International Journal of Scientific Research in Science, Engineering and Technology (www.ijsrset.com)
© 2020 IJSRSET | Volume 7 | Issue 2 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
DOI : https://doi.org/10.32628/IJSRSET207281

Stress Analysis of Square and Rectangular Cross Section Helical Spring

Ashish M. Choube*[1], Dr. R. U. Sambhe[1]
*[1] Assistant Professor (Mechanical Engineering), Jawaharlal Darda Institute of Engineering & Technology, Yavatmal, Maharashtra, India
ashish_choube@jdiet.ac.in[1] (Corresponding Author)
[1]Professor & Head (Mechanical Engineering), Jawaharlal Darda Institute of Engineering & Technology, Yavatmal, Maharashtra, India

ABSTRACT

Springs are nothing but the elastic body which deflects when loaded and comes back in its original shape when load removed. It has wide range of an applications, mainly used in automobile sector, in brakes and clutches, in watches, toys etc. The cross sections of spring may be circular, square or rectangular. When load is applied on spring, it will deflect and shear stresses will be generated. If the length of spring is higher, spring may buckle also. This article deals with analysis of square and rectangular cross section helical spring using FE approach and validated with analytical equations. Here, free length of spring is also changed to observe effect of shear stresses in square and rectangular cross section of spring.

Keywords: Helical Spring, FE results, Stress Analysis

I. INTRODUCTION

The helical coils are made up of a wire coiled in the form of a helix and are intended for compressive, tensile and torsional loads. The cross-section of the wire from which the coil is made may be circular, square or rectangular. The helical coils with square and rectangular cross section are not recommended unless a space limitation makes it necessary. Square or rectangular wire is used to obtain the increased load capacity in the smallest space, but this means that these coils are highly stressed.

In this article, a circular helical spring of material Carbon steel SAE 1050 is considered in which one side of the spring is fixed and axial load is applied at the other end of the spring.

The dimensions of circular spring considered are as follow.

Wire diameter (d) =8mm
Mean diameter (D) =46mm
Pitch (p) =11mm
Spring index(C) =5.75
Axial force (F) =1000N

By considering above dimensions of circular springs shear stress and deflection are calculated analytically. For analysis purpose, circular spring is converted into square and rectangular cross section spring with same volume of material. After that with varying various length, shear stresses and deflections are calculated analytically and compared with FE results.

The analytical method used for determination of stresses for circular spring is as follows.

II. FOR CIRCULAR HELICAL SPRINGS

For circular helical spring, following dimensions are considered.

Wire diameter (d) =8mm,

Mean diameter (D) =46mm,

Pitch (p) =11mm,

Spring index (C) =5.75,

Wahl's correction factor (Ks) =1.263,

Free length (Lf) =125mm and

Axial force (F) =1000 N.

For material Carbon steel SAE 1050, following material properties are used as shown in Table I

Table I: Material Properties of Carbon Steel SAE 1050

Sr.No.	Symbols	Parameters	Values
1	E	Young's modulus	2.1×10^5Mpa
2	μ	Poisson's ratio	0.295
3	G	Modulas of rigidity	80×10^3Mpa

Deflections (δ) and shear stresses of circular helical springs are evaluated by equation 2.1 and 2.2

$$\delta = \frac{8FD^3 n}{Gd^4} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2.1)$$

$$\tau_{\max} = \frac{Ks 8FD}{\pi d^3} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2.2)$$

III. For Square cross section helical springs

For analysis on square cross section helical springs, circular springs are converted into square cross section springs with same volume of material.

For this, following dimensions are considered.

Breadth (b=7mm),

Width (h=7mm),

Mean diameter (D) =46mm,

Pitch (p) =11mm,

Free length (Lf) =124mm,

Axial force (F) =1000N.

