EXPERIMENTAL AND FEA ANALYSIS OF COMPOSITE LEAF SPRING BY VARYING THICKNESS

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Abstract

The work is carried out on composite leaf spring of a commercial vehicle. The objective of this work is to carryout design and analysis of composite leaf spring with experimental design consideration and loading condition. The material of leaf spring is E-GFRC (Glass Fiber reinforced composite). The GFRC leaf springs are manufactured by hand lay-up method which were evaluated and study. The model of composite leaf spring is prepared and analyzed using ANSYS14.5 for the deflection and stresses under defined loading condition. The experimental and FEA result compared for validation. The dimension of conventional leaf spring is taken with varying thickness for evaluation of result and Static analysis is performed

Keywords: *E-glass/epoxy composite, ANSYS14.5, Static Analysis.*

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1. INTRODUCTION

Automotive industries need tremendous amount of metal, alloys for producing different parts of the vehicle. The replacement of metals was a distant dream but due to rapid development in glass, polymers, ceramics, synthetic fibers and some organic and inorganic substances have been proved as the turning point [1]. More interesting aspect is, by combining two or more materials one can obtain improved mechanical properties of materials. Composites have better properties such as high specific strength, stiffness and hardness [2]. Due to the mentioned properties composite find wide range of applications not only with respect to properties but also with its weight and cost effectiveness. One such application is composite leaf spring [3]. Leaf springs are mainly used in suspension systems to absorb shock loads in automobiles like light motor vehicles, heavy duty trucks and in rail systems. It carries lateral loads, brake torque, driving torque in addition to shock absorbing. The advantage of leaf spring over helical spring is that the ends of the spring may be guided along a definite path as it deflects to act as a structural member in addition to energy absorbing device. According to the studies made a material with maximum strength and minimum modulus of elasticity in the longitudinal direction is the most suitable material for a leaf spring [4].

In this analysis GFRC leaf spring is compared with varying thickness [5]. Static testing condition is applied and result are compared by creating virtual models of composite leaf spring.

2. MAREAIAL PROPERTIES AND DESIGN SPECIFICATION

Glass fiber reinforced plastics is a composite material in which the volume fraction of fiber is 70% considering rule of mixture [6]. The low density and high specific strain of composites provides high specific strain energy capacity [7].

Table-1 Properties of composite leaf spring

Parameter	Value
Longitudinal Elastic Modulus, E_1	60.52 Gpa
Transverse elastic modulus, E_2	10.37 Gpa
Major poission's Ratio, V_{12}	0.230
Minor poission's Ratio , V_{21}	0.0390
In plane shear Modulus, G_{12}	4.014 Gpa
Density	2110 Kg/m^3

The glass fiber are earliest know fiber used in reinforcement. The main advantage of glass fiber reinforced composite is low cost, high strength, high chemical resistance and good insulating properties however the main disadvantage of glass fiber in composite is low elastic modulus poor adhesion polymer[8]

2.1Selection of Fiber

Fig-1 Fibricated composite Leaf Spring

Table-2 .Properties of fiber

Sr.No.	Type of Fiber	Properties
1	Glass Fiber	-
a)	E-glass	High Stiffness, high buckling, weak in shear, low cost.
b)	S-glass	High Stiffness, high buckling, weak in shear, high cost.
2	Carbon fiber	High strength, high modulus, low density, high temperature resistance, considerably high cost.
3	Ceramic	High temperature resistance, low thermal conductivity.

From the above table we are choosing the E-glass fiber and resin epoxy Choosing for fabrication of composite leaf spring.

2.2 Design Specification of Composite Leaf Spring

The leaf spring behaves like a cantilever beam. It is subjected to bending stresses, longitudinal and transverse shear stress. The spring is designed on the basis of constant width and Varying thickness. Leaf spring is manufactured by hand lay-up technique as shown in fig. 1. It is more suitable and economical compared to filament winding technique as the cross-section area is constant throughout the leaf spring. The specification for the spring is as follows: Total length of the spring is = 1010 mm, Thickness = 28,30,32 mm, Width = 45 mm.

3. RESULT AND DUSCUSSION

3.1 Experimental & Analytical Results

Experimental analysis of the leaf spring is done on Universal Testing Machine[6]. Glass fiber composite leaf spring is tested on the same. Load is applied at the center of the spring. The load is applied in a gradual intervals of 50kg. The table 3 shows experimental and analytical results at a load of 300kg.

Table- 3 Experimental & Analytical results at -load 300kg for stress and deflection of GFRC

Thickness mm	**Analytical result**		**Experimental result**	
	Deflection mm	**Stresses N/mm^2**	**Deflection mm**	**Stresses N/mm^2**
28	128.97	252.75	92	252.10
30	104.85	220.18	75	220.15
32	86.40	193.51	61	193.30

3.2 3D-Finite Element Analysis (FEA)

For 3D finite element analysis of present work is done in Ansys 14.5 using a 3D element suitable for composite analysis known as “SOLID 186” and is an 20-noded element useful for structural analysis of composite which facilitates near about 250 layers.

