International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 12 Issue 2 ǁ February 2024 ǁ PP. 217-244

Design an analysis by using composite material

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Date of Submission: 08-02-2024 Date of acceptance: 23-02-2024

I. INTRODUCTION

1.1 Problem Statement:

Theobjectiveofthepresentworkistodesignandanalysis, of mono steel leaf spring and also laminated composite leafspring made of two different composite materials i.e. E-glass/epoxyand Carbon/epoxy composites. Laminated composite leaf spring ofsinglelayerwithuni-directionalfiberorientationanglei.e.00isconsidered. A virtual model of Steel leaf spring was created in CATIAV5 R20 .Model is imported in ANSYS 14.5 for analysis by applyingnormal load conditions. After analysis a comparison is made betweenexisting conventional steel leaf spring and laminated mono compositeleafspringthatareE-glass/epoxyandCarbon/epoxyintermsofdeflections andstresses,tochoosethe bestone.

1.2 Objectives:

- To reduce the weight of the mono leaf spring in vehicle toincreasethe fuelefficiency.
- Static analysis of standard Steel leaf spring, E-glass epoxyspring, & Carbon fiber spring using FEA. Determining effectsofdeflectionandbending stress.
- ManufacturingandTestingofCompositeLeafsprings.
- Comparison and Validation of results by Theoreticalcalculations andTesting.

1.3 Scope:

- This design helps in the replacement of the conventional steelleaf springs with composite mono leaf spring with better ridequality.
- To achieve substantial weight reduction in the suspensionsystembyreplacingsteelleafspringwithcompositeleafspring.

1.4 Methodology:

- Firstweselecttheprojecttopic.
- Design and Analysis of Leaf spring by using compositematerial.
- ThenweStudythematerial.
- Selectthematerialfordesigncomponent.
- Design forleafspring.
- ❖ Conventionalsteelleafspring
- ❖ E-Glassfiber/epoxyandCarbonfiber/epoxy
- Theoreticaldesignforallabovematerial
- FEAusingAnsysworkbenchforallmaterial.
- Resultandcomparisonchart
- Result
- Futurescope

- Conclusion

SoftwareRequiredFortheProject:

- CATIAV5R20

- ANSYSWORKBENCH14.5

1.5 OrganizationofDissertation:

1.5.1 LeafSpring:

Inordertoconservenaturalresourcesandeconomizeenergy,weightreductionhasbeenthemainfocusofAutomobilemanufacturerinthepresentscenario.Weightreductioncanbeachievedprimarilybytheintroductionofbettermaterial,designoptimization and better manufacturing processes .The suspension leafspring is one of the potential items for weight reduction in automobileas it accounts for ten to twenty percent of the un sprung weight. Thishelps in achieving the vehicle with improved riding qualities. It is wellknown that springs, are designed to absorb and store energy and thenrelease it. Hence, the strain energy of the material becomes a majorfactor in designing the springs. The relationship of the specific strainenergycan beexpressedas

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

The introduction of composite materials was made itpossible to reduce the weight of the leaf spring without any reductionon load carrying capacity and stiffness. Materials have more elasticstrainenergystoragecapacityandhighstrength-to-weightratioascomparedtothoseofsteel.Severalpapersweredevotedtotheapplication of composite materials for automobiles Rajendran studiedthe application of composite structures for automobiles and designoptimization of a composite leaf spring. Great effort has been made bythe automotive industries in the application of leaf springs made fromcomposite materials S. Vijayarangan showed the introduction of fiberreinforced plastics (FRP) made it possible to reduce the weight of amachine element without any reduction of the load carrying capacity.Because of FRP materials high elastic strain energy storage capacityand high strength-to-weight ratio compared with those of steel, multi-leafsteelsprings arebeing replacedbymonoleafFRPsprings.

In every automobile, i.e. four wheelers and railways,the leaf spring is one of the main components and it provides a goodsuspension and it plays a vital role in automobile application. It carrieslateralloads,braketorque,drivingtorqueinadditiontoshockabsorbing. The advantage of leaf spring over helical spring is that theends of the spring may be guided along a definite path as it deflects toact as a structural member in addition to energy absorbing device. Thegeometryof theSteelleafspringisshowninFig.1.5.1

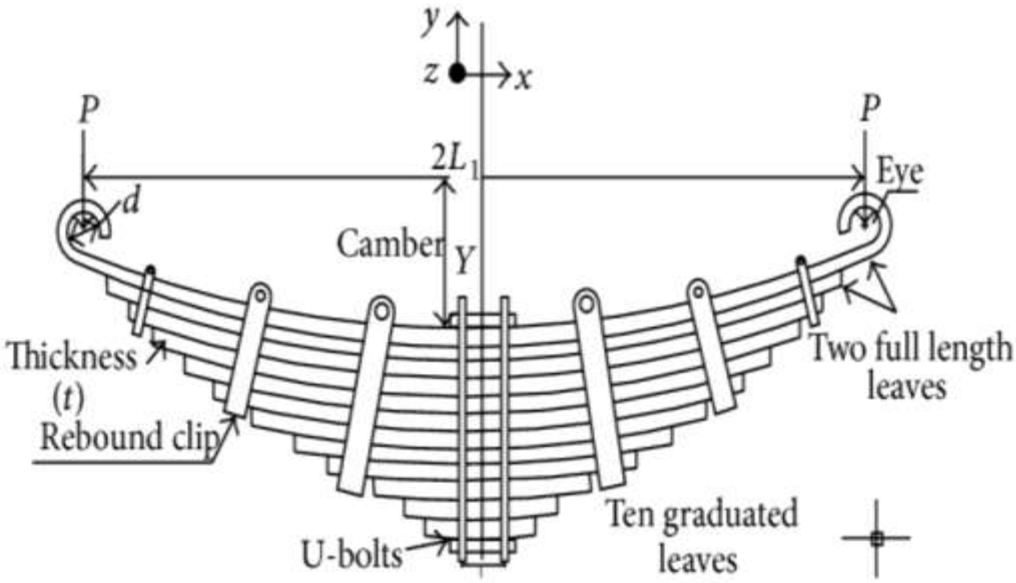


Fig.1.5.1LeafSpring

1.5.2 CompositeMaterial:

Acompositematerialisdefinedasamaterialcomposedof twoor moreconstituentscombinedona macroscopic scale bymechanicalandchemicalbonds.Typicalcompositematerialsarecomposed of inclusions suspended in a matrix. The constituents retaintheir identities in the composite. Normally the components can bephysically identified and there is an interface between them. Manycomposite materials offer a combination of strength and modulus thatareeithercomparabletoorbetterthananytraditionalmetallicmaterials. Because of their low specific gravities, the strength weight-ratioandmodulusweight-ratiosofthesecompositematerialsaremarkedlysuperiortothoseofmetallicmaterials.Thefatiguestrengthweight ratios as well as fatigue damage tolerances of many compositelaminates excellent. For these reasons, fiber composite have emergedas a major class of structural material and are either used or beingconsideredassubstitutionsformetalinmanyweight-criticalcomponents in aerospace, automotive and other industries. Anotherunique characteristic of many fiber reinforced composites is their highinternaldamping.Thisleadstobettervibrationenergyabsorptionwithin the material and results in reduced transmission of noise andvibrationtoneighboringstructures.Highdampingcapacityofcompositematerialscanbebeneficialinmanyautomotiveapplications in which noise, vibration, and hardness is a critical issuefor passenger comfort. Among the other environmental factors thatmaycausedegradationinthemechanicalpropertiesofsomepolymericmatrixcompositesareelevatedtemperatures, corrosivefluids,andultravioletrays.Inmanymetalmatrixcomposites,oxidation of the matrix well as adverse chemical reaction betweenfibers and matrixareof greatconcernat hightemperature.

1.5.3 Applications:

Commercial and industrial applications of composite s areso varied that it is impossible to list them all. The major structuralapplication areas, which include aircraft, space automotive, sportinggoods, and marine engineering. A potential for weight saving withcomposites exists in many engineering field. The first major structuralapplication of composite is the corvette rear leaf spring in 1981. Auni-leaf E-glass – reinforced epoxy has been used to replace a ten-leafsteel springwith nearly an80% weightsavings.Otherstructuralchassiscomponents,suchasdriveshaftsandroadwheels,havebeensuccessfullytestedinthelaboratoriesandarecurrentlybeingdevelopedforfuturecarsandvans.Themetalmatrixcompositescontainingeithercontinuousordiscontinuousfiberreinforcements,the latter being in the form of whiskers that are approximately 0.1-0.5μmindiameterandhavealengthtodiameterratioupto200.Particulate-reinforcedmetalmatrixcompositescontainingeitherparticles or platelet that ranges in size from 0.5 to 100 μm. Dispersion-strengthened metal matrix composites containing particles that are lessthan 0.1 μm in diameter. And metal matrix composites are such asdirectionallysolidifiedeutecticalloys.

1.5.4 Benefits:

- Weightreduction.
- Highstrength.
- Corrosiveness.
- Lowspecificgravity.

1.5.5 SelectionofMaterial:

Materials constitute nearly 60%-70% of the vehicle costand contribute to the quality and the performance of the vehicle. Evena small amount in weight reduction of the vehicle, may have a widereconomicimpact.Compositematerialsareprovedassuitablesubstitutes for steel in connection with weight reduction of the vehicle.Hence, the compositematerials have beenselectedfor leaf springdesign.

1.5.6 FiberSelection:

The commonly used fibers are carbon, glass, keviar, etc. Among these,theglassfiberhasbeenselectedbasedonthecostfactorandstrength.

The types of glass fibers are C-glass, S-glass and E-glass. The C-glassfiberisdesignedtogiveimprovedsurfacefinish.S-glassfiberisdesigntogiveveryhighmodular,whichisusedparticularlyinaeronauticindustries.TheE-glassfiberisahighqualityglass,whichis used as standard reinforcement fiber for all the present systems wellcomplying with mechanical property requirements. Thus, E-glass fiberwas found appropriate forthisapplication

1.5.7 ResinsSelection:

In a FRP leaf spring, the inter laminar shear strengths is controlled bythe matrix system used. Since these are reinforcement fibers in thethickness direction, fiber do not influence inter laminar shear strength.Therefore, the matrix system should have good inter laminar shearstrengthcharacteristicscompatibilitytotheselectedreinforcementfiber. Many thermosetresinssuchaspolyester, vinylester, epoxyresin are being used for fiber reinforcement plastics (FRP) fabrication.Among these resin systems, epoxies show better inter laminar shearstrength and good mechanical properties. Hence, epoxy is found to bethe best resins that would suit this application. Different grades ofepoxy resins and hardener combinations are classifieds, based on themechanical properties. Among these grades, the grade of epoxy resinselected is Dobeckot 520 F and the grade of hardener used for thisapplication is 758. Dobeckot 520F is asolvent lessepoxy resin.Whichincombinationwithhardener758curesintohardresin?Hardener 758 is a low viscosity polyamine. Dobeckot 520 F, hardener758combination is characterizedbycuring atroomtemperature..

II. LITERATUREREVIEW

2.1 History:

Investigationofcompositeleafspringintheearly60'sfailed to yield the production facility Because of inconsistent fatigueperformanceandabsenceofstrongneedformassreduction.Researches in the area of automobile components have been receivingconsiderable attention now. Particularly the automobile manufacturersand parts makers have been attempting to reduce the weight of thevehiclesinrecentyears.Emphasisofvehiclesweightreductionin1978 justified taking a new look at composite springs. Studies aremade to demonstrate viability and potential of FRP in automotivestructural application. The development of a lite flex suspension leafspring is first achieved. Based on consideration of chipping resistancebase part resistance and fatigue resistance, a carbon glass fiber hybridlaminated spring is constructed. A general discussion on analysis anddesign of constant width, variable thickness, and composite leaf springis presented. The fundamental characteristics of the double taperedFRPbeamareevaluatedforleafspringapplication.Recentdevelopmentshavebeenachievedinthefieldofmaterialsimprovement and quality assured for composite leaf springs based onmicrostructure mechanism. All these literature report that the cost ofcomposite; leaf spring is higher than that of steel leaf spring. Hence anattempt has been made to fabricate the composite leaf spring with thesamecostasthatofsteelleaf spring.

Material properties and design of composite structures arereportedinmanyliteratures.Verylittleinformationareavailableinconnection with finite element analysis of leaf spring in the literature,than too in 2D analysis of leaf spring. At the same time, the literatureavailableregardingexperimentalstressanalysismore.Theexperimental procedures are described in national and internationalstandards. Recent emphasis on mass reduction and developments inmaterialssynthesisandprocessingtechnologyhasledtoprovenproduction–worthyvehicleequipment.

2.2 ReviewofPapers:

K.Ashwini Prof C.V. Mohan Rao [1]:- This review is designed to be acomprehensivesourcefordesigningaleafspringusingvariouscomposites as the Automobile industries are showing keen interest forreplacing steel leaf springwith that of a composite leaf spring toobtain reduction in weight, which is an effective measure for energyconservationasitreducesoverallfuelconsumptionofthevehicle.