Deflections (δ) and shear stresses ($\tau_{\max}$) of square cross section helical spring are evaluated by equation 2.3 and 2.4.

$$\delta = \frac{5.66 nFD^3}{Gh^4} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2.3)$$

$$\tau_{\max} = \frac{4.8FD^{0.75}}{h^{2.75}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2.4)$$

For FE analysis purpose, CAD model of square cross section helical spring is created and imported in FEA software ANSYS. Here one side of spring kept constant and load is applied on other side. By giving boundary conditions, deflection and shear stress of square cross section springs are calculated for various length.

Table II shows the comparison of analytical and FE results for square cross section helical springs on various length.

	Deflection (mm)		Shear stress (n/mm²)	
	Analytical	FE	Analytical	FE
L_f=225	56	56	402	325
L_f=200	49	49		331
L_f=150	36	37		330
L_f=125	29	28		326
L_f=75	17	16		352

The contours of deflection and shear stress of square cross section spring are determined shown in Fig.1 to Fig.5.

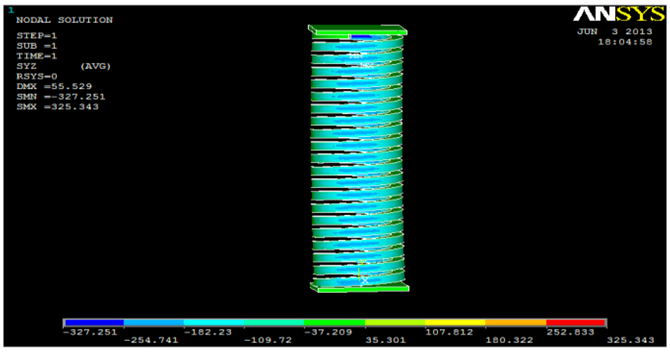

Fig.1 Deflection and shear stress contour for square cross section helical spring for Length 225 mm

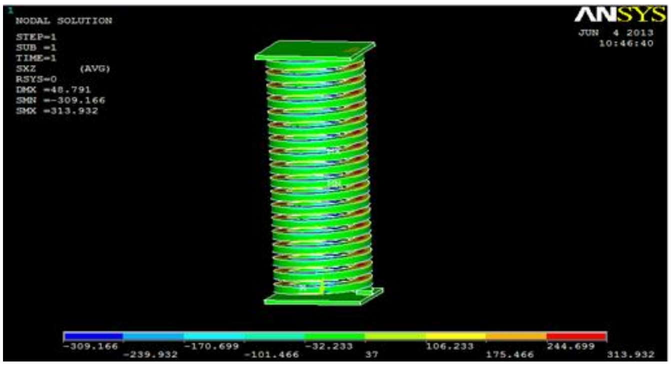

Fig.2 Deflection and shear stress contour for square cross section helical spring for length 200 mm

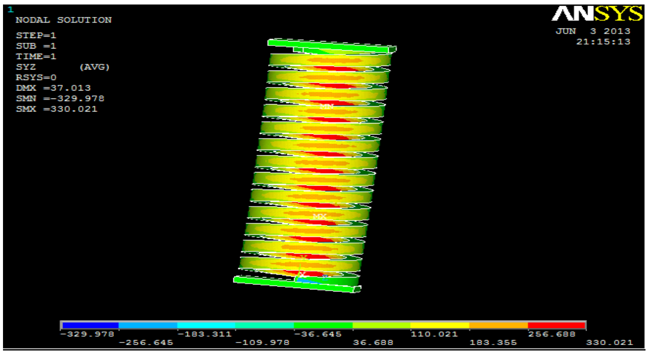

Fig.3 Deflection and shear stress contour for square cross section helical spring for Length 150 mm

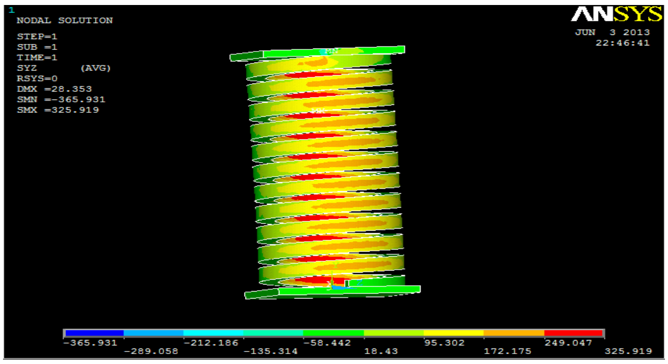

Fig.4 Deflection and shear stress contour for square cross section helical spring for Length 125 mm

