Design and Comparative Performance Analysis of Multi Leaf Spring by F.E.A.

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Abstract: The present paper presents the design and comparative performance analysis of multi leaf spring for truck axle. Material selection is one of the most important criteria for optimized performance. Multi leaf spring was modelled in Pro-E and further analysis was carried out by ANSYS. The ANSYS static analysis of multi leaf springs made of High Carbon Steel, 55Cr5 and 55Si7 material respectively for maximum stress, deflection and stiffness were compared with each other. Chromium having corrosion resistance and also increases the resistance to oxidation at high temperatures and promotes a ferritic microstructure. Silicon increases resistance to oxidation, both at high temperatures and in strongly oxidizing solutions at lower temperatures. It promotes a ferritic microstructure and increases it strength. Analysis of three material shows that 55Cr5 is superior to High Carbon Steel and 55Si7 in terms of maximum stress and deflection.

Keywords: Multi Leaf Spring, Equivalent Stress, Equivalent Strain, Deformation, Pro-e, ANSYS.

Introduction: Leaf spring absorbs the vertical vibrations and impacts due to road irregularities by means of variations in the spring deflection so that the potential energy is stored in spring as strain energy and then gradually releases to maintain comfort in automobiles like light motor vehicles, heavy duty trucks and in rail systems. It carries lateral loads, brake torque, driving torque in addition to shock absorbing. Increasing competition and innovations in automobile sector tends to modify the existing products or replacing old products by new and advanced material products. The purpose of this research is to compare the performance of three different steels named High Carbon Steel, 55Si7 and 55Cr5 under static loading conditions. The specimen, under this research work, consists of eight leaves. The finite element analysis (FEA) is a computing technique that is used to obtain approximate solutions to the boundary value problems in engineering. Dakshraj Kothari et al. [2] static and fatigue life analysis of two conventional leaf springs made of respectively SUP 9 & EN 45. These springs are compared for maximum stress, deflection and stiffness as well as fatigue life. U. S. Ramakanth et al. [3] work is carried out on multi leaf springs having nine leaves used by a commercial vehicle. Fatigue analysis of leaf springs is carried out for steel leaf springs, and Static analysis for steel leaf springs, composite leaf springs and hybrid leaf springs. Abdul Karim Selman Abdul Karim et al. [7] have investigated rational technique to design leaf spring for light truck in this study. The magnitude of stress in lower side surface for all leaves of spring is more than stress in upper side surface. Peiyong Qin et al. [8] presents detailed finite element modelling and analysis of a two-stage multi-leaf spring, a leaf spring assembly, and a Hotchkiss suspension using ABAQUS.

Design of Multi Leaf Spring:

Table 1: Data required for designing

Load carried by spring	10 KN
Span length	1000 mm
Width of leaf	65 mm
Thickness of leaf	10 mm
Distance between U bolts attached to axle	60 mm
Camber	60 mm

No. of full length leaves	2
No. of graduated leaves	6
Diameter of eye	30mm

Selection of Material: Many industries are manufacturing steel leaf spring by various materials depending upon the strength and economical requirements. These materials High Carbon Steel, 55Si7 and 55Cr5 are widely used for the production of parabolic leaf spring and conventional multi leaf spring. Leaf spring absorbs the vertical vibrations, shocks and bump loads (induced due to road irregularities) by means of spring deflection, so that the potential energy stored in the leaf spring and then relieved slowly. Ability to store and absorb more amount of strain energy insures the comfortable suspension system so it becomes necessary to decide the material of the leaf spring to be analysed. The materials High Carbon Steel, 55Si7 and 55Cr5 steel characteristics related to spring performance are studied and found to be suitable materials for further analysis. These materials were used by researchers due to their better characteristics are as followings:

Table 2: Mechanical properties of steel materials

Mechanical Properties	55Si7	55Cr5	High Carbon Steel
Tensile Strength (MPa)	1962	1600	635
Yield Strength (MPa)	1470	1250	490
Young’s Modulus (GPa)	210	207	210
Poisson’s Ratio	0.3	0.266	0.30
Density (Kg/m^3)	7850	7750	7850

Length of Leaf Spring Leaves:

Effective length of spring:

= span-2/3 x distance between u bolts

= 1000-2/3 x 60 = 960 mm.

