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Finite element Analysis of Fiber Reinforced Plastics Mono Leaf Spring as Alternative for Conventional Multi Leaf Spring

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***Abstract*—In late year vehicle businesses are for the most part focusing on weight decrease and in improving the riding quality which is identified with body structure, the substitution of lightweight materials. Decreasing weight while expanding or keeping up the quality of items is getting the chance to be exceedingly significant research issues in this cutting edge world. Composite materials are one of the material families which are drawing in scientists and being arrangements of such an issue. The presentation of fiber strengthened plastics (FRP) is utilized to decrease the heaviness of the item with no decrease in burden conveying limit and spring rate. The objective of this work is to conduct a comparative analysis of the steel v/s virtual model of composite leaf spring for comparing the deciding parameters which are deformations, stresses, and natural frequencies .**

Keywords*— *Leaf spring, E-Glass/Epoxy, FEAST, deflection, Natural frequency

INTRODUCTION

In order to marmalade natural resources and skimp and save dynamism, weight reduction has been the main emphasis of automobile manufacturers in the present scenario. The suspension leaf spring is one of the potential items for weight reduction in automobiles as it accounts for 10% - 20% of the unstrung weight which results vehicle with more fuel efficiency and improved riding qualities. For structural applications where high strength to weight and stiffness to weight ratio are required, Composite materials are ideal.

Suspension system:

To isolate from road shocks in the form of bounce, pitch, roll or sway which may aid to additional stresses along with poor riding suspension system is good quality suspension is needed. A System, made up of parts which absorbs road shocks collectively is suspension system. It also includes spring and a damper along with spring device and various mountings. A spring is an elastic body, whose function is to distort when loaded and to recover its original shape when the load is removed. [1] The different types of springs are:

1. Helical springs
2. Conical and volute springs
3. Torsion and spiral springs
4. Leaf springs
5. Disc or Belleville springs
6. Special purpose spring

Leaf spring:

Leaf spring is prime element of the suspension system. The general movement caused by the road undulations can be controlled by leaf spring for the wheels during acceleration, braking and turning.

Composites:

Composites are hybrid materials formed with various materials to withstand their individual structural benefits as a single structural element and stockpiling limit and High solidarity to weight proportion [2].

Sr No	Steel	Composites
1	Less specific modulus	High specific modulus
2	Less strength	High strength
3	Increased weight	Reduced weight
4	More fuel consumption	Less fuel consumption
5	Highly corrosive	Less corrosive
6	less damping capacity	High damping capacity
7	More vibration and noise	Less vibration and noise
8	Shorter fatigue life	Longer fatigue life

Assumptions considered are:

- All non-linear effects are excluded.
- The Stress-Strain Relationship for composite material is linear and elastic; hence Hooke’s law is applicable for composite materials
- Leaf spring is assumed to be in vacuum.
- The load is distributed uniformly at the middle of the leaf spring.
- Leaf spring has a uniform, rectangular cross section [3].

Vibratory movement is executed, When flexible bodies (bar, shaft, spring) are uprooted from the balance position by methods for outside powers, and after that discharged because of when a body is dislodged, the inward powers as versatile or strain vitality are available in the body. At discharge, these powers carry the body to its unique position. at the point when the body achieves the harmony position, because of which the body keeps on moving the other way the entire of the flexible or strain vitality is changed over into dynamic vitality. The entire of the active vitality is again changed over into strain vitality because of which the body again comes back to the harmony position and vibratory movement is rehashed inconclusively along these lines. Two general instances of vibrations are Free and constrained vibrations. The framework under free vibration will vibrate at least one of its normal frequencies, which are properties of the dynamical framework set up by it’s mass and solidness appropriation. At the point when a framework sways under the activity of powers inside the framework itself without outer powers, free vibrations happen. Vibration occurring under the excitations of outside powers is called constrained vibration [4]. By methods for spring diversions, vehicle vibrations, stuns and knock loads (incited because of street anomalies) are consumed by leaf springs, with the goal that potential vitality is put away in the leaf spring and after that eased gradually. Agreeable suspension framework is guaranteed with the capacity to store and ingest more measures of strain vitality [6]. If the event that overlays are unidirectional, disappointment happens when the burden is connected residual way because of delamination wonder. Thus, layering in various directions is advisable. (45/0/90/15/0/90/45) lay-up is utilized to fortify it every which way [8].

I. DESIGN OF LEAF SPRING

Material selection:

About 60%-70% of the vehicle cost and add to the quality and the presentation of the vehicle is established by materials. Indeed, even a limited quantity in weight decrease with higher common recurrence of the vehicle, may have a more extensive financial effect. Composite materials are demonstrated as reasonable substitutes for steel regarding weight decrease of the vehicle with riding solace [9].

