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"Comparative Analysis of Two Wheeler Suspension Helical Compression Spring for Conventional and Composite Material at Different Loading Condition"

Yogesh P Shingane[1], Dr. D. M. Patel[2], Prof. H. G. Patil[3]

PG Scholar, Department of Mechanical Engineering, D. N. Patel College of Engineering, Shahada, M.S., India[1]

Associate Professor, Department of E&TC Engineering, D. N. Patel College of Engineering, Shahada, M.S., India[2,3]

Abstract— Presently the automobile manufacturers are facing challenges of improvements in the quality and performance of the components together with the reduction in weight and cost of manufacturing. Efforts are directed towards the use of alternative materials in design which results in increase of strength to weight ratio. The use of composite materials is increasing in the design of automobile components due to their light weight and costs. The present work attempts to study the feasibility of select composite materials in the design of helical compression spring used in automobile suspension systems. The design of helical compression spring is first analyzed for the conventional steel material and then compared with that of for the composites used as spring materials study their behaviors at the different loading conditions. Composite materials considered for the analysis are Eglasss/Epoxy and Carbon/Epoxy. The modeling of the helical spring has been done using software and simulation were performed using ANSYS to predict the stresses, deflections at the stated loads. It was found that the stresses developed in conventional steel helical compression spring is more as compared to the stresses developed in composite material helical compression spring. Also the deflection is observed to be higher for composite materials. The results indicate that composite materials are feasible option at normal loading conditions which will also reduce the manufacturing and maintenance costs.

Keywords— Helical compression spring, Composite materials, E-glass/Epoxy, Carbon/Epoxy and Finite Element Analysis.

I. INTRODUCTION

Helical coil compression springs are generally used for absorb the energy due to the impacts and to form a flexible link which deflects under loading and restore the objects to the normal position where the disturbing forces are removed. These springs mostly in the suspension system of two wheelers (motor bikes) may fail due to overloading which occurs in Indian conditions .Automobile manufacturers today are facing challenges to reduce the manufacturing and maintenance costs without confirming the quality and functionality of parts .Helical compression springs contribute majorly in the total costs and weight of the suspension system and are therefore liable for modification improvement in design. To analyze the design of a spring used in a two wheeler vehicle with the objectives of comparing the behavior of conventional material and composites used as spring materials.

Fig.1 Helical coil compression springs

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II. TYPES OF SPRINGS

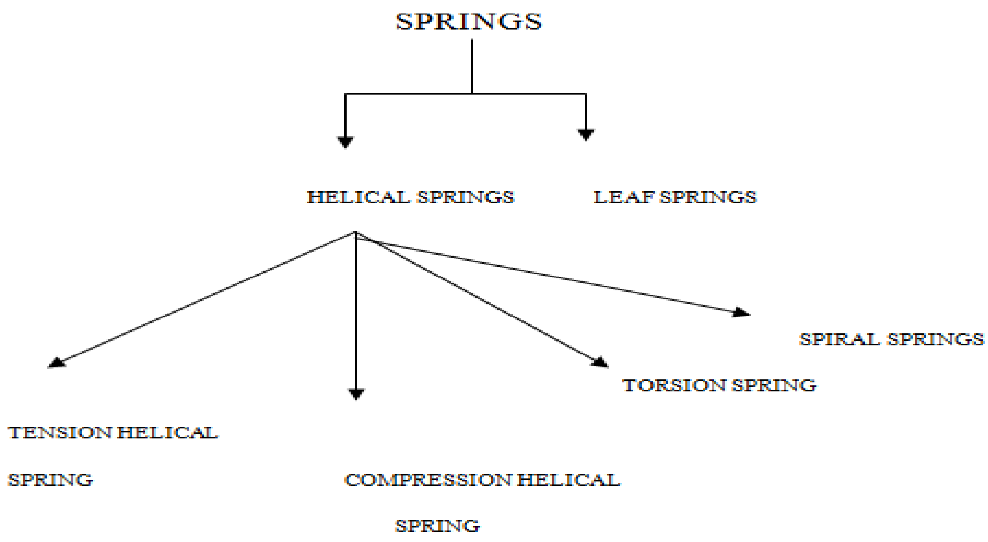

Fig.2 Classification of springs

III. TYPES OF HELICAL SPRING

DEFINITON: - It is made of wire coiled in the form of helix.

CROSS-SECTION: Circular, square or rectangular

CLASSIFICATION: 1)) Compression helical springs

2) Tension helical spring

Though there are many types of sprigs, these are the main springs which we can see often. There are four standard types on helical compression springs. They are plain end, squared end, plain-ground end, and squared-ground.