KeJun,WuZhenyu,ChenXiaoyingYingZhiping[2]:-Compositeleaf spring has gained considerable attention due to its high specificstrength/modulusandcorrosionresistance.Itsdesignmethodandperformance investigation are the research hotspots in the applicationfieldofcompositestructures.Thispaperpresentsanoverviewofresearch results on the material selection, the design method of thejoint and the spring body of composite leaf springs, including stiffnesscalculation method and optimization method. This article also gives anoverview of performance investigation results reported in the literatureforthemodal,damping,anddynamicstiffness,responsetolowfrequencyimpact,creepbehavior,fatigueperformanceandloadingperformance ofcompositeleafsprings. Finally,theemergingtrendsintheresearch of compositeleaf springs aresummarized.

T.Keerthivasan,S.M.Shibi,C.K.Tamilselvan[3]:-Leafsprings,oldest forms of suspension system used in automobiles. The behaviorof the automobile sys- tems is based on performance of leaf spring.Heavy weight of leaf spring is considered as drawback. To avoid this,researchers pointed out in reducing weight of leaf spring with the helpof alternate materials. Objective of this paper is to reduce weight ofleaf spring by using composite materials like Glass, carbon, Aramidfibers and Epoxy resin. The different specimens were prepared using.Manual layup method, they are taken for Flexural, tensile and Impacttest. All values are tabulated and compared. Mahendra Sharma, PawanSharma,SumitSharmaAnalysisofSteelMadeLeafSpringusingFEA Tool ANSYS Mathematical and computer modeling have beenplayinganincreasinglyimportantroleintheComputerAidedEngineering (CAE) process of many products in the last 60 years.Simulation offers great advantages in the development and analysisphase of products and offers a faster, better and more cost effectiveway than using physical prototypes alone. This paper analyses themechanics characteristic of a composite leaf spring made from glassfiberreinforcedplasticsusingtheANSYSsoftware.Consideringinterleaf contact, the stress distribution and deformation are obtained.Takingthesinglespringasanexample,comparisonbetweentheperformanceoftheGFRPandthesteelspringis presented.Thecomparison results show that the composite spring has lower stressesand much lower weight. Then the automotive dead weight is reducedobservably.

TrivediAchyutV. Prof. R.M. Bhoraniya[4]:- The Automobile firmhas shown greater interest for replacement of conventional steel leafspringwiththatofcompositeleafspring,asthecompositematerialhashighstrengthtoweightratio,goodcorrosionresistance.Theobjective of this work is to compare the load enhancing capacity, andweight savings of composite leaf spring with respect to conventionalsteel leaf spring. The dimensions of an existing conventional steel leafspring of a Light design calculations. Static Analysis of 3-D model ofconventionalleafspringisperformedusinganalysiscommercialsoftware.Andthatdimensionsareusedforcompositemultileafspringaswellbytakingcompositesascarbon/EpoxyandGraphite/Epoxy.Theconstraintsarestressanddeformationandweight of composite leaf spring with respect to conventional steel leafspring.Forstaticconditionstaticanalysisdoneandforrealtimeproblem dynamic analysis work present here. Design and Analysis ofLeafspringbyusingcompositematerial

G harinathgowd, e venugopalgoud [5]:-Leaf springs are special kindof springs used in automobile suspension systems. The advantage ofleaf spring over helical spring is that the ends of the spring may beguided along a definite path as it deflects to act as a structural memberin addition to energy absorbing device. The main function of leafspring is not only to support vertical load but also to isolate roadinduced vibrations. It is subjected to millions of load cycles leading tofatiguefailure.Staticanalysisdeterminesthesafestressandcorrespondingpayloadoftheleafspringandalsotostudythe behavior of structures under practical conditions. The present workattempts to analyze the safe load of the leaf spring, which will indicatethespeedatwhichacomfortablespeedandsafedriveispossible.AtypicalleafspringconfigurationofTATA-407lightcommercialvehicle ischosenfor study.Finite elementanalysis has beencarriedout todeterminethesafe stresses andpayloads.

AchamyelehAKassie,RRejiKumarandAmrutRao[6]:- Theautomobileindustryhasshownincreasedinterestinthereplacementofsteelspringwithfiberglasscompositeleafspringduetohighstrength to weight ratio. In this paper reducing weight of vehicles andincreasingormaintainingthestrengthoftheirsparepartsisconsidered. As leaf spring contributes considerable amount of weightto the vehicle and needs to be strong enough, a single E-glass/Epoxyleaf spring is designed following the design rules of the compositematerials considering static loading only. The constant cross sectiondesign of leaf springs is employed to take advantages of ease of designanalysisanditsmanufacturingprocess.Anditisshownthattheresulting design stresses are much below the strength properties of thematerial, satisfying the maximum stress failure criterion. The designedcompositeleafspringhasalsoachieveditsacceptablefatiguelife.Thisparticulardesignismadespecificallyforlightweightvehicles.

Miss. GulshadKarimPathan*, Prof. R.K.Kawade, Prof. N.Jamadar[7]:-Present time the main issue of automobile industry are weightreduction.Theautomobileindustryhaslookingforanyimplementation or modification to reduce the weight of the vehicle.The suspension leaf spring is one of the potential items for weightreduction in automobile as it accounts for 10% to 20% of the unspringweight. The introduction of composite leaf spring made of E-glassfiber epoxy resin has made it to possible to reduce the weight of springwithoutanyreductiononloadcarryingcapacityandstiffness.Theachievementofweightreductionwithadequateimprovementofmechanical properties has made composite a very good replacementmaterialforconventionalsteelspring.Thisworkdealswiththereplacementofmulti-leafsteelspringwithmonocompositeleafspringfortheLCVCarryingcapacityandstiffness.Thedesignconstraintswerelimitingstressesanddisplacement.Modelingandanalysis of both the steel and composite leaf springs have been doneusing ANSYS 14.5software.

Edward Nikhil Karlus, Rakesh L. Himte, and Ram Krishna Rathore[8]:- The intent of 21st century for automotive sector is fuel economyandemissions;duetothistheautomotivedesignersarerevisitingautomotivesystemsandpartsforreducingthemassofthevehicles.For suspension system, leaf spring is one of the key targets for weightreduction because it adds in unsprung mass; which affects the ride ofthe vehicle. To move further, we are going to optimize the parabolicmono leaf spring for the material as composite and the best possibledesignparameterstodesignlightestspringmeetingalldesignconstraintsaslength,width,suspensiontravelandvariousdesignstresses. The basic theory for leaf spring design hasbeen recheckedfor authentication with advanced finite element analysis. This papergives the automotive designer to find out better design for parabolicleaf spring implementation in place of present mono leaf spring onvehicle. The results of this paper give good values for the automotivemanufacturertostandardizethedesignandoptimizationmethodology.

M.Raghavedra,SyedAltafHussain,V.Pandurangadu,andK.PalaniKumar[9]:- Thispaperdescribesdesignandanalysisoflaminated composite mono leaf spring. Weight reduction is now themainissueinautomobileindustries.Inthepresentwork,thedimensions of an existing mono steel leaf spring of a Maruti 800passenger vehicle is taken for modeling and analysis of a laminatedcomposite mono leaf spring with three different composite materialsnamely, E-glass/Epoxy, S-glass/Epoxy andCarbon/Epoxy subjectedto the same load as that of a steel spring. The design constraints werestressesanddeflections.Thethreedifferentcompositemonoleafsprings have been modeled by considering uniform cross-section, withunidirectional fiber orientation angle for each lamina of a laminate.Staticanalysisofa3-DmodelhasbeenperformedusingANSYS 10.0. Compared to mono steel leaf spring the laminated compositemono leaf spring is found to have 47% lesser stresses, 25%~65%higher stiffness, 27%~67% higher frequency and weight reduction of73%~80%isachieved.

MujawarAjij I., Prof. S.D.Katekar [10]:- In today's scenario, the mainweightage of investigation is to reduce the weight of product whileupholdingitsstrength. To solve problem inthisregard compositematerials play an important role. In this paper decreasing the weight oflight vehicle is considered. The foremost component of the suspensionsystem of vehicle is leaf spring, it has substantial amount of weight,and it is necessary it would have ample strength because it needs toresist vibrations and jolts during its working. The prominence of thepaperistoreducetheoverallweightofsuspensionsystemandimproveloadcarryingcapacityoftheleafspringbyusingthecomposite material. The design considerations for this study are stressand deflection. The work also gives focus on the application of FEAconcepttocomparetwo materialsforleafDesignandAnalysisofLeafspring by using composite material spring and propose the one havinghigher strength toweightratio.Twomaterials used for comparisonare; conventional steel and composite S- Glass/Epoxy. In the presentwork deflection and Natural frequency induced in the two leaf springsare compared the solid modelling of leaf spring is done in CATIA V5andanalyzedusingANSYS 14.5.

Shahrukh Salam, GunendraYadav and Harsh R. Agrawal [11]:- Leafspring is one of the key components of vehicle suspension system. Abigdemeritofaleafspringisthatconventionalleafspringsareusuallymanufacturedandassembledbyusingnumberofl eafsmadeofsteelandhence theweightismore.

So, by reducing the number of leaves and increasing the strength ofleaves, we can reduce the weight of the leaf spring unit for absorbingthe same amount of shock and thus providing better stability to theautomobile.Thiswillbe abetter suspension.

A composite leaf spring can be made by a composite material called as"E-Glass/Epoxy".EGlassfiberreinforcedepoxycompositeswasfabricatedbyfillingvaryingconcentrationofaluminumox ide(Al2O3),magnesiumhydroxide(Mg(OH)2),siliconcarbide(SiC),andhematitepowder.

Here, PRO-E and ANSYS are used for the modelling and analysis ofleaf spring. Leaf springs made up of steel and E-Glass/Epoxy areanalyzed.

Bytheresultsobtainedfromtheanalysis,acomparisonoftwomaterials is also done to obtain the most suitable material. At present,the leaf spring unit used in the car has a total weight of about 16kilograms.So,wecanreplacetheleafspringusedinthecarwithanother leaf spring of a better material. It will also help to optimize theleaf spring suspension system by reducing the weight and increasingthestability.

PankajSaini, AshishGoel, Dushyant Kumar [12]:-Reducing weightwhile increasing or maintaining strength of products is getting to behighlyimportantresearchissueinthismodernworld.Compositematerials are Design and Analysis of Leaf spring by using compositematerial one of the material families which are attracting researchersand being solutions of such issue. In this paper we describe design andanalysis of composite leaf spring. The objective is to compare thestresses and weight saving of composite leaf spring with that of steelleafspring.Thedesignconstraintisstiffness.TheAutomobileIndustry has great interest for replacement of steel leaf spring with thatofcompositeleafspring,sincethecompositematerialshashighstrengthtoweightratio,goodcorrosionresistance.Th ematerialselected was glass fiber reinforced polymer (E-glass/epoxy), carbonepoxyandgraphiteepoxyisusedagainstconventionalsteel.Thedesign parameters were selected and analyzed with the objective ofminimizing weight of the composite leaf spring as compared to thesteel leaf spring. The leaf spring was modeled in Auto-CAD 2012 andtheanalysiswasdoneusing ANSYS 9.0software

2.3 Comment:

Fromthereviewofabovepapersitisseenthatmanypeoplehavework in design and analysis of composite leaf spring. Some people didstatic analysis, dynamic analysis and Fatigue test. They also comparedanalytical results with FEA results using ANSYS software. They havedesignedandfabricatedcompositeleafspringanddidstaticanddynamicandfatiguetest.Theyhavecomparedtheres ultsforstressand deflection for steel and composite leaf spring. The review of thesepapers shows that the deflection and bending stress for composite leafspring is less as compare tosteel leaf spring also there is weightreductionincase of compositeleafspring.

III. MATERIALSFORLEAFSPRING

Thematerialusedforleafspringsisusuallyaplaincarbonsteel having 0.90 to 1.0% carbon. The leaves are heat treated after theforming process. The heat treatment of spring steel products greaterstrengthandthereforegreaterloadcapacity,greaterrangeofdeflection andbetterfatigueproperties.

<u>Carbonfibers</u>:

Theiradvantagesincludehighspecificstrengthandmodulus,lowcoefficientofthermalexpansionandhighfatiguestreng th. Graphite, when used alone has low impact resistance. Itsdrawbacks include high cost, low impact resistance and high electricalconductivity.

<u>Glassfibers</u>:

ThemainadvantageofGlassfiberoverothersisitslowcost. It has high strength, high chemical resistance and good insulatingproperties. The disadvantagesare low elastic modulus poor adhesionto polymers, low fatigue strength and high density, which increase leafspring weight and size.Alsocrack detection becomes difficult.

