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# FINITE ELEMENT ANALYSIS OF HELICAL COMPRESSION SPRING FOR TWO WHEELER AUTOMATIVE FRONT SUSPENSION

**Arif Ahmad Ansari *1 and Prof. K. K. Jain2**

[*1]Research Scholar, M.E. (Machine Design), Department of Mechanical Engineering, Shri Ram Institute of Technology, Jabalpur (MP), India

[2]Associate Professor, Department of Mechanical Engineering, Shri Ram Institute of Technology, Jabalpur (MP), India

## ABSTRACT

The current paper deals with the stress analysis of a helical compression spring, which is employed in two wheeler's Automotive Front Suspension belonging to the medium segment of the Indian automotive market. In the design of this kind of spring both the elastic characteristics and the fatigue strength have to be considered as significant aspects. In addition to this particular elastic property, as a consequence of the research effort in reducing the mass of components typical of the automotive industry, these springs have to face very high working stresses. The structural reliability of the spring must be ensured. So for this purpose the static stress analysis using finite element method has been done in order to find out the detailed stress distribution and deformation of the spring. The present work deals the structural analysis for modelling the structural behaviour of helical compression springs. The design of spring in suspension system is very important. In this work a helical type of spring is designed and a 3D model is created using Catia. Structural analysis has been conducted on the helical compression spring by varying the spring material such as Structural steel, Stainless Steel and Chromium Vanadium. For this analysis, loads are considered as bike weight, single person. Structural analysis is done to validate the strength. The present Study makes an attempt to compare the results for selecting best material for springs.

***Keywords-*** *Helical compression spring, Suspension system, Structural analysis, Stress distribution, Deformation.*

## I. INTRODUCTION

The function of the suspension system in a vehicle is to prevent road shocks from being transmitted to the vehicle components and passengers, to safeguard from the road shocks, to preserve the stability of vehicle in motion, to maintain the road wheels in contact with the road surface. Coil springs are crucial suspension elements used on light passenger vehicle necessary to minimize the vertical vibrations impacts and bumps due to road irregularities and to create a comfortable ride. In vehicle coil spring is under static and dynamic load.

Two-Wheeled Vehicles form an essential part of public transport for the urban middle class population of India. The suspension system for such two wheeler vehicles is very poor as concerned with the ride comfort of the passengers. Nowadays the trend in the industries is moving towards the weight reduction in every component and springs are also not exempted. As helical coil compression springs are one of the main parts of the suspension system, it becomes quite necessary to do the complete stress analysis of the spring. Spring is defined as an elastic body that has the primary function to deflect or distort under load and to return to its original shape when the load is removed. First step in the design of spring is to determine the loads and the deflections required for a given spring application depending upon the type of the loading. In addition to selection of the material must be made. The assumption is that an element of an axially loaded helical spring behaves as a straight bar in pure torsion. If F be the load acting axially on the spring, $d$ is the diameter of the spring wire, $D$ is the mean diameter of the coil, and then forces acting on the element are resolved into a twisting moment, acting in a radial plane and a direct axial shearing force F. The stresses set up by the twisting moment are considered first and then superimposed on the stresses due to the direct shear. At the inner side of the coil, the shear stress due to the direct axial load F added such that it produces the torque moment, at this point. Thus the stress range at inner side of the coil is normally much higher than elsewhere. Therefore maximum shear stress at the inside of the coil given by

Where

$$\frac{k\,x FD}{\pi d^3}$$

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$$k = \frac{4C-1}{4C-4} + \frac{0.615}{C}$$

$$C = D/d$$

k is called as Wahl's factor used for considering stress correction because of curvature effect and *C* is called as spring index. Stress obtained by these formulae can be cross checked by finite element method for better understanding of the stress distribution. The deflection is given by formula

$$\frac{8FC^3n}{Gd}$$

Where *G* is the shear modulus of material and *N* is the number of active coils in the spring.