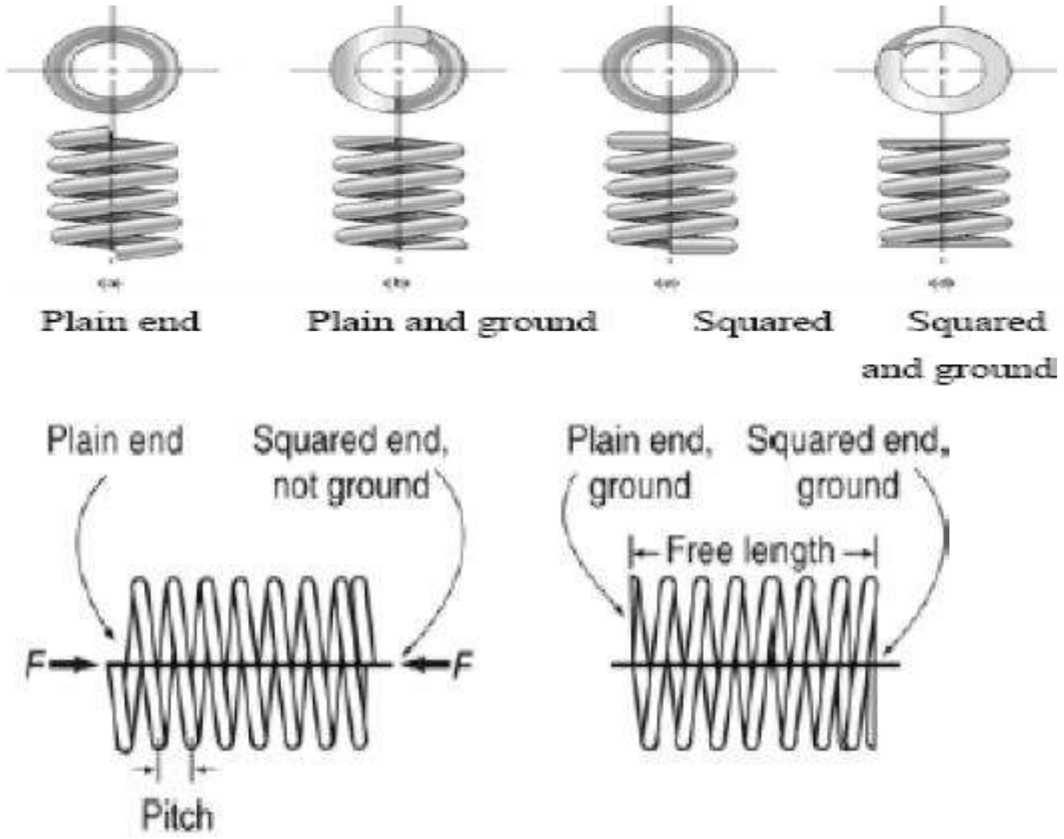

Fig.3 Types of helical spring

A spring with plain ends has non-interrupted helicoids the ends are the same as if a long spring had been cut into sections. A spring with plain ends that are squared or closed is obtained by deforming the ends to a zero-degree helix angle. Springs should always be both squared and ground for many applications, because a better transfer of the load is obtained. A spring of squared and ground ends compressed between rigid plates can be considered to have fixed ends.

IV. CONCEPT OF SPRING DESIGN

In new design of spring have the following considerations:

• Space into which the spring must fit and operate.

• Forces and deflections working values.

• Requires accuracy and reliability.

• Tolerances and permissible variations in specifications.

• Environmental conditions such as temperature, presence of a corrosive atmosphere.

• Cost and qualities needed.

These factors used to select a material and specify suitable values for the diameter of spring wire, the number of coils, mean coil diameter and the free length and the spring rate needed to satisfy working force deflection requirements. The design constraints are that the size of wire should be commercially available and that the stress at the solid length be no longer greater than the torsional yield strength.

