Nat. Volatiles & Essent. Oils, 2021; 8(6): 6220-6229

Mechanical Characteristics And Analysis Of Composite Leaf Spring Reinforced With Aluminium

R. Anand[1] , Nibros faruk[2] , Aravind Yuvaraj[3]

[1,3]Assistant Professor, Department of Mechanical Engineering.

[,2]Assistant Professor, Department of Aeronauticall Engineering Dhanalakshmi Srinivasan College of Engineering and Technology, Mamallapuram.

ABSTRACT

The subject gives a brief look on the suitability of composite leaf spring on vehicles and their advantages. Efforts have been made to reduce the cost of composite (Glass fibre reinforced with Aluminium) leaf spring to that of steel leaf spring. The achievement of weight reduction with adequate improvement of mechanical properties has made composite a very replacement material for convectional steel. Material and manufacturing process are selected upon on the cost and strength factor. The design method is selected on the basis of mass production. Also found the suitable ratio (50:50, 65:35 & 60:40) of glass fibre – epoxy. From the comparative project, it is seen that the composite leaf spring are higher and more economical than convectional leaf spring.

Keywords: composite (GFRP) , w

INTRODUCTION

In order to conserve natural resources and economize energy, weight reduction has been the main focus of automobile manufacturers 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 automobiles as it accounts for 10% - 20% of the unsprung weight. This achieves the vehicle with more fuel efficiency and improved riding qualities.

Originally called laminated or carriage spring, **leaf spring** is a simple form of spring, commonly used for the suspension in wheeled vehicles. It is also one of the oldest forms of springing, dating back to medieval times.An advantage of a leaf spring over a helical spring is that the end of the leaf spring may be guided along a definite path.

The introduction of composite materials was made it possible to reduce the weight of leaf spring without 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 with those of steel, multi-leaf steel springs are being replaced by mono-leaf **composite** springs. The composite material offer opportunities for substantial weight saving but not always be cost-effective over their steel counterparts.

Fortunately, composites have these characteristics. Fatigue failure is the predominant mode of in-service failure of many automobile components. This is due to the fact that the automobile components are subjected to variety of fatigue loads like shocks caused due to road irregularities traced by the road wheels, the sudden loads due to the wheel traveling over the bumps etc. The leaf springs are more affected due to fatigue loads, as they are apart of the unstrung mass of the automobile.

The fatigue behavior of Glass Fiber Reinforced Plastic (GFRP) epoxy composite materials has been studied in the past. Theoretical equation for predicting fatigue life is formulated using fatigue modulus and its degrading rate. This relation is simplified by strain failure criterion for practical application. A prediction method for the fatigue strength of composite structures at an arbitrary combination of frequency, stress ratio and temperature has been presented. These studies are limited to mono-leaf springs only. In the present work, a seven-leaf steel spring used in passenger cars is replaced with a composite multi leaf spring made of glass/epoxy composites. The dimensions and the number of leaves for both steel leaf spring and composite leaf springs are considered to be the same.