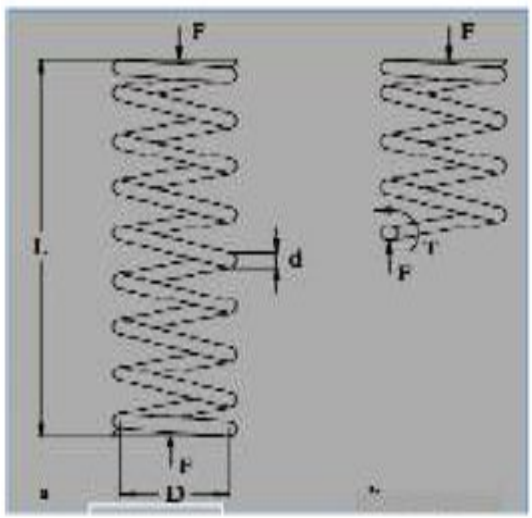


***Fig. (a) Axially loaded helical spring (b) Free body diagram showing that wire is subjected to torsional shear and a direct shear***

## II. FINITE ELEMENT ANALYSIS

The finite element method (FEM), sometimes referred to as finite element analysis (FEA), is a computational technique used to obtain approximate solutions of boundary value problems in engineering. A boundary value problem is a mathematical problem in which one or more dependent variables must satisfy a differential equation everywhere within a known domain of independent variables and satisfy specific conditions on the boundary of the domain. Boundary value problems are also sometimes called field problems. The field is the domain of interest and most often represents a physical structure. A General Procedure for Finite Element Analysis as below as-

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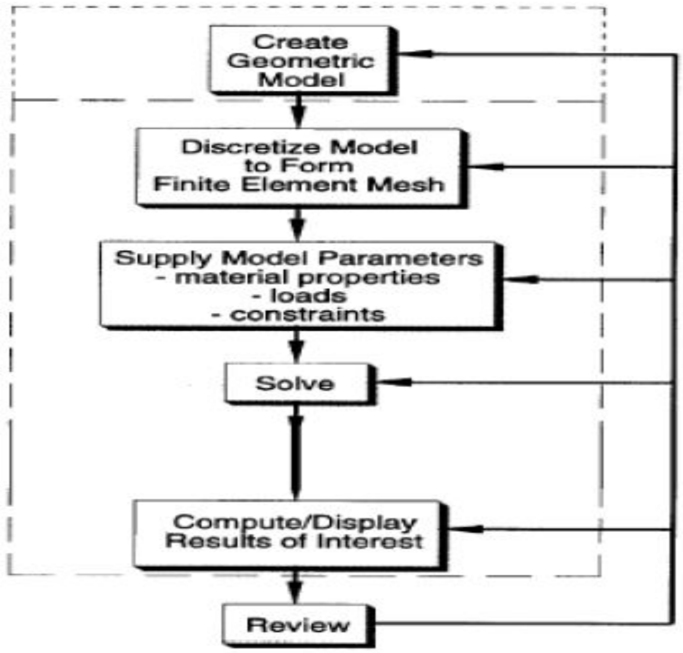


## III. GEOMETRY AND MATERIAL PROPERTIES

Specifications of the spring under consideration are given in the table 1. This spring is used in front suspension. Spring is made up of Structural steel, Stainless Steel and Chromium Vanadium material with squares and grounded ends. The material properties are given in the table 2.

