DESIGN AND ANALYSIS OF FIBREGLASS COMPOSITE LEAF SPRING IN LIGHT WEIGHT VEHICLE

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ABSTRACT

The automobile industry has shown increased interest in the replacement of steel spring with fibreglass composite leaf spring due to high strength to weight ratio. Therefore, the aim of this paper is to present a low cost fabrication of complete mono composite leaf spring and mono composite leaf spring with bonded end joints. Also, General study on the analysis and design. A single leaf with variable thickness and width for constant cross sectional area of unidirectional glass fibre reinforced plastic (GFRP) with similar mechanical and geometrical properties to the multi leaf spring, is to be designed. The results is to show that unsprung width decreases hyperbolically and thickness increases linearly from the spring eyes towards the axle seat. The finite element results using ANSYS software showing stresses and deflections were to be verified with analytical. The design constraints were stresses and displacement.

Keywords: Glass Fibre, Leaf Spring, Pro/E, Ansys

I. INTRODUCTION

Material becomes a major factor in designing the springs. In order to conserve natural resources and economize energy, weight reduction has been the main focus of automobile manufacturer in the present scenario. Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes. The suspension leaf spring is one of the potential items for weight reduction in automobile as it accounts for ten to twenty percent of the un sprung weight. This helps in achieving the vehicle with improved riding qualities. It is well known that springs, are designed to absorb and store energy and then release it. Hence, the strain energy of the relationship of the specific strain energy can be expressed as

$$U = \frac{\sigma^2}{\rho E}$$

Where σ is the strength, ρ the density and E the Young's modulus of the spring material. It can be easily observed that material having lower modulus and density will have a greater specific strain energy capacity. The introduction of composite materials was made it possible to reduce the weight of the leaf spring with out any reduction on load carrying capacity and stiffness. Since; the composite materials have more elastic strain energy storage capacity and high strength-to-weight ratio as compared to those of steel. Several papers were devoted to the application of composite materials for automobiles. It studied the application of composite structures for automobiles and design optimization of a composite leaf spring. Great effort has been made by the automotive industries in the application of leaf springs made fromcomposite materials. It showed theintroduction of fiber reinforced plastics (FRP) made it possible to reduce the weight of a machine element without any reduction of the load carrying capacity. Because of FRP materials high elastic strain energy storage capacity and high strength-to-weight ratio compared with those of steel, multi-leaf steel springs are being replaced by mono leaf

FRP springs. In every automobile, i.e. four wheelers and railways, the leaf spring is one of the main components and it provides a good suspension and it plays a vital role in automobile application. 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.

II. MATERIALS USED FOR MONO COMPOSITE LEAF SPRING

2.1 Fiberglass

Fiberglass, (also called fiberglass and glass fiber), is material made from extremely fine fibers of glass. It is used as a reinforcing agent for many polymer products; the resulting composite material, properly known as fiber-reinforced polymer (FRP) or glass-reinforced plastic (GRP), is called "fiberglass" in popular usage. Glassmakers throughout history have experimented with glass fibers, but mass manufacture of fiberglass was only made possible with the invention of finer machine tooling. In 1893, Edward Drummond Libbey exhibited a dress at the World's Columbian Exposition incorporating glass fibers with the diameter and texture of silk fibers. This was first worn by the popular stage actress of the time Georgia Cayvan. What is commonly known as "fiberglass" today, however, was invented in 1938 by Russell Games Slayers of Owens-Corning as a material to be used as insulation. It is marketed under the trade name Fiberglas, which has become a generic zed trademark. A somewhat similar, but more expensive technology used for applications requiring very high strength and low weight is the use of carbon fiber.

2.2 Fiber Formation

Glass fiber is formed when thin strands of silica-based or other formulation glass is extruded into many fibers with small diameters suitable for textile processing. The technique of heating and drawing glass into fine fibers has been known for millennia; however, the use of these fibers for textile applications is more recent. Until this time all fiberglass had been manufactured as staple (a term used to describe naturally formed clusters or locks of wool fibers). The first commercial production of fiberglass was in 1936. In 1938 Owens-Illinois Glass Company and Corning Glass Works joined to form the Owens-Corning Fiberglas Corporation. When the two companies joined to produce and promote fiberglass, they introduced continuous filament glass fibers. Owens-Corning is still the major fiberglass producer in the market today.