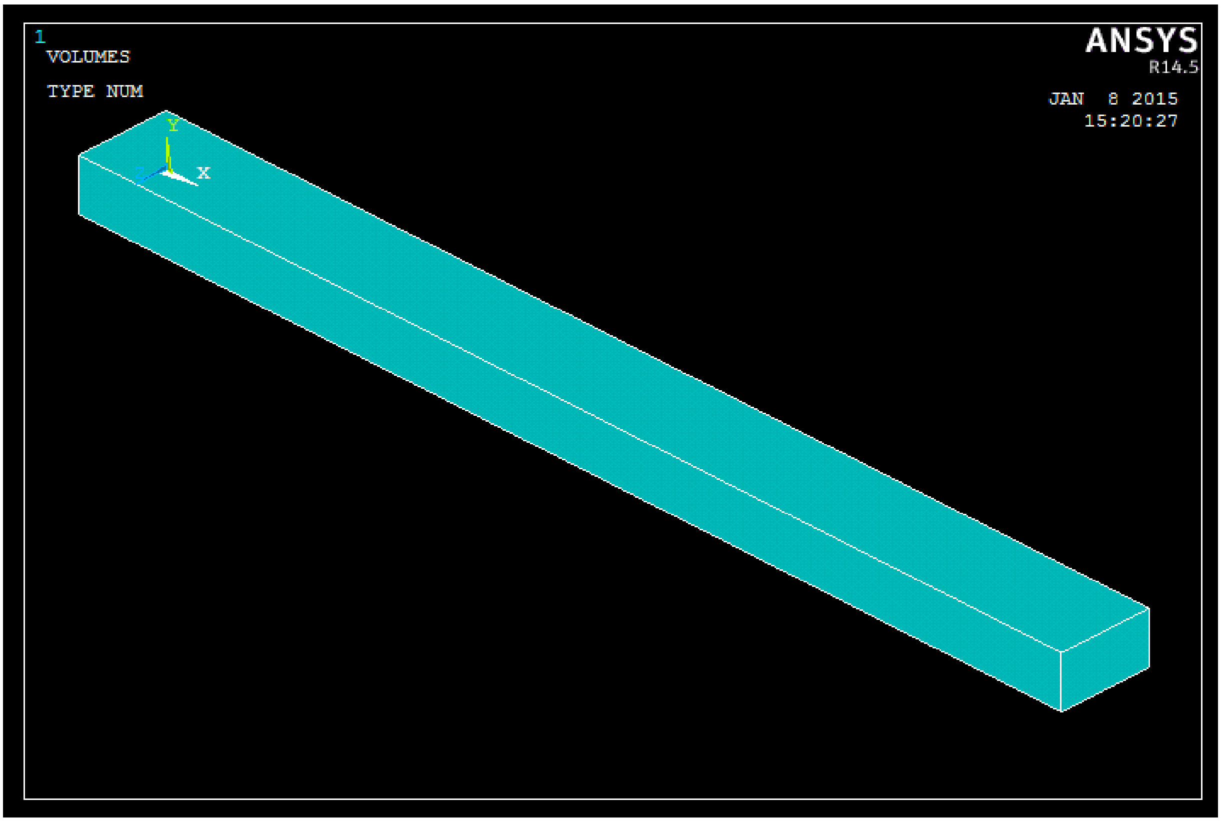


Fig-2: 3-D Model of leaf spring

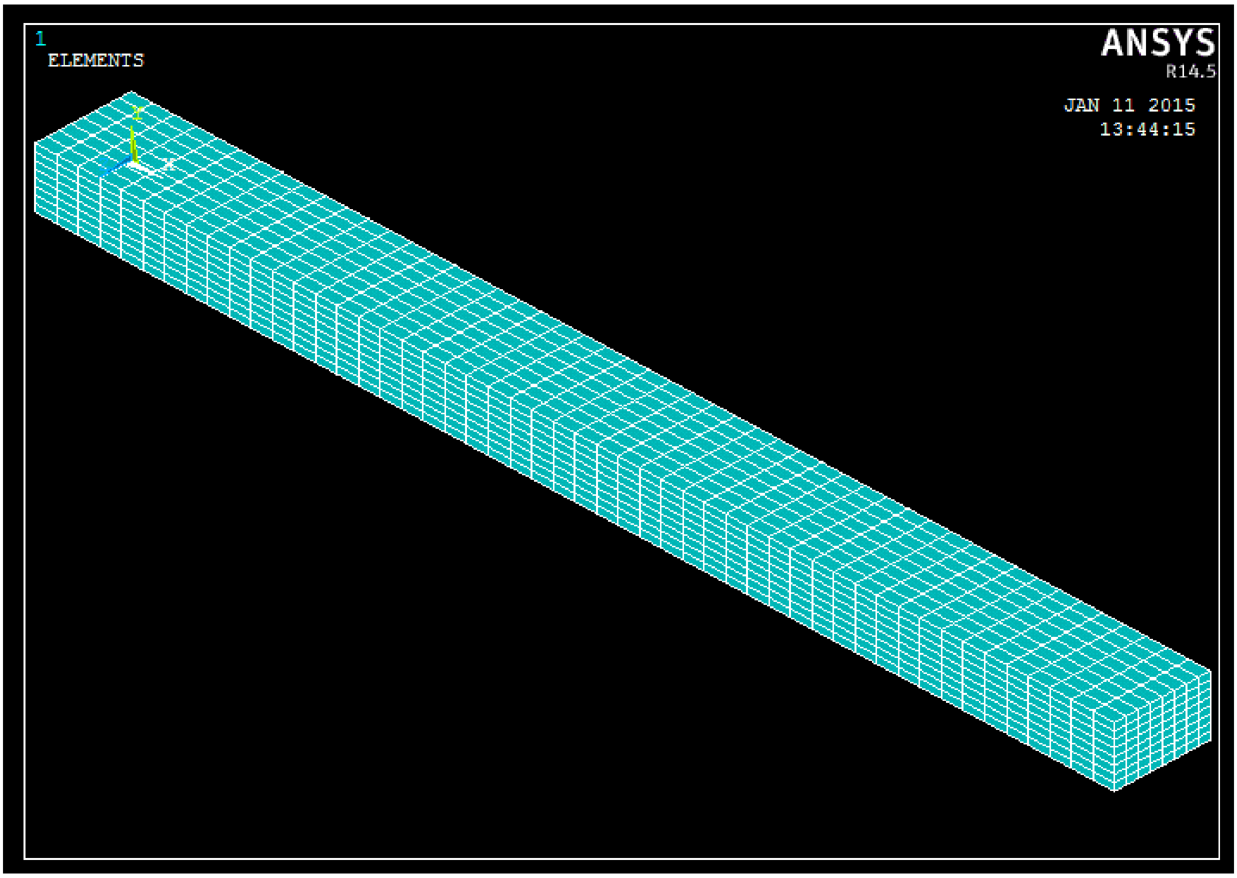


Fig-3: Meshed model of leaf spring

For the leaf spring is consider as cantilever beam with one end fixed and at other end load applied shown in fig4.