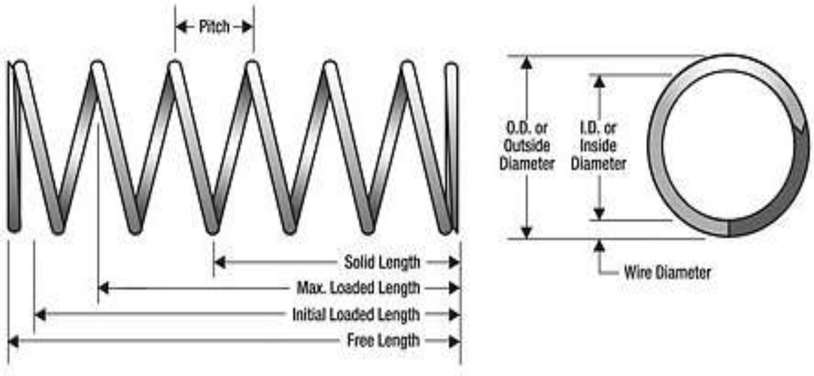

Fig.4 Spring Design

V. WHY A COMPOSITE MATERIAL FOR HELICAL SPRING?

From last thirty years composite materials, plastics and ceramics have been the dominant emerging materials. The volume and number of applications of composite materials have developed steadily, penetrating and conquering new markets continuously. Modern composite materials constitute a significant proportion of the engineering materials market ranging from everyday products to sophisticated niche applications. While composites have already proven their worth as weight-saving materials, the current challenge is to make them cost effective. The efforts to produce economically attractive composite components have resulted in several innovative manufacturing techniques currently being used in the composites industry. It is acceptable, particularly for composites, that to produce new technology in manufacturing technology is not enough to overcome the cost obstacle. It is essential that there be an integrated effort in design, material, process, tooling quality assurance, manufacturing, and even program management for composites to become competitive with metals. Further, the need of composite for lighter construction materials and more seismic resistant structures has placed high emphasis on the use of new and advanced materials that not only decreases dead weight but also absorbs the shock & vibration. Composites are now extensively being used for rehabilitation/ strengthening of pre-existing structures that have to be retrofitted to make them seismic resistant, or to repair damage caused by seismic activity. Unlike conventional materials (e.g. steel), the properties of the composite material can be accomplished by considering the structural relevance. Both material and structural design involves while design of a structural component using composite materials. Composite properties (e.g. stiffness,) can be differed continuously over a lot range of values under the control of the modifier. Careful selection of reinforcement type allows finished product characteristics to be bespoke to almost any specific engineering necessity. While the use of composites will be a only better choice in many criterion, material selection in others will depend on factors such as working lifetime needs, number of items to be produced, complexity of product shape, possible savings in product costs and on the experience & skills the designer in tapping the optimum value of composites. In some instances, best results may be achieved through the use of composites in combination with traditional materials.

VI. OBJECTIVE OF THE STUDY

The following are the objectives of the study:

1) Study existing helical spring and its design.
2) Geometric modeling of existing helical spring.
3) To carry out linear static analysis of existing helical spring.
4) To carry out analysis of helical spring design for same loading condition.
5) To carry out experimental validation with obtained results
6) Recommendation of new solution for weight optimization.

Stresses and deflections are obtained from finite element analysis for both materials are compared and conclusions are drawn.

VII. METHODOLOGY

1) 3D modeling of helical spring as per dimension.
2) Analysis of helical spring in ANSYS 18 for static loading condition.
3) For weight optimization we use Glass Fiber (GF) as a composite material for helical spring.
4) Design of helical spring for composite material by using analytical calculation.
5) 3D model of helical spring as per result of hand calculation.
6) Analysis of helical spring in ANSYS 18 for static loading condition.
7) If all result are OK then go for manufacturing, if not then again design and analysis by using ANSYS 19.
8) After manufacturing, observe result by using UTM for stresses & deflection in helical spring.
9) Compare all results.

VIII. DESIGN CALCULATION OF HELICAL SPRING

Specification of spring

Spring wire diameter (d) = 8 mm

Mean coil diameter (D) = 40 mm

Free length of spring (L_s) = 160 mm

No of turns (n) = 11

Spring Index (C) = For given specification, Spring Index (C) = = 5

Wahls stress factor(K)= + K = + = 1.31

Deflection **(**y) =

Maximum shear stress **(**τ_{max}) =

The present work attempts to analyze the design of a helical compression spring (as shown in fig 1) used in the suspension system of a two wheeler (motor-bike) currently used in Indian roads.

Load considerations :

Now weight of bike= 131 kg

Let weight of 1 person= 70 kg

Weight of bike and 1 person= 131+70=201 kg

Weight of 2 persons= 140 kg

Weight of 2 person and bike=131+140=271 kg

W1=201 kg and W2=271 kg

Suspension is 65 %

Hence 65% of 201= = 130.65 kg

Similarly 65% of 271 = = 176.15 kg

Consideration of dynamics load it will be double

Therefore W1= 130.65 X 2 = 261.3 kg

And W2 = 176.15 X 2 = 352 kg

Now load - F=Wx9.81

F1=W1x9.81 = 261.3x 9.81 = 2563.35 N

F2=W2x9.81 = 352x9.81 = 3453.12 N

For single shock absorber weight

F1=2563.35/2 = 1281.7 N

F2 = 3453.12/2 = 1726.6 N

MATERIAL- 1) Steel

Sr.No	Specification	Value
1	Density(g/cm^3)	7.85
2	Allowable shear stress (Mpa)	480
3	Modulus of rigidity (N/mm^2)	80000
4	Modulus of elasticity (N/mm^2)	210000
5	Ultimate Tensile strength (Mpa)	505
6	Yield tensile strength (Mpa)	215
7	Poissons Ratio	0.3