The types of fiberglass most commonly used are mainly E-glass (alumino-borosilicate glass with less than 1 wt% alkali oxides, mainly used for glass-reinforced plastics), but also A-glass (alkali-lime glass with little or no boron oxide), E-CR-glass (alumino-lime silicate with less than 1 wt% alkali oxides, has high acid resistance), C-glass (alkali-lime glass with high boron oxide content, used for example for glass staple fibers), D-glass (borosilicate glass with high dielectric constant), R-glass (alumino silicate glass without MgO and CaO with high mechanical requirements), and S-glass (alumino silicate glass without CaO but with high MgO content with high tensile strength).

2.3 Properties

Glass fibers are useful because of their high ratio of surface area to weight. However, the increased surface area makes them much more susceptible to chemical attack. By trapping air within them, blocks of glass fiber make good thermal insulation, with a thermal conductivity of the order of 0.05 W/(m·K).

The strength of glass is usually tested and reported for "virgin" or pristine fibers—those which have just been manufactured. The freshest, thinnest fibers are the strongest because the thinner fibers are more ductile. The more the surface is scratched, the less the resulting tenacity. Because glass has an amorphous structure, its properties are the same along the fiber and across the fiber. Humidity is an important factor in the tensile strength. Moisture is easily adsorbed, and can worsen microscopic cracks and surface defects, and lessen tenacity. In contrast to carbon fiber, glass can undergo more elongation before it breaks. There is a correlation between bending diameter of the filament and the filament diameter. The viscosity of the molten glass is very important for manufacturing success. During drawing (pulling of the glass to reduce fiber circumference), the viscosity should be relatively low. If it is too high, the fiber will break during drawing. However, if it is too low, the glass will form droplets rather than drawing out into fiber.

III. METHODOLOGY

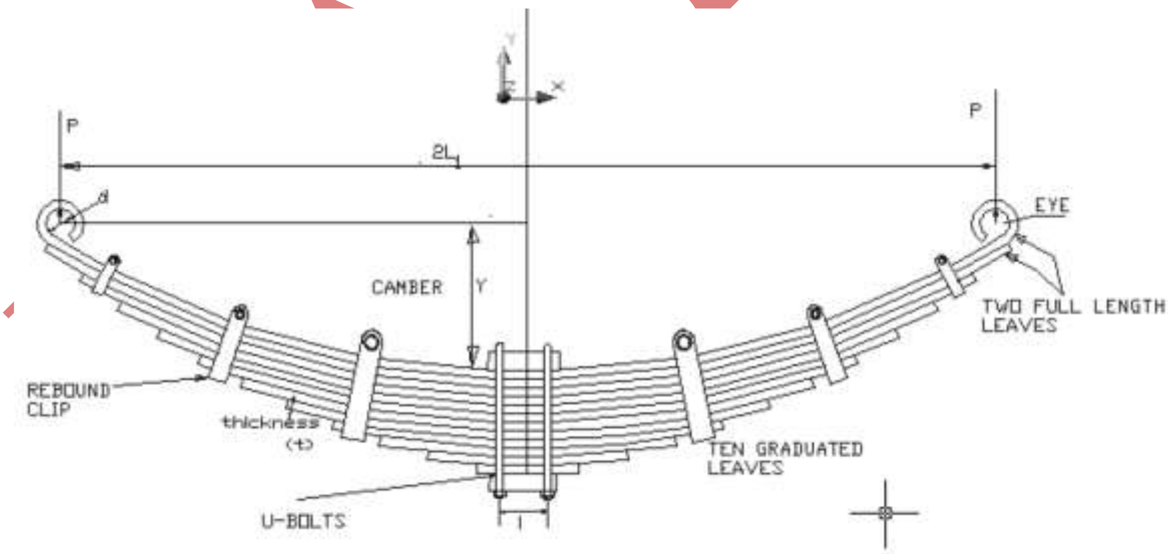
3 .1 Designs of Composite Mono Leaf Spring:

Considering several types of vehicles that have leaf springs and different loading on them, various kinds of composite leaf spring have been developed. In multi-leaf composite leaf spring, the interleaf spring friction plays a spoil spot in damage tolerance. It has to be studied carefully.

