Design and Analysis of Leaf Spring Using Composite Material

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ABSTRACT

Nowadays automobile industries are showing great interest in composite material rather than conventional materials due to its high strength to weight ratio, high strain energy storing capacity and corrosion resistance. Reducing the weight and keeping the same load carrying capacity and strength is becoming one of the important research issues today. Therefore automobile industries are manufacturing new vehicle which provide high efficiency and low cost for better fuel efficiency and comfort ride the weight reduction should be carried. It can be done by introducing composite material, new manufacturing techniques and by optimization of design. The material selected is glass fiber reinforced polymer (E-glass/epoxy) against conventional leaf spring (steel) it is design and analyzed by minimizing the weight. The main objective of this paper is verifying the results using ANSYS 12.1 and modeling in CATIA V5 software and showing stress and deflection results by theoretical calculations. The main constraints are stress, deflection and weight. Compared to conventional leaf spring ,composite leaf spring have lower value of stress and high natural frequency and strain energy .The weight reduction is 83% reduced compare to steel leaf spring.

Keywords*: CATIA V5, ANSYS 12.1, Leaf spring, FEA (finite element analysis), E-glass/epoxy*

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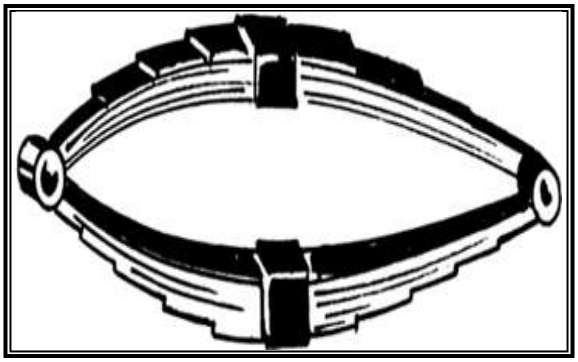
1. INTRODUCTION

In Automobile industries due to new innovations and competitions tends to modify the old parts with new advanced materials. In order to conserve economy and natural resources weight reduction is one of the important research issues today. In order to increase fuel efficiency and weight reduction new manufacturing technique, advanced composite material and design optimization is needed. A composite material is combination of fiber such as carbon, Kevlar, graphite or e-glass in matrix when they combined they shows excellent mechanical properties rather than individual .application of composites are marine engineering, space crafts, aircrafts etc. Leaf spring is one of the types of suspension system which absorbs shock and vibrations in automobile. It is one of the weight reduction parts which contribute for 10-20%of un-sprung weight.

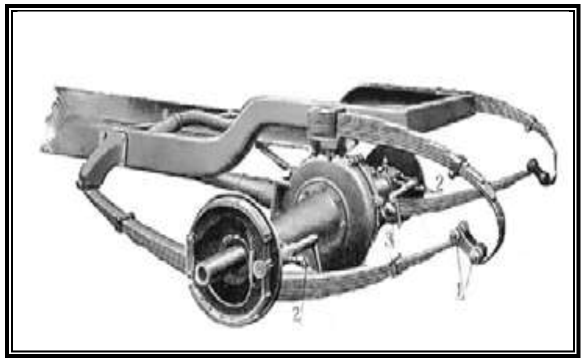
Introduction of composite leaf spring make possible to reduce weight and improving smooth ride comfort and fuel efficiency without reduction in load carrying capacity and stiffness.

