbon fiber has less weight as compare to other material hence weight of leaf spring optimized along with strength

VI.CONCLUSION

1.Experimental results of loading & deflection are matching with the FEM results hence we can replace carbon fiber leaf at steel leaf spring due to advantage of reduction of weight by 76.4 %.

2 .Experimental natural frequency of carbon fiber specimen rod matches with the ANSYS results with 4.5% difference which is inacceptable range.

3. Stress level is same in both the springs of steel & carbon leaf as cross section area is same.

4. Due to reduction in mass of carbon fiber leaf, suspension performance will be greater than leaf spring.

5. This carbon leaf spring will be corrosion free hence friction noise problem will be no more and no need of greasing the leaf springs as in steel leaf case.

6. Loading deflection - ANSYS results of steel leaf & carbon fiber leaf are compared and found similar with 9% of acceptable range of difference

7. Under the same static load conditions deflection and stresses of steel leaf spring and composite leaf spring are found with the great difference.

8. Deflection of Composite leaf spring is less as compared to steel leaf spring with the same loading condition

VII. REFERENCES

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