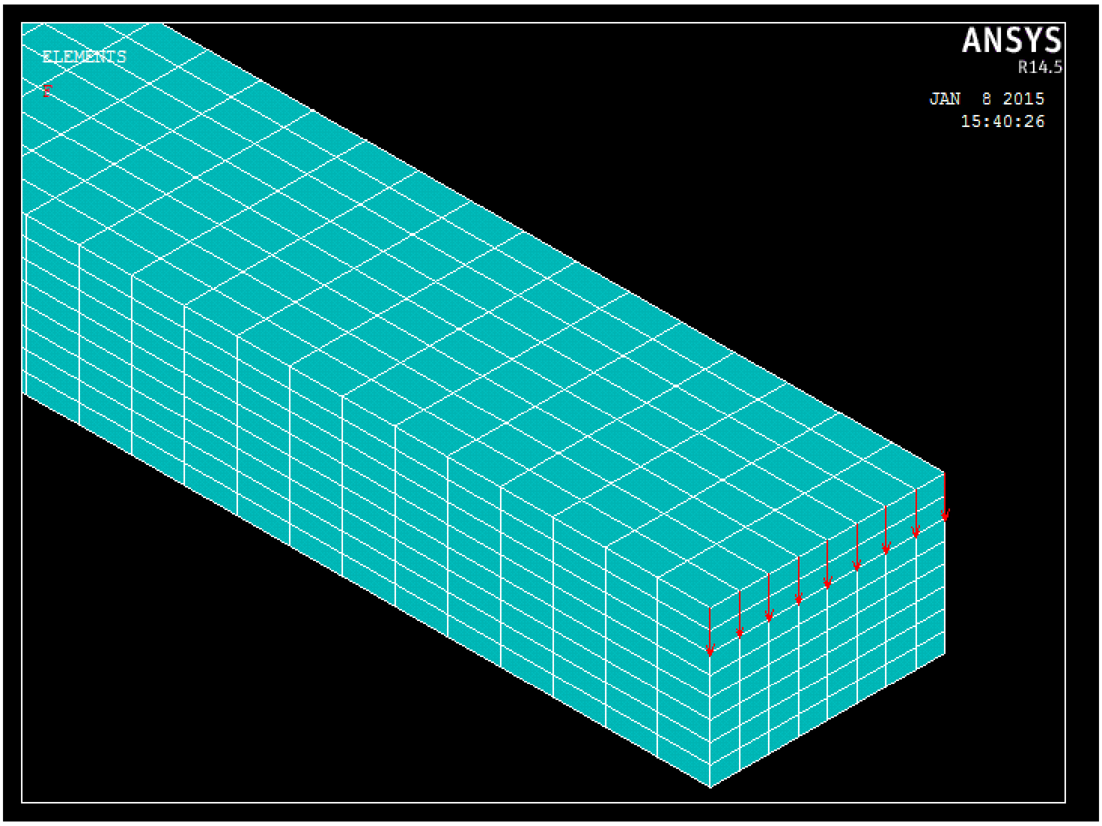


Fig-4: Fixed support with load

3.3 Deflection for composite leaf spring at varying thickness.

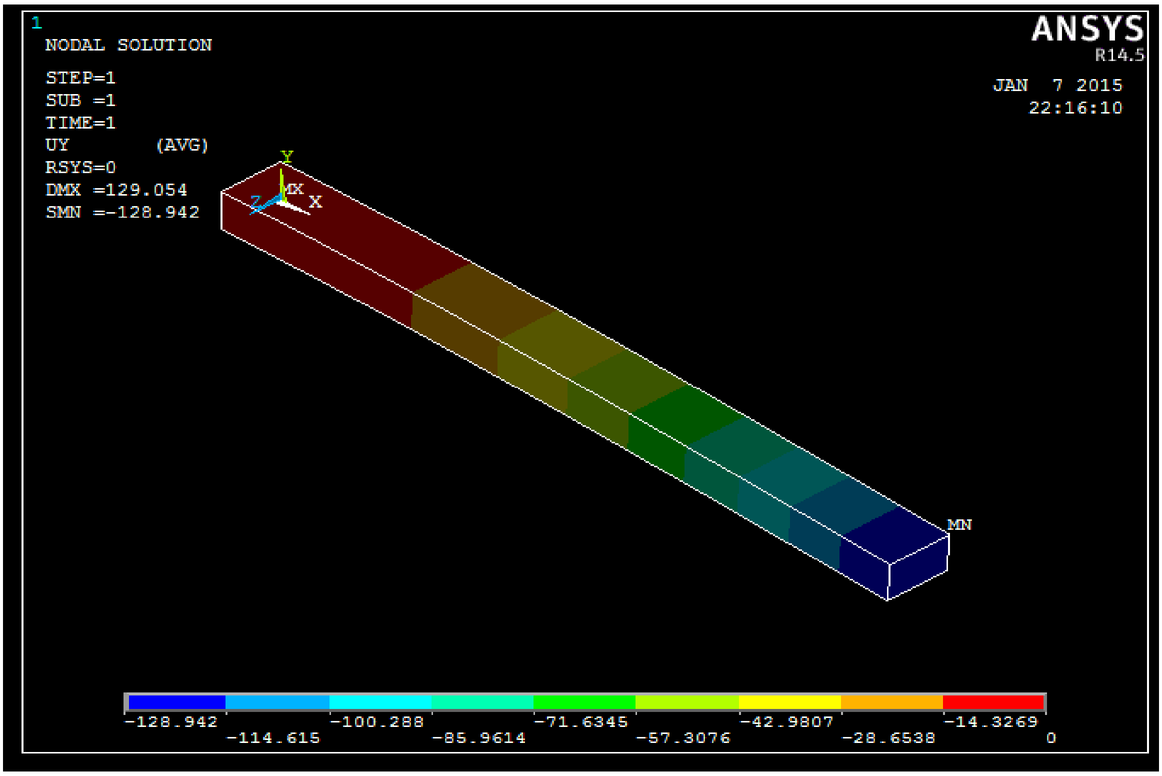


Fig-5: Deflection of Composite leaf spring at thickness 28mm