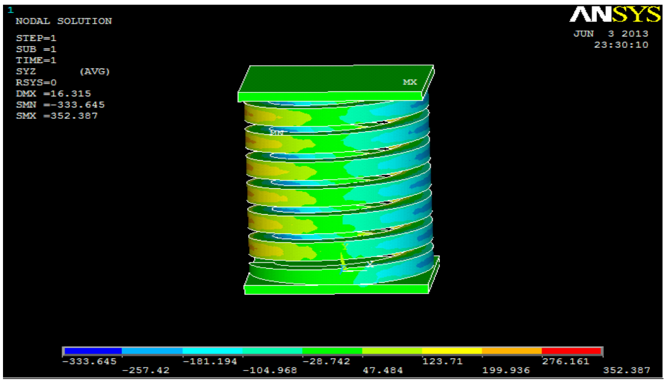

Fig.5 Deflection and shear stress contour for square cross section helical spring for Length 75 mm

IV. FOR RECTANGULAR HELICAL CROSS SECTION SPRING

For analysis on rectangular cross section springs, circular springs are again converted into rectangular cross section springs with same volume of material.

For analysis of rectangular helical spring, following dimensions are considered.

Breadth (b=10mm),

Width (h=5mm),

Mean diameter (D) =46mm,

Pitch (p) =11mm,

Free length (Lf) =124mm,

Axial force (F) =1000N.

Table I shows the material properties for rectangular helical spring.

Deflections (δ) and shear stresses ($\tau_{\max}$) of rectangular cross section helical springs are evaluated by using equation 2.5 and 2.6

$$\delta = \frac{2.83nFD^3(b^2 + h^{2)}}{b^3h^3G} \quad \text{................ (2.5)}$$

$$\tau_{\max} = \frac{FD}{K_1bh^2} \quad \text{.......................(2.6)}$$

Where, k1=Factor for rectangular helical springs which varies with breadth to width ratio.

The analytical and FE results of rectangular cross section helical spring are determined with different breadth to width ratio are given in Table III and Table IV.

TABLE III: Analytical And FE Results Of Rectangular Cross Section Helical Spring For B =1.5 H

	Deflection (mm)		Shear stress (n/mm²)	
	Analytical	FE	Analytical	FE
L_f=225	57	58	340	347
L_f=200	50	49		314
L_f=150	37	36		366
L_f=125	30	30		321
L_f=75	17	17		308

Table IV: Analytical and FE Results Of Rectangular Cross Section Helical Spring for B =2 H

	Deflection (mm)		Shear stress (n/mm²)	
	Analytical	FE	Analytical	FE
L_f=225	67	69	374	394
L_f=200	59	60		347
L_f=150	43	43		402
L_f=125	35	34		352
L_f=75	20	19		334

The contours of deflection and shear stress of rectangular cross section spring with different breadth to width ratio are determined shown in Fig.6 to Fig.15.

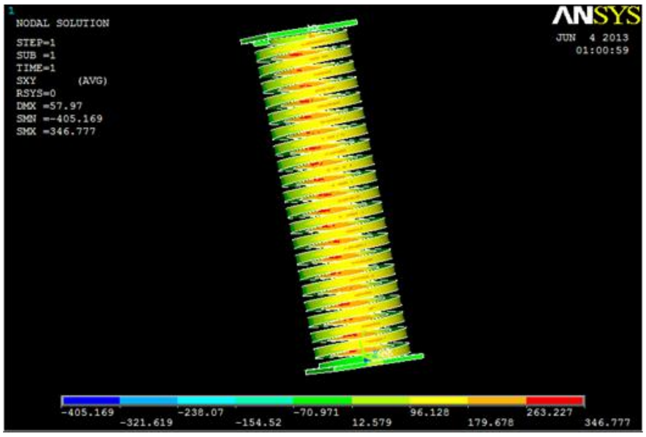

Fig.6 Deflection and shear stress contour for rectangular cross section helical spring for Length 225 mm (B =1.5 H)