Leaf spring is classified as:

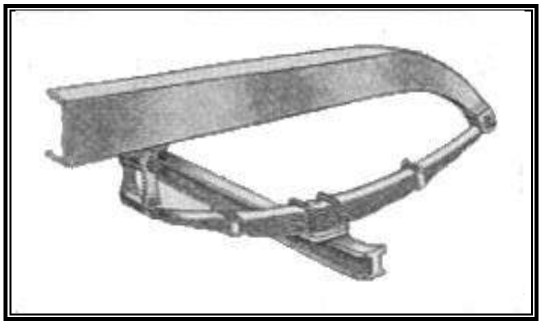
- Elliptic
- Three quarter elliptic
- Semi elliptic
- Quarter elliptic



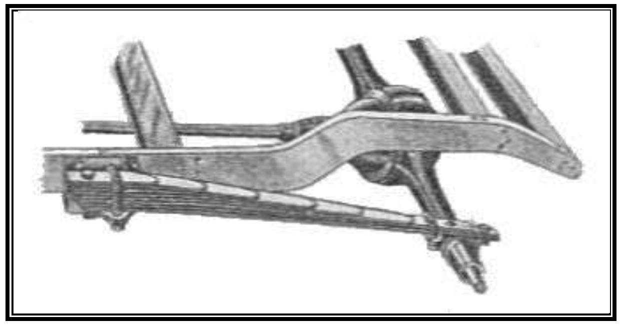
(a) Elliptic



(b) Three quarter elliptic



(c) Semi elliptic



(d) Quarter elliptic

Leaf spring is elastic spring body used as a type of suspension system in automobile .on application of load it get expanded and regain its original shape and size .Therefore initial curvature is provided so that they get straighten under the load .The leaves are held together with the help of centre bolt. The uppermost leaf is the main or master leaf and has a eye at the ends for supports. One part is connected with axle and other with shackle with the help of bush using antifriction material like bronze or rubber .rubber is more preferred due to non corrosive property. The number of leaves are provided to master leaf in the number of trimmed form called as graduated leaves .the master leaf has to withstand vertical load and the load due to sideway and twisting .rebound clip are provided at intermediate position so that graduated leaves will share the stress which on coming on the master leaf.

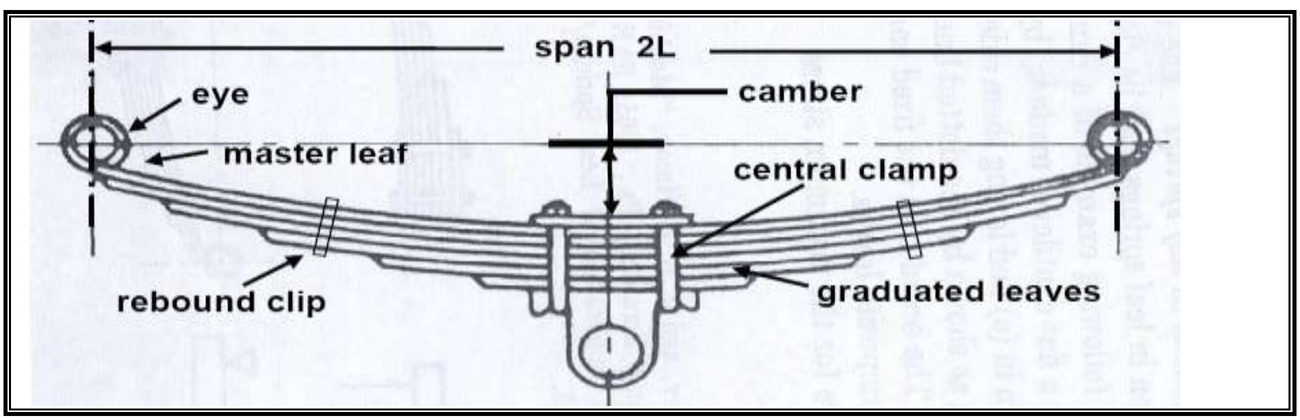


Fig-1: Parts of leaf spring

Theoretical calculation are performed by keeping the value of stiffness constant and verifying by calculation

$$\boldsymbol{stress}(\boldsymbol{\sigma}\mathbf{b}) = \frac{6\text{xWxL}}{\text{bxt\^{}2}}$$

$$y = \frac{\text{4XWXL \^{}3}}{\text{EXbXt \^{}3}}$$

$$U = \frac{\text{W\^{}2}}{\text{E X }\rho\text{\^{}2}}$$

W=total weight (kg);