LITERATURE REVIEW

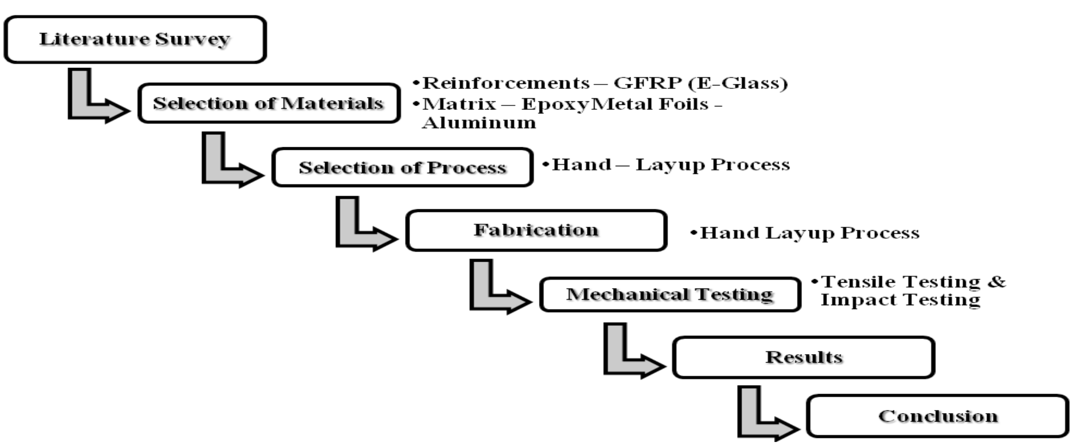
Investigation of composite leaf spring in the early 60's failed to yield the production facility because of inconsistent fatigue performance and absence of strong need for mass reduction. Researches in the area of automobile components have been receiving considerable attention now. Particularly the automobile manufacturers and parts makers have been attempting to reduce the weight of the vehicles in recent years. Emphasis of vehicles weight reduction in 1978 justified taking a new look at composite springs. Studies are made to demonstrate viability and potential of FRP in automotive structural application. The development of a liteflex suspension leaf spring is first achieved. Based on consideration of chipping resistance base part resistance and fatigue resistance, a carbon glass fiber hybrid laminated spring is constructed. A general discussion on analysis and design of constant width, variable thickness, composite leaf spring is presented. The fundamental characteristics of the double tapered FRP beam are evaluated for leaf spring application. Recent developments have been achieved in the field of materials improvement and quality assured for composite leaf springs based on microstructure mechanism. All these literature report that the cost of composite; leaf spring is higher than that of steel leaf spring. Hence an attempt has been made to fabricate the composite leaf spring with the same cost as that of steel leaf spring. Material properties and design of composite structures are reported in many literatures. Very little information are available in connection with finite element analysis of leaf spring in the literature, than too in 2D analysis of leaf spring. At the same time, the literature available regarding experimental stress analysis more.

Mahmood M Shokrieh et al , A four-leaf steel spring used in the rear suspension system of light vehicles is analyzed using ANSYS V5.4 software. The finite element results showing stresses and deflections verified the existing analytical and experimental solutions. Using the results of the steel leaf spring, a composite one made from fiberglass with epoxy resin is designed and optimized using ANSYS. Main consideration is given to the optimization of the spring geometry. The objective was to obtain a spring with minimum weight that is capable of carrying given static external forces without failure. The design constraints were stresses (Tsai–Wu failure criterion) and displacements. The results showed that an optimum spring width decreases hyperbolically and the thickness increases linearly from the spring eyes towards the axle seat. Compared to the steel spring, the optimized composite spring has stresses that are much lower, the natural frequency is higher and the spring weight without eye units is nearly 80% lower.

J.P. Hou et al , This paper presents the design evolution process of a composite leaf spring for freight rail applications. Three designs of eye-end attachment for composite leaf springs are described. The material used is glass fibre reinforced polyester. Static testing and finite element analysis have been carried out to obtain the characteristics of the spring. Load–deflection curves and strain measurement as a function of load for the three designs tested have been plotted for comparison with FEA predicted values. The main concern associated with the first design is the delamination failure at the interface of the fibres that have passed around the eye and the spring body, even though the design can withstand 150 kN static proof load and one million cycles fatigue load. FEA results confirmed that there is a high interlaminar shear stress concentration in that region. The second design feature is an additional transverse bandage around the region prone to delamination. Delamination was contained but not completely prevented. The third design overcomes the problem by ending the fibres at the end of the eye section.

D.M. Brouwer et al , The support stiffness of a parallel leaf-spring flexure should ideally be high, but deteriorates with increasing displacement. This significant characteristic needs to be quantified precisely, because it limits the use of parallel leaf-spring flexures in precision mechanisms. We present new and refined analytic formulas for the stiffness in three dimensions taking into account shear compliance, constrained warping and limited parallel external drive stiffness. The formulas are supplemented by a finite element analysis using shell elements to include anticlastic curving effects. Several approximation equations are presented for determining the drive force precisely. Even at relatively large deflections the derived formulas are in good agreement with the finite element results.