The following cross-sections of mono-leaf composite leaf spring for manufacturing easiness are considered.

1. Constant thickness, constant width design.
2. Constant thickness, varying width design.
3. Varying width, varying thickness design.

PROCEDURE:



IV. RESULTS& DISCUSSION

4.1 Finite Element Method using Pro/ENGINEER and ANSYS

Experimental results from testing the leaf springs under static loading containing the stresses and deflection are listed in the Table. These results are also compared with FEA in Table. Testing has been done for unidirectional mono composite leaf spring only. Since the composite leaf spring is able to withstand the static load, it is concluded that there is no objection from strength point of view also, in the process of replacing the conventional leaf spring by composite leaf spring. The major disadvantages of composite leaf spring are chipping resistance. The matrix material is likely to chip off when it is subjected to a poor road environments (that is, if some stone hit the composite leaf spring then it may produce chipping) which may break some fibers in the lower portion of the spring. This may result in a loss of capability to share flexural stiffness. But this depends on the condition of the road. In normal road condition, this type of problem will not be there. Composite leaf springs made of polymer matrix composites have high strength retention on ageing at severe environments. The steel leaf spring was replaced with an composite one. The objective was to obtain a spring with minimum weight which is capable of carrying given static external forces by constraints limiting stresses and displacements. The weight of the leaf spring is reduced. Thus, the objective of the unsprung mass is achieved to a larger extent. The stresses in the composite leaf spring are much lower than that of the steel spring.