Fiber selection:

Wide scope of filaments from which to make a choice is accessible. Frequently a fiber is chosen due to physical properties alongside thought of mechanical (modulus and quality) and warm properties(coefficient of warm development and warm conductivity). Frequently a fiber is chosen due to physical properties The material utilized straightforwardly influences the amount of storable vitality in the leaf spring as vertical vibrations and effects are cushioned by varieties in the spring redirection with the goal that the potential vitality is put away in spring as strain vitality and after that discharged gradually. Along these lines, expanding the vitality stockpiling ability of a leaf spring guarantees an increasingly consistent suspension framework. There are kinds of glass strands , C-glass (improved surface completion), S-glass (exceptionally high measured), E-glass (astounding glass, which is utilized as standard fortification fiber for all the present frameworks well agreeing to mechanical property necessities). In this manner, for this application E-glass fiber was discovered proper.

Resin selection:

In a FRP leaf spring, fortification of strands is in the thickness heading, fiber doesn't impact entomb laminar shear quality, which is constrained by the grid framework utilized. Along these lines, the network framework ought to have great entomb laminar shear quality attributes similarity to the chose fortification fiber. Numerous thermoset saps, for example, polyester, vinyl ester, epoxy sap are being utilized for fiber support plastics (FRP) creation. Among these gum frameworks, epoxies show better great mechanical properties with better entomb laminar shear quality. It is portrayed as beneath which makes increasingly reasonable for this application.

• Good mechanical and electrical properties.
• Faster curing at room temperature.
• Good chemical resistance properties.

Specific design data:

Many industrial visits ,past recorded data shows that widely used materials for manufacturing of conventional leaf springs are manufactured by EN45, EN45A, 60Si7, EN47, 50Cr4V2, 55SiCr7 and 50CrMoCV4 etc.

Selection of Cross section:

Constant thickness, varying width design: Thickness is kept constant over the entire length of the leaf spring while the width varies from a minimum at the two ends to a maximum at the center.

Varying width, varying thickness design: Width is kept constant over the entire length of the leaf spring while the thickness varies from a minimum at the two ends to a maximum at the center.

Constant thickness, constant width design : Both thickness and width are varied throughout the leaf spring such that the cross section area remains constant along the length of the leaf spring.

In the present work, only constant cross-section design method is selected due to easiness in hand lay-up and accommodation of continuous reinforcement of fibers. Since the cross-section area is constant throughout the leaf spring, same quantity of reinforcement fiber and resin can be fed continuously during manufacturing.

Design data for leaf spring:

Simply supported beam is considered .

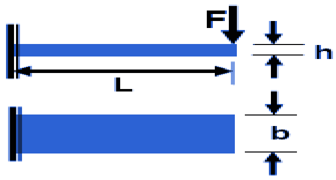

Fig. 1 Leaf Spring

Leaf spring is having rectangular cross section.

I Leaf Spring Specifications

Parameter (mm)	Value
Straight length (2L)	965
Leaf Thickness (t)	10
Leaf Width (b)	50
Camber (c)	112

II. MATERIAL PROPERTIES OF (65SI7) EN47 STEEL LEAF SPRING

Sr. No.	Parameter	Value
1	Young's Modulus E (MPa)	2.1×10^5
2	Poisson's ratio	0.266
3	Tensile strength ultimate (MPa)	1272
4	Tensile yield strength (MPa)	1158
5	Density (kg/m^3)	7.86×10^{-6}

For this work, the test steel leaf spring used is of 60Si7(EN 47). The composition of material is 0.56 C%, 1.80 SI%, 0.70 Mn%, 0.045 P%,0.045 S%

Unidirectional E-Glass/epoxy composite material is

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selected because of the material point of view in longitudinal direction of fibers. The relative highlighted advantages are high strength to weight ration and high strain energy storing capacity.

III. MATERIAL PROPERTIES OF E-GLASS/EPOXY

Sr.No.	Parameter	Value
4	Tensile strength, MPa	900
5	Compressive strength, MPa	450
6	Poisons Ratio	0.217
7	Density	2160
8	Flexural modulus (E) MPa	40000

From the values listed in above table , it is cleared that deflection of composite leaf spring is comparatively less for same loading than that of steel leaf spring resulting in better riding experience.

II. 3-D MODELLING

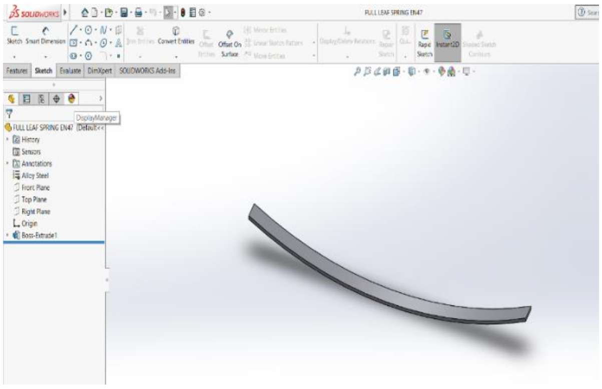

Fig. 2 3-D MODEL

III. BOUNDARU CONDITIONS

The six degrees of freedom are constraint. Y,Z axes are fixed. And X axis is free. Beam will act like roller supported beam.

Fig. 3 Simply Supported beam

IV. FINITE ELEMENT ANALYSIS

Analysis is carried out with FEAST. IGS. File is imported from Solidworks 17. For the analysis purpose mid-surface of the plate is extracted. Then thickness is applied to it. Meshing is done with 2 D element quad. It is more convenient to work in 2 D for composites as the thickness to length ratio is very high. and manufacturing is done with layering so. Then uniformly distributed load is applied in the interval value of 50N . After that the required elements are defined. This steps are done in preprocessing.