Properties	**Values**	**Unit**
Young'smodulus	210000	Mpa
Tensilestrength	650-880	Mpa
Elongation	8-25	%

Fatigue	275	Mpa
Yieldstrength	350-550	Mpa
Density	7700	Kg/m^3

Table3.1MechanicalpropertiesofEN47 Steel(Original leafSpring)

Sr.No.	Properties	E-glass/epoxy	Carbonepoxy
1	EX(MPa)	43000	177000
2	EY(MPa)	6500	10600
3	EZ(MPa)	6500	10600
4	PRXY	0.27	0.27
5	PRYZ	0.06	0.02
6	PRZX	0.06	0.02
7	GX(MPa)	4500	7600
8	GY(MPa)	2500	2500
9	GY(MPa)	2500	2500
10	(kg/mm^3)	0.000002	0.0000016

Table3.2MechanicalpropertiesofE-glass/epoxyand carbonepoxy

IV. DESIGNCALCULATIONS,CADGEOMETRYANDANALYSIS

4.1 Problemidentification:

The Maruti Omni van is basically a Japanese commercialvan that has been converted with some modification into a passengervehicle. This is basically an underpowered vehicle mainly due to itsexcessive weight. It is heavier than a car because its body is not aerodynamical, also due to its stance, it appears to be slightly unstable. Inhigh speed crosswinds, the Omni becomes unstable and shaky becausetheir wheelsare smalland the Centre of gravity ishigh. The Omnialso has tendency to pitch and bounce on an uneven terrain. The ridequality is also not up to regular standards due to the suspension, whichappearstobeleafspringlinkage.CurrentissueinAutomobile,Aerospace, and Marine etc. is to reduce the weight of product bymaintaining its strength. In Automobile sector, Leaf spring of steelmaterialwhichisusedinsuspensionsystemcanbereplacedbycomposite material due to its high strength to weight ratio and thecompositematerialshavemoreelasticstrainenergystoragecapacity.

Parameters	**Value**
Lengthoftheleaf	936mm
Thickness	8mm
Width	50mm
FreeCamber	200mm

Table4.1Dimensionsofthemarutiomnicar

4.2 DesignCalculation:

Here Weight and initial measurements of four wheeler "OMNI" Lightcommercial vehicleistaken.
Weightofvehicle=1200kg
Maximum load carrying capacity= 1000 kgTotal weight= 1200+ 1000 = 2200 kgTaking factor of safety (FS) = 2Accelerationduetogravity(g)=9.81m/s2
Therefore;TotalWeight=2200×9.81=21582N
Since the vehicle is 4-wheeler, a single leaf spring corresponding tooneofthe wheelstakesup one4thof thetotalweight.
=21582/4 =5395.5N

But2F =5395.5N,F =2697.75 N

Spanlength,2L=936mm,L=468mm.
NowtheMaximumBendingstress of aleafspringisgivenbytheformula-
$\sigma = (6 \times f \times l)/(n \times b \times t2)$
σ = (6 × 2697.75 × 468)/ (2 × 50 × 8 X 8)σ=1183.63N/mm2

TheTotalDeflection oftheleafspringisgiven by
$\delta = (6 \times f \times l3)/(E \times n \times b \times t3)$
δ= (6 ×2697.75×468 X468X468)/(2.1×105 ×2×50×8X8 X 8)
$\delta = 154.31 mm$
Measureddataoftheabovestatedlightweightfourwheelervehicles.

Straightlengthoftheparabolicleafspring(L)=936mm

Sr.no	Load	Stress	Deformation
1	2697.75	1183.63	154.31
2	1000	438.75	57.2
3	2000	877.5	114.4
4	3000	1316.25	171.6
5	4000	1755	228.8
6	5000	2193.75	286
7	6000	2632.5	343.2
8	7000	3071.25	400.4

Table4.3.1TheoreticalCalculationsfororiginalleafspring.

4.3 HandCalculations:

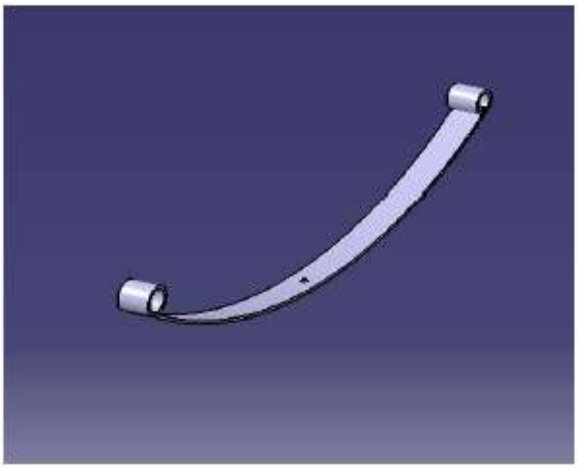
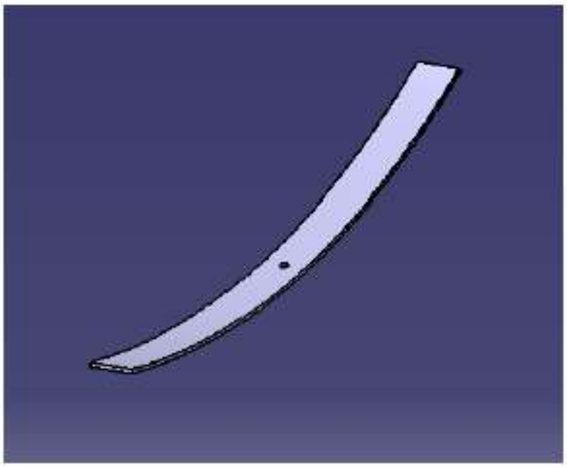
Sr.no.	Load	Stress	Deformation
1	2697.75	591.81	137.31
2	1000	219.375	50.89
3	2000	438.75	101.79
4	3000	658.125	152.69
5	4000	877.5	203.59
6	5000	1096.875	254.49
7	6000	1316.25	305.39
8	7000	1535.625	356.29

Table4.3.2TheoreticalCalculationsforglassfiber.

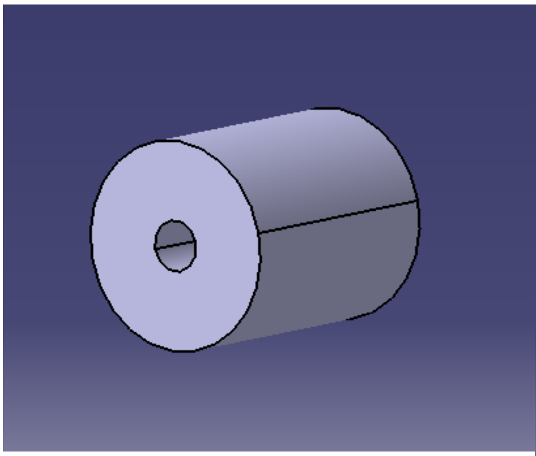
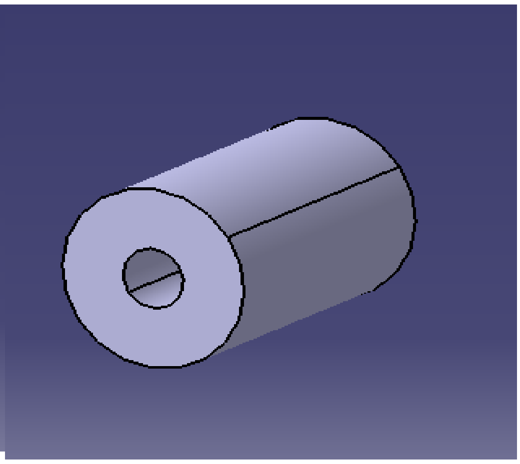
Sr.no.	Load	Stress	Deformation
1	2697.75	1052.12	112.96
2	1000	390	41.87
3	2000	780	83.74
4	3000	1170	125.61
5	4000	1560	167.48
6	5000	1950	209.36
7	6000	2340	251.23
8	7000	2730	293.1

Table4.3.3TheoreticalCalculationsforcarbonfiber.

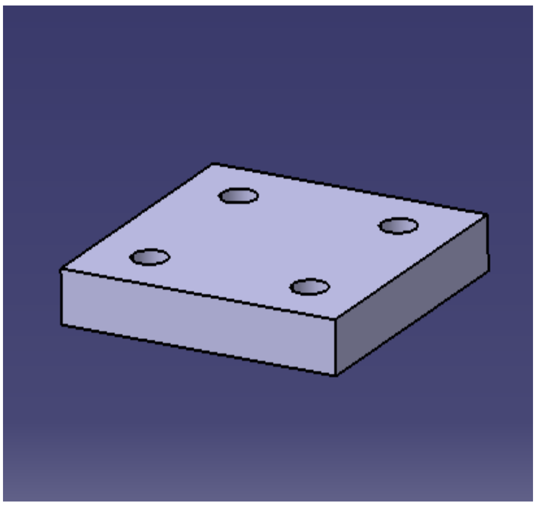
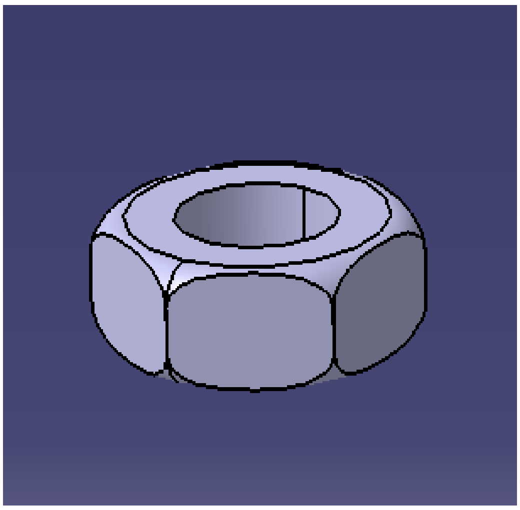
4.4 Detail,AssemblyandDraftingoftheLeafSpring:

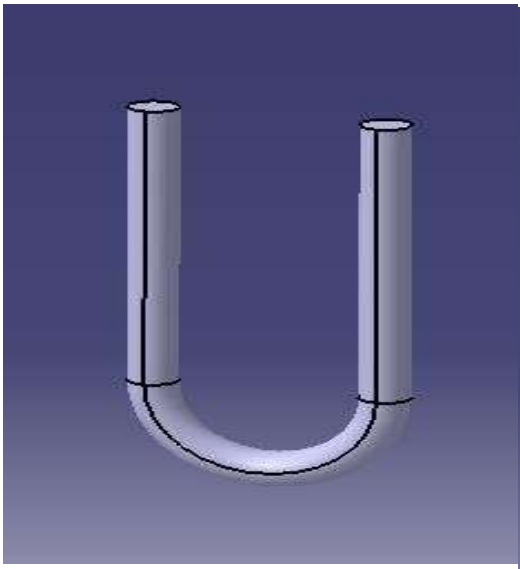
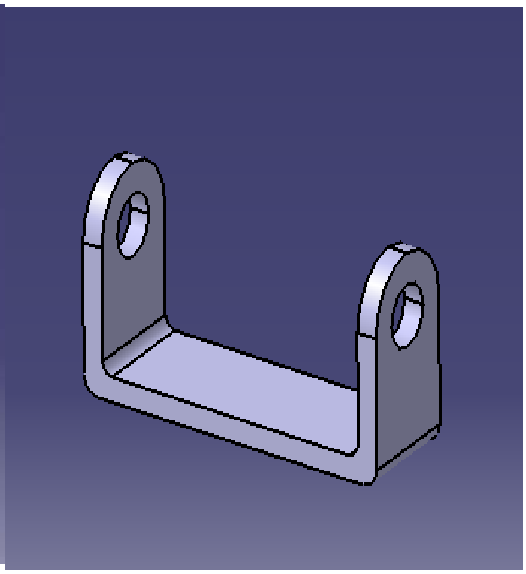
Leaf1 leaf2

