VALIDATION OF A LEAF SPRING BY ANSYS SOFTWARE

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Abstract: A leaf spring is the simplest type of suspension system which is widely used in commercial vehicles. The leaf spring is astructural member and acts as an energy absorbing system on the virtue of its deflection according to hook's law. In this research work leaf springs are analyzed using ANSYS 19.1 software which is a finite element analysis software considering full payload condition as well as empty load condition. This paper includes the study of deflection and stress distribution of a leaf spring with theoretical calculations.
Keywords: leaf Spring, analysis, ANSYS.

I. INTRODUCTION

A spring is an elastic body, whose expand in size when load applied and regain its original shape when removed according to hook's law. Leaf spring is the simplest form of spring used in the suspension system of vehicle.It absorbs automobile vibrations, shocks and loads by springing action and to some extend by damping functions.It absorbs energy in the form of potential energy. Springs capacity to absorb and store more strain energy makes the suspension system more comfortable. Most widely used leaf spring type is semi-elliptic inheavy and light automobile vehicles. The leaf spring is made-up of a number of steel leaves. Each leaf is of a different length, but with equal width and thickness. The uppermost longest leaf having bushes at its two ends, is called the master leaf. The ends are directly connected to the side member of the vehicle frame as shown in figure 1.

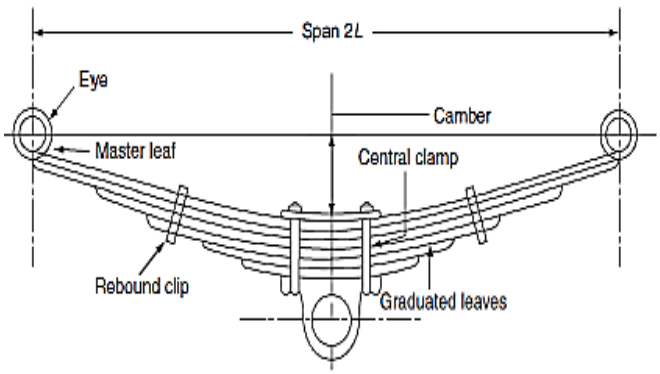

Figure 1: Semi elliptical leaf spring

II. DESIGN OF A SEMI-ELLIPTICAL SPRING

Leaf spring of vehicle TATA ACE MEGA XL is selected for the analysis. Table 1 shows the details of the Tata Ace Mega XL.

Table 1: Basic Details of Vehicle

Sr. No.	Parameter	Value
1	Gross vehicle weight (GVW)	2.1 tonne
2	Payload	1 tonne
3	Width of all leaves	60 mm
4	Thickness of all leaves	8 mm
5	Number of leaves including master	3
6	Leaf Span (2L)	1072 mm
7	Camber Height	95.4 mm
8	Type of Spring	Semi-elliptic leaf spring

Leaf Spring geometry parameters are shown in Table 2.

Table 2: Geometry parameters

Parameter	Value	Unit
n	3	-
L	536	mm
b	60	mm
t	8	mm

Mechanical Properties of a convention spring material is listed in Table 3.

Table 3: Material Properties

Sr. No.	Material	Modulus of Elasticity (GPa)	Poisson's Ratio	Density (kg/m^3)
1	55Si2Mn90	210	0.29	7850

III. ANALYSIS OF SPRING

Geometrical model of a leaf spring has been prepared using the available data in the Ansys workbench 19.1 as which is shown in figure 2.

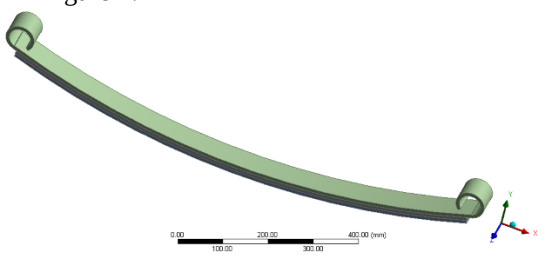

Figure 2 Geometrical model

Following equation is used for the analysis validation of the spring.

$$\delta = \frac{6\ X\ P\ X\ L^3}{E\ X\ n\ X\ b\ X\ t^3} \quad \text{……..Eq 1.}$$

$$\sigma = \frac{6\ X\ P\ X\ L}{n\ X\ b\ X\ t^2} \quad \text{……..Eq 2.}$$

Where,
P = load on the spring (N), L length of the spring (mm)
n = number of leaves, b = width of leaf (mm)
E = modulus of elasticity (MPa), t = thickness of leaves (mm)

From Equation 1, it is cleared that deformation of spring is inversely proportional to a modulus of elasticity and number of leaves presented in the spring.