As stresses applied are less that ultimate value so results willbe linear. Results are generated in post processing.

A. *Total Deformation , Equivalent Stresses for Steel*

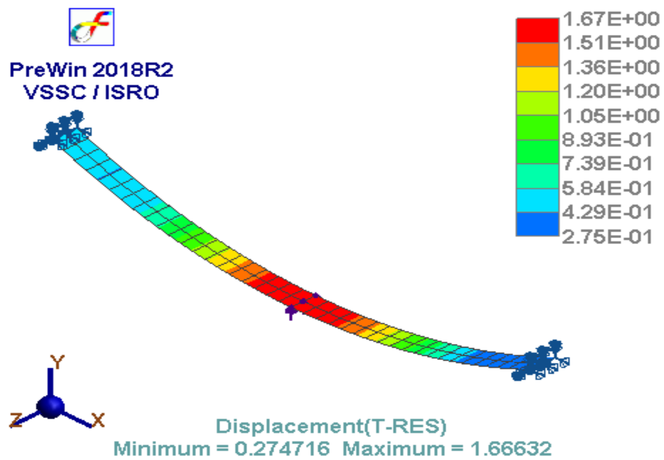

Fig. 4 Total Deformation @ 100N

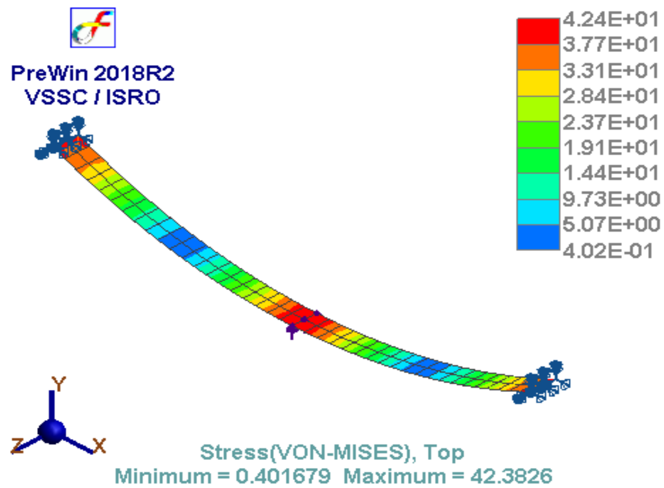

Fig. 5 Equivalent Stress @ 100N

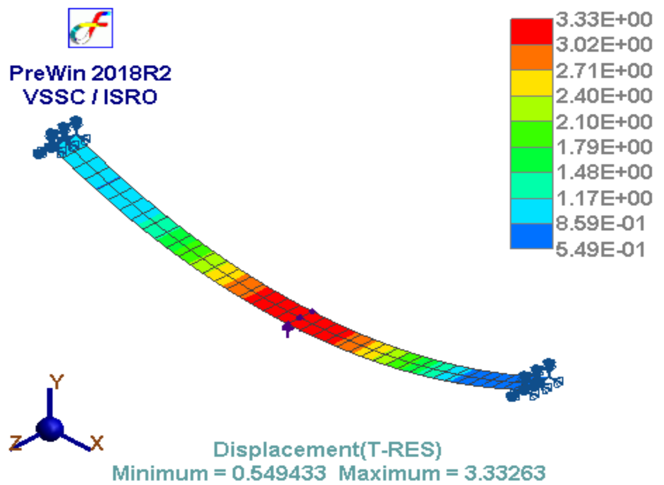

Fig. 6 Total Deformation @ 200N

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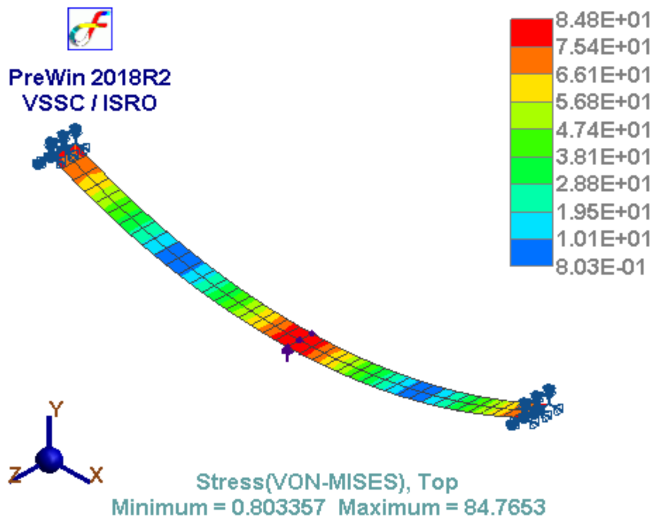