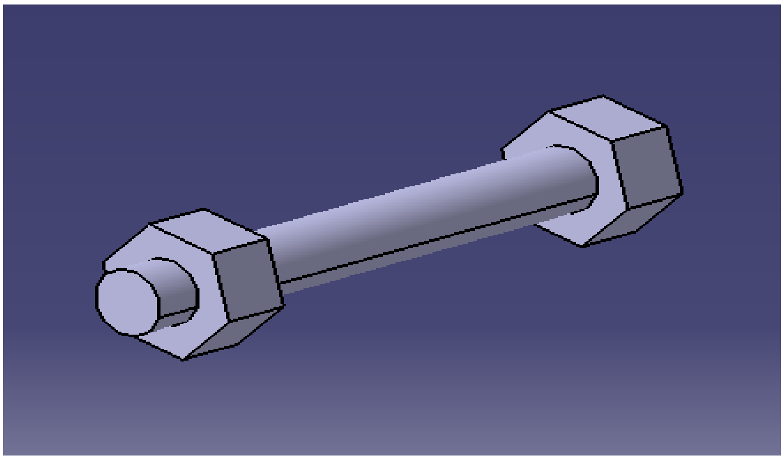
Bushd53Bushd42

Squareplate Nut

C-Clamp 1 C-Clamp 2



Nut andBolt
Fig.4.4.1Detailsoftheleafspring

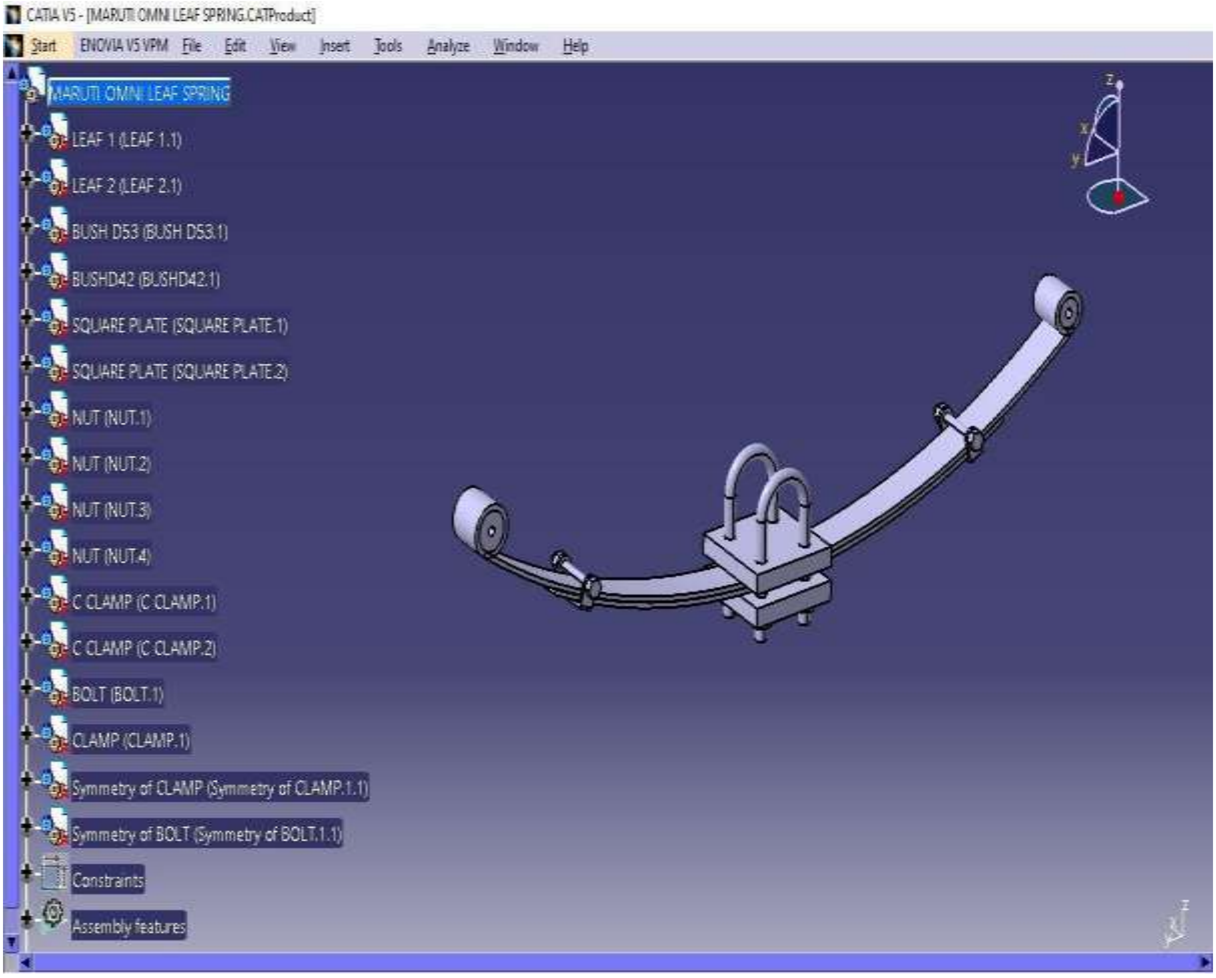


Fig4.4.2 Assemblyofleafspring

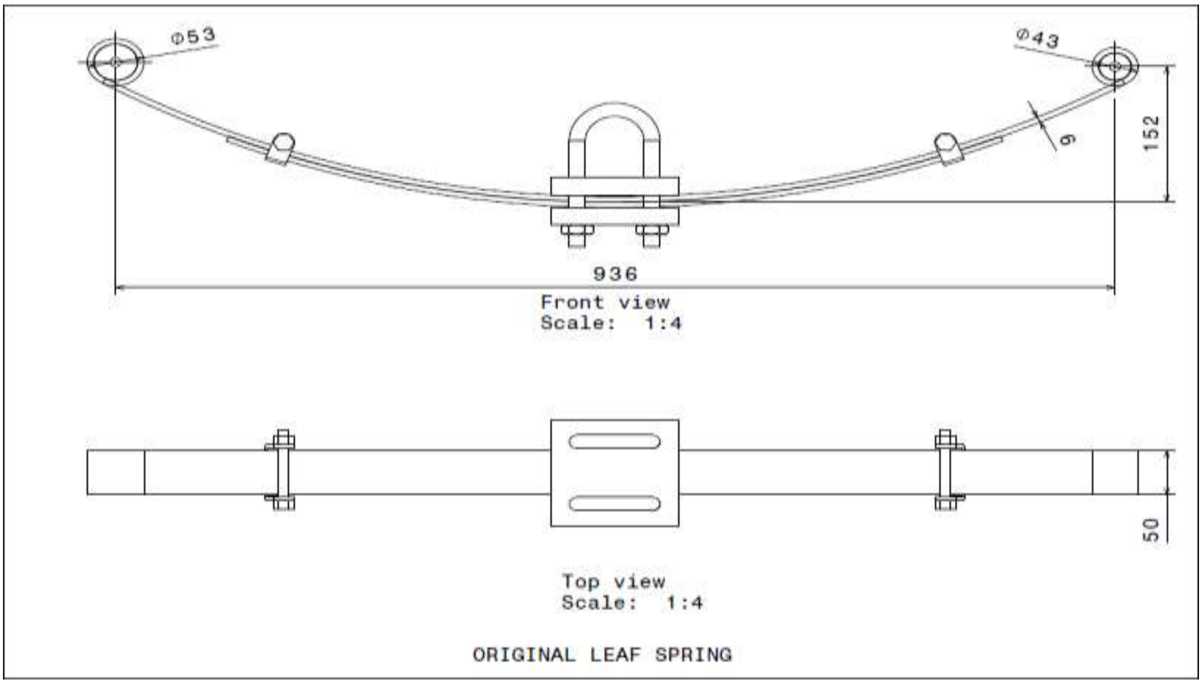


Fig4.4.3Draftingoforiginalleafspring

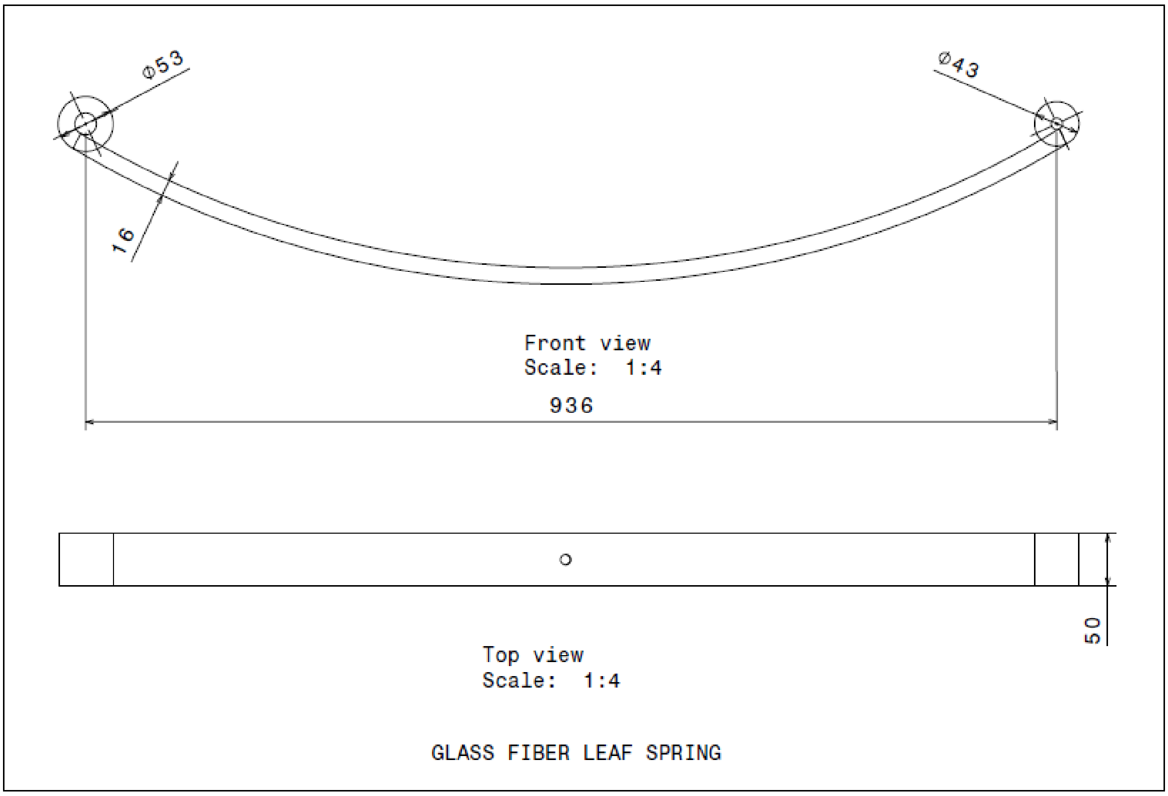


Fig4.4.4 DraftingofGlass fiberleafspring

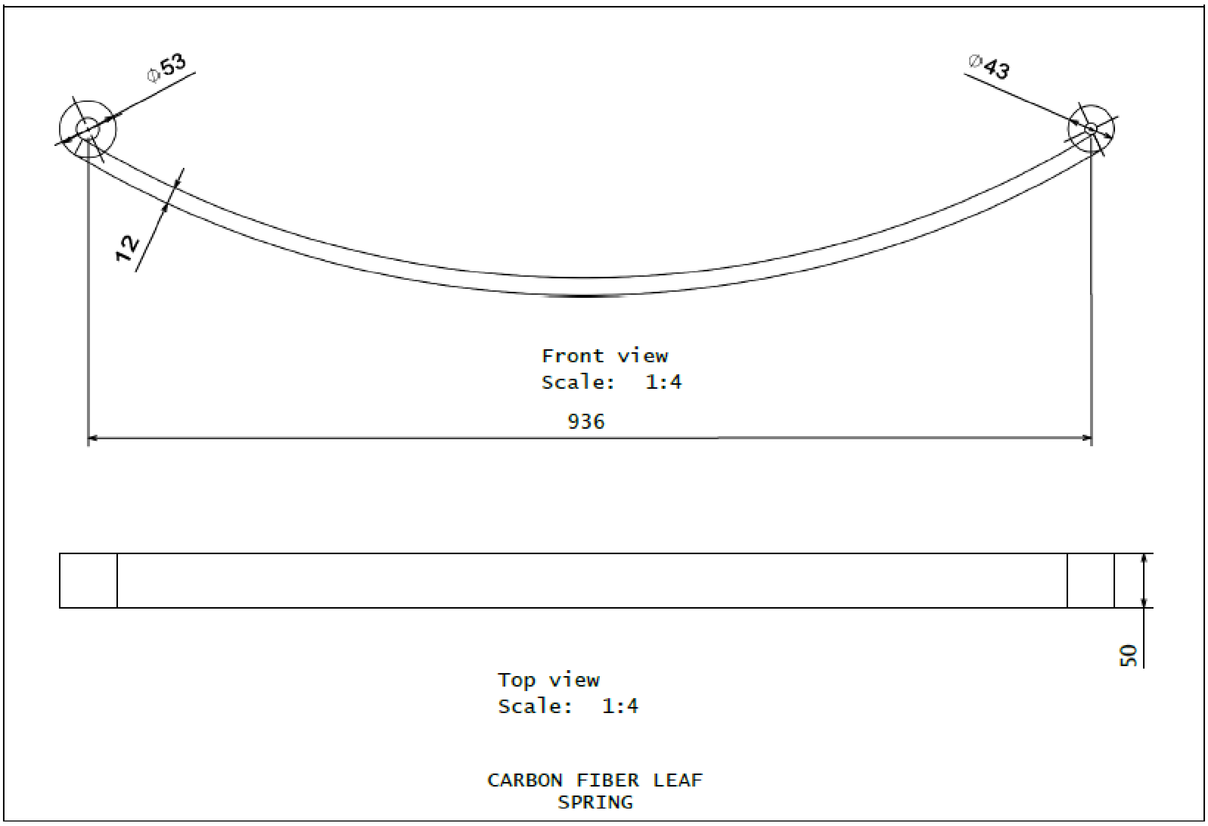


Fig4.4.5 Draftingofcarbon fiberleafspring

4.5 AnalysisResult:

4.5.1 Originalleafspring.

Deformation Stress

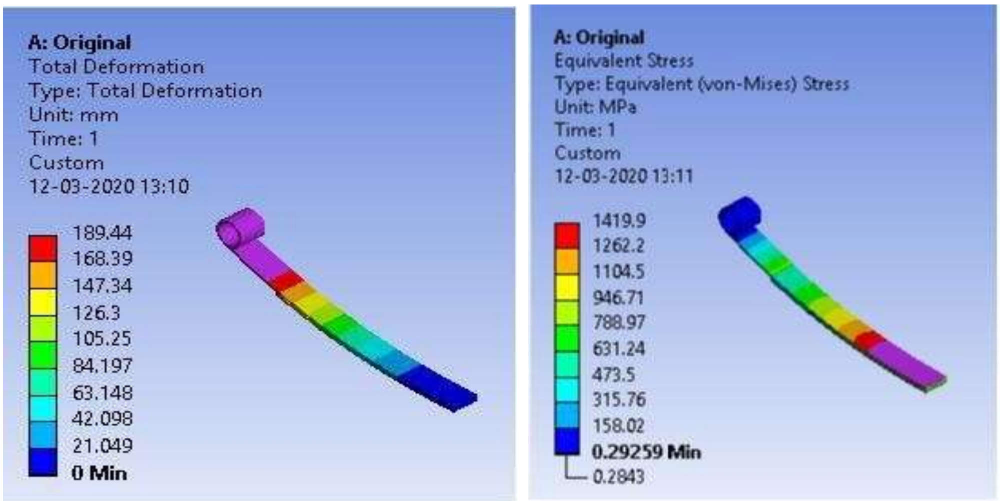


Fig4.5.1ADeformationandstressfor2697.5Nload

Deformation Stress

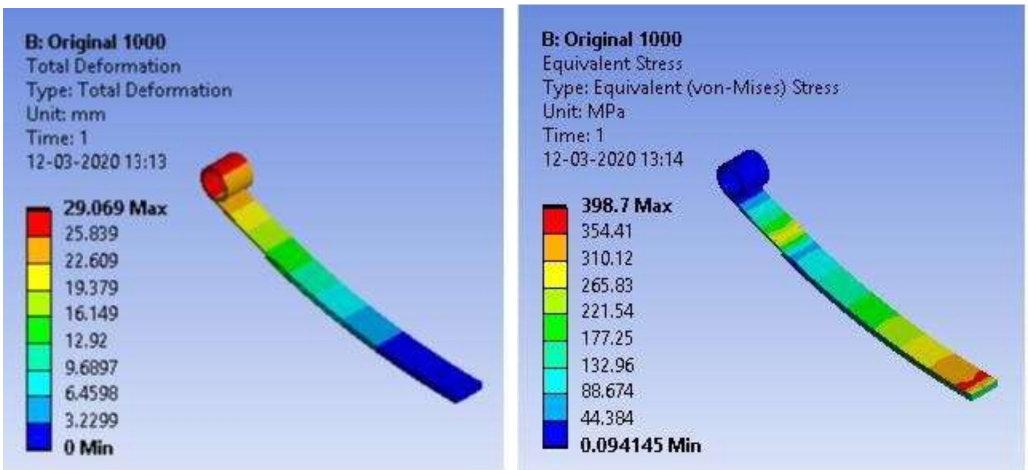


Fig4.5.1 BDeformation andstressfor1000Nload

Deformation Stress

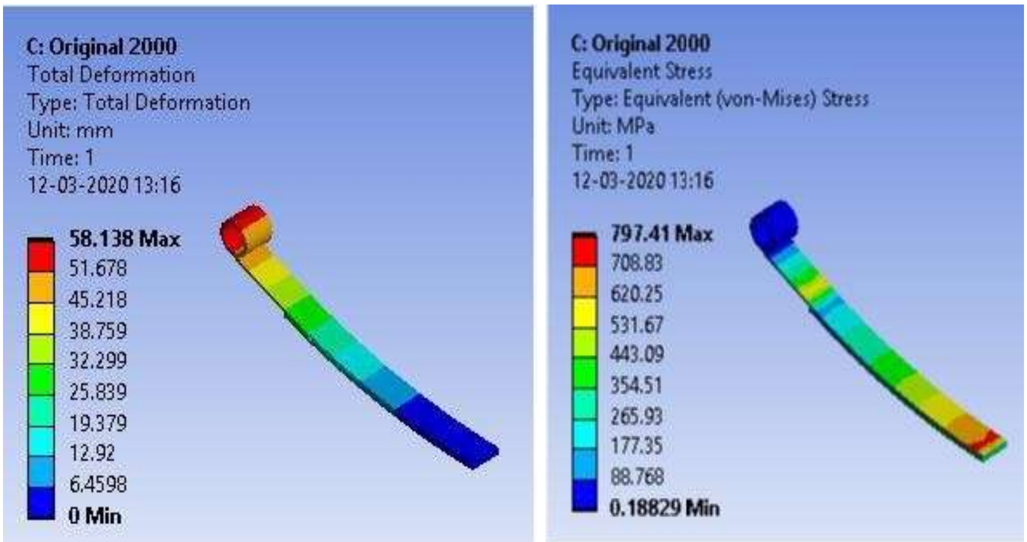


Fig4.5.1 CDeformation andstressfor2000Nload

