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A Replacement of Steel by C Glass/Epoxy Composite Material in Conventional leaf spring for weight reduction.

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ABSTRACT

Weight reduction is the important factor automobile manufacturer. In automobile leaf spring is potential item for weight reduction which accounts for 10-25 % of un sprung weight. Material with maximum strength and minimum modulus of elasticity is most suitable for leaf spring, and composite spring reduces weight of automobile without reducing the load carrying capacity.
In present project work comparative analysis of c-glass/epoxy composite leaf spring and steel leaf spring is done by analytical, FEA using ANSYS 12. The result of FEA is also experimentally verified.

Keywords— **leaf spring , composite material, FEM**

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I. INTRODUCTION

Springs are crucial suspension elements on cars, necessary to minimize the vertical vibrations, impacts and bumps due to road irregularities and create a comfortable ride. A leaf spring, especially the longitudinal type, is a reliable and persistent element in automotive suspension systems. These springs are usually formed by stacking leafs of steel, in progressively longer lengths on top of each other, so that the spring is thick in the middle to resist bending and thin at the end where it attaches to the body. A leaf spring should support various kinds of external forces but the most important task is to resist the variable vertical forces [1]. Springs are unlike other machine/structure components in that they undergo significant deformation when loaded; their compliance enables them to store readily recoverable mechanical energy. It is well known that springs, in general, are designed to absorb and store energy and then release it. Hence, the strain energy of the material and the shape become a major factor in designing the springs.

In a vehicle suspension, when the wheel meets an obstacle, the springing allows movement of the wheel over the obstacle and thereafter returns the wheel to its normal position (i.e., to be resilient). 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 is 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, this leads to deflecting the spring. This changes the length between the spring eyes.Thisdocument is a template. An electronic copy can be downloaded from the conference website. For questions on paper guidelines, please contact the conference publications committee as indicated on the conference website. Information about final paper submission is available from the conference website.

II. LITERATURE SURVEY

H.A. AI-Quireshi was designed, fabricated and tested a single leaf variable thickness spring of glass fiber reinforced plastic (GFRP) with similer mechanical and geometrical properties to the multi leaf spring . The testing was performed experimentally in the laboratory and was followed by the road test. Comparison between the performance of the GFRP and the multileafsteel spring is presented. Study demonstrate that composite can be used for leaf spring for light trucks (jeep) and can meet the requirements together with substantial weight saving[3].

C. Subramanian, S. Senthilvelan attempts to design and evaluate the performance of double bolted end joint for thermoplastic composite leaf spring. Injection molded 20% glass fiber reinforced polypropylene leaf springs were considered for the joint strength evaluation. Servo hydraulic test facility is utilized to evaluate the static and fatigue performance of the bolted joint. Various bolt sizes were utilized for the joint and its performances were evaluated under static loading condition to understand the effect of fit between bolt and its hole of the joints. Ultimate bearing strength of the joint is found to decrease with the increase in the clearance between bolt and part hole. Joints were subjected to various amplitudes of completely reversed fatigue loads to evaluate the endurance strength. Load–deflection hysteresis plot of the joint under fatigue conditions is continuously measured and used as the bearing damage index of the joint. Inspection of the bearing surface tested under static and fatigue loading condition revealed severe matrix deformation and fibrillation. In spite of unidirectional load being acted at the joint, curved nature of the bearing surface induces bi-axial stresses, which results in severe matrix fibrillation at the bearing surface[4]. Failure morphology under static conditions shows net-tension beside the bearing damage. Failure morphology under fatigue condition revealed net-tension, and shear-out failures besides the bearing damages.

Abdul Rahim Abu Talib, Aidy Ali, G. Goudah, NurAzidaChe Lah, A.F. Golestaneh have developed a finite element models to optimize the material and geometry of the composite elliptical spring based on the spring rate, log life and shear stress parameters. The influence of the ellipticity ratio on the performance of woven roving–wrapped composite elliptical springs was investigated both experimentally and numerically. The study demonstrated that composite elliptical springs can be used for light and heavy trucks with substantial weight reduction. The results showed that the ellipticity ratio significantly influenced the design parameters. Composite elliptic springs with ellipticity ratios of a/b = 2 had the optimum spring parameters [5].An easy way to comply with the conference paper formatting requirements is to use this document as a template and simply type your text into it.