***Table 1. Physical dimensions of a spring***

| Sr. No. | Description | Spring Specification |
|---|---|---|
| 1 | Diameter of spring wire | 12 mm |
| 2 | Mean diameter of spring | 60 mm |
| 3 | Pitch | 24 mm |
| 4 | Free length of spring | 300 mm |
| 5 | Number of active coils | 10 |
| 6 | Number of total coils | 12 |

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*Table 2. Material properties for helical compression springs*

| Sr. No. | Material | Poisson Ratio | Young Modulus (MPa) | Density( $kg/m^3$) |
|---|---|---|---|---|
| 1 | Structural Steel | 0.3 | 2.e+011 | 7850 |
| 2 | Stainless steel | 0.3 | 2.0684e+011 | 7917 |
| 3 | Cr-Vn | 0.3 | 1.93e+011 | 7917 |

**Theoretical Calculation for the Helical Compression Spring:**

**For Structural Steel**

Spring index, C = D/d =60/12=5

Wahl's stress factor, $k = \frac{4C-1}{4C-4} + \frac{0.615}{C} = \frac{4x5-1}{4x5-4} + \frac{0.615}{5} = 1.3105$

Equivalent Stress (MPa)= $\frac{k\,xFD}{d^3} = \frac{1.3105x1000x60}{3.14x12^3} = 371.74$ MPa

Deflection of spring, $\frac{FC^3n}{Gd} = \frac{8x1000x5^3x12}{79300x12} = 10.85$ mm

**For Stainless steel**

Spring index, C = D/d = 60/12=5

Wahl's stress factor, $k = \frac{4C-1}{4C-4} + \frac{0.615}{C} = \frac{4x5-1}{4x5-4} + \frac{0.615}{5} = 1.3105$

Equivalent Stress (MPa) = $\frac{k\,xFD}{d^3} = \frac{1.3105x1000x60}{3.14x12^3} = 371.32$ MPa

Deflection of spring, $\frac{WC^3n}{Gd} = \frac{8x1000x5^3x12}{79300x12} = 11.46$ mm

**For Cr-Vn**

Spring index, C = D/d = 60/12=5

Wahl's stress factor, $k = \frac{4C-1}{4C-4} + \frac{0.615}{C} = \frac{4x5-1}{4x5-4} + \frac{0.615}{5} = 1.3105$

Equivalent Stress (MPa) = $\frac{k\,xFD}{d^3} = \frac{1.3105x1000x60}{3.14x12^3} = 372.84$ MPa

Deflection of spring, $\frac{FC^3n}{Gd} = \frac{8x1000x5^3x12}{80000x12} = 10.25$ mm

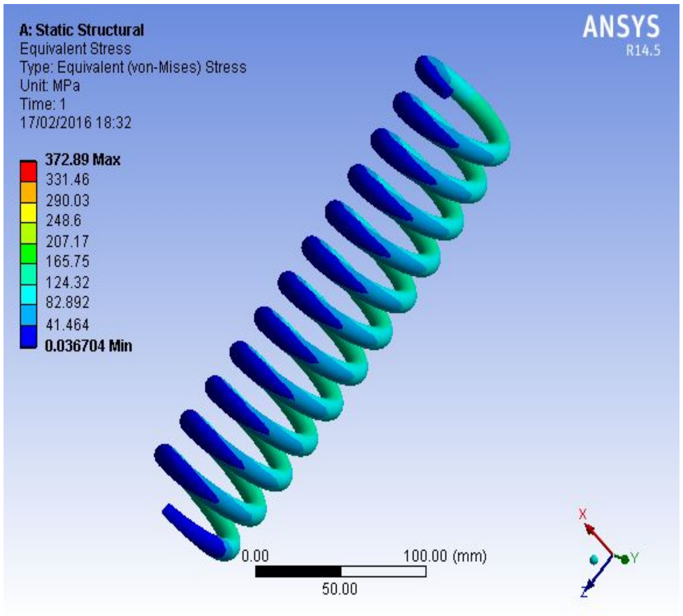
**Theoretical Results**

| Sr. No. | Material | Equivalent Stress (MPa) | Deformation (mm) |
|---|---|---|---|
| 1 | Structural Steel | 371.74 | 10.85 |
| 2 | Stainless steel | 371.32 | 11.46 |
| 3 | Cr-Vn | 372.84 | 10.25 |