Deformation Stress

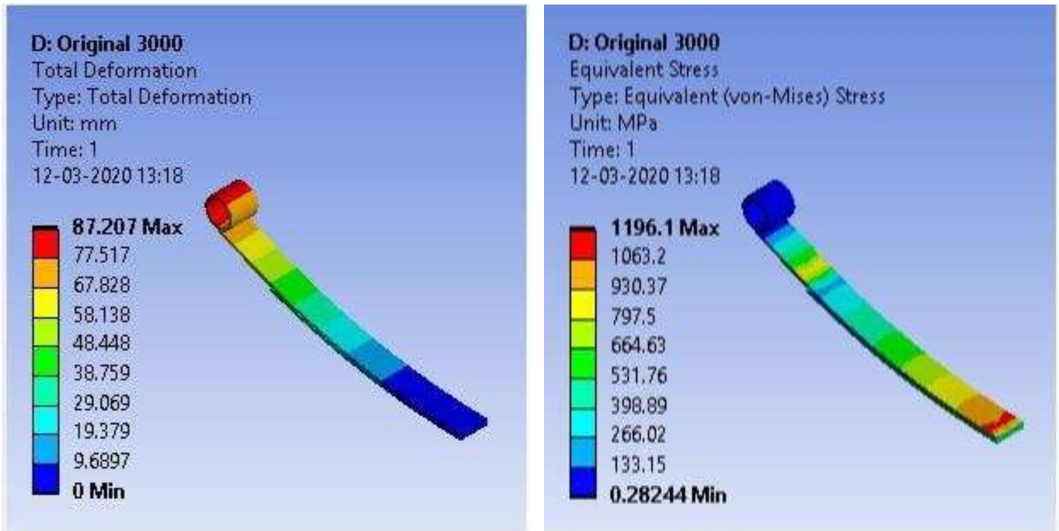


Fig4.5.1 DDeformation andstress for3000Nload

Deformation Stress

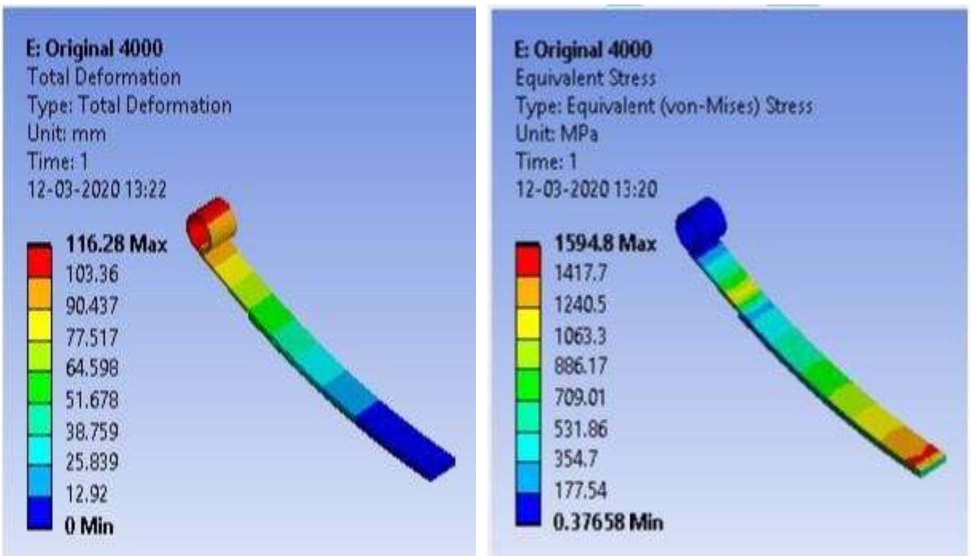


Fig4.5.1 EDeformation andstress for4000Nload

Deformation Stress

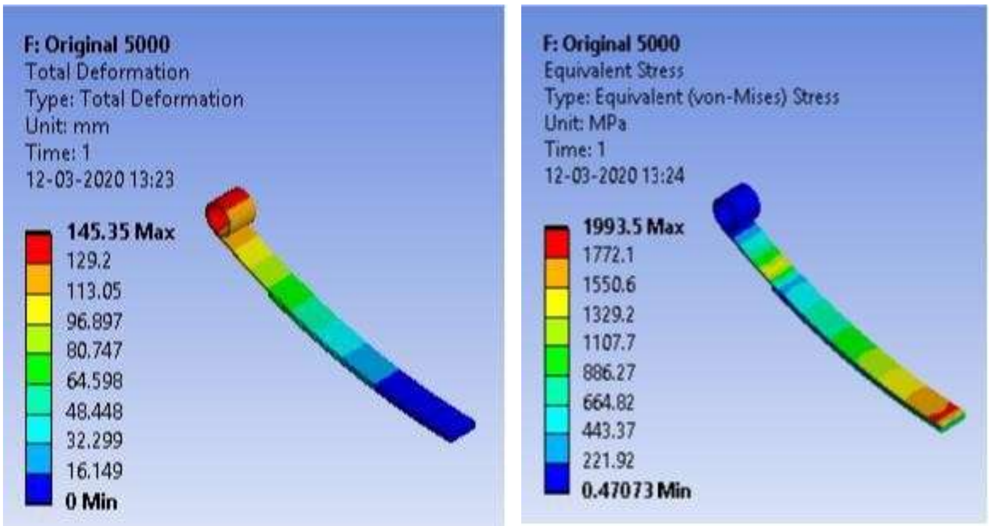


Fig4.5.1FDeformation andstressfor5000Nload

Deformation Stress

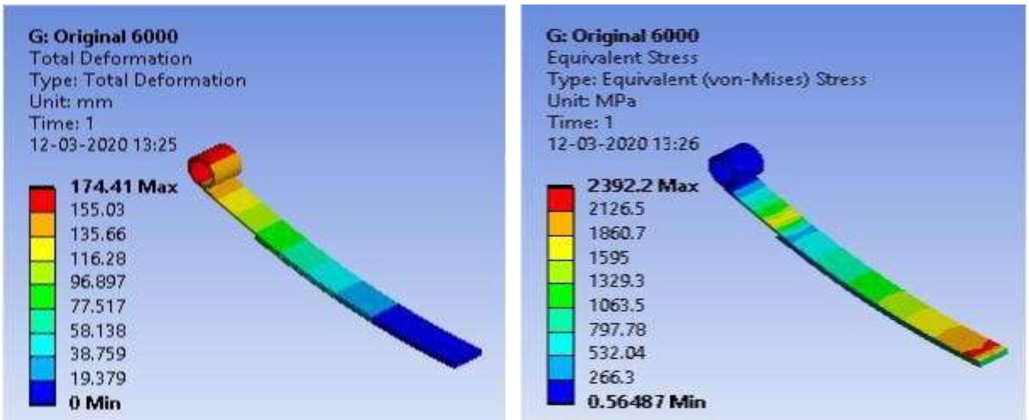


Fig4.5.1 GDeformation andstress for6000Nload

4.5.2 Glassfiber

Deformation Stress

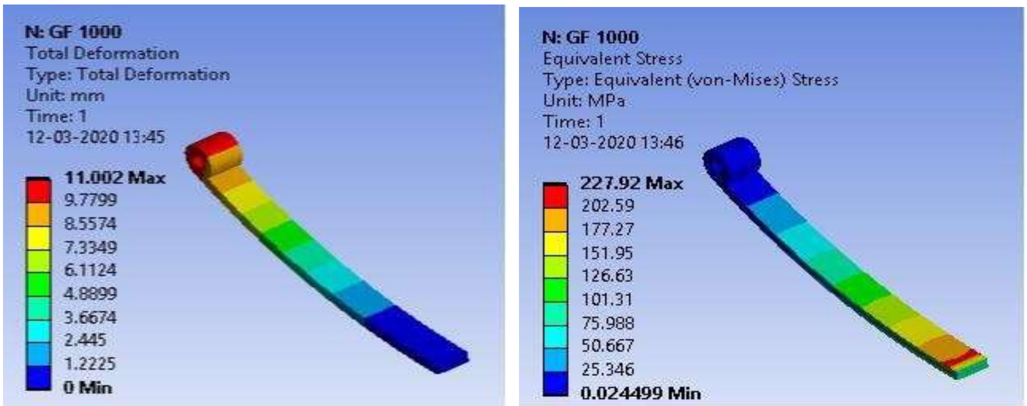


Fig4.5.2 ADeformationandstressfor1000Nload

Deformation Stress

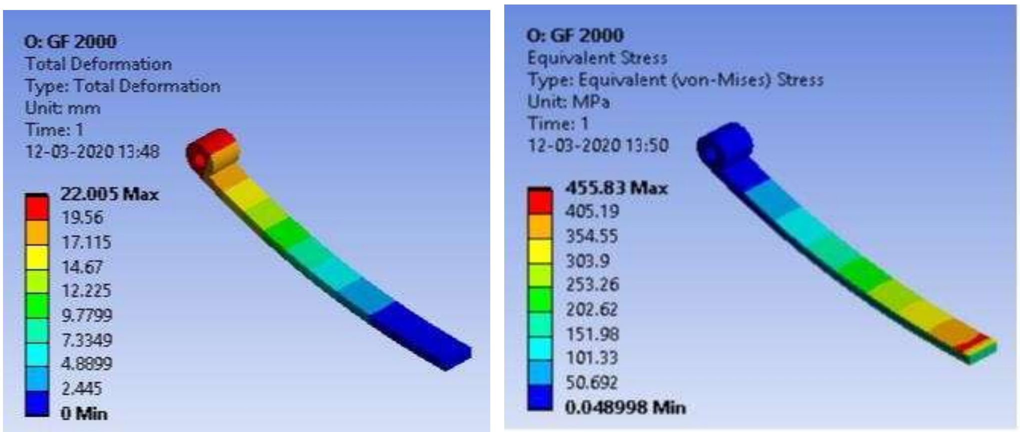


Fig4.5.2BDeformationandstressfor2000Nload

Deformation Stress

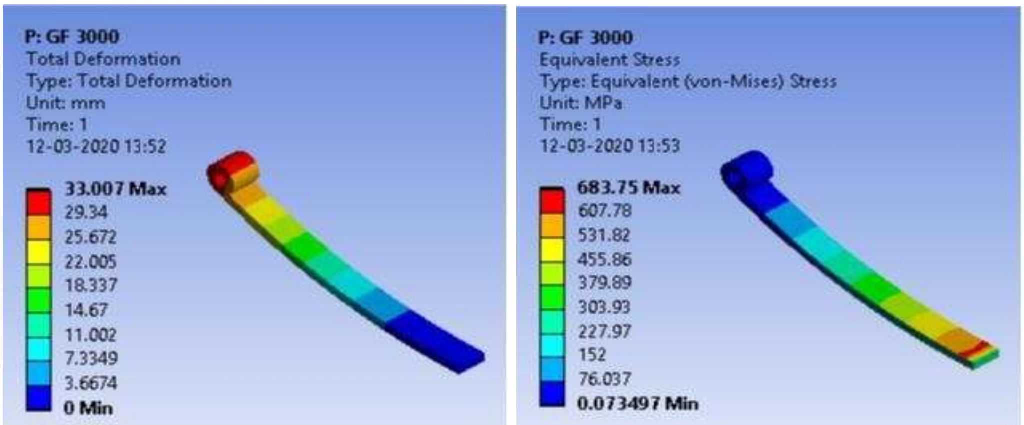


Fig4.5.2CDeformationandstressfor3000Nload

Deformation Stress

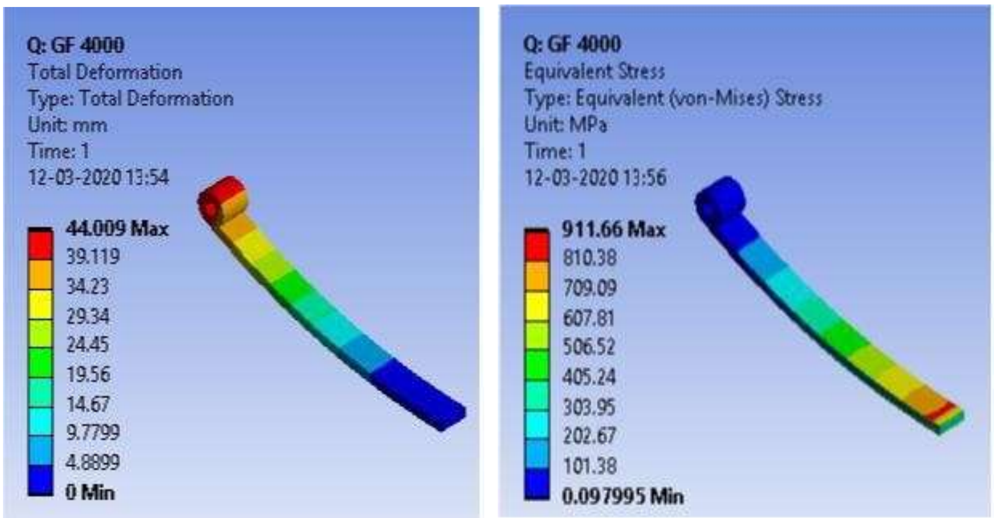