For load F1=1281.7 N

Deflection (y) =

(y) = =22.02 mm

Maximum shear stress (τ_{max}) =

The stress generated in the helical spring is lower than the allowable design stress. So design is safe.

(τ_{max}) = =334.03 N/mm^2

For load F2=1726.6 N

Deflection (y) =

(y) =29.67 mm

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Maximum shear stress (τ_{max}) =

(τ_{max}) =450 N/mm^2

The stress generated in the helical spring is lower than the allowable design stress. So design is safe.

Table 1: - Design calculation for Stress and Deflection values at various loads(Conventional Steel Helical spring)

Sr. No.	Load applied on conventional Helical spring (N)	Maximum shear stress (τ_{max}) in MPA	Deflection (y) occurred in (mm)
1.	1281.7	334.03	22.02
2.	1726.6	450	29.67

IX. MATERIAL SELECTION

Material properties of Conventional steel spring

Sr.No	Specification	Value
1	Density(g/cm^3)	7.85
2	Allowable shear stress (Mpa)	480
3	Modulus of rigidity (Mpa)	80000
4	Modulus of elasticity (Mpa)	210000
5	Ultimate Tensile strength (Mpa)	505
6	Yield tensile strength (Mpa)	215
7	Poissons Ratio	0.3

Material properties of Composite spring:- E-glass /epoxy

Sr. no	Properties		E-glass/epoxy
1	YOUNG MODULUS(E)	E_X(MPa)	43000
		E_Y(MPa)	6500
		E_Z(MPa)	6500
2	POISSONS RATIO	PR_{XY}	0.27
		PR_{YZ}	0.06
		PR_{ZX}	0.06
3	SHEAR MODULUS(G)	G_X(MPa)	4500
		G_Y(MPa)	2500
		G_Z(MPa)	2500
4	DENSITY	ρ(kg/mm^3)	0.000002

X. MODELING AND ANALYSIS OF STEEL HELICAL SPRING

A. Modeling of Steel helical spring-

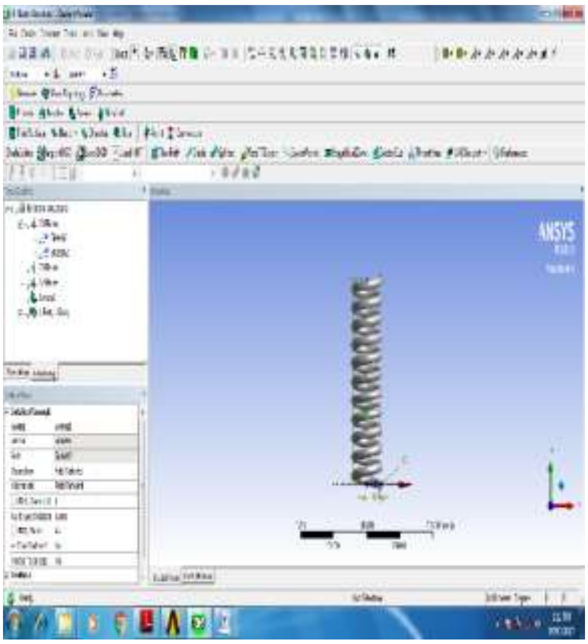

Fig.5 Drawing of Steel helical spring

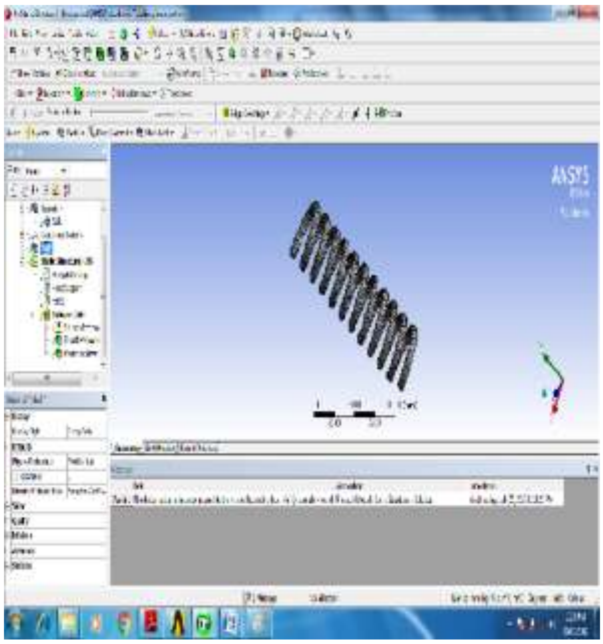

Fig.6 3D Modeling of Steel helical spring (Meshed body)