L = span – 2/3 x distance between U bolts

= 1000 – 2/3 x 60 = 960 mm

Length of smallest leaf:

$$L = \frac{\text{Effective length}}{n-1} + \text{ ineffective length}$$

Smallest leaf $\frac{960}{7} + 40$ = 177 mm

2nd leaf $= \frac{960}{7} \times 2 + 40 = 314$ mm

3rd leaf $= \frac{960}{7} \times 3 + 40 = 451$ mm

4th leaf $= \frac{960}{7} \times 4 + 40 = 588$ mm

5th leaf $= \frac{960}{7} \times 5 + 40 = 721$ mm

6th leaf $= \frac{960}{7} \times 6 + 40 = 863$ mm

7th (full length leaf) leaf $= \frac{960}{7} \times 7 + 40 = 1000$ mm

8th is full length leaf = 1000 mm

Finite Element Analysis of Multi Leaf Spring:

FEA consists of a computer model of a material or design that is stressed and analyzed for specific results.

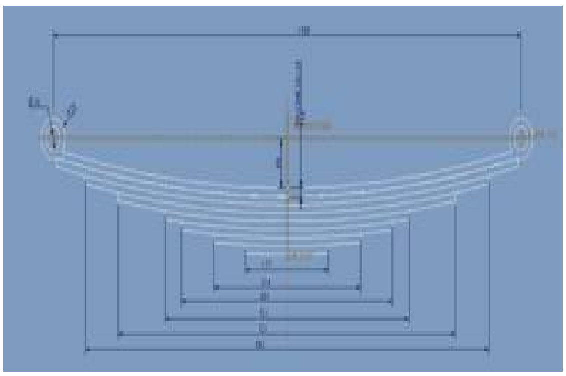

Fig 1: Front view of Multi Leaf Spring

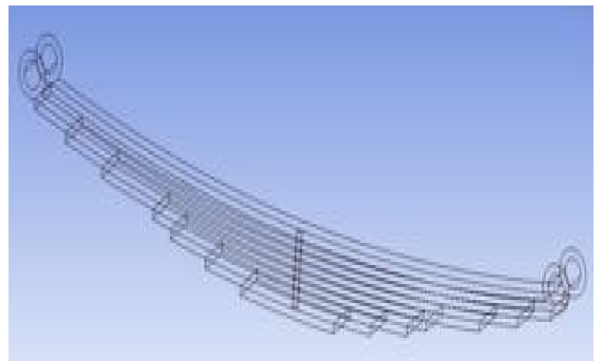

Fig 2: Isometric view of Multi Leaf Springs

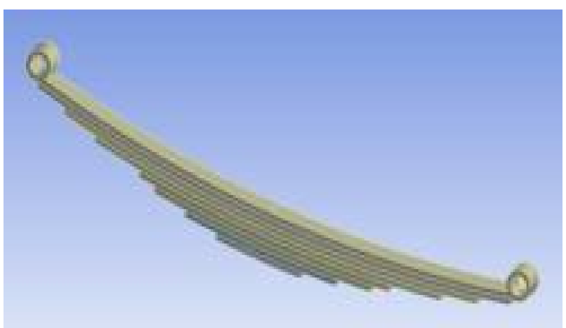

Fig 3: 3-D Model

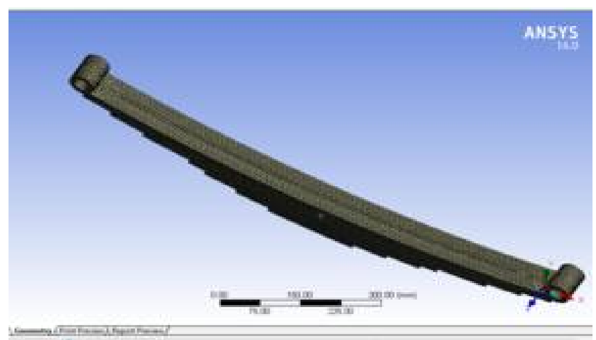

Fig 4: Meshing of Model

Select mesh type and size, apply on the component. Mesh size is taken 7 mm and type is taken tetrahedral. Number of elements are 101244 and number of nodes are 176011.