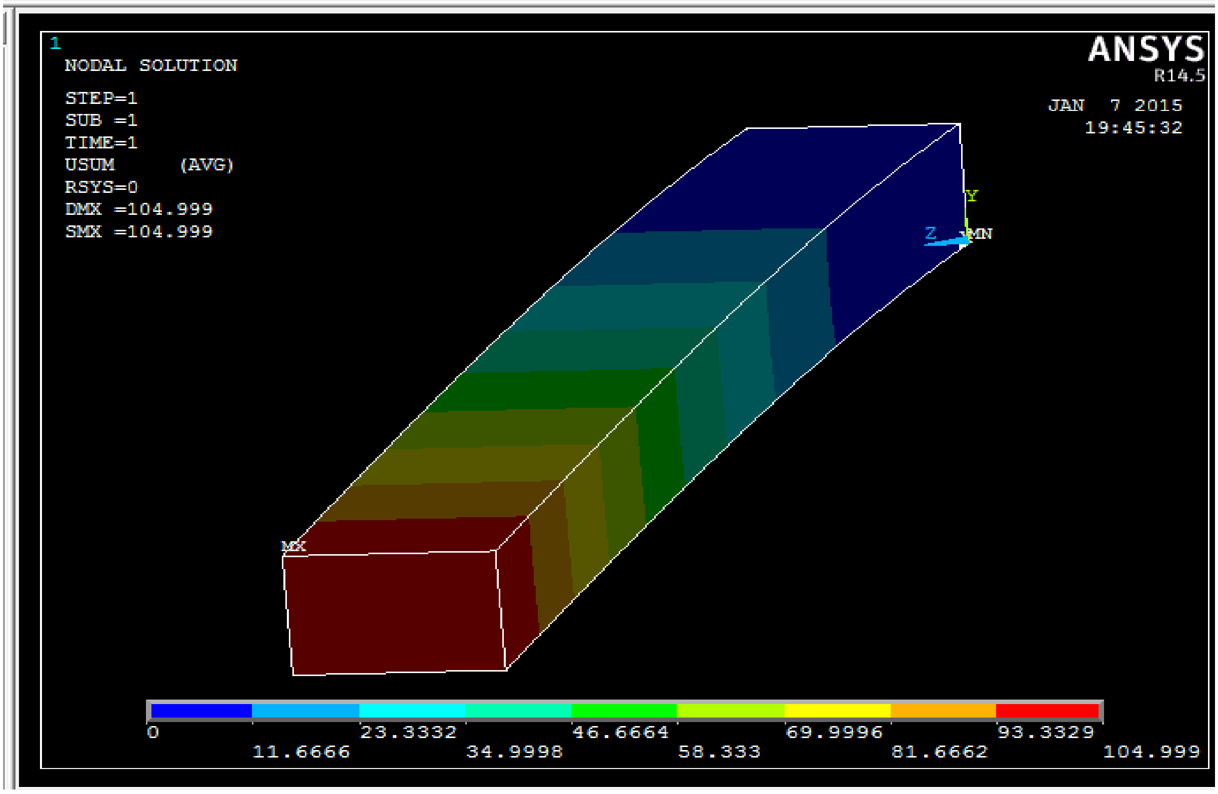


Fig-6: Deflection of Composite leaf spring at thickness 30mm

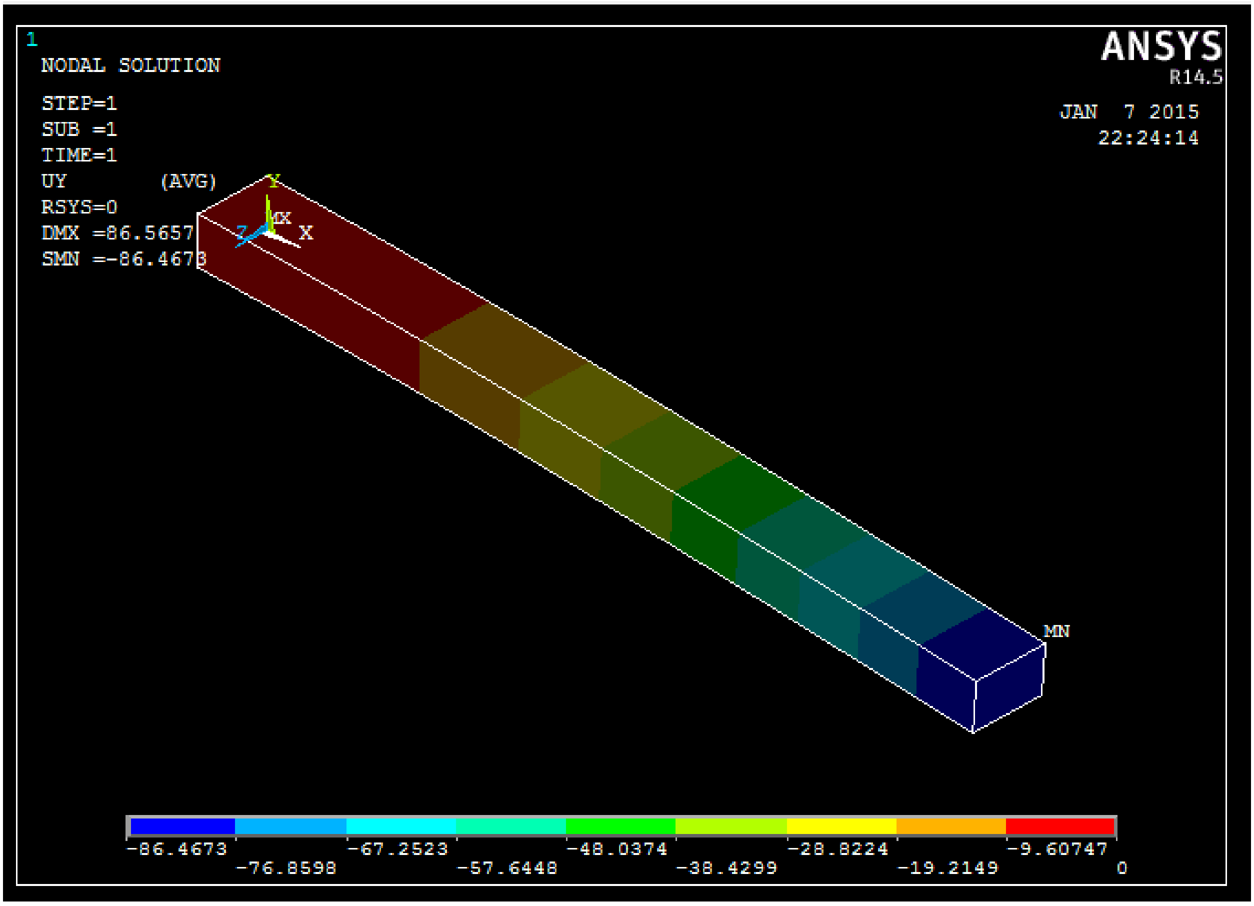


Fig-7: Deflection of Composite leaf spring at thickness 32mm

Fig-5, 6, 7 shows the deflection result of composite leaf is less as compared to conventional leaf spring.

Table-4: FEA results at load 300kg deflection of Composite leaf spring at thickness 28mm,30mm and 32mm.