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B. 3D Modeling of Steel helical spring in ANSYS

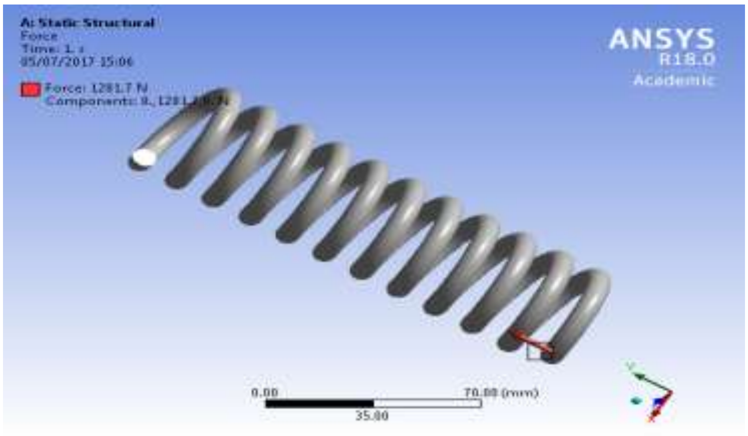

Fig.7 3D Modelling of Steel helical spring (Defining Force)

C. FEA-Result Analysis Of Steel helical Spring

Application of Load on spring = 1281.7 N

Maximum shear stress contour of steel helical spring at 1281.7 N.

Maximum deflection contour of steel helical spring at 1281.7 N.

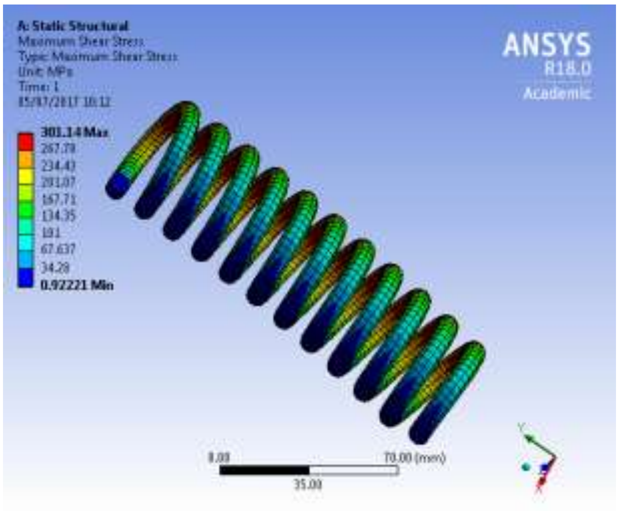

Fig.8 Maximum shear stress contour steel Helical spring at 1281.7 N.

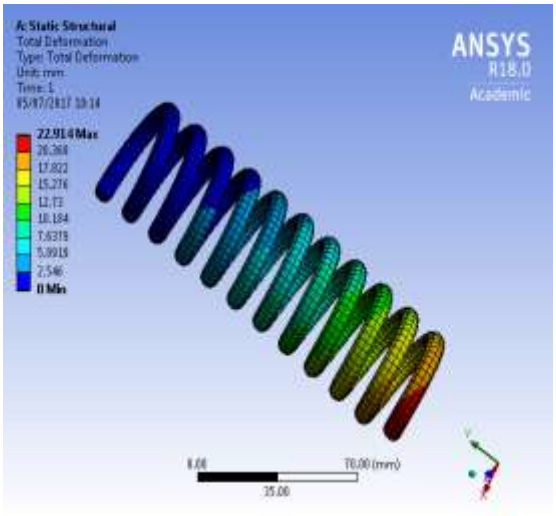

Fig. 9 Maximum deflection contour of steel helical Spring at 1281.7 N.