IV. LOAD CASE

There are two load cases performed for all iterations as shown in table:

- Fully loaded condition
- Self-Weight condition without payload

Table 4: Load cases

	Units	Fully Loaded	Empty
Mass	kg	2100	1100
Load	N	20601	10791
Number of Leaf Spring	-	4	4
2P	N	5150.25	2697.75
P		2575.125	1348.875
σ	MPa	718.89	376.56
δ	mm	122.94	64.40

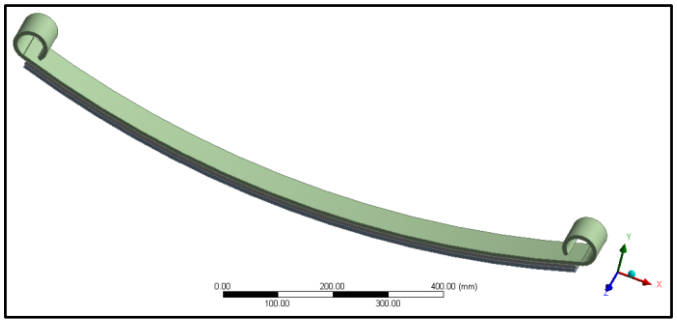

Figure 2. 3D Model of Leaf Spring.

Figure 3 . 3D Mesh Model of Leaf Spring.

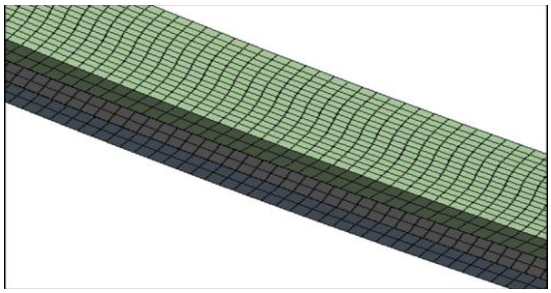

Figure 4. Enlarge view of a 3D Meshing Model of Leaf Spring.

Mesh statistics are as per below:
Nodes: - 52619
Elements: - 52617

V. BOUNDARY CONDITIONS

Fixed support boundary condition is applied as shown in figure 5.

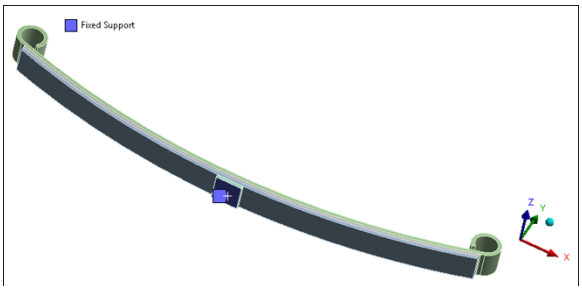

Figure 5. Boundary condition of Leaf Spring.

VI. LOADING CONDITION

Load Case - 1
The value of load 2575 N is applied considering full payload with self-weight of the vehicle as shown in figure 6.

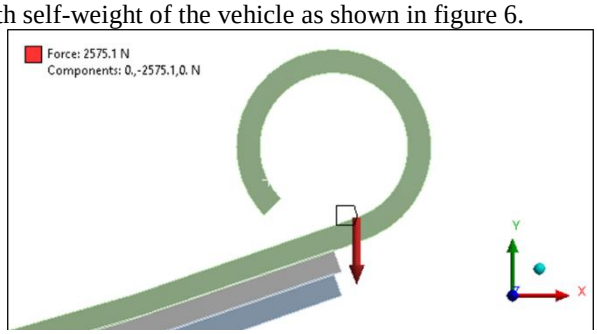

Figure 6. LC1 of Leaf Spring.