III. OBJECTIVE

The objectives of the project are outlined below.

- Selection of best suitable fiber and resin for the fabrication of composite leaf spring.
- Evaluation of mechanical properties of C-glass/epoxy composite (Modulus of elasticity, tensile strength, etc.)
- Fabrication of C-glass/epoxy based composite leaf spring with optimum volume fraction of matrix phase and fiber phase.
- A single leaf, variable thickness spring of C-glass/epoxy composite material with similar geometrical properties to the steel spring is designed fabricated and tested.
- The analytical procedure is followed by finite element analysis and the results are verified by experimentally.

Properties of the steel C-glass/Epoxy leaf spring used in this work are shown in Table .

Table .Propertiesof C-glass/Epoxy leaf spring

Sr.No	Parameter	Value
1	Tensile modulus along X direction Ex, Mpa	29000
2	Tensile modulus along Y direction Ey, Mpa	3909
3	Tensile modulus along Z direction Ez, Mpa	3909
4	Tensile strength of material, Mpa	1370
5	Compressive strength of material, Mpa	685
6	Poisons ratio along XY direction (NUxy)	0.217
7	Poisons ratio along YZ direction (NUyz)	0.366
8	Poisons ratio along ZX direction (NUzx)	0.217
9	Density Kg/m^3	$1.7x10^{-6}$

Properties of the steel EN47 leaf spring used in this work are shown in Table .

Table .Propertiesof steel leaf spring

Sr.No	Parameter	Value
1	Density (×1000 kg/m3)	7.7-8.03
2	Poisson's Ratio	0.27-0.30
3	Elastic Modulus (GPa)	190-210
4	Tensile Strength (Mpa)	1158
5	Yield Strength (Mpa)	1034
6	Elongation (%)	15
7	Reduction in Area (%)	53
8	Hardness (HB)	335

FEA Analysis of steel leaf spring

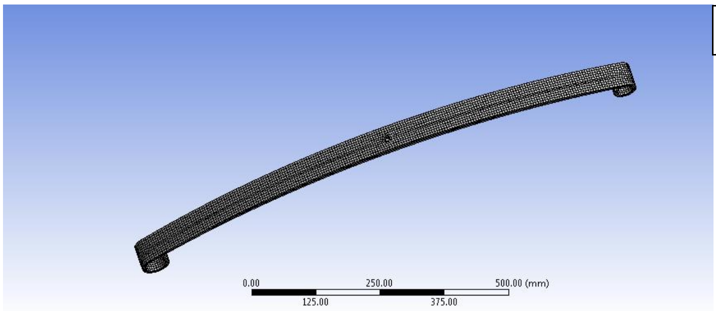

Fig . Mesh model of steel leaf spring.

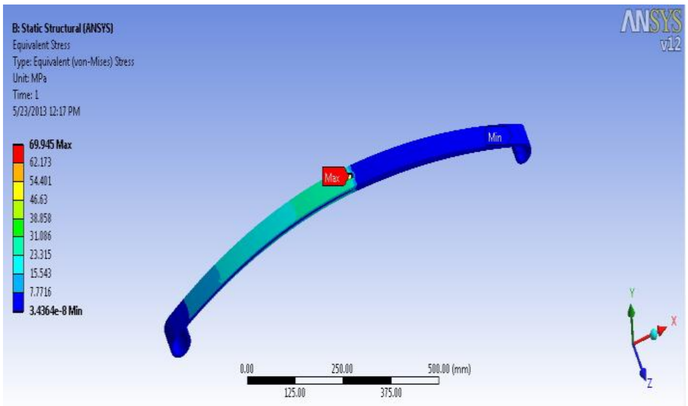

Fig .Stresses in steel leaf spring.