Fig. 6 Equivalent Stress @ 200N

A. Total Deformation , Equivalent Stresses for E-Glass/Epoxy

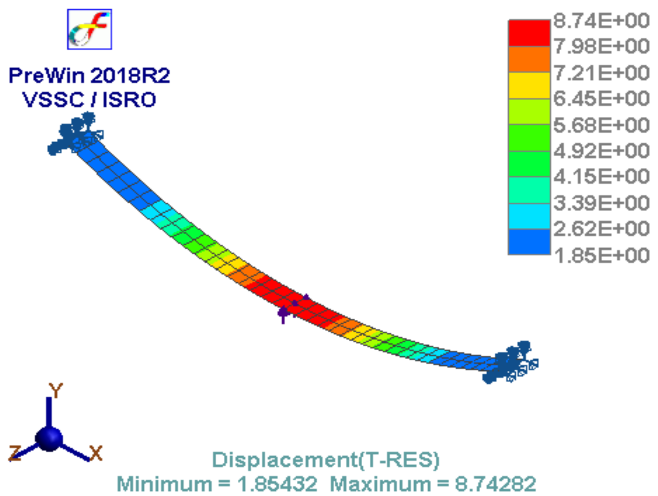

Fig. 7Total Deformation @ 100N

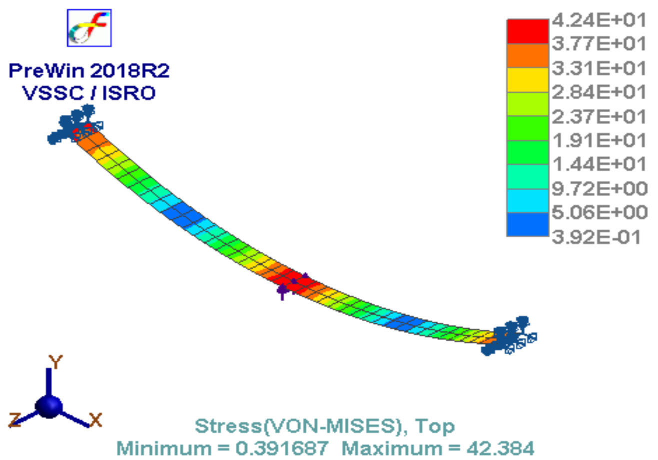

Fig. 8 Equivalent Stress @ 100N

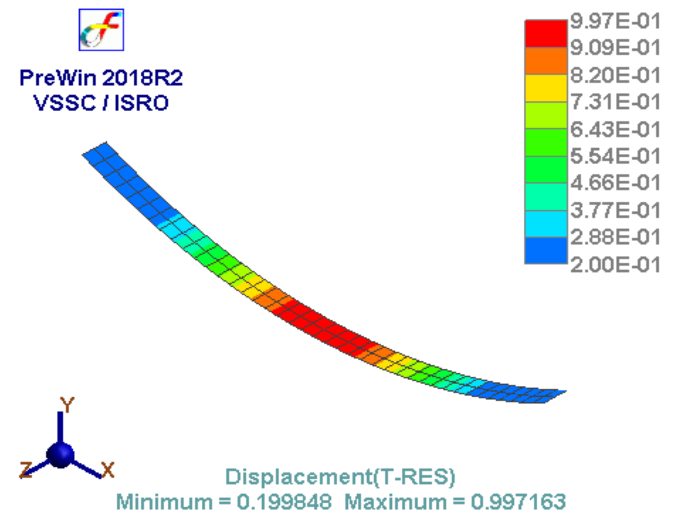

Fig. 9 Total Deformation @200N

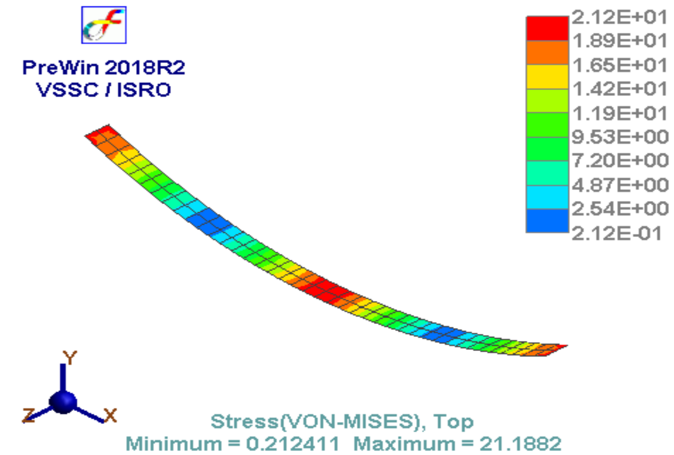

Fig.10 Equivalent Tress @ 200N

A. Total Deformation , Equivalent Stresses for Carbon/Epoxy

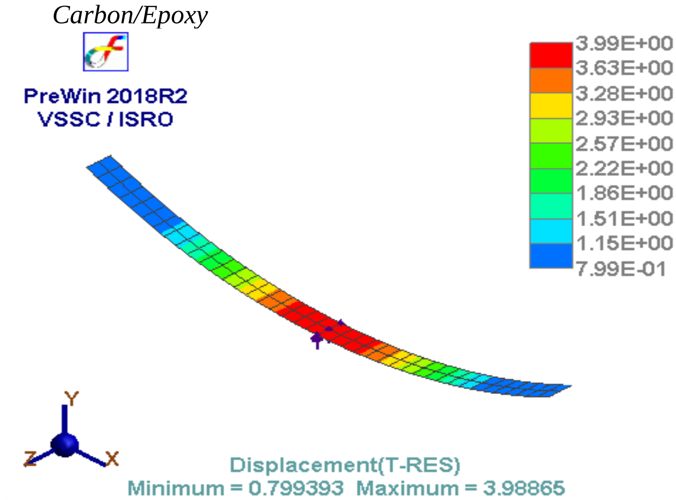

Fig. 11 Total Deformation @100N

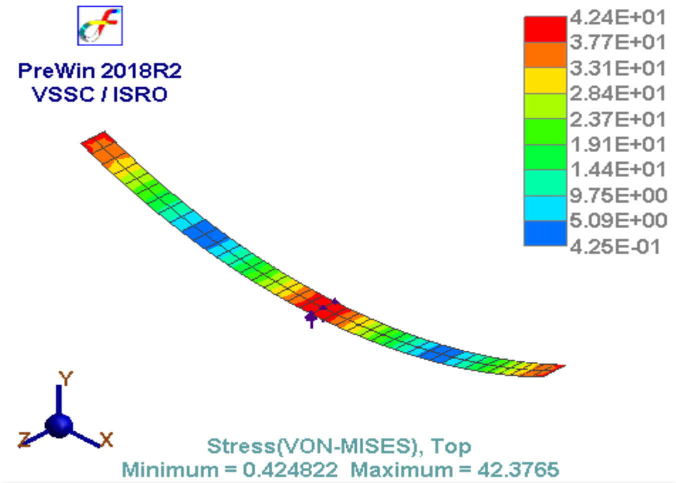

Fig. 12 equivalent Stress 100N

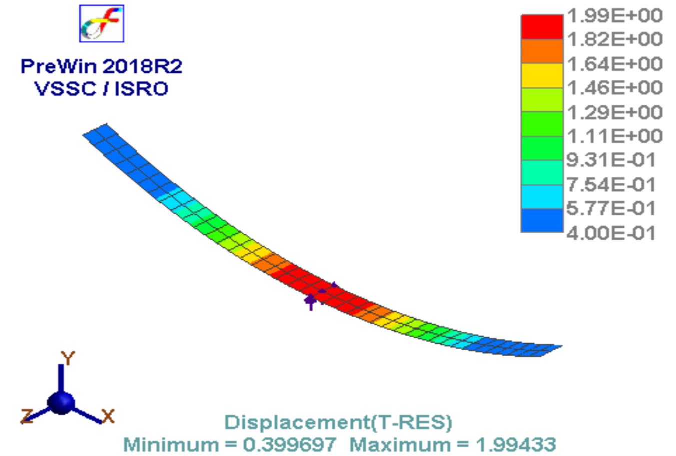

Fig. 13 Total Deformation @200N