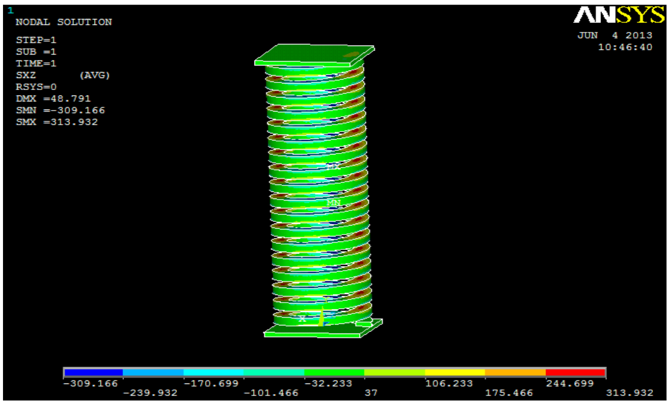

Fig.7 Deflection and shear stress contour for rectangular cross section helical spring for Length 200 mm (B =1.5 H)

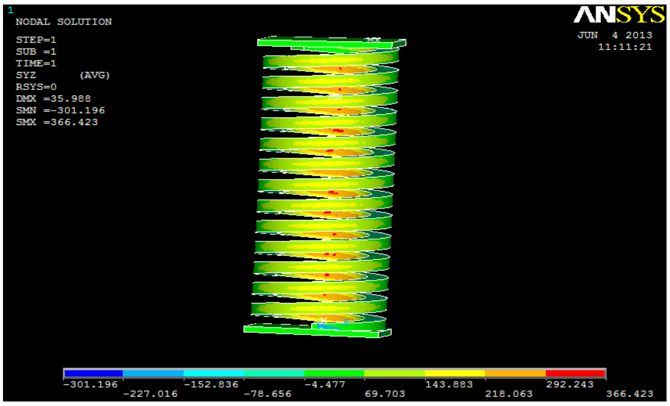

Fig.8 Deflection and shear stress contour for rectangular cross section helical spring for Length 150 mm (B =1.5 H)

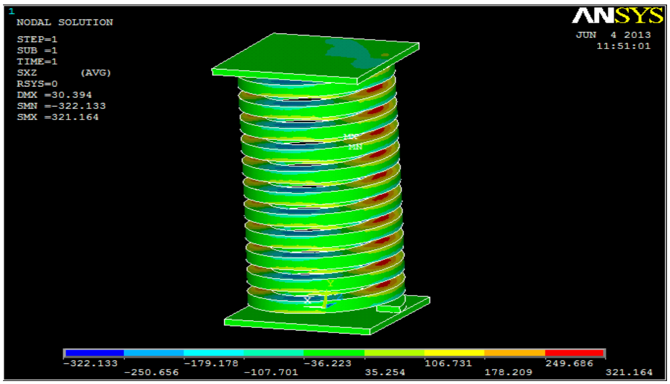

Fig.9 Deflection and shear stress contour for rectangular cross section helical spring for Length 125mm (B =1.5 H)

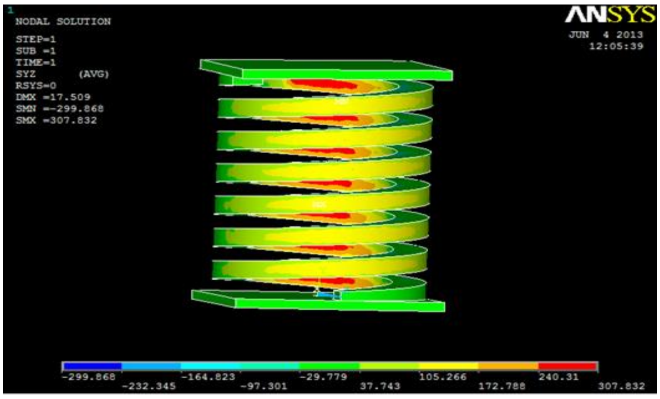

Fig.10 Deflection and shear stress contour for rectangular cross section helical spring for Length 75 mm (B =1.5 H)