METHODOLOGY

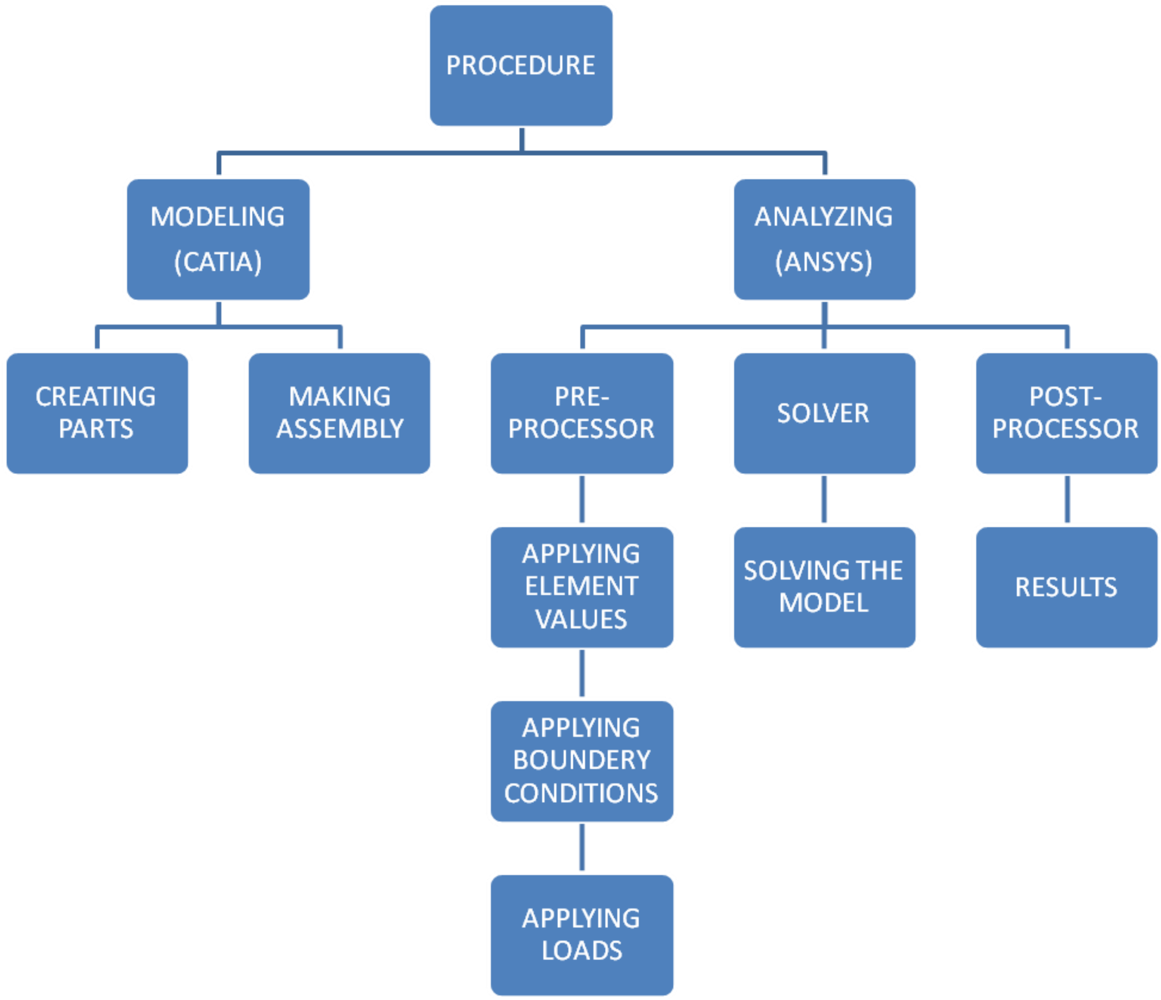


COST ESTIMATION:

SI NO	PARTS	PRICE
1.	EPOXY RESINE LY566	900
2.	HARDNER HY951	200
3.	GLASSFIBRE	500
4.	TRANSPORT CHARGE	1100
5.	MASK & GLOVES	800
6.	WAX	720
7.	MARKER & SCISSOR	495
8.	LABOUR	500
9.	SCALE	10
	TOTAL	5225

SI NO	TEST	PER PIECE	NO OF PIECES	PRICE
1.	TENSILE	200	4	800
2.	COMPRESSION	200	4	800
3.	IMPACT	200	2	400
			TOTAL	1200

SOFTWARE OVERVIEW



MODELING COMPOSITES

Composites are somewhat more difficult to model than an isotropic material such as iron or steel. We need to take special care in defining the properties and orientations of the various layers since each layer may have different orthotropic material properties. In this section, we will concentrate on the following aspects of building a composite model:

- Choosing the proper element type
- Defining the layered configuration
- Specifying failure criteria
- Following modeling and post-processing guidelines

CHOOSING THE PROPER ELEMENT TYPE

The following element types are available to model layered composite materials: SHELL99, SHELL91, SHELL181, SOLID46, and SOLID191. Which element we choose depends on the application, the type of results that need to be calculated, and so on. Check the individual element descriptions to determine if a specific element can be used in our ANSYS product.