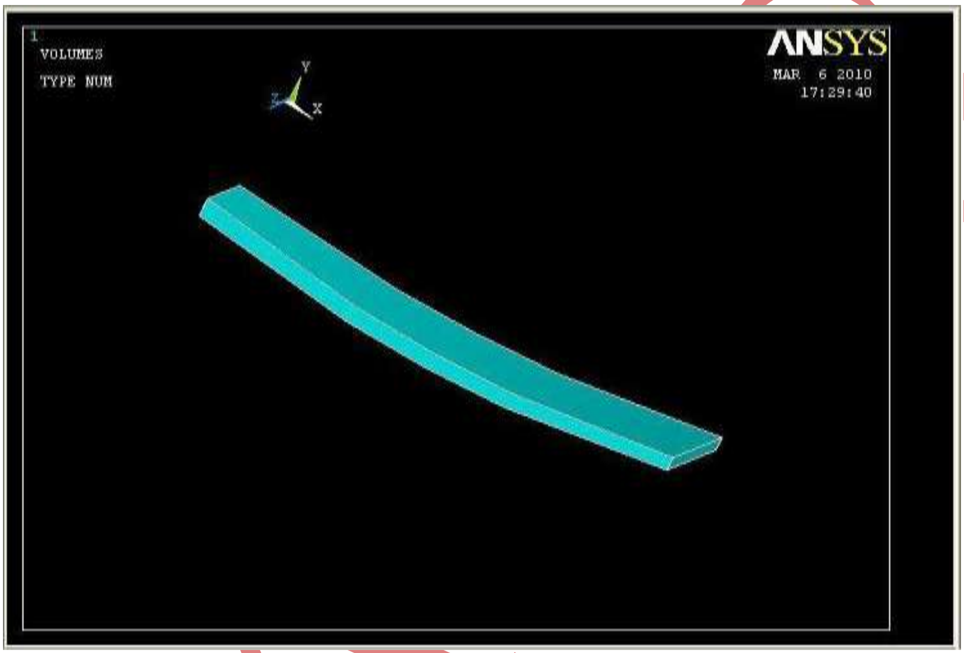


FIG.1: FEA MODEL

4.2 Create the FEA Model

In the pull-down menu at the top of the Pro/E window, select *Applications >Mechanica* An information window opens up to remind you about the units you are using. Press Continue In the MECHANICA menu at the right, check the box beside FEM Mode and select the command Structure. A new toolbar appears on the right of the screen that contains icons for creating all the common modeling entities (constraints, loads, idealizations). All these commands are also available using the command windows that will open on the right side of the screen or in dialog windows that will open when appropriate. Notice that a small green coordinate system WCS has appeared. This is how you will specify the directions of constraints and forces. Other coordinate systems (e.g. cylindrical) can be created as required and used for the same purpose. The MEC STRUCT menu appears on the right. Basically, to define the model we proceed down this menu in a top-down manner. Model is already selected for you which opens the STRC MODEL menu. This is where we specify modeling information. We proceed in a top-down manner. The Features command allows you to create additional simulation features like datum points, curves, surface regions, and so on. Idealizations let you create special modeling entities like shells and beams. The Current CSYS command lets you create or select an alternate coordinate system for specifying directions of constraints and loads.

4.3 Assigning Materials

Our last job to define the model is to specify the part material. In the STRC MODEL menu, select

Materials > Whole Part

In the library dialog window, select a material and move it to the right pane using the triple arrow button in the center of the window. In an assembly, you could now assign this material to individual parts. If you select the Edit button, you will see the properties of the chosen material. At this point, our model has the necessary information for solution (constraints, loads, material).

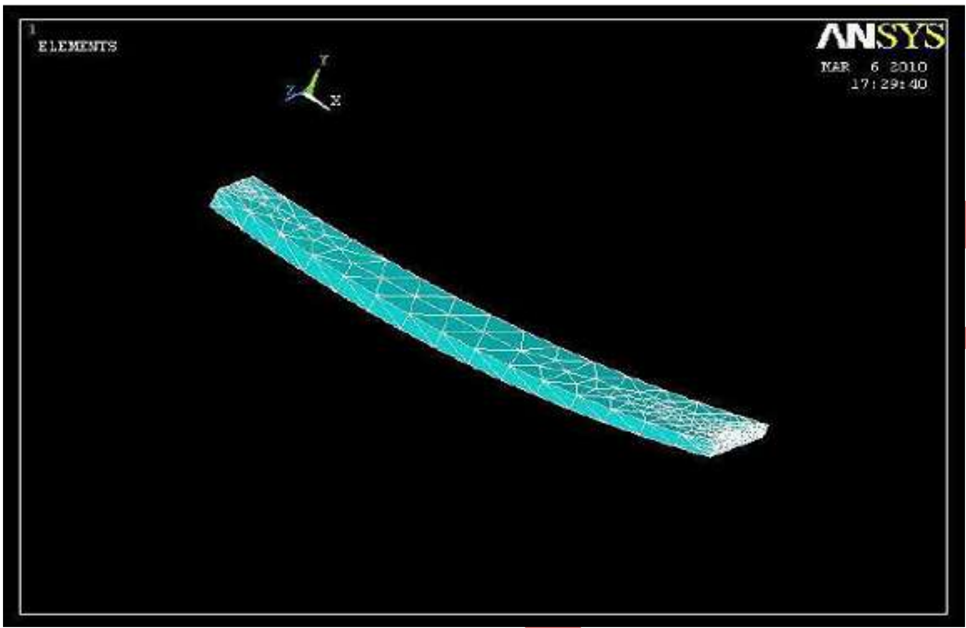


FIG.2: FEA MESH

4.4 Viewing the Results

There are myriad possibilities for viewing FEM results. A common one is the following:

General Postprocessor > Plot Results > Contour Plot > Nodal Solution.

Pick the Von Mises stress values, and select Apply. You should now have a color fringe plot of the Von Mises stress displayed on the model.