L=span length (mm);

t=thickness of leaf spring;

Y=deflection (mm);

E=modulus of elasticity (Mpa)

U=strain energy (J)

ρ= density of material (kg/^3)

Young's modulus (Mpa)	2x10^5
μ	0.3
BHN	534-601
Su t (Mpa)	2000
Sy t (Mpa)	1800
ρ (kg/m^3)	7850

Table-1: Properties of steel material

1.1 Theory of Composite Material:-

The composite material used is E-glass /e-poxy.the composite is the combination of matrix and fiber which are insoluble with each other and maintains the physical phases. Matrix keep the fiber in desired position and orientation .matrix is more ductile than fiber and responsible for the toughness, fiber gives stiffness to the composite and keeps the (L/D) ratio high due to which there is effective distribution of load.

Why composite?

[1]. Low density
[2]. High strength
[3]. High young's modulus
[4]. Good fatigue strength
[5]. Good corrosion resistance
[6]. High abrasion and wear resistance

Ex(Mpa)	43000
Ey (Mpa)	6500
Ez(Mpa)	6500
μ xy	0. 27
μ yz	0.06

µ zx	0.06
G x (Mpa)	4500
G y(Mpa)	2500
G z(Mpa)	2500
P(kg/mm^3)	.000002

Table-2: Properties of E-glass/E-poxy

2. METHODOLOGY:-

The process of work and comparison between composite and steel is carried out. Weight reduction .stress, deflection strain energy, modulus of elasticity such parameters are calculated through the theoretical calculation and compare using software through modelling and analysis.