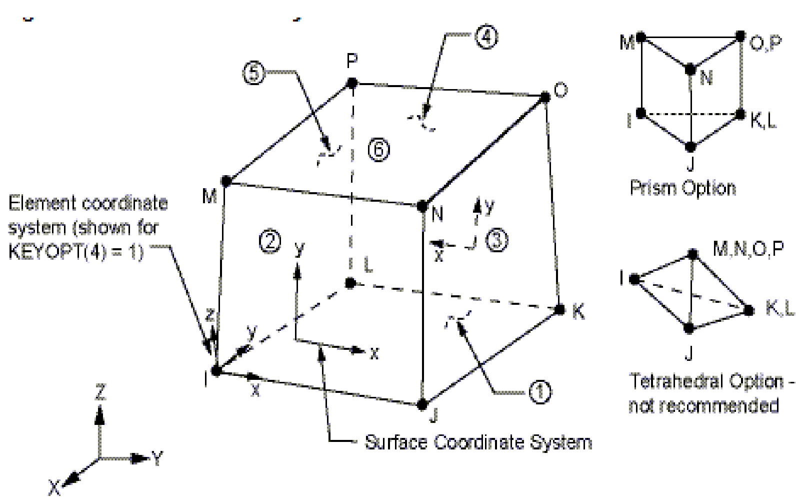
❖ **SOLID46 - 3-D Layered Structural Solid Element**

SOLID46 is a layered version of the 8-node, 3-D solid element, SOLID45, with three degrees of freedom per node (UX, UY, UZ). It is designed to model thick layered shells or layered solids and allows up to 250 uniform-thickness layers per element. Alternately, the element allows 125 layers with thicknesses that may vary bilinearly over the area of the layer. An advantage with this element type is that you can stack several elements to model more than 250 layers to allow through-the-thickness deformation slope discontinuities. The user-input constitutive matrix option is also available. SOLID46 adjusts the material properties in the transverse direction permitting constant stresses in the transverse direction.