Analysis of High Carbon Steel, 55Si7 and 55Cr5 Multi Leaf Spring:

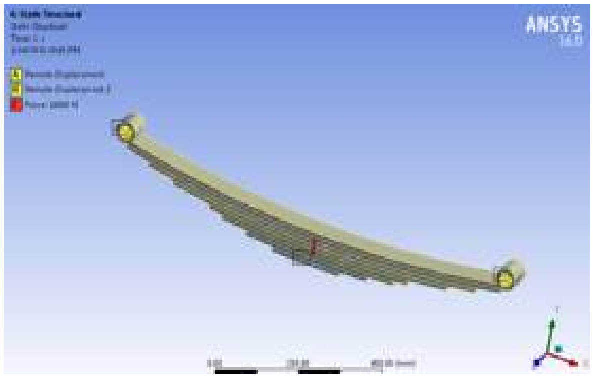

Fig 5: Boundary Conditions

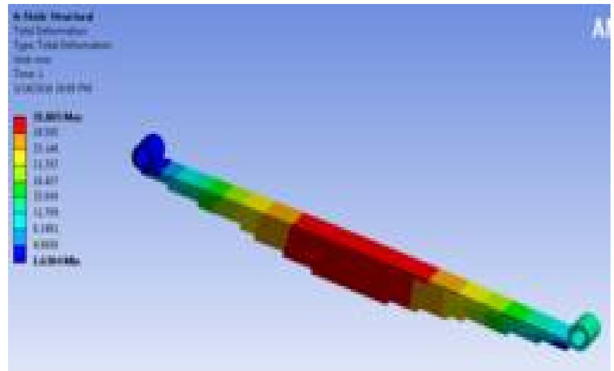

Fig 6: Total Deformation of H.C.S.

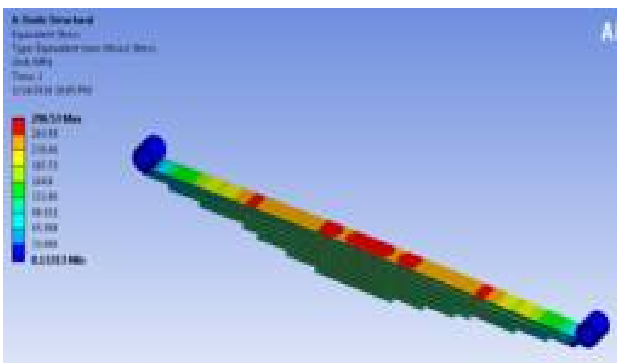

Fig 7: Equivalent Stress of H.C.S.