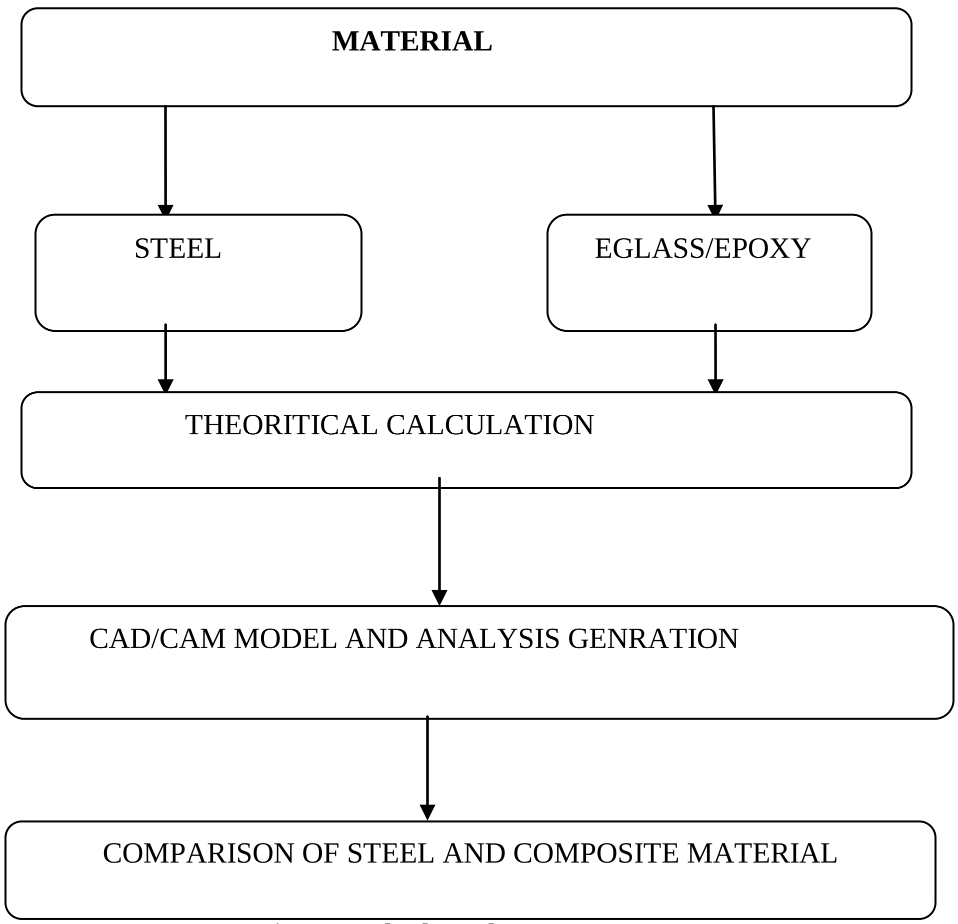


Fig-2: Work Flow Chart

3. LITERATURE REVIEW

[1]. U. S. Ramakant& K. Sowjanya [1] in their research paper they discussed the analysis of composite mono leaf spring made of E-glass. The deflection and stress distribution has been carried out. They observed that there is large deflection in the conventional spring than composite spring. steel leaf spring possesses more weight than composite leaf spring.

[2]. Shishay Amare Gebremeskel, [2] they found that work has been carried out on a multi leaf spring having nine leaves used by a commercial vehicle. It was having two full length leaves in which one is with eyed ends and seven graduated length leaves. The material of the leaf spring is E-glass. Bending stress and

deflection are the target results. A comparison of both i.e. experimental and FEA results have been conducted. When the leaf spring was fully loaded, the variation in the defection was 0.632 % in experimental and FEM results.

[3]. Dhoshi et al. [3] they discussed the analysis and the modification of the leaf spring used in tractor trailer using FEA. The theoretical calculations were use for finding out the correct dimensions of the multileaf spring for given loading conditions. The stress distribution was observed in FEA for the same spring modeled. It has been found that if number of leaf springs were reduced from 20 to 13 in this case there is not much difference in the stress distribution and also the design is safe. This can be achieve by weight reduction approximately by 6 Kg.. and cost reduction by 20%.

[4]. Shokrieh and Rezaei [4] they studied on optimization of the composite leaf spring. The FEA results were verified by the existing experimental solutions. Then shape and the weight optimization were carried out. It has been observed that E-glass saves the 80% of the weight

[5]. Venkatesan and Devrajan [5] in their paper they discussed the analysis of the composite leaf spring in vehicle . The objective of the work was to compare the load carrying capacity, stiffness and the weight reduction. The development of a composite leaf spring having constant cross sectional area, where the stress level at any station in the leaf spring has been considered constant due to the parabolic type of the thickness of the spring, has proved to be very effective. The study demonstrated that composites can be used for leaf springs for light weight vehicles and meet the requirements, together with substantial weight savings. The 3-D modelling of composite leaf spring is done and analyzed using ANSYS. A comparative study has been made between composite and steel leaf spring with respect to weight, cost and strength. From the results, it has been observed that the composite leaf spring is lighter and more economical than the conventional steel spring with similar design specifications. Composite leaf spring reduces the weight by 83 % for E-Glass/Epoxy, over conventional leaf spring.

[6]. Rahman et al. [6] in their work discussed the non linear analysis of the parabolic spring. This paper studied response of a leaf spring of parabolic shape, assumed to be made of highly elastic steel. Numerical simulation was carried out using both the small and large deflection theories to calculate the stress and the deflection of the same beam. Non-linear analysis has been found to have significant effect on the beam's response under a tip load. It has been seen that the actual bending stress at the fixed end, calculated by nonlinear theory, is 2.30-3.39 % less in comparison to a traditional leaf spring having the same volume of material. Interestingly, the maximum stress occurs at a region far away from the fixed end of the designed parabolic leaf spring.