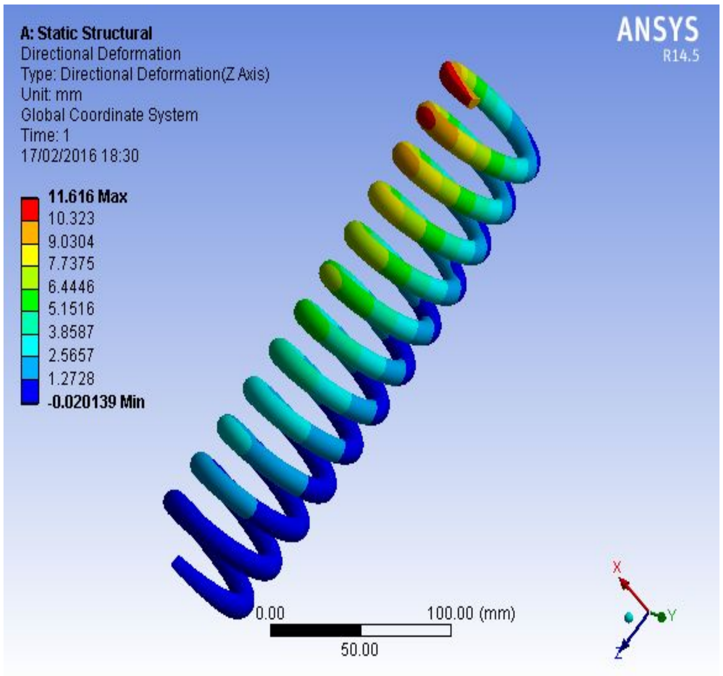
**Finite Element Analysis for the Helical Compression Spring:**

**For Structural Steel**

**Equivalent Stress**




**Directional Deformation**



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**Total Deformation**

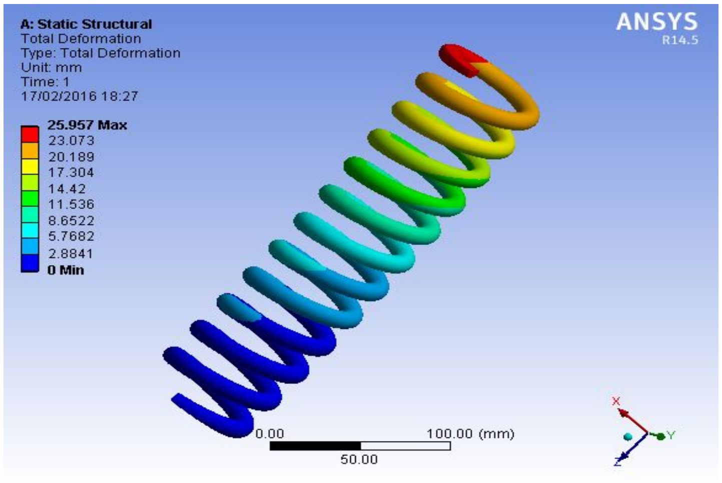
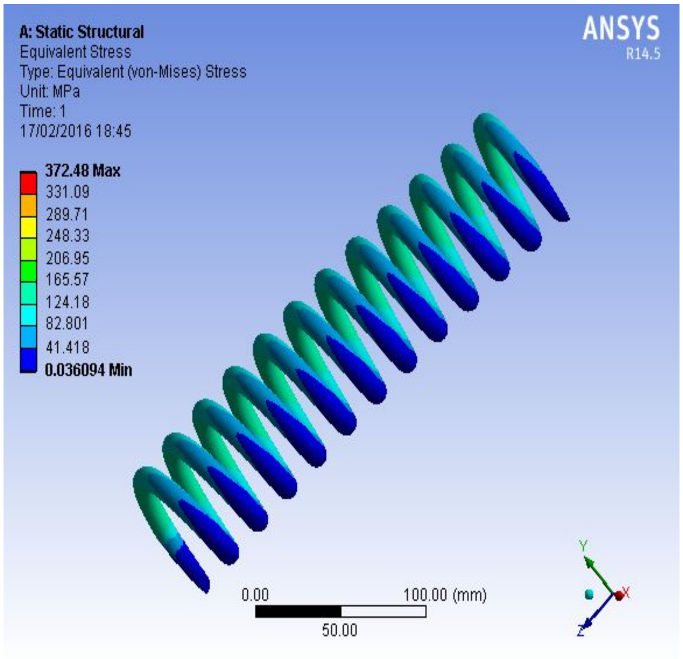