Thickness mm	Deflection mm	
	Steel	Composite
28	152.52	129.054
30	119.49	104.999
32	96.33	86.565

3.4 Stress for Composite Leaf Spring at Varying Thickness

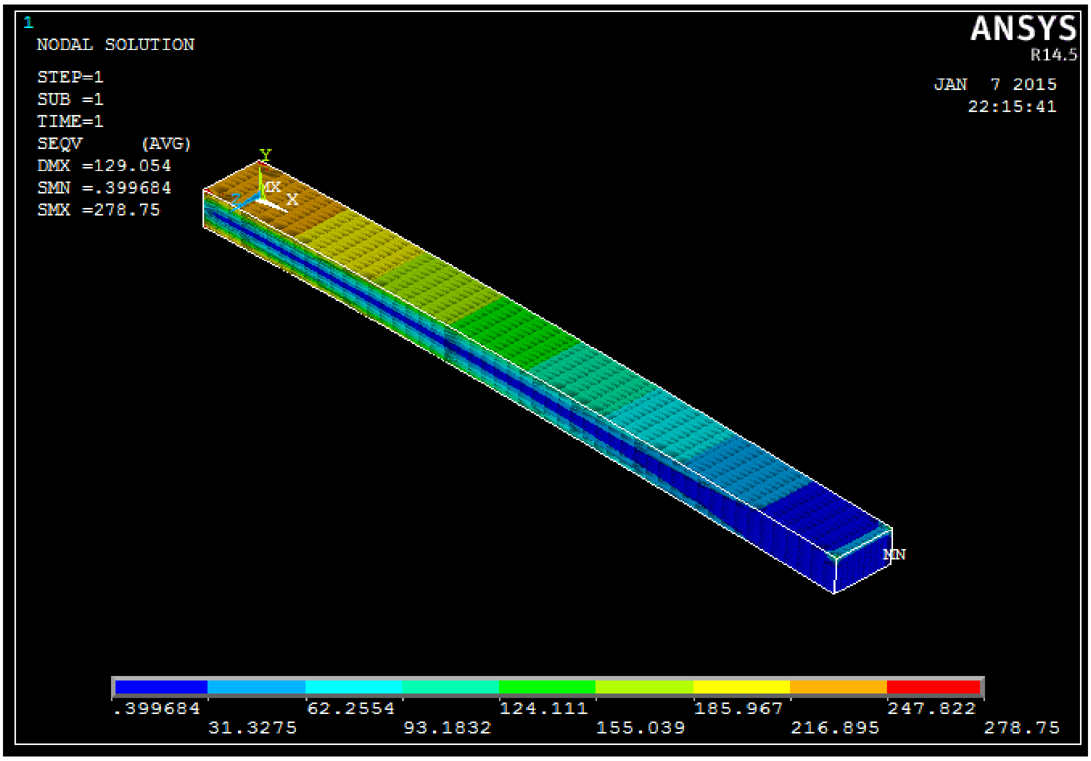


Fig-8: Stress of Composite leaf spring at thickness 28mm

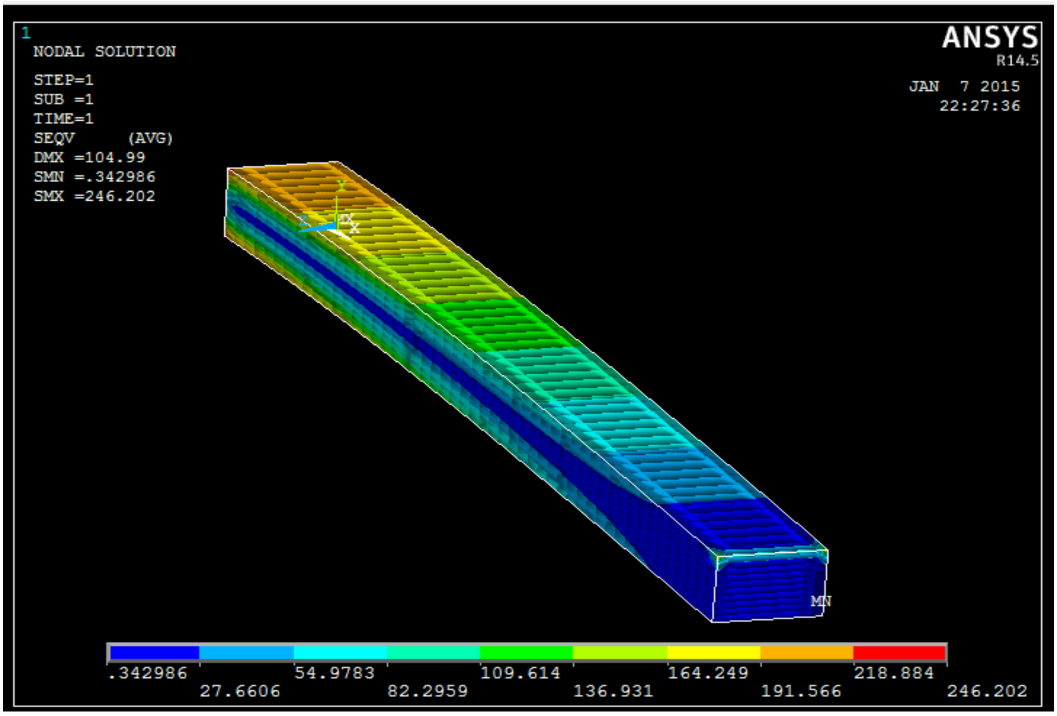