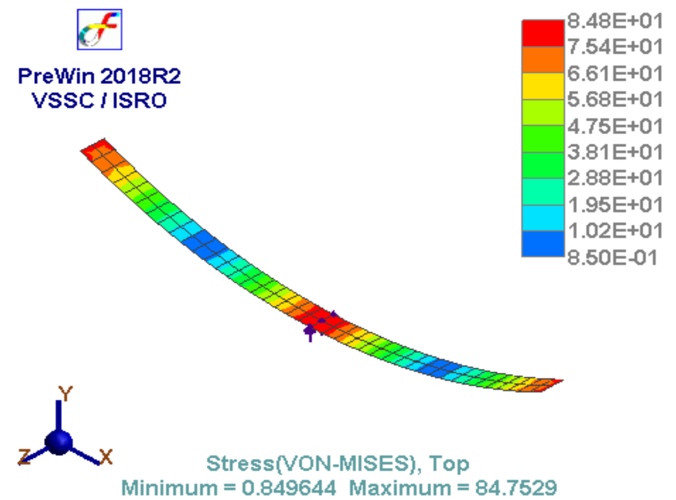

Fig. 14 Equivalent Stress 200N

B. Modal Analysis of EN47

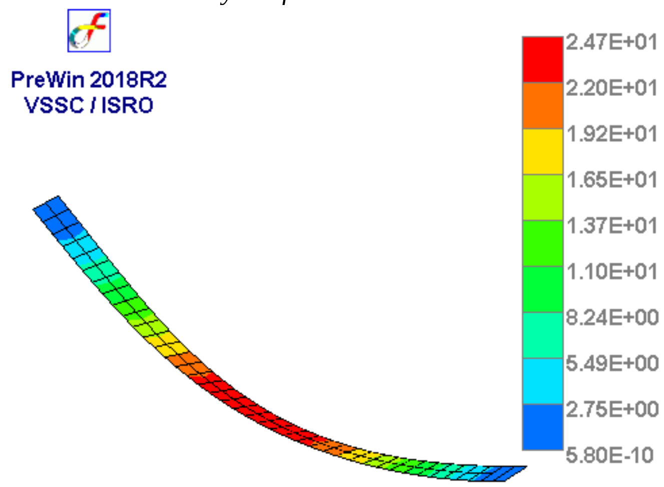

Fig.15 MODE 1 FREQUENCY 54.522 Hz

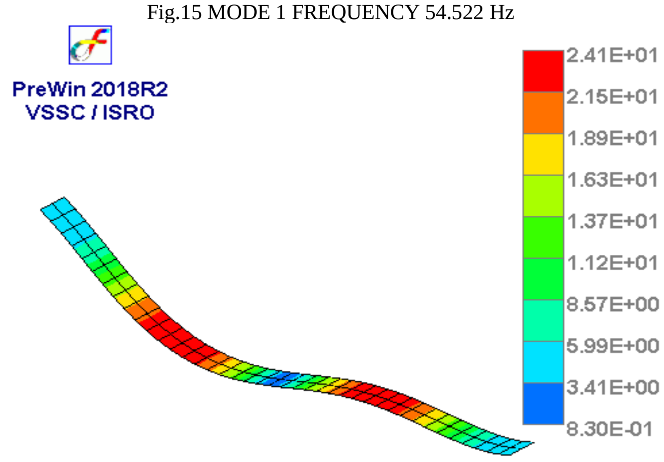

Fig. 16 MODE 2 FREQUENCY 151.012 Hz

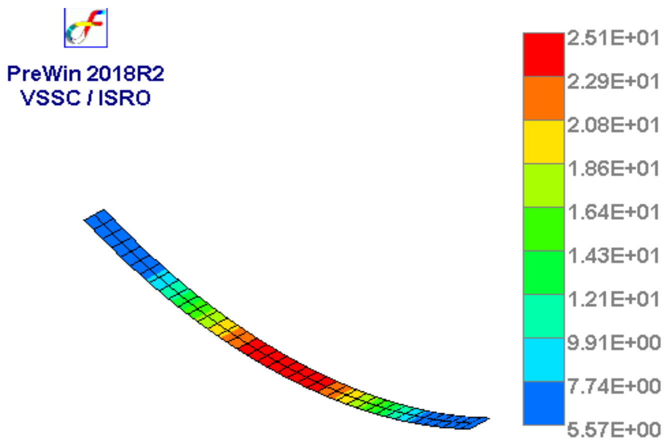

Fig. 17 MODE 3 FREQUENCY 191.81 Hz

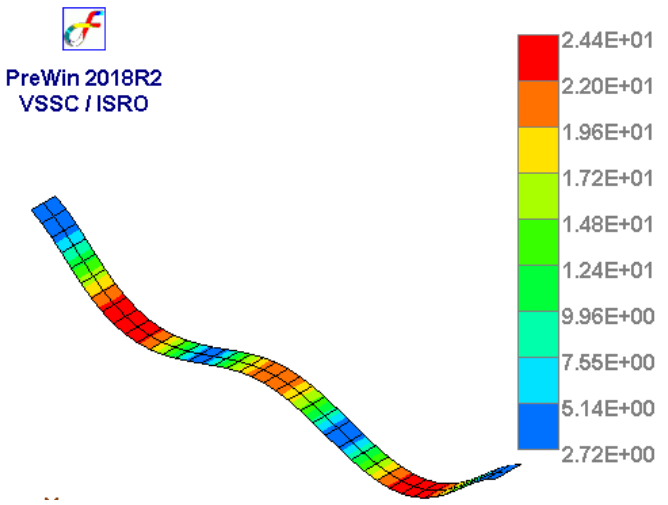

Fig. 18 MODE 4 FREQUENCY 292.74 Hz

A. Modal Analysis of E-Glass/Epoxy

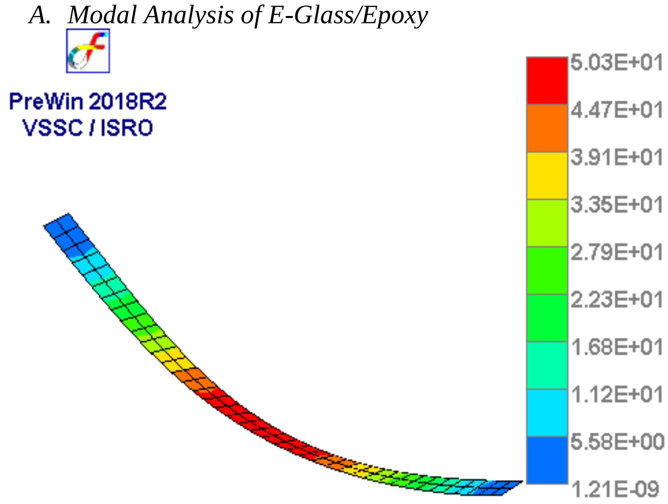

Fig. 19 MODE 1 FREQUENCY 48.3765 Hz

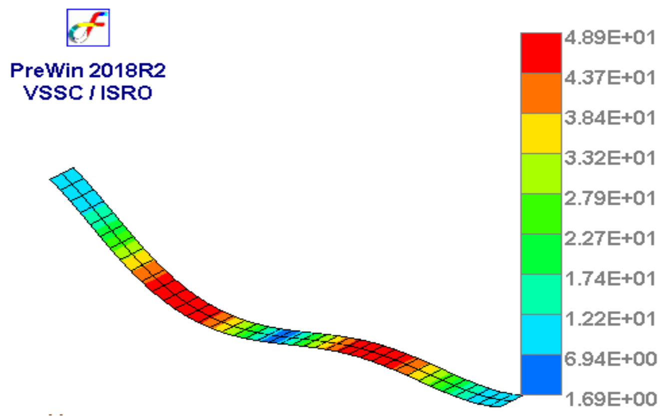

Fig. 20 MODE 2 FREQUENCY 133.991 Hz

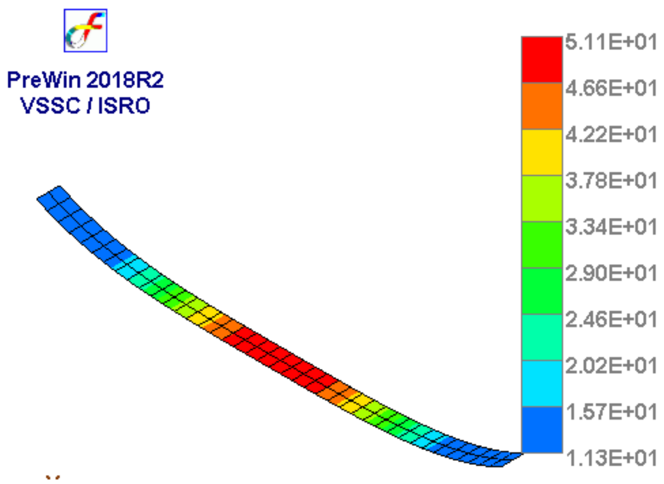

Fig. 2 MODE 3 FREQUENCY 170.73 Hz