4. RESULTS AND CONCLUSION:-

4.1 Von Mises Stress In Steel and E-Glass/Epoxy

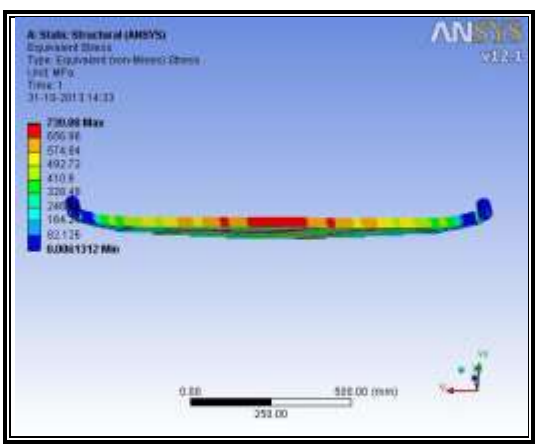


Fig 3: - Von Mises Stress 739.08 Mpa

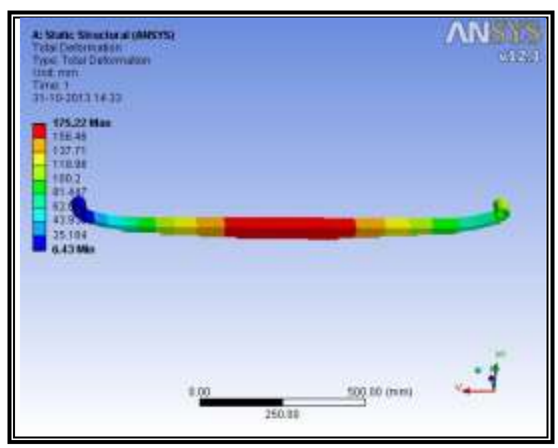


Fig 4: Von Mises Stress For E-Glass 237.4Mpa

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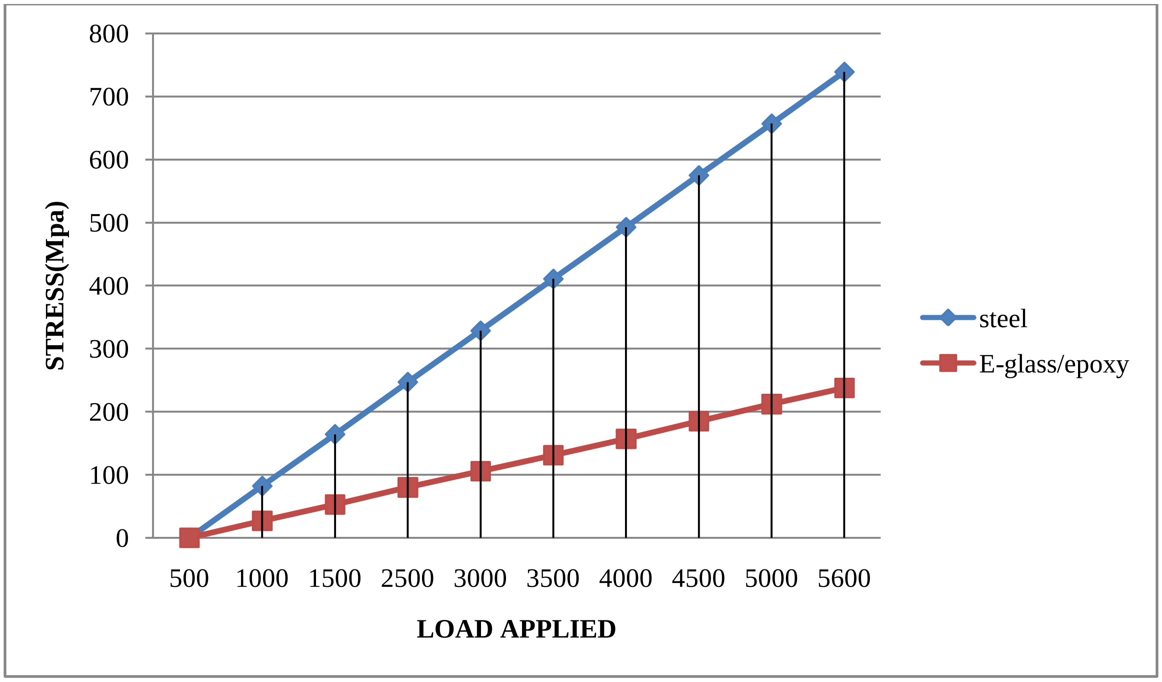