Load Case 2
The value of load 1348.9 N is applied considering only self-weight of the vehicle as shown in figure 7.

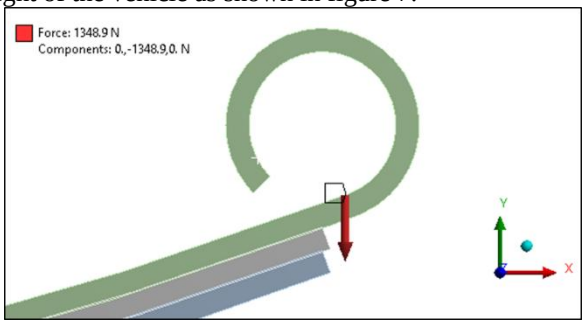

Figure 7. LC2of Leaf Spring.

VII. RESULTS – DEFORMATION (mm)

Load Case 1

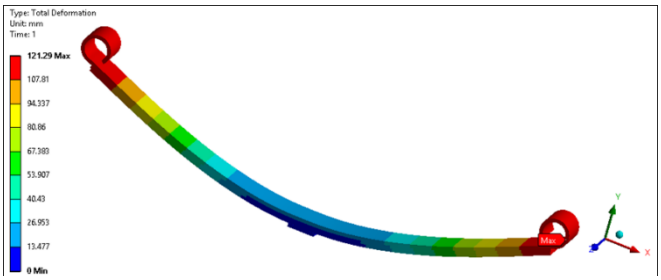

Figure 8. LC1 of Leaf Spring.

Load Case 2

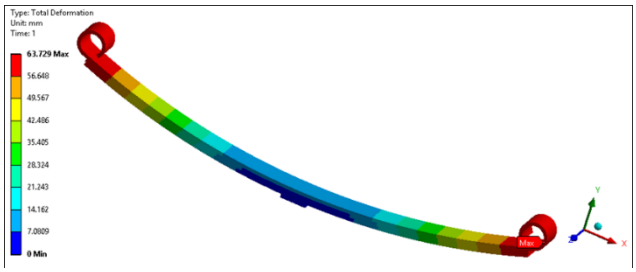

Figure 9. LC2 of Leaf Spring.

VIII. RESULTS – STRESS (MPa)

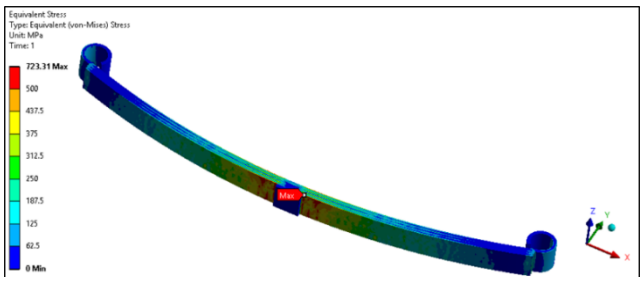

Figure 10. LC1 of Leaf Spring.

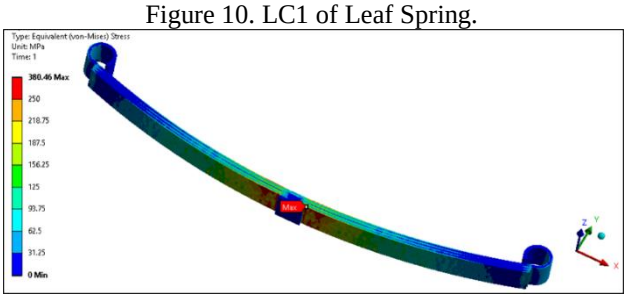

Figure 11. LC2 of Leaf Spring.

Table 6 Comparison

Load Case	Analytical Deformation (mm)	Simulation Deformation (mm)	% Variation	Analytical Stress (MPa)	Simulation Stress (MPa)	% Variation
1	122.94	121.29	1.34	718.89	723.31	-0.61
2	64.40	63.73	1.03	376.56	380.46	-1.04

IX. CONCLUSION

In the present work, the multi-leaf spring is modeled in Static structural domain of ANSYS software. The results were discussed in the preceding section and it is concluded that, for the given design specification loading conditions are well within the safe limits. In further, FEA results are compared with theoretical calculations and are within 1% variation.

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