Fig4.5.2DDeformation andstress for4000Nload

Deformation Stress

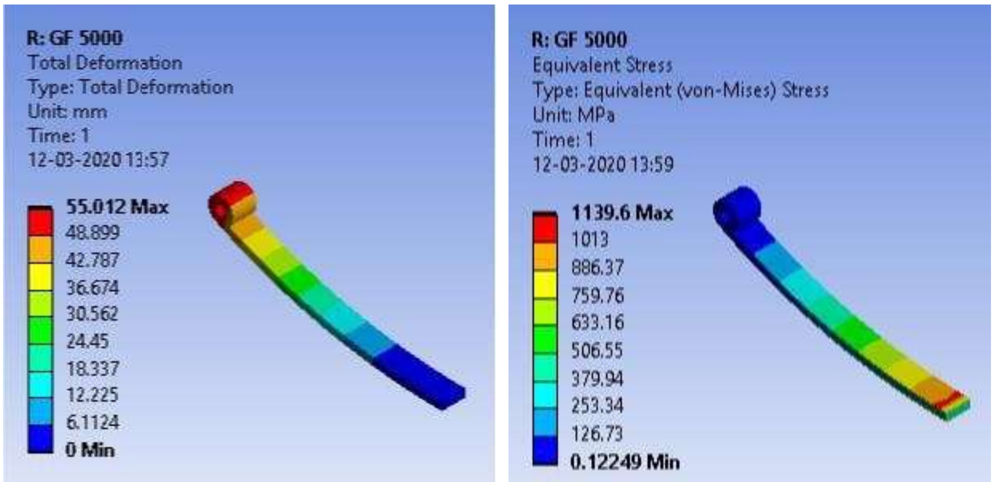


Fig4.5.2EDeformationandstress for5000Nload

Deformation Stress

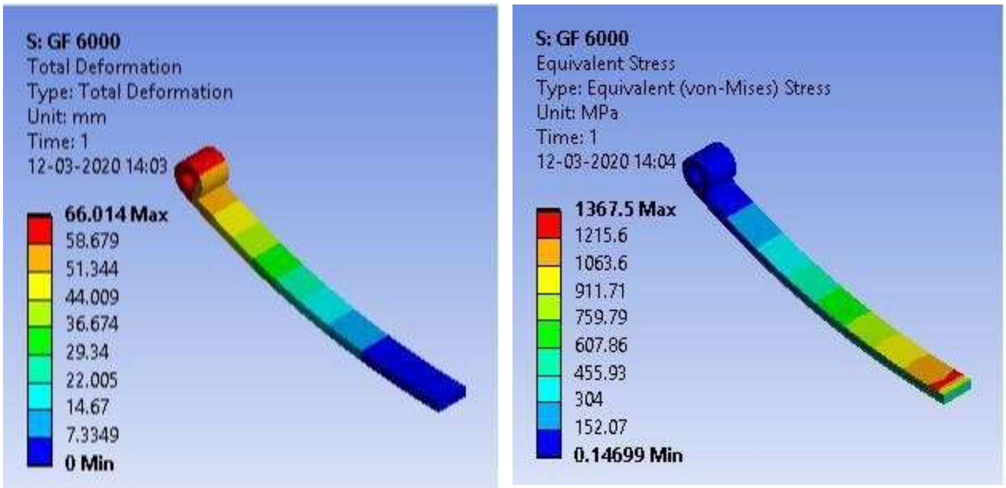


Fig4.5.2FDeformation and stress for6000Nload

4.5.3.Glassfiberwiththickness

Deformation stress

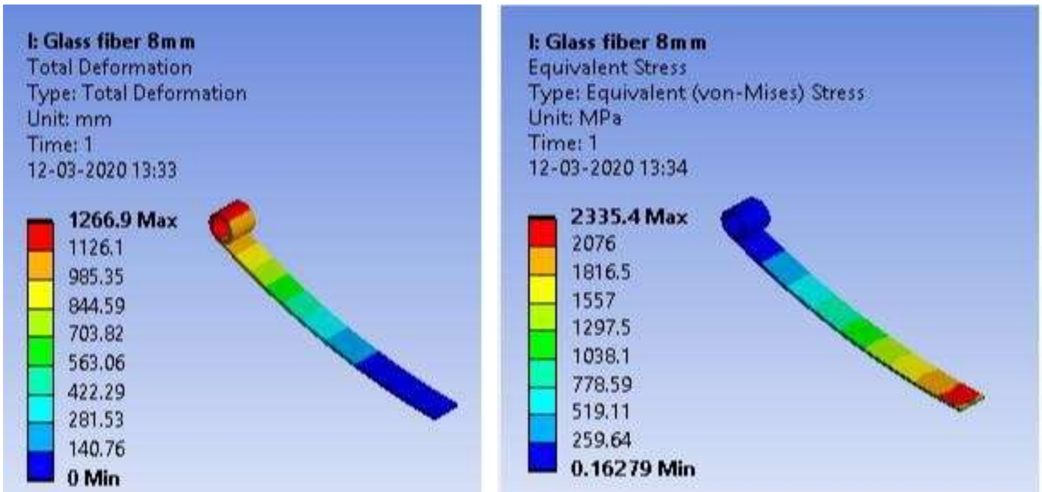


Fig4.5.3ADeformation andstress for8mmthickness.

Deformation stress

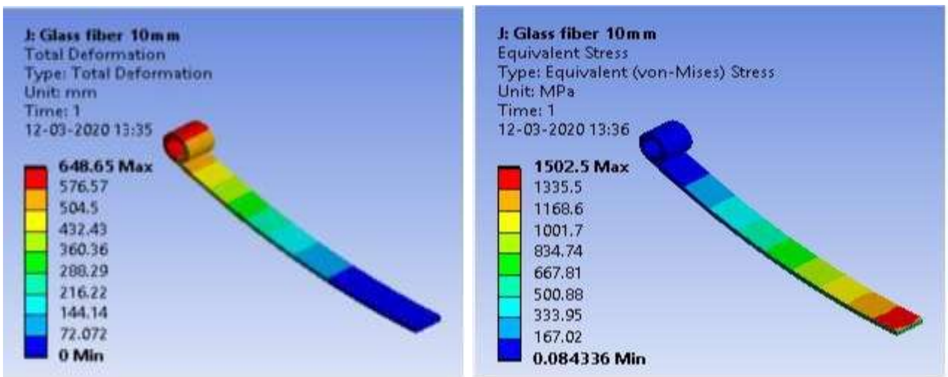


Fig 4.5.3 B Deformation and stress for 10mm thickness.

Deformation stress

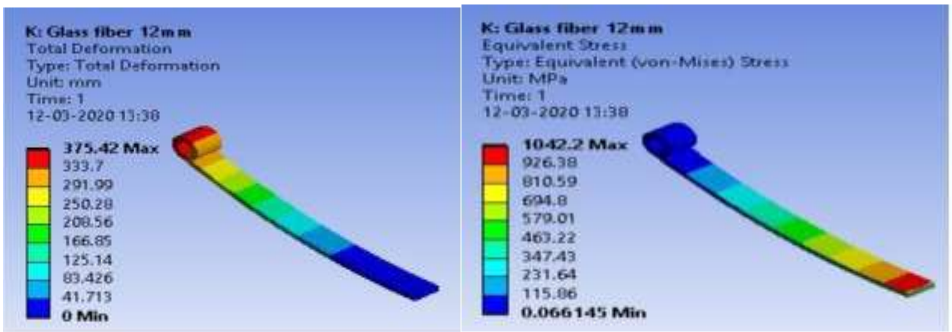


Fig4.5.3CDeformation andstressfor12mmthickness.

Deformation stress

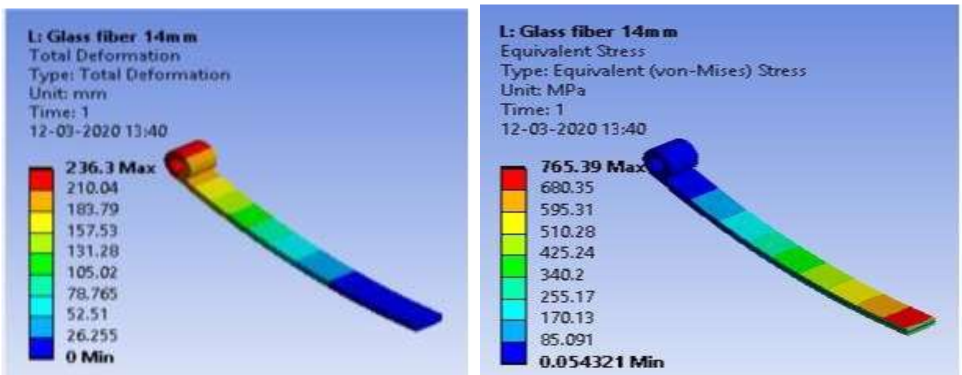


Fig4.5.3DDeformation andstressfor14mmthickness.

Deformation stress

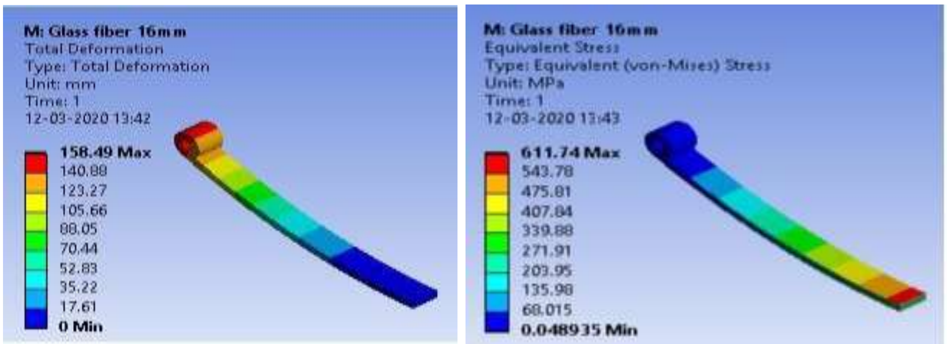


Fig4.5.3EDeformationandstressfor16mmthickness.