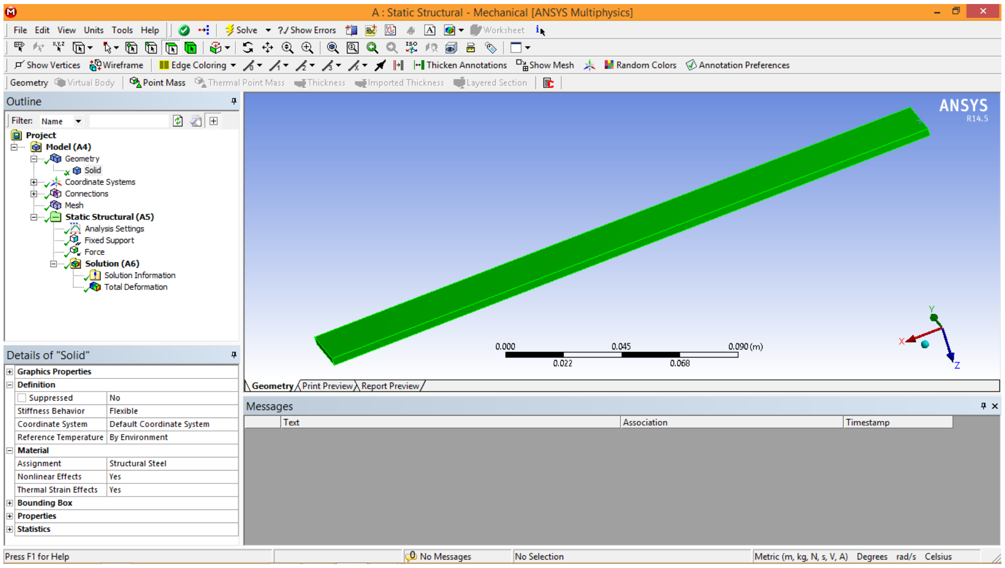
ELEMENT TYPE USED IN THE PROJECT

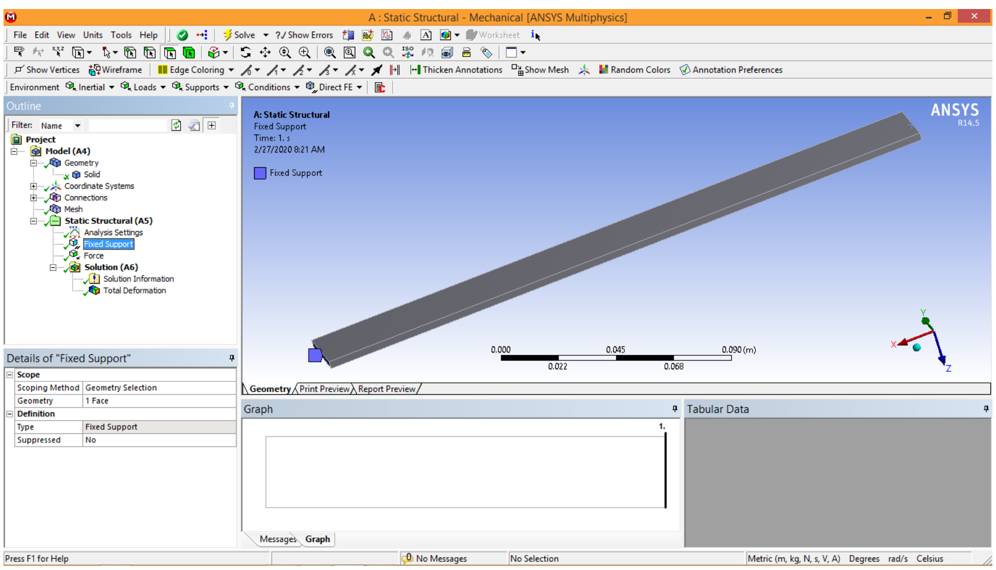
SOLID45 Element Description

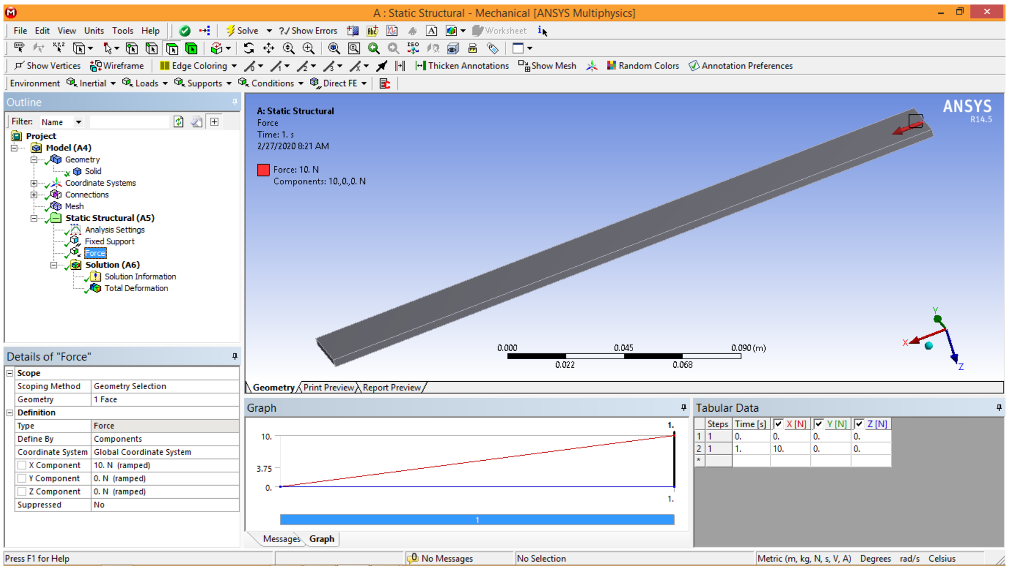
SOLID45 is used for the 3-D modeling of solid structures. The element is defined by eight nodes having three degrees of freedom at each node: translations in the nodal x, y, and z irections. The element has plasticity, creep, swelling, stress stiffening, large deflection, and large strain capabilities.