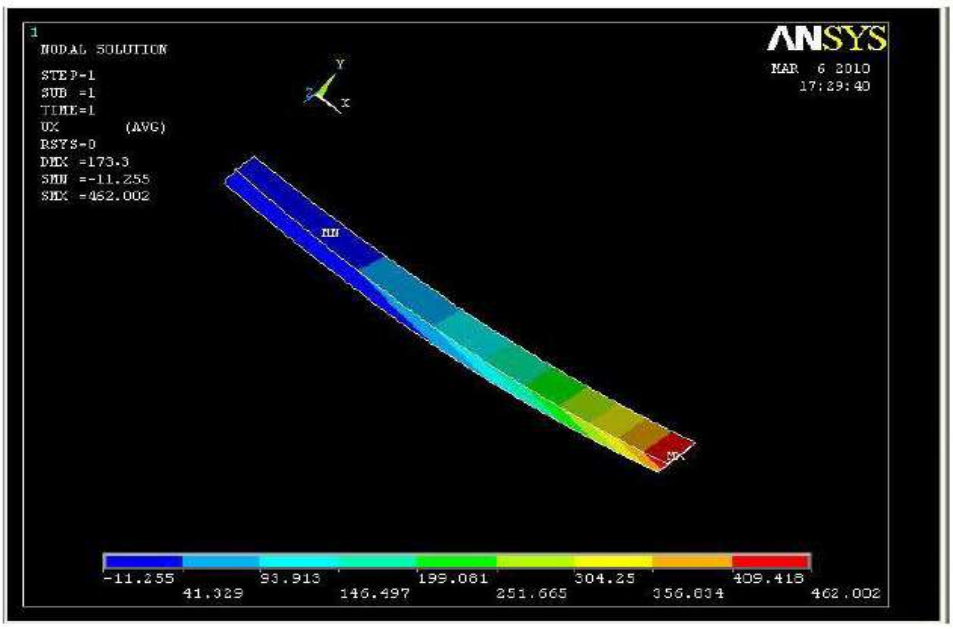


Fig.3: Stress Distribution for A-Glass Fiber Leaf Spring

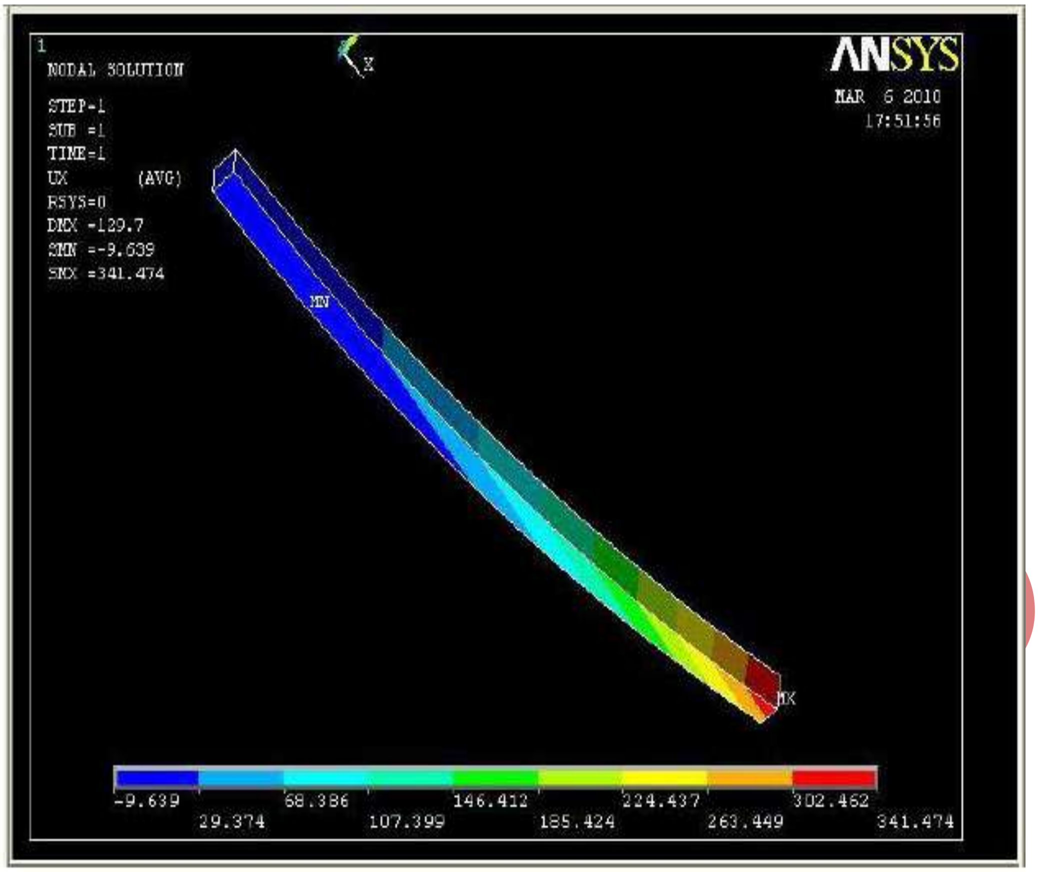


Fig.4: Stress Distribution for C-Glass Fiber Leaf Spring

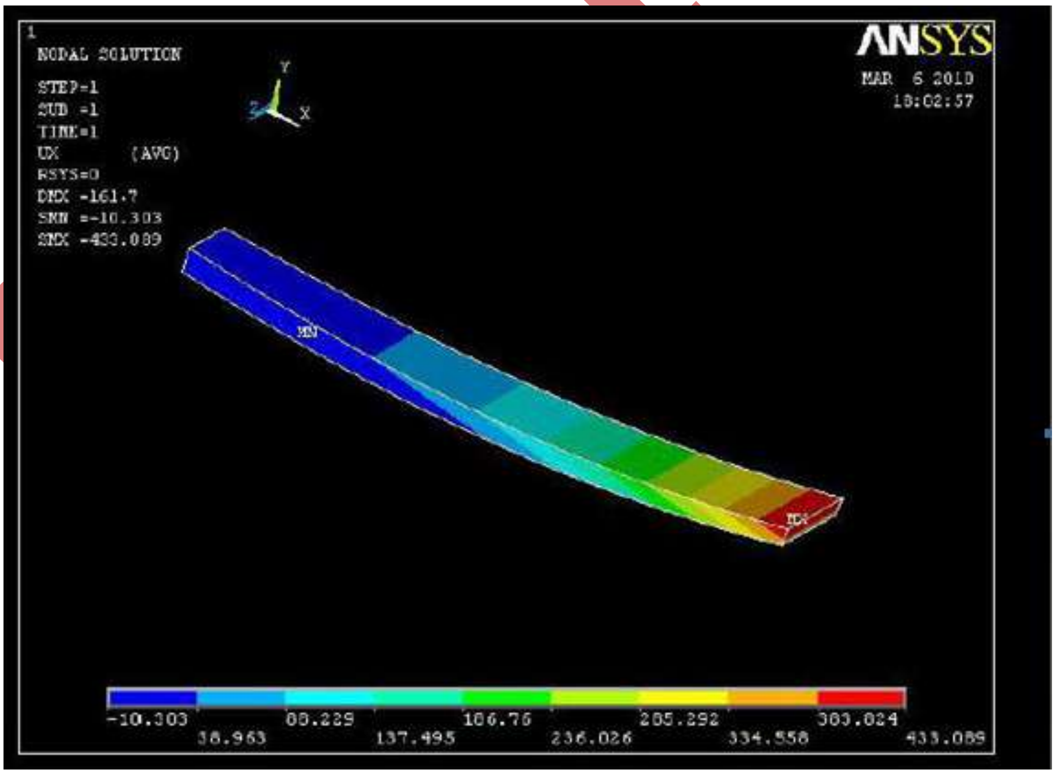


Fig.5 Stress Distribution for D- Glass Fiber Leaf Spring

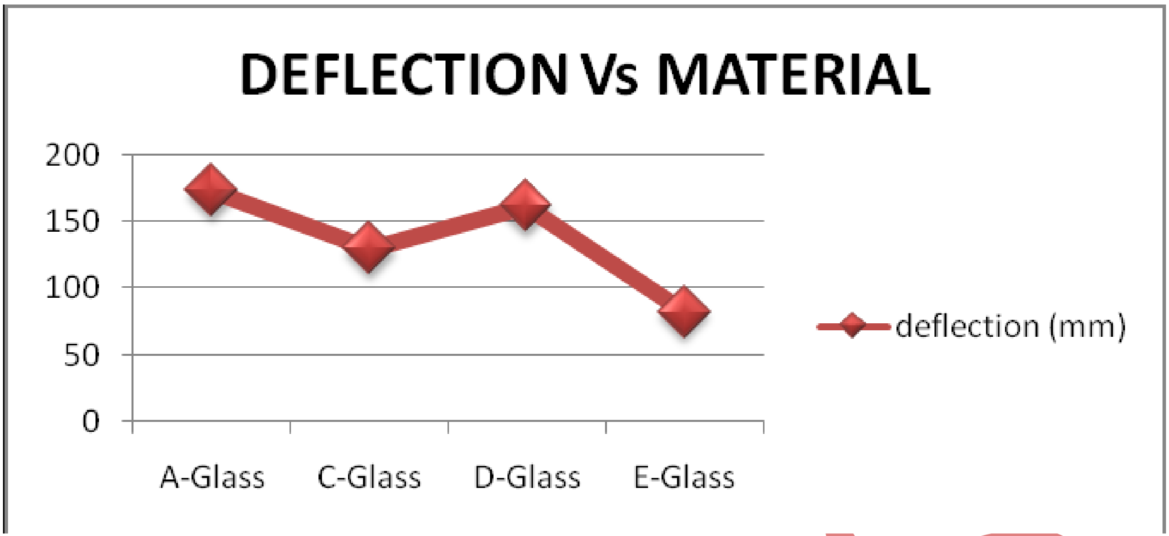


Fig 7 Deflection Vs Materials

Material	Static load (N)	Maximum deflection (mm)	Maximum stress (MPa)
Steel	4000	210.2	534.02
Fiber Generic A-Glass	4000	173.3	462.002
Fiber Generic C-Glass	4000	129.7	341.474
Fiber Generic D-Glass	4000	161.7	433.089
Fiber Generic E-Glass	4000	82.2	217.217

Table 1: Comparison Result of Load, Deflection & Stress

V. CONCLUSION