4.5.4 Carbonfiber

Deformation stress

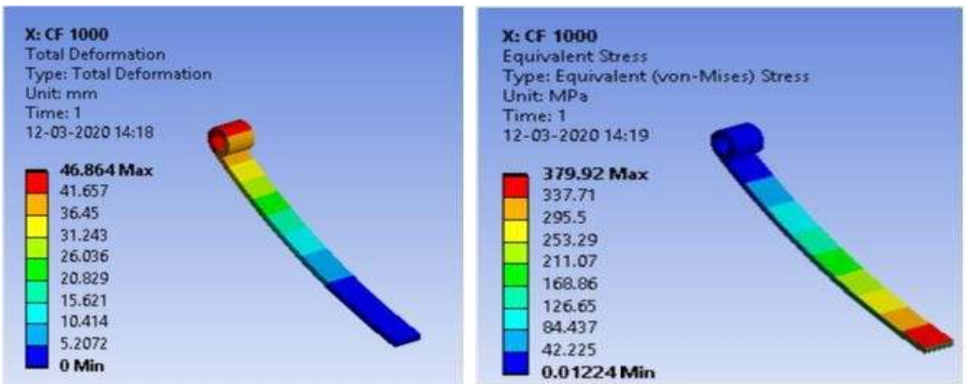


Fig4.5.4 ADeformation andstress for1000Nload.

Deformation stress

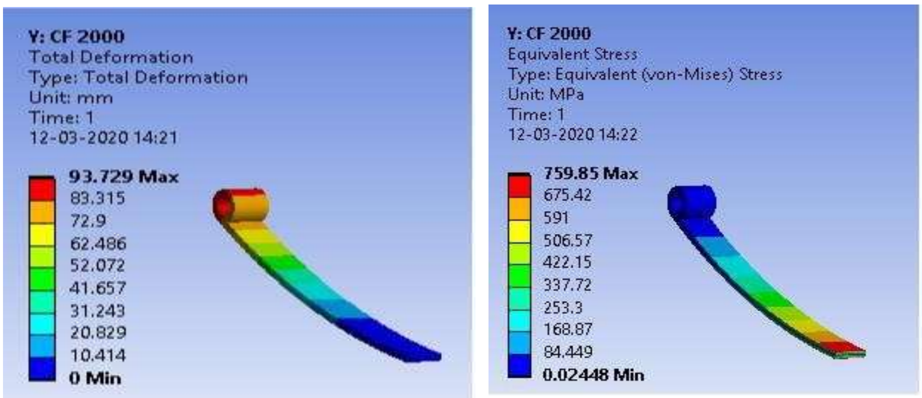


Fig4.5.4 BDeformationandstress for2000Nload.

Deformation stress

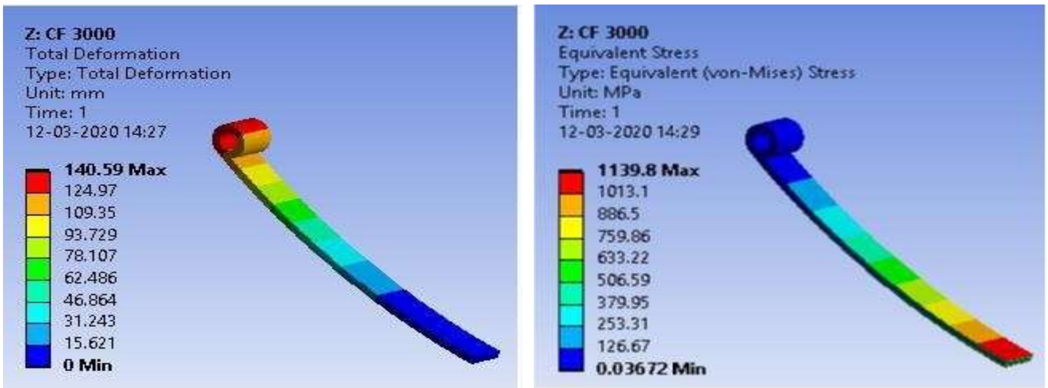


Fig4.5.4 CDeformationandstress for 3000Nload.

Deformation stress

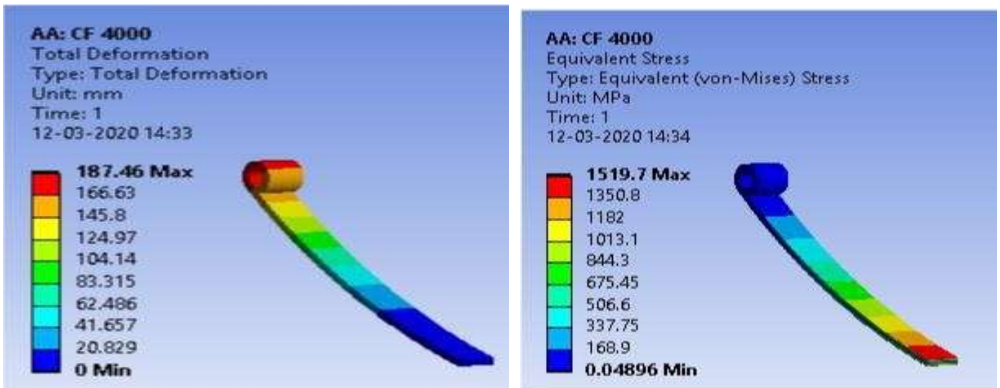


Fig 4.5.4 D Deformation and stress for 4000N load.

Deformation stress

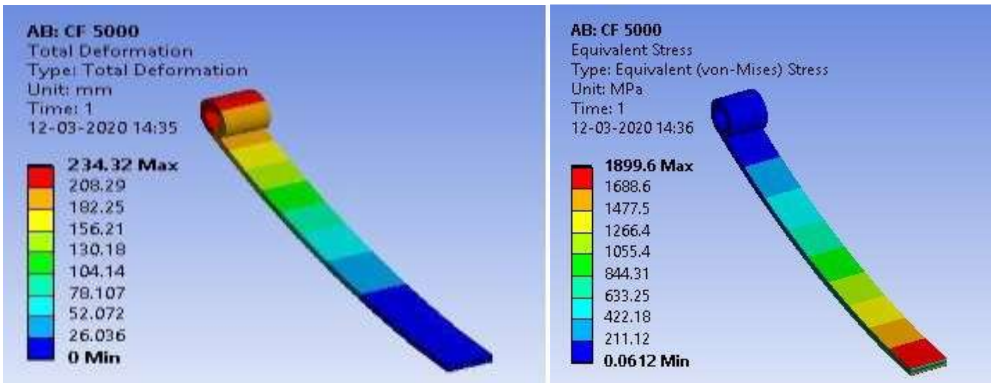


Fig4.5.4EDeformationand stressfor5000Nload.

Deformation stress

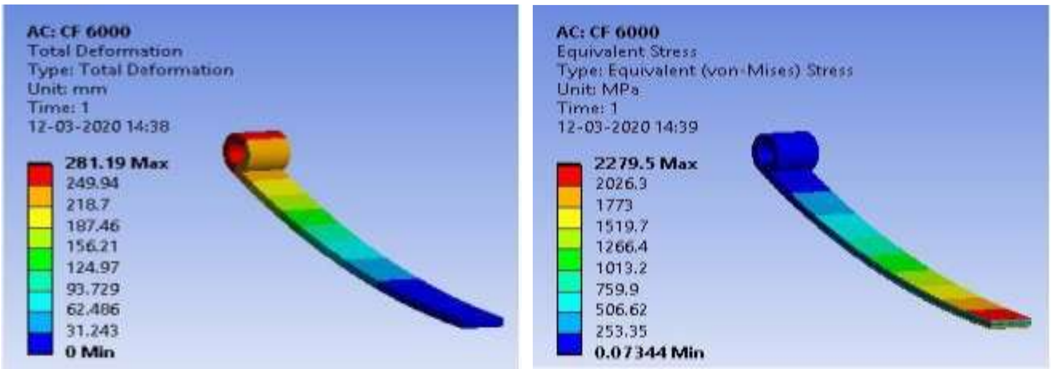


Fig4.5.4 FDeformation andstress for6000Nload.

4.5.5 Carbonfiberwiththickness

Deformation stress

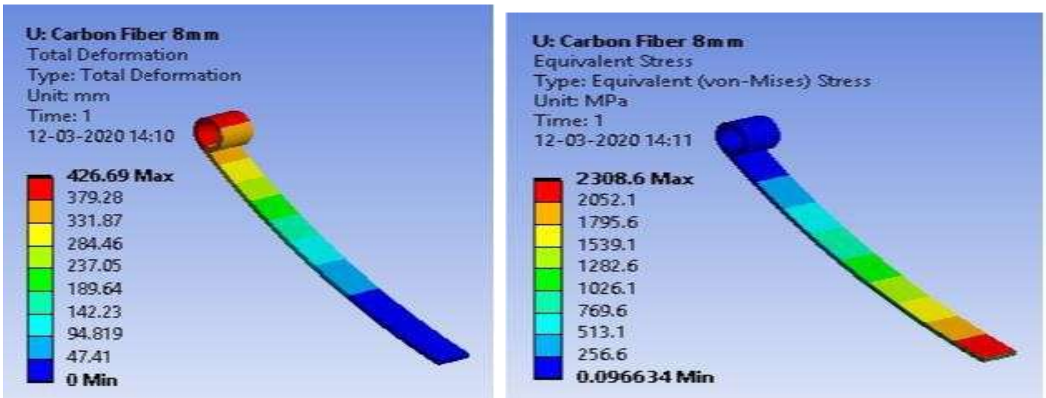


Fig4.5.5 ADeformation andstress for8mmthickness.

Deformation stress

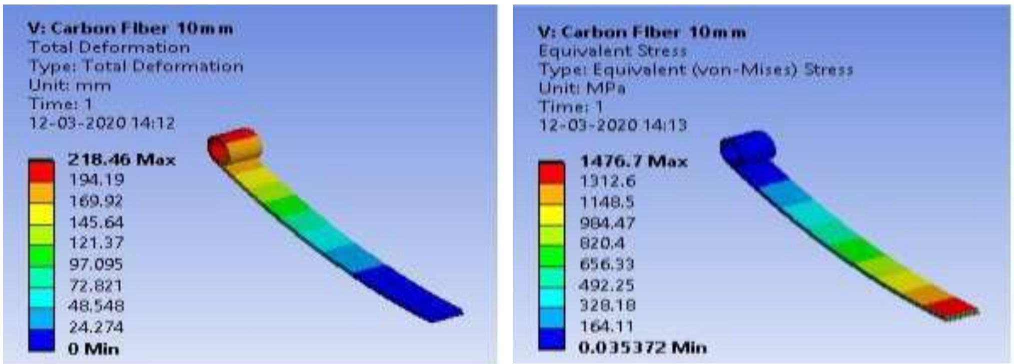


Fig4.5.5BDeformationandstress for10mmthickness.

Deformation stress

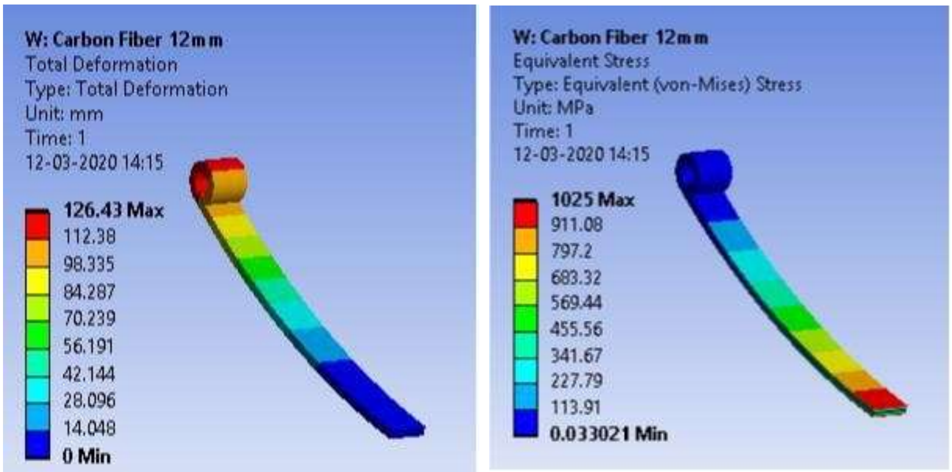


Fig4.5.5CDeformationandstress for12mmthickness.