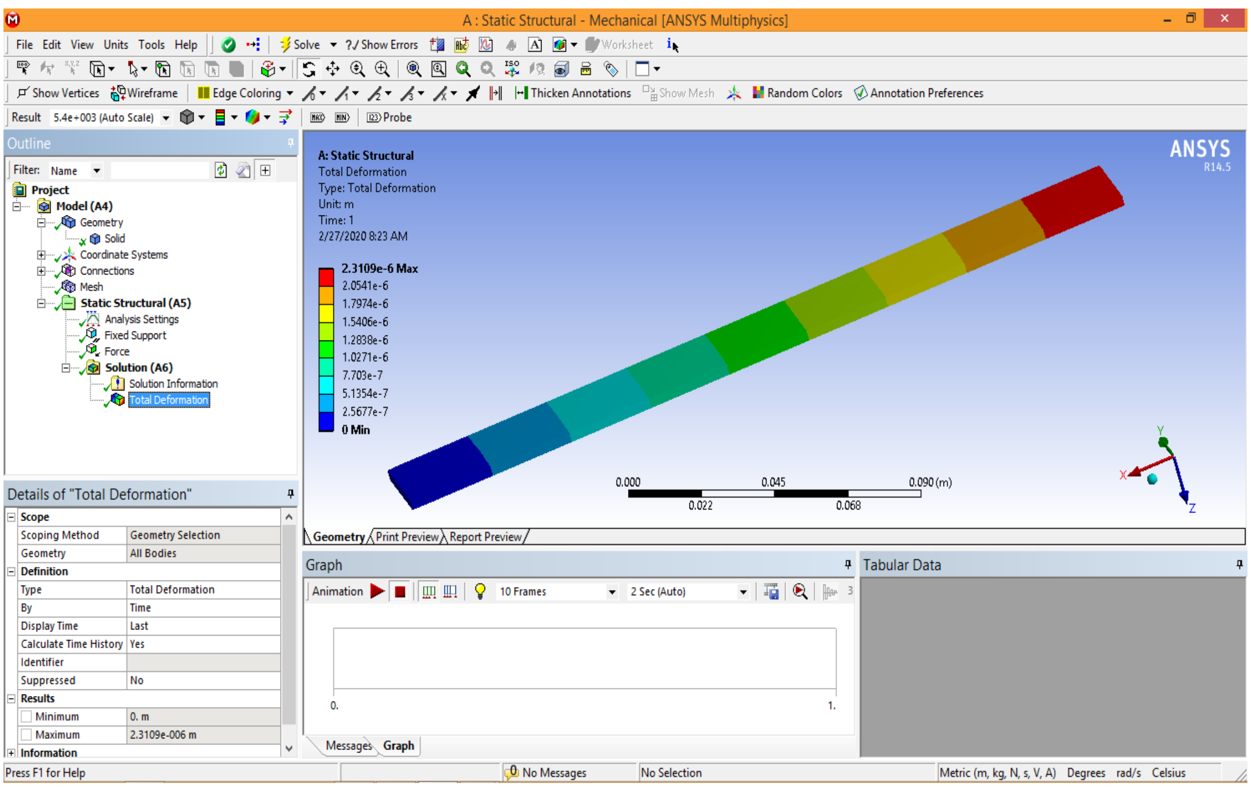
ANALYSIS RESULT


A : Static Structural - Mechanical [ANSYS Multiphysics]
Outline
Project
Model (A4)
Geometry
Solid
Coordinate Systems
Connections
Mesh
Static Structural (A5)
Analysis Settings
Fixed Support
Force
Solution (A6)
Solution Information
Total Deformation
Details of "Solid"
Graphics Properties
Definition
Suppressed No
Stiffness Behavior Flexible
Coordinate System Default Coordinate System
Reference Temperature By Environment
Material
Assignment Structural Steel
Nonlinear Effects Yes
Thermal Strain Effects Yes
Bounding Box
Properties
Statistics
ANSYS
R14.5
0.000 0.045 0.090 (m)
0.022 0.068
Geometry Print Preview Report Preview
Messages
Text Association Timestamp
Press F1 for Help
No Messages
No Selection
Metric (m, kg, N, s, V, A) Degrees rad/s Celsius