Fig-9: Stress of Composite leaf spring at thickness 30mm

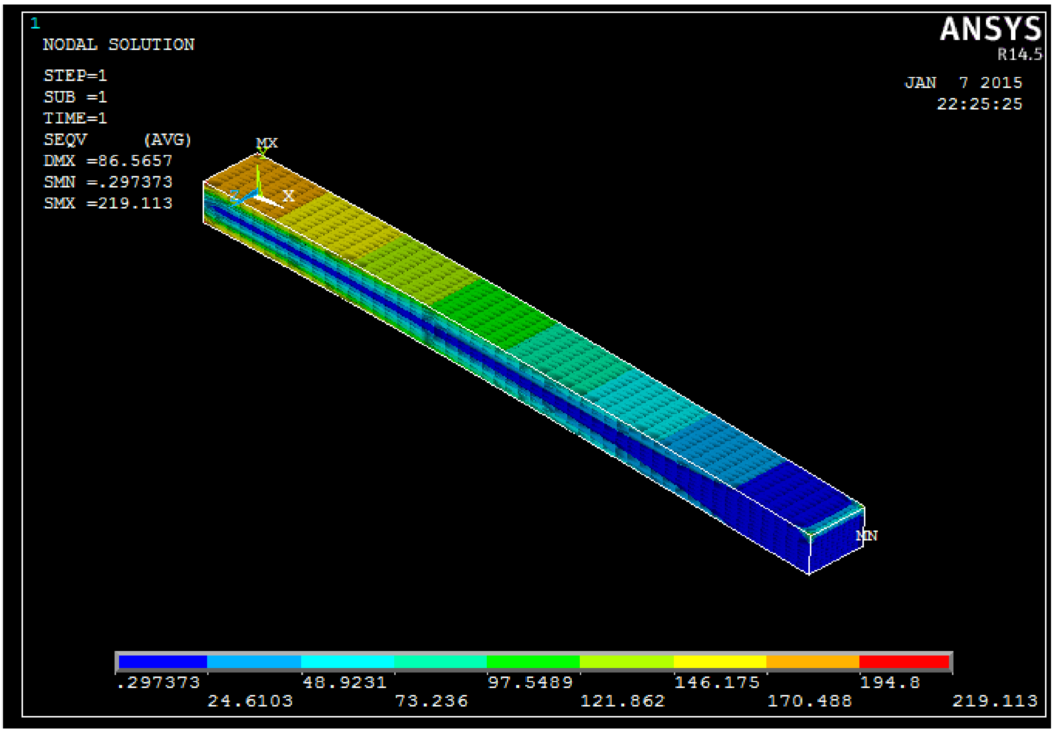


Fig-10: Stress of Composite leaf spring at thickness 32mm

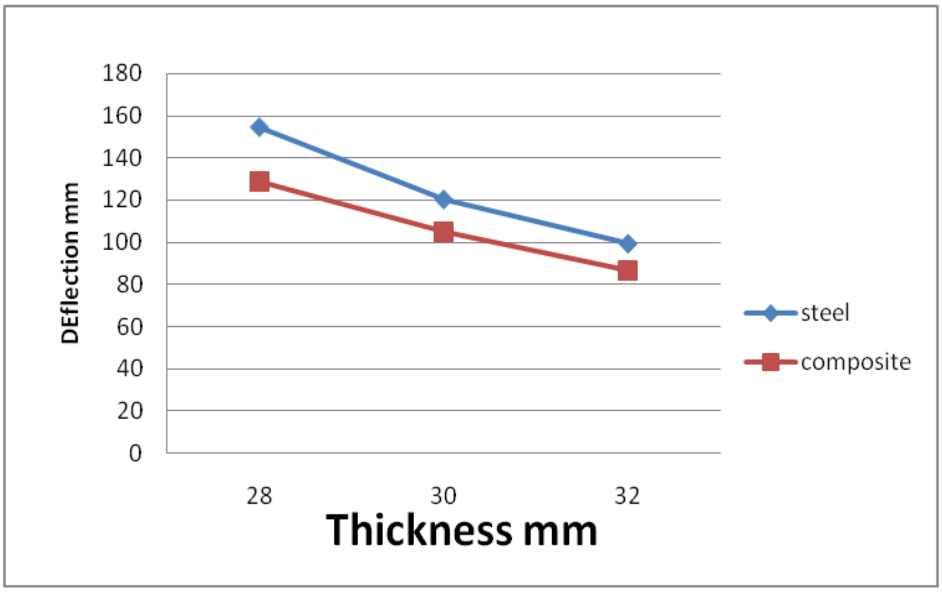
Fig- 8, 9, 10 shows the stresses result of composite leaf spring much lower as compared to conventional leaf spring at various thicknesses.