*Fig.1: Deformation and Equivalent stress of coil spring when load is 1000 N*

**For Stainless Steel**

**Equivalent Stress**



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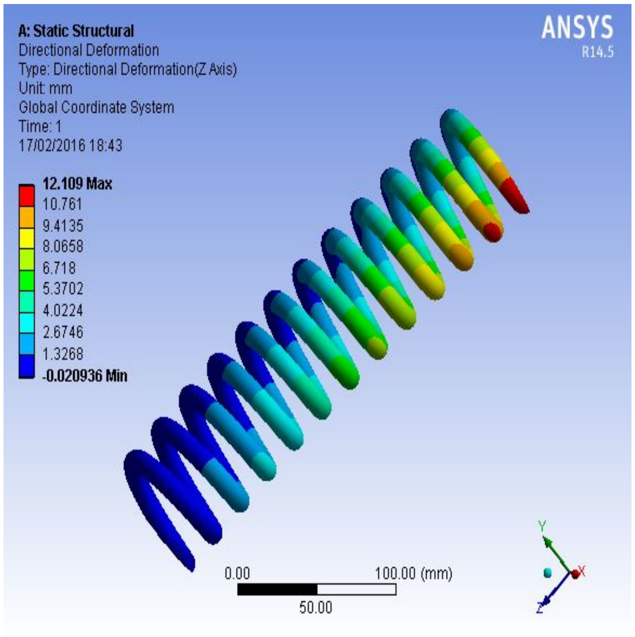
**Directional Deformation**




**Total Deformation**

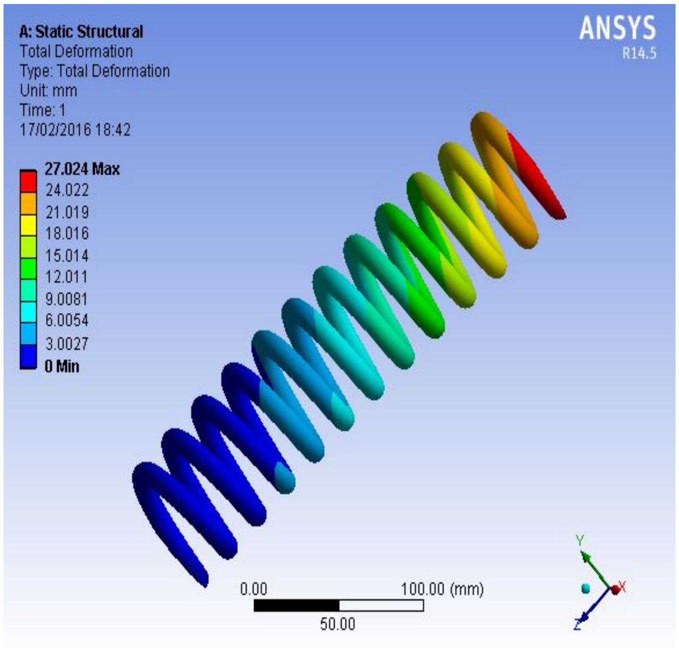
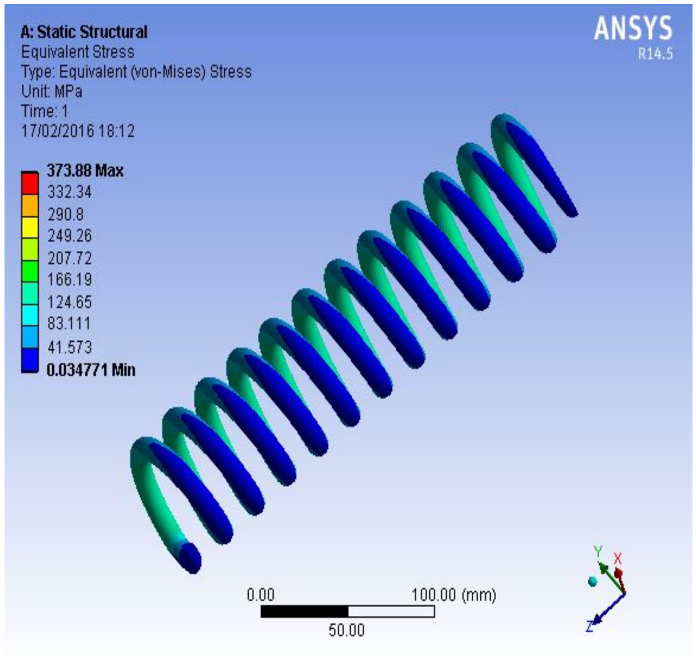