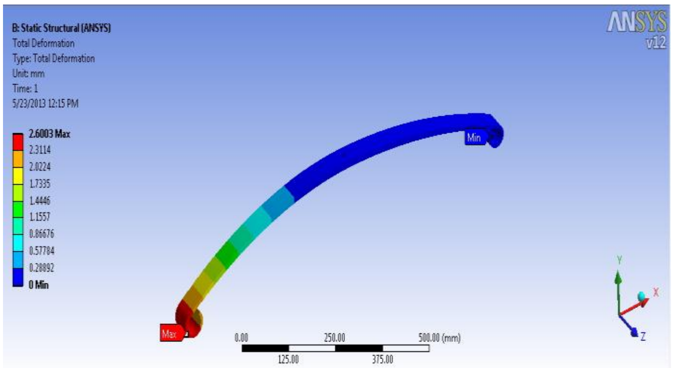

Fig .Deflection in Steel leaf spring.

Table. FEA result for steel leaf spring.

Sr. No	Cantilever load (W) N	Bending stress (σ) MPa	Deflection (δ) Mm
1	25	17.486	0.65007
2	50	34.972	1.3001
3	75	52.458	1.9502
4	100	69.945	2.6003
5	125	87.431	3.2503
6	150	104.92	3.9004
7	175	122.4	4.5505
8	200	139.89	5.2005
9	225	157.38	5.8506
10	250	174.86	6.5007

11	1560	1091.1	40.564

FEA Analysis of c glass/epoxy leaf spring

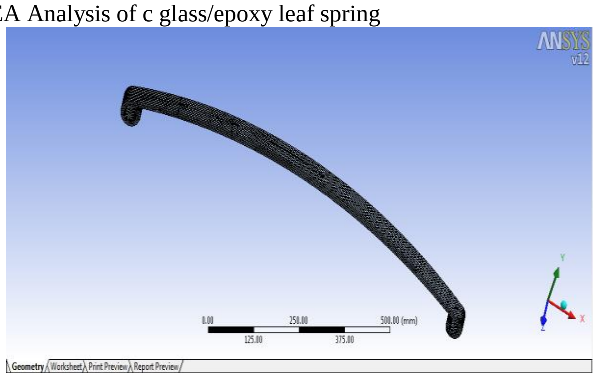

Fig Mesh model of composite leaf spring.

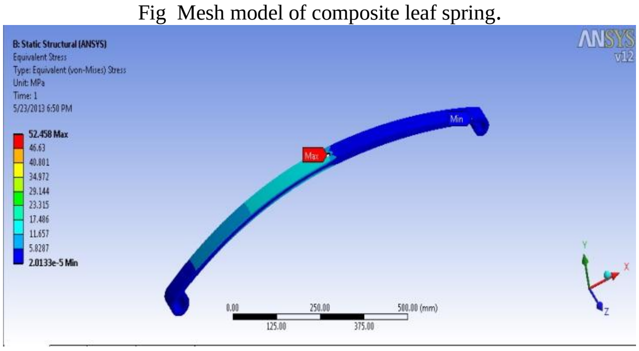

Fig .variation of stress in composite leaf spring

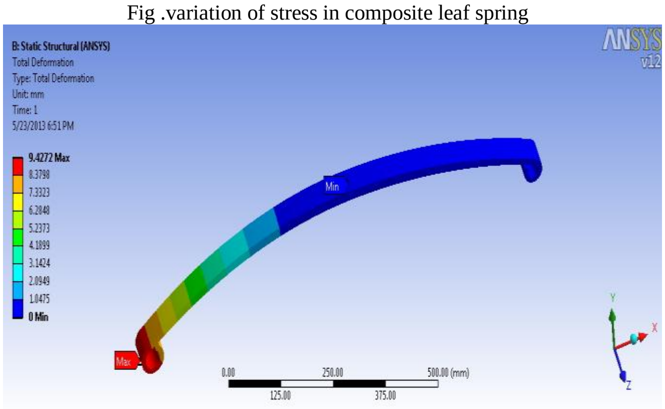

Fig .Deflection in composite leaf spring.

Table . FEA result for composite leaf spring.