V. RESULT

5.1. Comparisonofthethreeabovematerialsonbasisof Deformation, Stress and Weight by Theoretical calculations andANSYSResults:

5.1.1 onbasisofDeformation:

ANSYSResult

TheoreticalResult

	Original	
Load	Hand	ANSYS
1000	57.2	29.069
2000	114.4	58.13
3000	171.6	87.2
4000	228.8	116.28
5000	286	145.35
6000	343.2	174.45

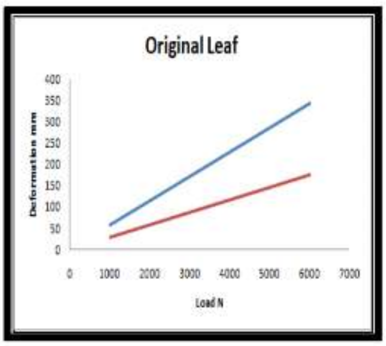


Fig5.1graphofdeformationfororiginalleafspring

	Glass Fiber	
Load	Hand	ANSYS
1000	50.89	58.73
2000	101.79	117.5
3000	152.69	176.21
4000	203.59	234.94
5000	254.49	293.68
6000	305.39	352.41

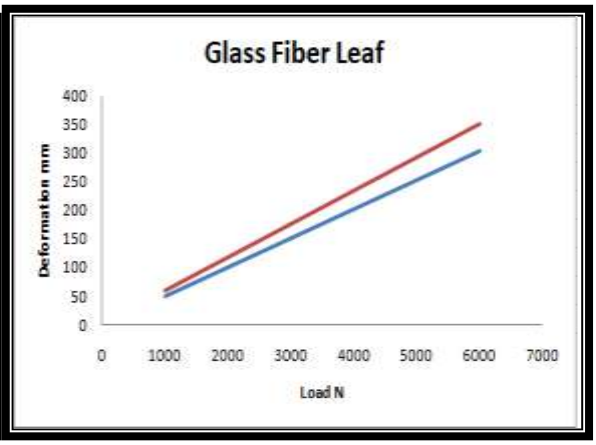


Fig5.2graphofdeformation forglassfiberleafspring

	Carbon Fiber	
Load	Hand	ANSYS
1000	41.87	46.86
2000	83.74	93.72
3000	125.61	140.59
4000	167.48	187.46
5000	209.36	234.32
6000	251.23	281.19

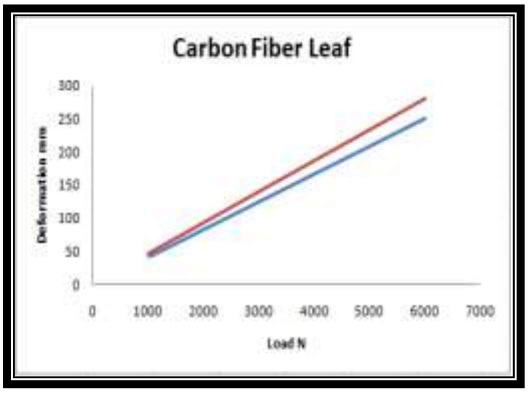


Fig5.3graphofdeformationforCarbonfiberleafspring

5.1.2 onbasis ofstress:

	Original	
Load	Hand	ANSYS
1000	438.75	398.6
2000	877.5	797.41
3000	1316.25	1196.1
4000	1755	1594.4
5000	2193.75	1993.5
6000	2632.5	2392.2

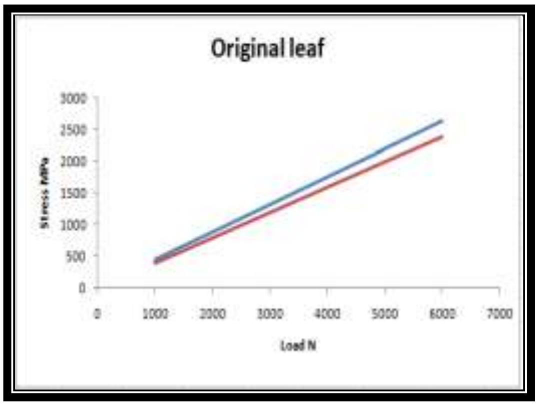


Fig5.4Graphofstressfororiginalleafspring

	Glass Fiber	
Load	Hand	ANSYS
1000	219.375	216.35
2000	438.75	453.51
3000	658.125	649.09
4000	877.5	865.38
5000	1096.875	1081.47
6000	1316.25	1298.1

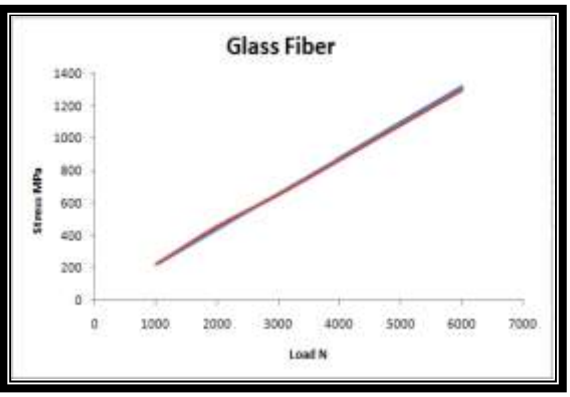


Fig5.5GraphofdeformationforGlassfiberleafspring

	Carbon Fiber	
Load	Hand	ANSYS
1000	390	379.92
2000	780	759.85
3000	1170	1139.8
4000	1560	1519.17
5000	1950	1899.6
6000	2340	2279.5

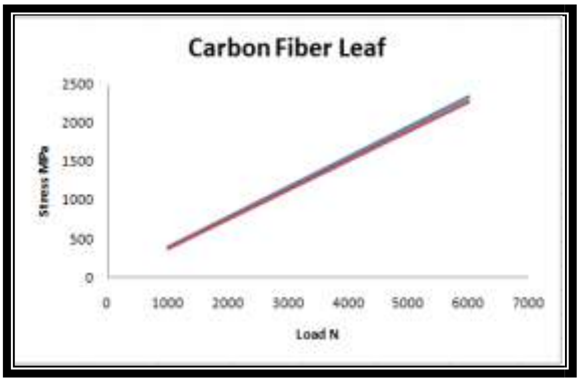


Fig5.6graphofdeformationforCarbonfiberleafspring

5.1.3. Onbasisofweight:

Sr. No.	Material	Weight (gm)
1	original	2366
2	G.F.	942
3	C.F.	580

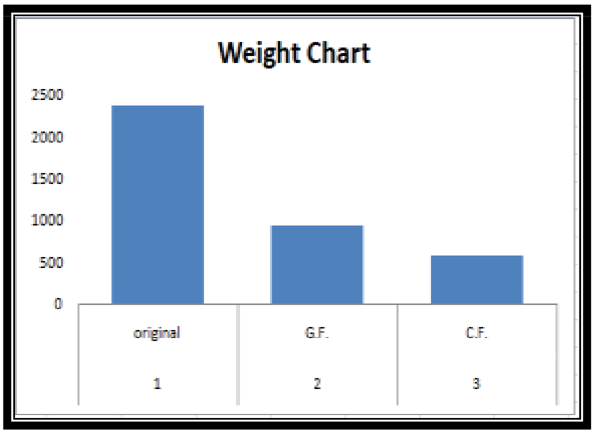


Fig5.7.GraphofWeight comparisonfortheabovematerials.

From the above plotted graphs it is clear that the CarbonFiber material is the best in every parameter. Henceforth we can go formanufacturingtheCarbonFiberCompositeleafspringandtestingiton UTM (Universal Testing Machine) with respect to Original leafSpring tocheckoutthe bestleafspring.

VI. MANUFACTURINGPROCESS

Theprimarymanufacturingmethodsusedtoproducecompositesinclude:

- ManualLay-Up
- Compressionmoulding
- Spray-Up
- FilamentWinding
- Injectionmoulding
- ResinTransfermoulding

6.1 Manuallay-upmethod:

It is an open molding method used for making compositematerials that differ from small to large size. Production of compositesusing this method is very slow but it is feasible to produce the enoughquantityusingmultiplemolds.Whencomparedtoothertypesofmolding methods, this one will be of less investment. Quality andproduction rate is based on the efficiency of the operator. The simplereplacementofleafspringbycompositeyieldsignificantweightsaving. It is not an easy task to replace steel by composite leaf spring.In these project glass fiber and carbon fiber and epoxy resin material isused to make the leaf. There are different types of techniques areavailableforthefabricationofcompositeleafspring.Forthefabrication of leaf spring we use the hand layup method. It is alsoknown as open moulding method and it required least amount whencomparetoothermethods.Thismethodisusedtofabricateallkindsofmaterials fromlargetoosmall. This methodincludes fiberandresinfor developing. Fiberis used inthe system inhandand resinwithbrush or roller. It is one of the simplest moulding methods with lowcost tooling and simple processing. For better quality surface, with thehelp of spray gun a gel type of coat is applied .Once the gel coat iscured, then the fiber is manually placed on the mould. The laminatingresin is applied by pouring, brushing, spraying, or using a paint roller.FRP rollers, paint rollers, or squeegees are used to consolidate thelaminate,thoroughlywettingthereinforcementandremovingentrapped air. Subsequent layers of fiberglass reinforcement are addedto build laminate thickness. The layer by layer of resin and fiber areappliedbythemethodofhandlayupmethod.Thisisknownassandwich construction.

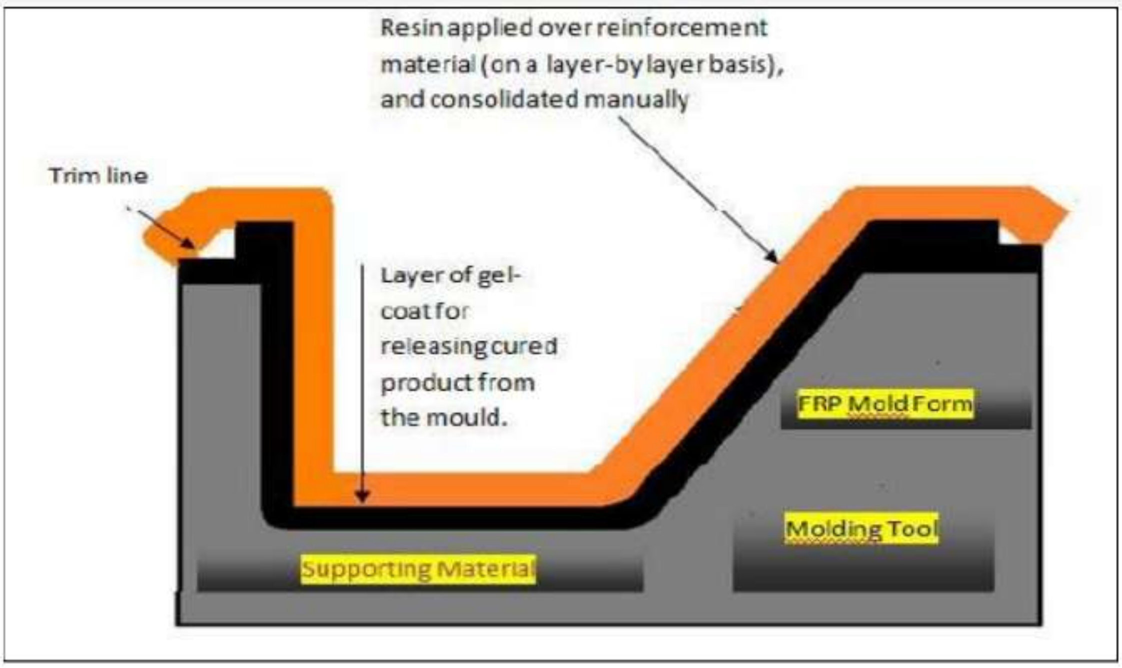


Fig6.1.SchematicRepresentationoftheHandlayupprocess

6.2 AdvantageofHandLayupProcess:
- Appropriateforlargeandproductswithcontouredsurfaces.
- Requireslimitedcapitalexpenses.
- Setupcostsandproductionlead timeareless.
- Doesnotrequirehighlytrainedandskilledpersonnel.
- Flexibleintermsofaccommodatingchangesindesign.
- Complexfeaturecanbefabricatedthroughusedofmolded-ininserts.

6.3 LimitationsofHandLayupProcess:
- Inappropriateforlargevolumeproduction.
- Laborintensive.
- Requireslong cure time, as material hardens at roomtemperature
- Qualitycontrolisdifficultasmanyprocessesarehighlydependent onmanualskills.
- Productsproducedthroughopenmoldingprocessyieldononegood moldingsurface.
- Theothersurfaceisroughandcoarseinsurfacefinish.
- Wastageof materialsmaybe high.
- Product-to-product variations in quality may be high.Remaining part
- Hardenerandresin
- Adhesive
- Taint

VII. CONCLUSIONANDFUTURESCOPE

Reducing weight and increasing strength of products havehighdemandsintheautomobileworld.Compositematerialscansatisfy these demands considerably. The present work involves thestaticanalysisofconventionalsteelspringandcompositespring .Model is preferred in CATIA V5R20 and then analysis is performedthrough ANSYS 14.0. A comparative study has been made betweensteelandcompositeleafspringtofindoutmaterialhavinghighstrength to weight ratio.From The results obtained it is concludedthat,

1) Bending stress and deflection occurred in the composite leaf springislessascomparedtoconventionalsteelspring.
2) ResultsobtainedthroughANSYSaregotvalidationfromTheoretical calculationsand Testing.
3) The natural frequency of composite leaf springs is higher than thesteel leaf spring and it’s far enough from the road frequency to avoidresonance.
4) CompositeE-glassepoxyspringhas30%andcarbonfiberhas55 % less weight than conventional steel spring. So composites can besuggested for monoleaf spring.

Future Scope:
1) Composite material having different grades can be compared andanalyzed
2) Fatigueanalysisofcompositemonoleafspring.

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