Table 2: FEA- Results for Stress and Deflection values at various loads (Steel Helical spring)

Sr. No.	**Load applied on conventional Helical spring (N)**	**Maximum shear stress (τ_{max}) in MPA**	**Deflection (y) occurred in (mm)**
1.	1281.7	301.14	22.91
2.	1726.6	426.62	30.55

Table 3: Weight of Steel helical spring observed in ANSYS

Sr. No.	**Material of spring**	**Weight observed in ANSYS**
1)	Conventional Steel helical spring	0.53829

XI. MODELING AND ANALYSIS OF COMPOSITE HELICAL SPRING

A. Modeling of Composite helical spring-

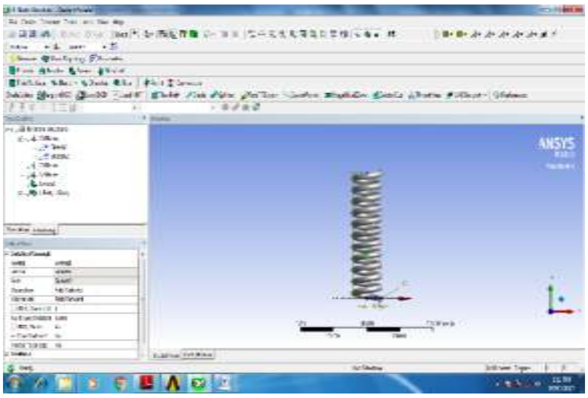

Fig.10 Drawing of Composite helical spring

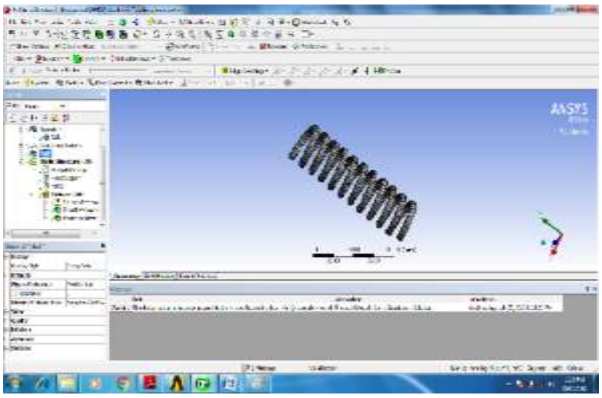

Fig.11 3D Modelling of Composite helical spring (Meshed body)

B. 3D Modeling of Composite helical spring in ANSYS

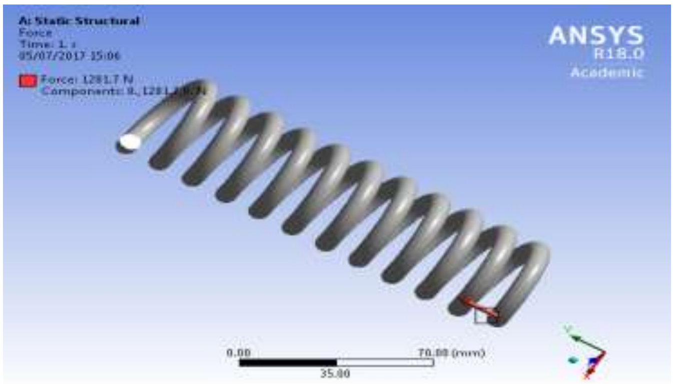

Fig. 12 3D Modelling of Composite helical spring (Defining Force)

XII. EXPERIMENTAL INVESTIGATION AND VALIDATION

A. Introduction to Testing

For experiments, the existing helical spring designed by the Sponsoring firm for vendors is put to test. The helical spring would normally encounter gradually applied loads. For reasons of safety, `sudden load' is already considered during its design phase. As such, the existing steel helical spring is tested for mechanical strength, while a trial is taken.

Fig. 13 Universal Testing Machine

B. Validation -Upon completion of the experimentation, the assembly is observed for any visible damage to the helical spring. The units are measured for their height, especially at the central region along the length of the unit with a general purpose retractable measuring tape. The recorded measurement does not highlighting any sag induced in the unit during the experimentation phase.

XIII. RESULT & DISCUSSION

International Journal of Advanced Research in Science Management and Technology

ISSN(Online)-2454-4159 *Volume 3, Issue 7, July 2017*

Table 4: Comparison of Theoretical, Static analysis (FEA) and Experimental results for Conventional Steel Helical spring

Sr. No.	LOAD (N)	Deflection (*y*) (mm)			
		Theoretical Result	Static Analysis Results (FEA)	Experimental Results (UTM Machine)	Percentage Variation observed
1)	1281.7	22.06	22.91	19.9	0.1 %
2)	1726.6	29.67	30.55	29.6	0.03 %

Table 5: Comparison of Theoretical, Static analysis (FEA) and Experimental results for Composite Helical spring