The development of a composite mono leaf spring having constant cross sectional area, where the stress level at any station in the leaf spring is 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 both steel and 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 .The analytical results were compared with FEA and the results show good agreement with test results. From the results, it is observed that the composite leaf spring is lighter and more economical than the conventional steel spring with similar design specifications. Adhesively bonded end joints enhance the performance of composite leaf spring for delamination and stress concentration at the end in compare with bolted joints.

REFERENCES

[1] **Rajendran, I., Vijayarangan, S.** Design and Analysis of a Composite Leaf Spring *Journal of Institute of Engineers* India 82 2002: pp. 180 – 187.

[2] **Dharam, C. K.** Composite Materials Design and Processes for Automotive Applications. The ASME Winter Annual Meeting, San Francisco, December 10-15, 1978.

[3] **Vijayarangan, S., Ganesan, N.** Static Stress Analysis of a Composite Bevel Gear using a Three-dimensional Finite Element Method *Computer Structures* 51 (6) 1994.

[4] **Tanabe, K., Seino, T., Kajio, Y.** Characteristics of Carbon/Glass Fiber Reinforced Plastic Leaf Spring,

[5] **Jones, R. M.** Mechanics of Composite Materials. 2e, McGraw-Hill Book Company, 1990.

[6] **ANSYS Inc**: ANSYS Users Manual, Rev. 1995, 5.2-Vol. I –Houston, PA.