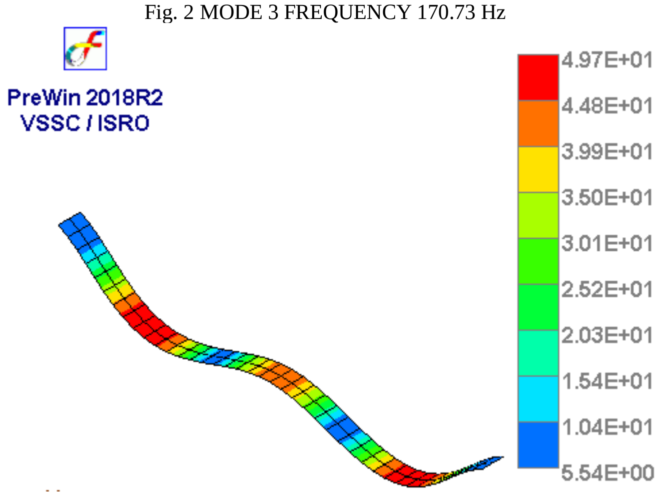

Fig. 3 MODE 4 FREQUENCY 259.746 Hz

B. Modal Analysis of Carbon/Epoxy

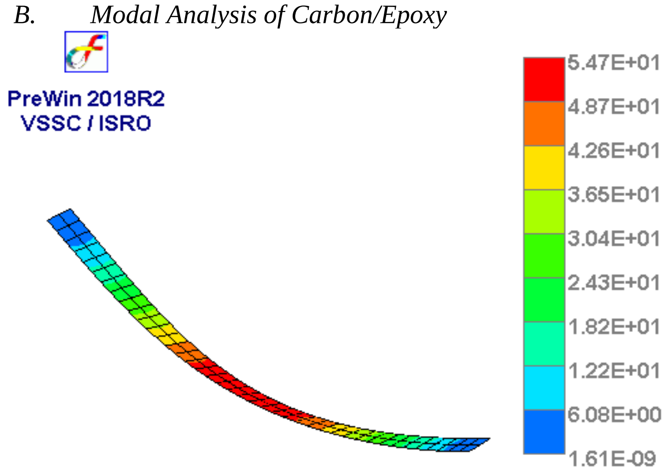

Fig. 23 MODE 1 FREQUENCY 110.43 Hz

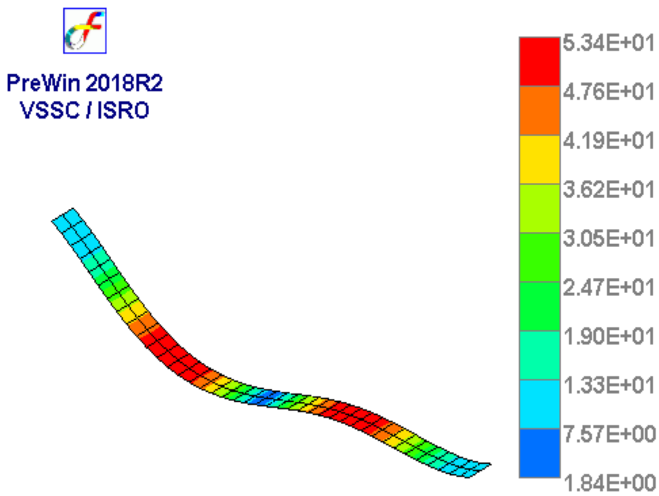

Fig. 4 MODE 2 FREQUENCY 305.857 Hz

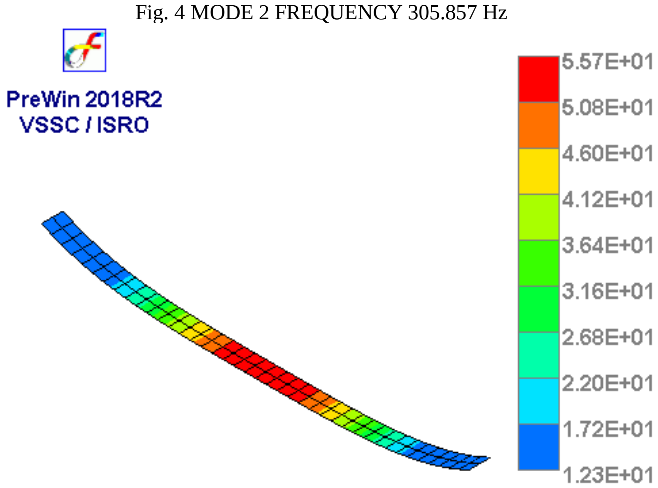

Fig. 25 MODE 3 FREQUENCY 385.981 Hz

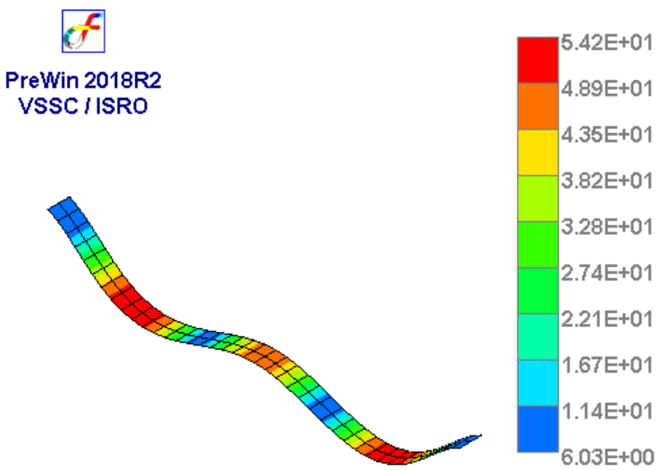

Fig. 26 MODE 4 FREQUENCY 592.943 Hz

V. RESULTS

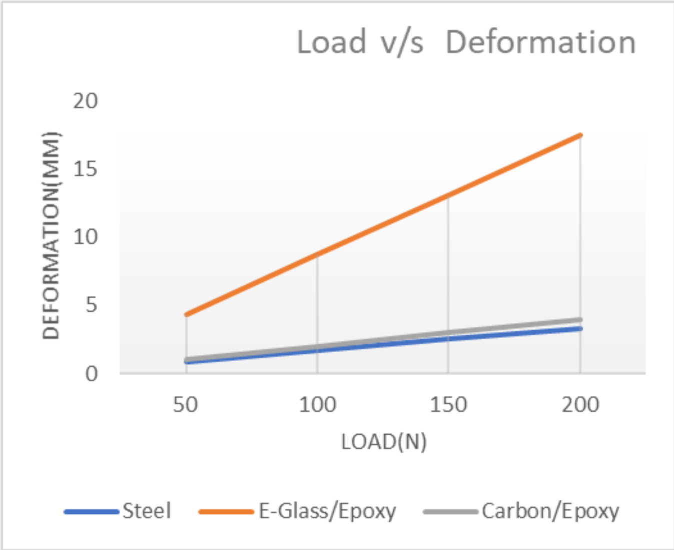

Fig. 27 Load V/s Deformation

V. NATURAL FREQUENCY

Mode	Natural Frequency(Hz)		
	Steel	E-glass/Epoxy	Carbon/Epoxy
1	54.5223	48.3765	110.43
2	151.012	133.991	305.857
3	191.818	170.73	385.981
4	292.745	259.746	592.943
5	484.035	429.469	980.416
6	548.931	488.508	1104.92
7	718.701	637.669	1455.8
8	813.979	723.921	1640.93
9	1005.5	892.116	2036.84

VI. DISCUSSION

The objective is to evaluate applicability of composite leaf spring . The comparison between steel leaf spring and composite leaf spring is made for the same stiffness and loading conditions. For same stiffness and loading conditions, stresses are nearly equal. Road irregularities generally have 55 Hz natural frequency. From table , it is highlighted that composites are having greater natural frequency than road irregularity. So with composites better riding comforts are achieved.

VII. CONCLUSION

The 3-D modelling of both steel and Composite leaf spring is done and analyzed using FEAST. GLASS FIBRE/E-POXY leaf spring can be used on smooth roads & also on rough road with very high performance. The study demonstrated that composites can be used for leaf springs for light weight vehicles for improved ride comfort. A comparative study has been made between E-Glass/Epoxy, Carbon/Epoxy and steel leaf spring with respect to deformation, Stresses, Natural frequency. From the results, it is observed that the composite leaf spring is more economical than the conventional steel spring with similar stiffness.

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