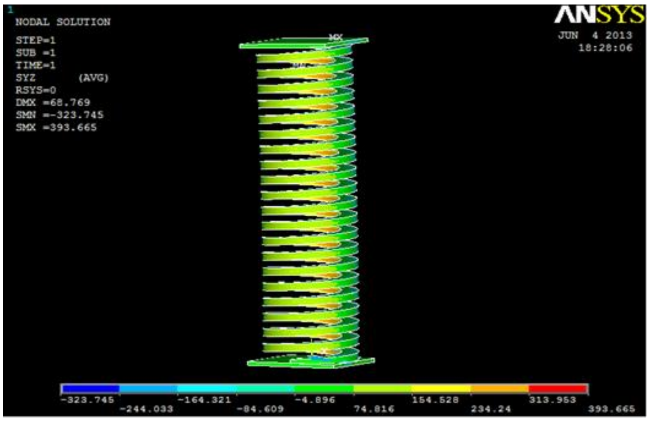

Fig.11 Deflection and shear stress contour for rectangular cross section helical spring for Length 225 mm (B =2 H)

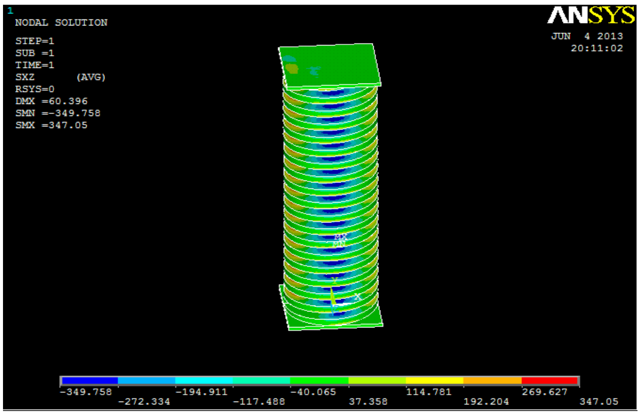

Fig.12 Deflection and shear stress contour for rectangular cross section helical spring for Length 200 mm (B =2 H)

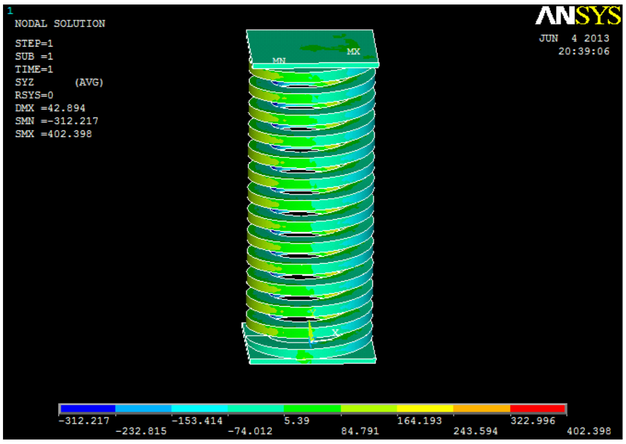

Fig.13 Deflection and shear stress contour for rectangular cross section helical spring for Length 150 mm (B =2 H)