Table-5: FEA results at load 300kg Stresses of Composite leaf spring at thickness 28mm,30mm and 32mm

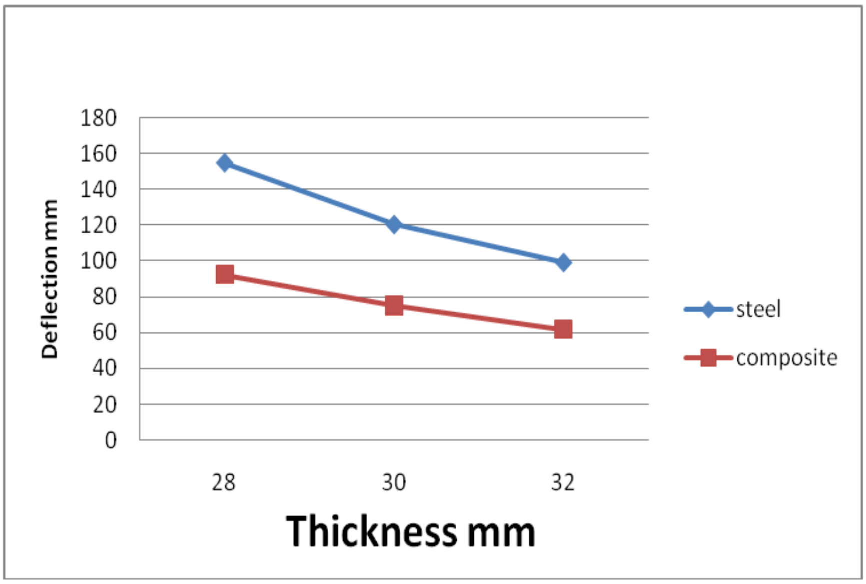
Thickness mm	Deflection mm	
	Steel	Composite
28	875.97	278.85
30	741.29	246.20
32	651.27	219.11

3.5. Graphical comparison of conventional and composite leaf spring

3.5.1 Thickness Vs Deflection

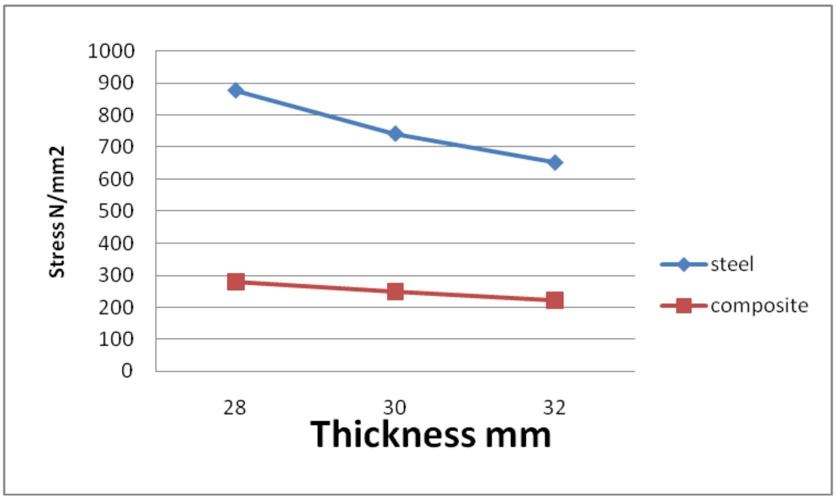


Graph-1: FEA Result

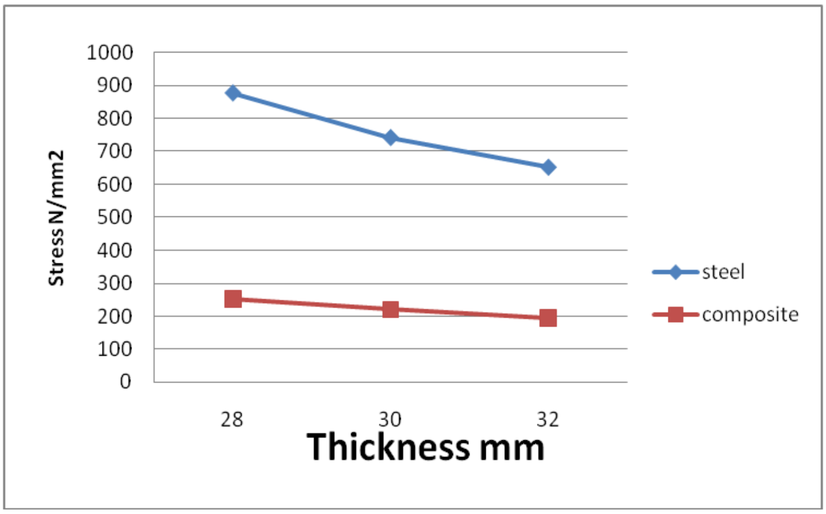


Graph-2: Experimental Result

3.5.2 Thickness Vs Stresses



Graph-3: FEA Result



Graph-4: Experimental Result

The above graph shows the great difference between the conventional leaf spring and composite leaf spring.

4. CONCLUSION

In the present research work a comparative study has been made of GFRC by varying thickness.GFRC leaf spring have been successfully fabricated by simple hand lay-up technique. Under static loading condition Defelction and stresses of GFRC are found with great difference with varying thickness.

FUTURE SCOPE

a) Analysis of leaf spring is done by varying width and varying thickness
b) Harmonic analysis with finding and compression of first five natural Frequencies.
c) As this analysis is under static load condition, so one can go for the analysis of composite & steel leaf spring under dynamic loading condition

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