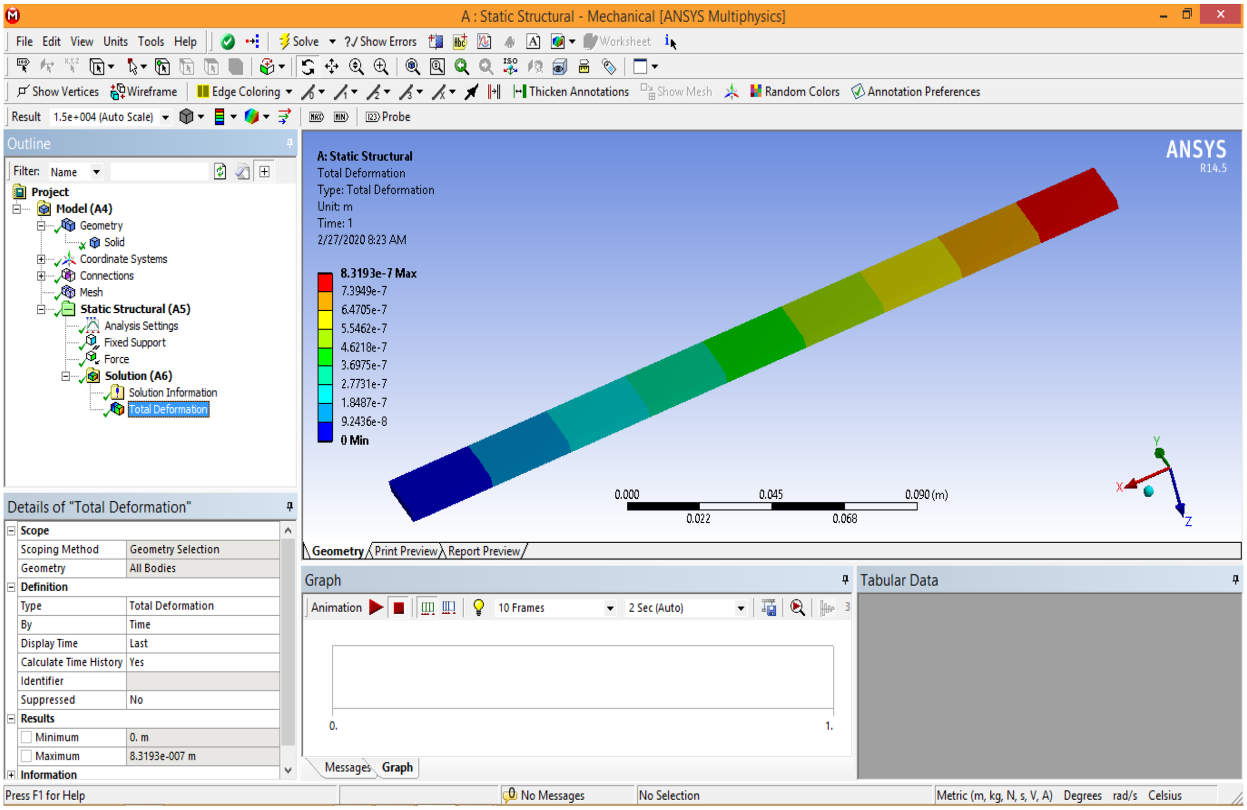

A : Static Structural - Mechanical [ANSYS Multiphysics]
Outline
Project
Model (A4)
Geometry
Solid
Coordinate Systems
Connections
Mesh
Static Structural (A5)
Analysis Settings
Fixed Support
Force
Solution (A6)
Solution Information
Total Deformation
Details of "Fixed Support"
Scope
Scoping Method Geometry Selection
Geometry 1 Face
Definition
Type Fixed Support
Suppressed No
A: Static Structural
Fixed Support
Time: 1. s
2/27/2020 8:21 AM
Fixed Support
ANSYS
R14.5
0.000 0.045 0.090 (m)
0.022 0.068
Geometry Print Preview Report Preview
Graph
Tabular Data
Messages Graph
Press F1 for Help
No Messages
No Selection
Metric (m, kg, N, s, V, A) Degrees rad/s Celsius