Sr. No	Cantilever load (W) N	Bending stress (σ) MPa	Deflection (δ) Mm
1	25	13.115	2.3568
2	50	26.229	4.7136
3	75	39.344	7.0704
4	100	52.458	9.4272
5	125	65.573	11.784
6	150	78.688	14.141
7	175	91.802	16.498
8	200	104.92	18.854
9	225	118.03	21.211

10	250	131.15	23.568
11	1560	818.35	147.06

Specification of the leaf spring test rig.

Table . Specification of the leaf spring test rig

Sr. No	Parameter	Values
1	Capacity (kN)	100
2	Starting speed at no load (mm/min)	0-250
3	Table size (mm)	250 x 2400
4	Clearance for compression test (mm)	0-400
5	Distance between the trolleys (adjustable) (mm)	500-2150
6	Ram stroke (mm)	250
7	Connected load (HP)	1.5
8	Voltage (volt)	440
9	Phase	3

Analytical Design of steel leaf spring
Thickness of plate, t = 14mm.
Width of plate, b = 50-12 = 38mm.
Length of plate or distance of the load W from the cantilever end, L = 525mm.
Youngs modulus of elasticity, E = 2.07 x 10^5 Mpa.
Yield tensile strength, Syt = 1034 Mpa.
Density, = 7800 Kg/m^3.

Table :6 Bending stress and Deflection of steel leaf spring.

Sr.No	Central load (W) N	Bending stress (σ) MPa	Deflection (δ) mm
1	50	10.31	0.65
2	100	20.62	1.30
3	150	30.94	1.96
4	200	41.25	2.16
5	250	51.27	3.26
6	300	61.88	3.92
7	350	72.20	4.57
8	400	82.51	5.23
9	450	92.83	5.88
10	500	103.1	6.53
11	3200	660.12	41.85

Analytical analysis of C-glass/Epoxy leaf spring
Thickness of plate, t = 18mm.

Width of plate, b = 50-12 = 38mm.

Length of plate or distance of the load W from the cantilever end, L = 525mm.

Youngs modulus of elasticity, E = 29420 Mpa.

Yield tensile strength, Syt = 1370 Mpa.

Density, = 1.692 x 10-6 Kg/m3.All paragraphs must be indented. All paragraphs must be justified, i.e. both left-justified and right-justified.

Table : Bending stress and Deflection of C-glass/Epoxy leaf spring.

Sr.No	Central load (W) N	Bending stress (σ) MPa	Deflection (δ) Mm
1	50	6.23	2.16
2	100	12.47	4.32
3	150	18.72	6.49
4	200	24.95	8.65
5	250	31.19	10.81
6	300	37.43	12.98
7	350	43.67	15.14
8	400	49.91	17.31
9	450	56.15	19.47
10	500	62.38	21.63
11	3200	399.29	138.5

Table .comparison of analytical and FEA result for steel leaf spring.

Sr. No	Cantilever load (W) N	Analytical result		FEA result	
		Bending stress (σ) MPa	Deflection (δ) Mm	Bending stress (σ) MPa	Deflection (δ) Mm
1	25	10.31	0.65	17.486	0.65007
2	50	20.62	1.30	34.972	1.3001
3	75	30.94	1.96	52.458	1.9502
4	100	41.25	2.16	69.945	2.6003

Table .comparison of analytical and FEA result for composite leaf spring.

Sr. No	Cantilever load (W) N	Analytical result		FEA result	
		Bending stress (σ) MPa	Deflection (δ) Mm	Bending stress (σ) MPa	Deflection (δ) Mm
1	25	6.23	2.16	13.115	2.3568
2	50	12.47	4.32	26.229	4.7136
3	75	18.72	6.49	39.344	7.0704
4	100	24.95	8.65	52.458	9.4272

IV. Conclusions

1. A steel leaf spring used in the rear suspension of light passenger cars was analyzed by analytical and finite element methods.

2. The finite element solutions show the good correlation for total deformation with analytical results.

3. The stresses in the composite leaf spring are much lower than that of the steel spring.

4. Study demonstrates that the composite can be used for leaf spring for the light vehicle and meet the requirement, together with the sustainable weight reduction.A conclusion section is recommended as it helps the readers to check the relevance. Conclusion may the scope of the work presented in the paper.

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