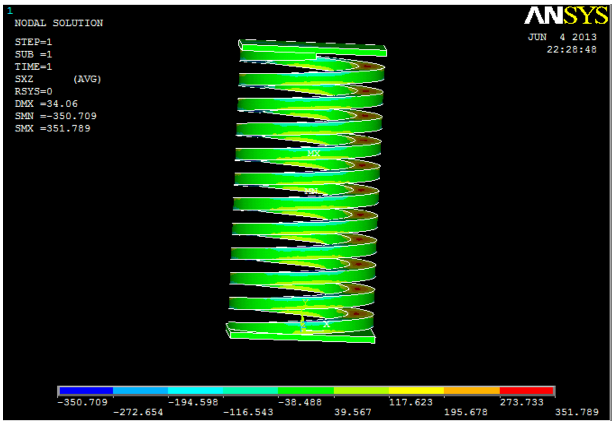

Fig.14 Deflection and shear stress contour for rectangular cross section helical spring for Length 125 mm (B =2 H)

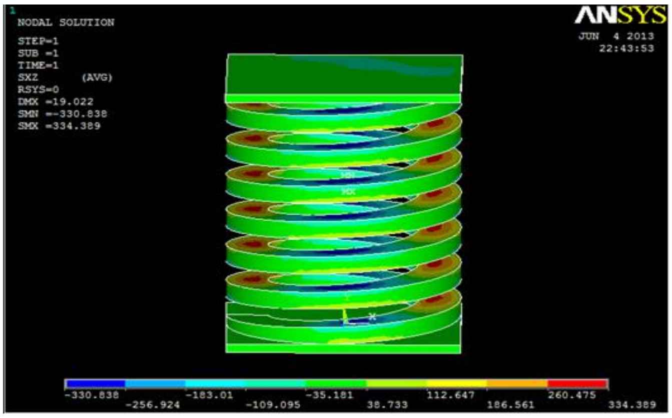

Fig.15 Deflection and shear stress contour for rectangular cross section helical spring for Length 75 mm (B =2 H)

V. RESULTS AND DISCUSSION

The analytical and FE results of square cross section and rectangular cross section helical springs are evaluated. From Table II, Table III and Table IV, it is observed that shear stresses developed in rectangular cross section is more than square rectangular cross section. In case of rectangular cross section, as breadth to width ratio increases shear stress also increases. In square and rectangular cross section, maximum shear stress is observed at the corners.

From stress analysis of square and rectangular cross section helical spring it can be concluded that square cross section springs are more preferable than rectangular cross section helical springs.

VI. REFERENCES

[1] V. Brijpuria, 2013, “Analysis of closed coil helical spring subjected to heavy duty” IJEA, vol-1, Issue-4, pp 50-55.

[2] Ashish M. Choube, D. V. Bhope, “Stress and Buckling Analysis of Helical Coil”, International Journal of Innovative Technology and Research(IJITR), Vol. 1, No. 6, 2013, pp. 570-573

[3] Ashish M. Choube “Finite Element Analysis of Helical Spring in Monosuspension System”, ISSN 2321 3361 © 2016 IJESC,

[4] J. Lee, “Free vibration analysis of cylindrical helical

[1] Springs by the pseudospectral method” Journal of Sound and Vibration, pp 185-196.

[5] Tausif M. Mulla, “Finite element analysis of helical coil compression spring for three wheeler automotive front suspension”. International Journal of Mechanical and Industrial Engineering (IJMIE), Vol-2, Issue-3, pp 74-77.

[6] B. D. Shiwalkar, Design Data for Machine Elements. 2012 Edition, pp79-92.

[7] Lingaiah K., Machine Design Data book, Second edition. pp 20.1-20.33.

[8] Dr. P. C. Sharma and Dr. D. K. Aggarwal, “Machine Design”, millennium edition, pp.307-384.

[9] R. S. Khurmi and J. K. Gupta, “Machine Design”, S. Chand publication, pp.820-844.

Cite this article as :

Ashish M. Choube, Dr. R. U. Sambhe, "Stress Analysis of Square and Rectangular Cross Section Helical Spring", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 7 Issue 2, pp. 362-367, March-April 2020. Available at doi : https://doi.org/10.32628/IJSRSET207281
Journal URL : http://ijsrset.com/IJSRSET207281