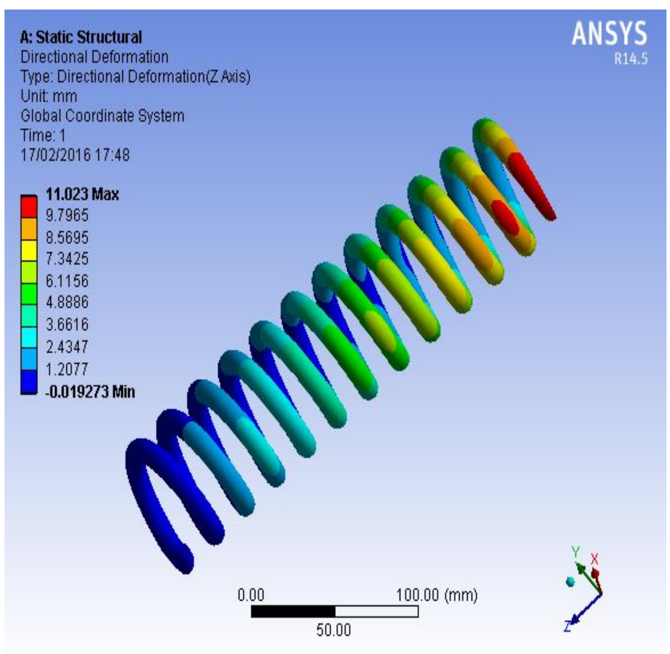

*Fig.2: Deformation and Equivalent stress of coil spring when load is 1000 N*

**For Cr-V**

**Equivalent Stress**




**Directional Deformation**



**Total Deformation**

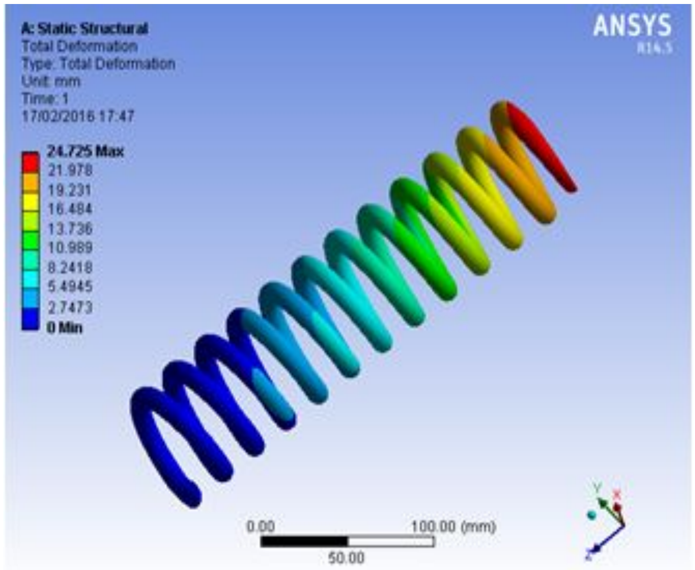



*Fig.3: Deformation and Equivalent stress of coil spring when load is 1000 N*

## IV. ANALYTICAL RESULT

| Sr. No. | Material | Equivalent Stress (MPa) | Directional Deformation (mm) | Total Deformation (mm) |
|---|---|---|---|---|
| 1 | Structural Steel | 372.89 | 11.616 | 25.957 |
| 2 | Stainless steel | 372.48 | 12.109 | 27.024 |
| 3 | Cr-Vn | 373.88 | 11.023 | 24.725 |

**Comparison between Theoretical and Analytical Result**

| Sr. No. | Theoretical Value | | | Analytical Value | | |
|---|---|---|---|---|---|---|
| | Material | Equivalent Stress | Deformation | Material | Equivalent Stress | Deformation |
| 1 | Structural Steel | 371.74 | 10.85 | Structural Steel | 372.89 | 11.616 |
| 2 | Stainless steel | 371.32 | 11.46 | Stainless steel | 372.48 | 12.109 |
| 3 | Cr-Vn | 372.84 | 10.25 | Cr-Vn | 373.88 | 11.023 |