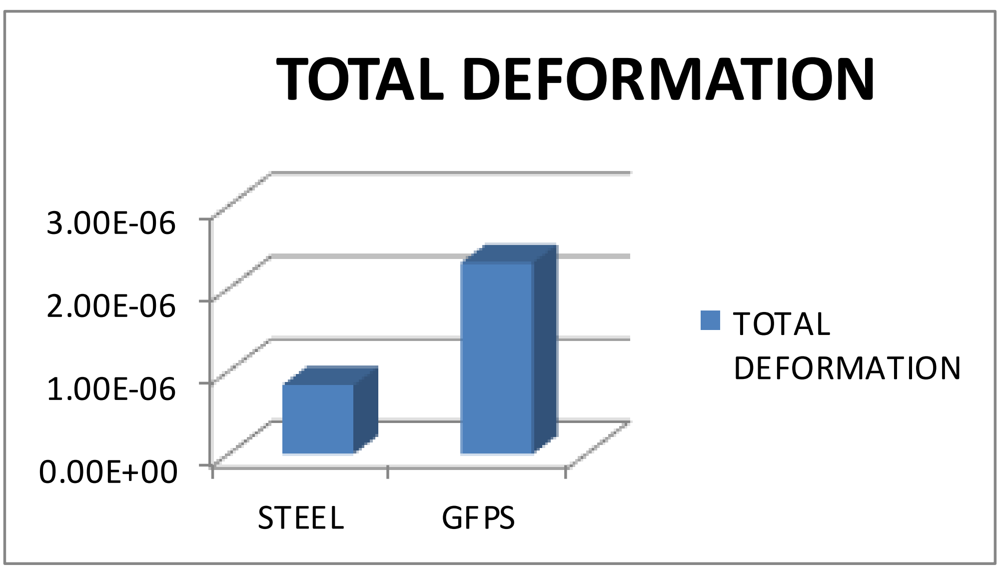
STEEL



GFRP



COMPRESSION OF RESULTS



CONCLUSION

Composite springs with varying width and thickness and constant cross section has been developed. These leaf springs are analyzed in ANSYS software with different composite materials along with the steel. A comparative study has been made between different composite materials and with the steel in respect of weight, deflection and stress. It can be observed that Aluminum is the best suitable material for replacing the steel in manufacturing of mono leaf spring. The savings in the weight is 70%.

REFERENCES

[1] Senthil kumar and Vijayarangan, "Analytical and Experimental studies on Fatigue life Prediction of steel leaf soringand composite leaf multi leaf spring for Light passanger veicles using life data analysis" ISSN 1392 1320 material science Vol. 13 No.2 2007.

[2] Shiva Shankar and Vijayarangan "Mono Composite Leaf Spring for Light Weight Vehicle Design, End Joint, Analysis and Testing" ISSN 1392 Material Science Vol. 12, No.3, 2006.

[3] Niklas Philipson and Modelan AB "Leaf spring modelling" ideon Science Park SE-22370 Lund, Sweden

[4] Zhi'an Yang and et al "Cyclic Creep and Cyclic Deformation of High-Strength Spring Steels and the Evaluation of the Sag Effect:Part I. Cyclic Plastic Deformation Behavior" Material and Material Transaction A Vol 32A, July 2001—1697

[5] Muhammad Ashiqur Rahman and et al "Inelastic deformations of stainless steel leaf springs-experiment and nonlinear analysis" Meccanica Springer Science Business Media B.V. 2009

[6] C.K. Clarke and G.E. Borowski "Evaluation of Leaf Spring Failure" ASM International, Journal of Failure Analysis and Prevention, Vol5 (6) Pg. No.(54-63)

[7] J.J. Fuentes and et al "Premature Fracture in Automobile Leaf Springs" Journal of Science Direct, Engineering Failure Analysis Vol. 16 (2009) Pg. No. 648-655.

[8] J.P. Hou and et al "Evolution Of The Eye End Design Of A Composite Leaf Spring For Heavy Axle Load " Journal of Science Direct, Composite Structures 78(2007) Pg. No. (351-358)

[9] Practical Finite Element Analysis by Nitin S. Gokhale [10] Composites – A Design Guide by Terry Richardson [11] ANSYS 10.0 Help for FEA Analysis.