Fig 5:- Graphical representation 0f stress vs load applied

4.2 Deflection in Steel And E-Glass/Epoxy

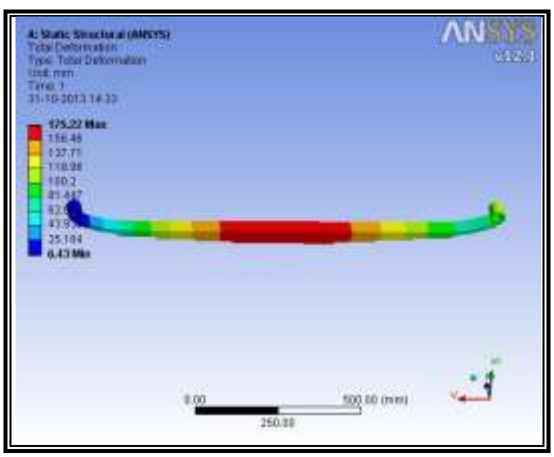


Fig 6: - maximum deflection in steel 176.22 mm

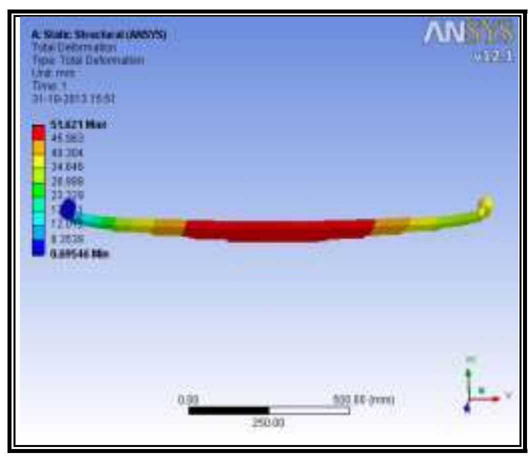


Fig 7: - Fig maximum deflection E-glass 51.621mm

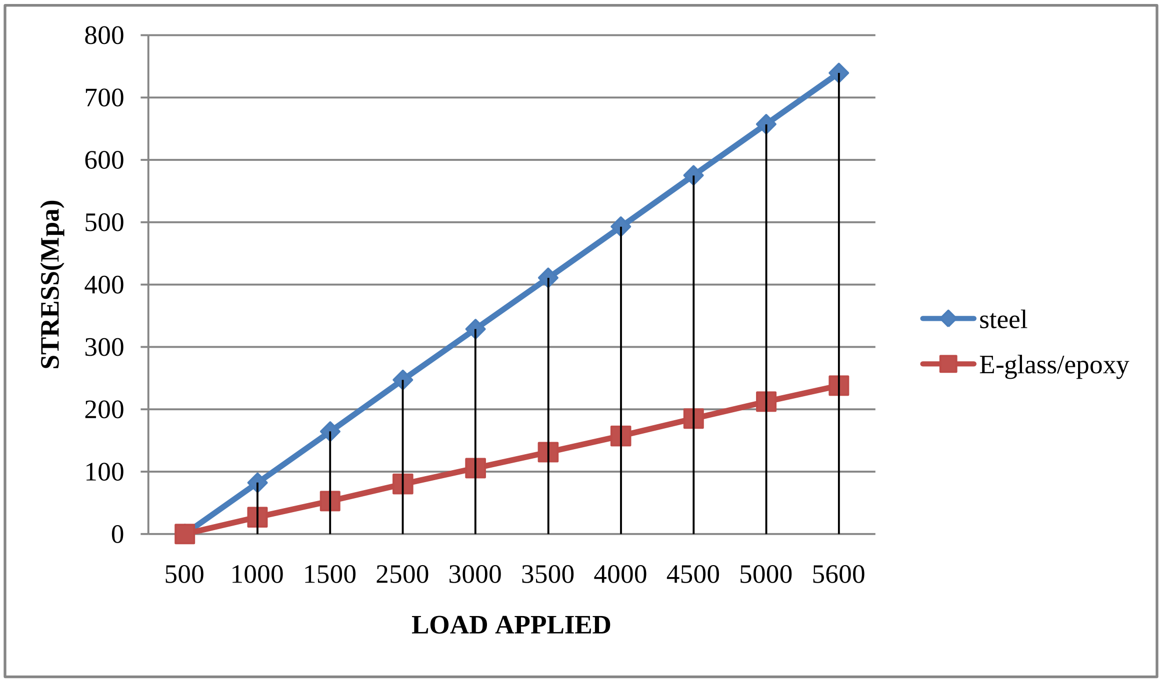


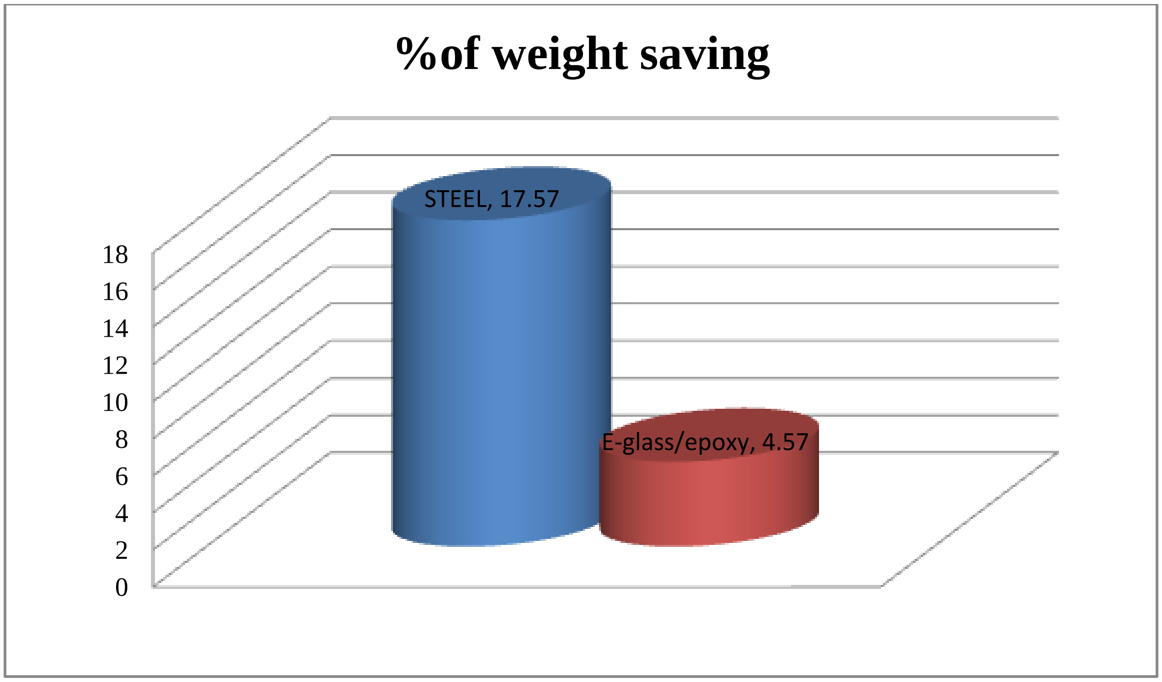
Fig 8:- graphical representation of maximum deflection vs load applied

material	Deflection(mm)	Stress(Mpa)	Weight(kg)
steel	176.22	739.08	17.56
	51.612	237.49	4.57

Table-3: Comparison Of Steel And E-Glass/Epoxy

4.3. Weight

The %of weight saving is directly influence of the fuel consumption and efficiency from this we can conclude that 74.94%of weight is saved by using composite material



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