## V. RESULTS & DISCUSSIONS

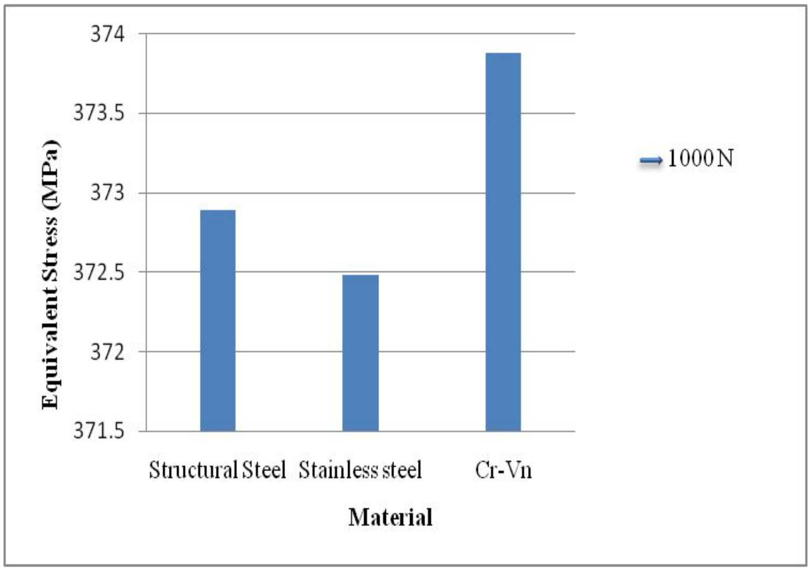



*Fig. Material vs. Equivalent Stress*

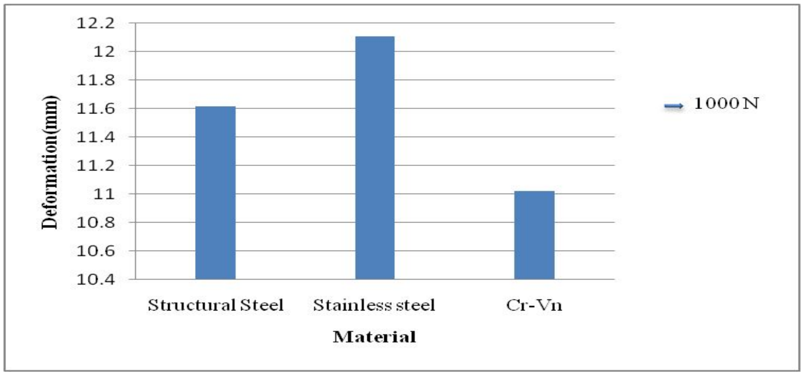



*Fig. Material vs. Deformation*

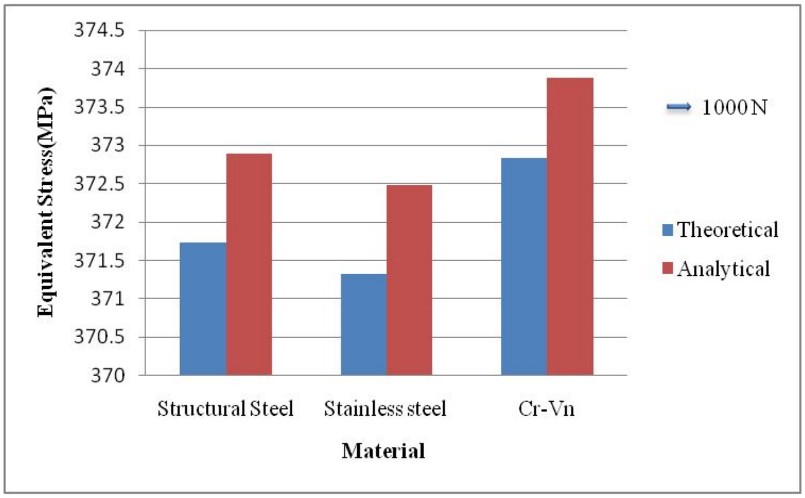



*Fig. Comparison between Theoretical and Analytical result for equivalent stress*

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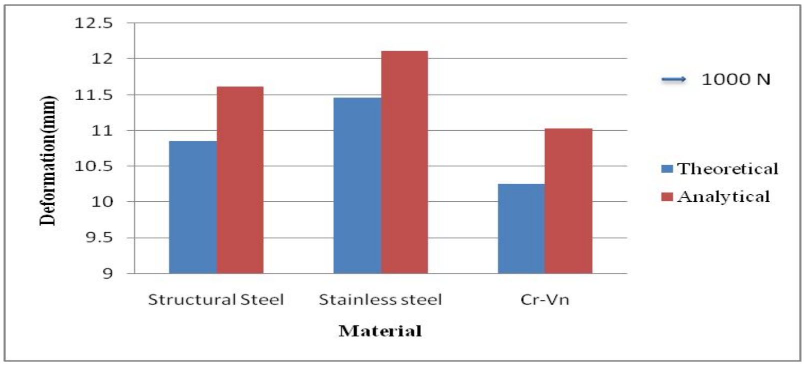


***Fig. Comparison between Theoretical and Analytical result for deformation***

Analysis on Helical Compression Spring has been done by structural mechanics approach and results were compared with different material of Helical Compression Spring of the shock absorber. Results shows that Helical Compression Spring possess less deformation and more stresses when material change. The proposed FE model is used to analyze the dynamic behaviour of Helical Compression Spring. The stiffness of the spring material increases, total deformation decreases and corresponding stresses will increase. When the deformation decreases the spring back effect is less and the use of dashpot can be eliminated and the spring alone can be used as suspension system.

## VI. CONCLUSIONS

- The comparative study has been carried out in between the theoretical values to the analytical values.
- The equivalent stress of chrome vanadium steel spring has more with compare to Stainless steel spring.
- The deflection pattern of the chrome vanadium steel spring less at specified weight with compare to the Stainless steel spring.
- It is observed that 95% of the similarity in deflection pattern and 97% similarity in stress pattern between Theoretical values to the analytical values.
- Helical Compression Spring possesses less deformation and more stresses when compared with different material.

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