Sr. No.	LOAD (N)	Deflection (*y*) (mm)			
		Theoretical Result	Static Analysis Results (FEA)	Experimental Results (UTM Machine)	Percentage Variation observed
1)	1281.7	70.49	69.46	67.7	0.02 %
2)	1726.6	94.46	92.61	90.2	0.03 %

Table 6: Weight reduction due to Optimization-Analytically

Design	Weight (Kg) (Analytically)	% Material required compared to existing design	% Material save compared to existing design
Existing(Steel)	0.53829	100	------------------
Optimized(Composite Material)	0.13891	25.80	74.2

Table 7: Weight reduction due to Optimization-experimentally

Design	Weight (Kg)	% Material required compared to existing design	% Material save compared to existing design
Existing(Steel)	0.770	100	------------------
Optimized(Composite Material)	0.186	24.16	75.84

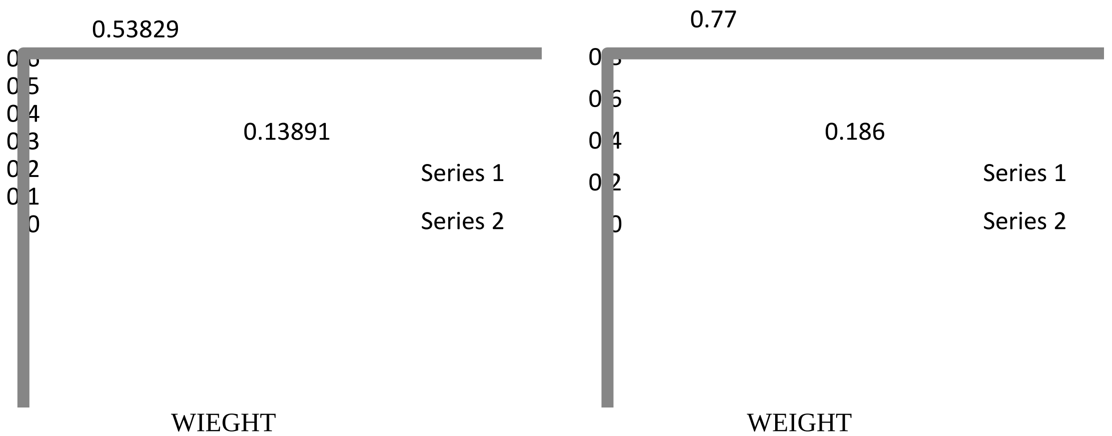

Fig.14 Comparison graph result of weights in steel Helical Spring and composite Helical spring- (a) Analytically (b) Experimentally

XIV. CONCLUSION

The composite Helical spring is lighter than conventional steel Helical spring with similar design specifications but not always is cost- effective over their steel counter parts. Composite materials have more elastic strain energy storage capacity and high strength to weight ratio as compared with those of steel. Therefore, it is concluded that composite helical spring is an effective replacement for the existing steel helical spring in automobile.

- E-glass epoxy is better than using Mild-steel as however stresses are little bit greater than mild steel, E-glass epoxy is having good yield strength worth.
- The weight of the helical spring is reduced considerably about 74.2% by replacing steel Helical spring with composite Helical spring. Thus, the objective of reducing the unstrung mass.
- 0.399 Kg weight reduction achieved by optimized design than existing design.
- 50 - 80 % reduction in stresses.
- Actual physical model is done for validation using optimized design parameters and it is found that the design is safe.

REFERENCES

[1] Dr. Dhananjay. R. Dolas , Kuldeep. K. Jagtap JNEC,Aurangabad (1 Feb. 2016), "Analysis of Coil Spring Used in Shock Absorber using CAE", International Journal of Engineering Research, Volume No.5, Issue No.2, pp : 123- 126

[2] Mr. Harshad B. Pawar1, Prof. Amol R. Patil2, Dr. Sanjay B. Zope3 (*2016*), "Analysis and Optimization of a Helical Compression Coil Spring used for TWV", *Vol-2 Issue-1 2016 IJARIIE-ISSN(O)-2395-4396* .

[3] Ganesh Bhimrao Jadhav1, Prof. Vipin Gawande2 1Research Student (Mechanical Department, Dr D.Y. Patil Institute Of Technology (2015), "Review On Development And Analysis Of Helical Spring With Combination Of Conventional And Composite MateriaLS", International Journal of Engineering Research and General Science Volume 3, Issue 2, March-April, 2015.

[4] Logavigneshwaran S.1, Sriram G.2, Arunprakash R.3, Design and Analysis of Helical Coil Spring in Suspension System, International Journal For Trends In Engineering & Technology Volume 9 Issue 1 – September 2015 - ISSN: 2349 - 9303

[5] Muhammad Abu Rahat1, Muhammad Ferdous Raiyan2, MD. Safayet Hossain3, J.U. Ahamed4, Nahed Hassan Jony5 (2015), "Design and Fabrication of a Spring Constant Testing Machine and Determination of Spring Constant of a Compression Spring", International Journal of Engineering Research ISSN:2319-6890)(online), 2347-5013(print) Volume No.4, Issue No.9, pp : 574-578 01 Sept. 2015

[6] Animesh Das1, Awinash kumar2 Selection of Spring Material Using PROMETHEE Method, *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*

[7] Bhavesh R. Valiya1 Prashant S. Bajaj2, An Experimental and Theoretical Analysis and Modification of a Shock Absorber of Bajaj Discover 150CC, *IJSRD - International Journal for Scientific Research & Development| Vol. 3, Issue 10, 2015 | ISSN (online): 2321-0613*

[8] K vinay Kumar, Design and analysis of helical apring in two wheeler suspension system, IJRAET,

[9] Mr Ganesh Jadhav, #2Prof: Vipin Gawande, Design And Analysis Of Helical Spring With Combination Of Conventional And Composite Materials, International Engineering Research Journal (IERJ) Special Issue 2 Page 4930-4934, 2015

[10] Sangmesh Pattar1, Sanjay S.J2, V.B.Math3, Static Analysis Of Helical Compression Spring, Ijret: International Journal of Research in Engineering and Technology

[11] C.Madan Mohan Reddy1 D.Ravindra Naik2 Dr M.Lakshmi Kantha Reddy3, Analysis And Testing Of Two Wheeler Suspension Helical Compression Spring, IOSR Journal of Engineering (IOSRJEN), Vol. 04, Issue 06 (June. 2014)

[12] Sourabh G. Harale1, Prof. M. Elango , Design of Helical Coil Suspension System by Combination of Conventional Steel andComposite Material, International Journal of Innovative Research in Science,Engineering and TechnologyVol. 3, Issue 8, August 2014

[13] Youli Zhu *, Yanli Wang, Yuanlin Huang, Failure analysis of a helical compression spring for a heavy vehicle's suspension system,

[14] Satbeer Singh Bhatia* , Ajeet Bergaley, Analysis of the Design of Helical Compression Spring to Study the Behaviour of Steel and Composites Used as Spring Materials, INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY, August, 2014]

[15] B. Praveen kumar1, P. Sampath Rao2, Investigation on Reduction in Premature Failure of Locomotive Coil Springs, International Journal of Engineering Research & Technology (IJERT) Vol. 3 Issue 9, September- 2014

[16] N.Lavanya1, P.Sampath Rao2 M.Pramod Reddy3. Design and Analysis of A Suspension Coil Spring For Automotive Vehicle, *N.Lavanya et al. Int. Journal of Engineering Research and Applications, ISSN : 2248-9622, Vol. 4, Issue 9(Version 5), September 2014,* pp.151-157

[17] Koneti.Manikanta*, N.Amaranageswararao, Modification of a Two Wheeler Suspension System using Fea, *Int. Journal of Engineering Research and Applications, Vol. 4, Issue 11(Version - 4), November 2014*

ISSN(Online)-2454-4159 *Volume 3, Issue 7, July 2017*

[18] MacArthur L. Stewart1, A Computational Approach For Evaluating Helical Compression Springs, Ijret: International Journal of Research in Engineering and Technology

[19] Supriya Burgul, Literature Review on Design, Analysis and Fatigue Life of a Mechanical Spring, International Journal Of Research In Aeronautical And Mechanical Engineering

[20] Gajendra Singh Rathore1*, Upendra Kumar Joshi2 , Fatigue Stress Analysis Of Helical Compression Spring:A Review , International Journal of Emerging Trends in Engineering and Development Issue 3, Vol.2 (May 2013)

[21] K Pavan Kumar1*, S Praveen Kumar1 and G Guru Mahesh1, Static Analysis Of A Primary Suspension Spring Used In Locomotive, *Int. J. Mech. Eng. & Rob. Res. 2013*

[22] M.Sudhakar Reddy1,B.Madhusudhan Reddy2, The Study of Premature Failure of Springs Used In Railway Coaches, *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE).*

[23] Niranjan Singh, General Review Of Mechanical Springs Used In Automobiles Suspension System, International Journal of Advanced Engineering Research and Studies

[24] Mehdi Bakhshesh1 and Majid Bakhshesh2, Optimization of Steel Helical Spring by Composite Spring, International Journal Of Multidisciplinary Sciences And Engineering, Vol. 3, NO. 6, JUNE 2012.

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