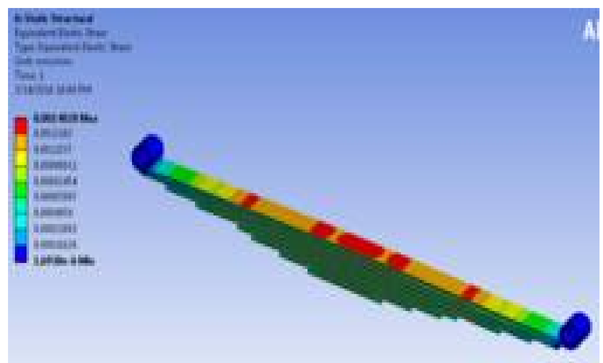

Fig 8: Equivalent Strain of H.C.S

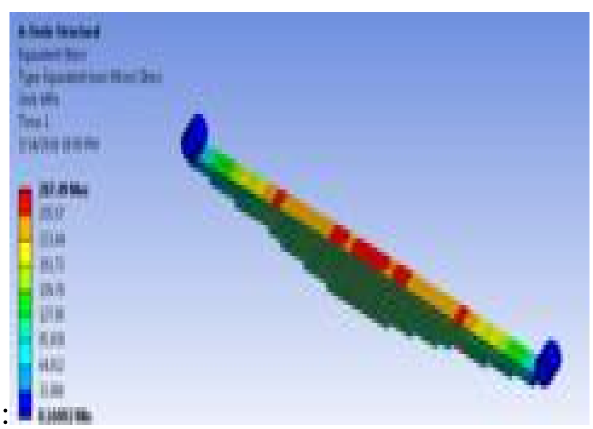

Fig 9: Equivalent Stress of 55Si7

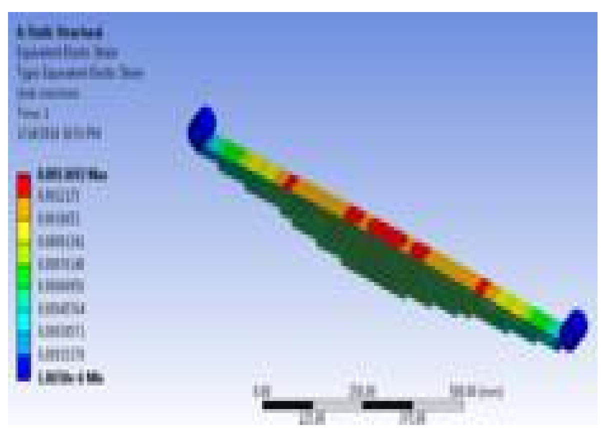

Fig 10: Equivalent Strain of 55Si7

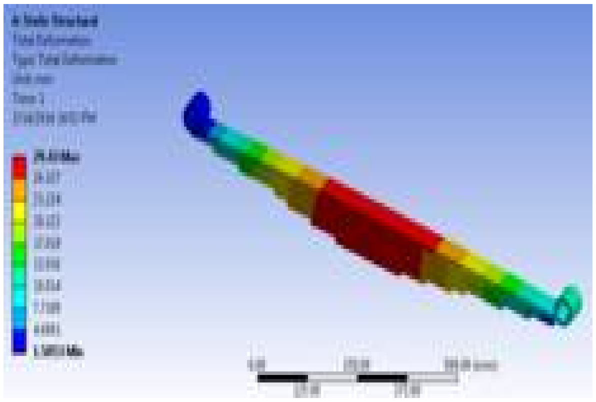

Fig 11 Total Deformation of 55Si7

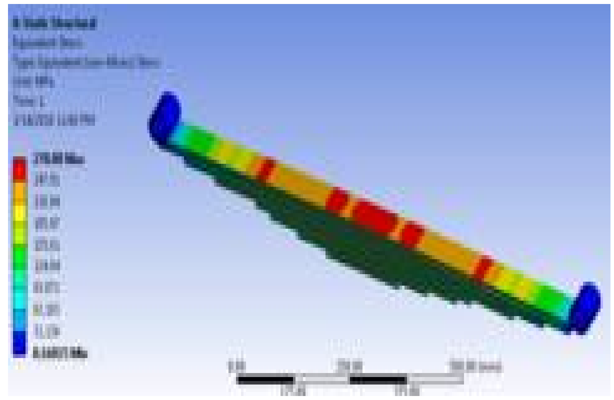

Fig 12 Equivalent Stress of 55Cr5

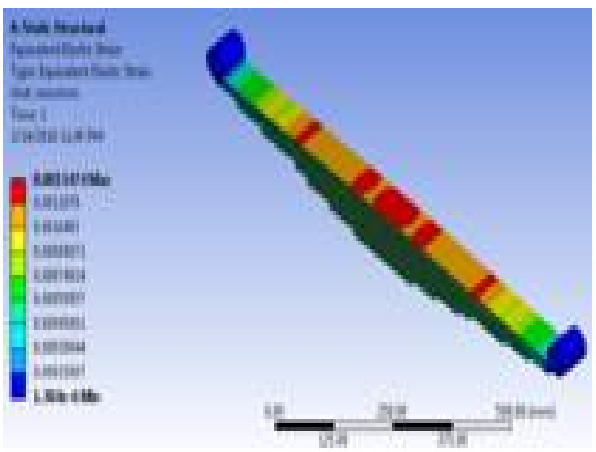

Fig 13: Equivalent Strain of 55Cr5

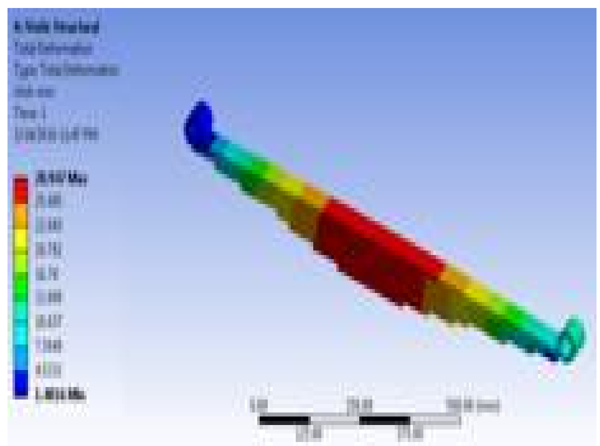

Fig 14: Total Deformation of 55Cr5

Result & Conclusion:

Static Analysis of Steel Leaf Spring Using F.E.A. are as follows:

Parameters	**F.E.A.**		
	55Si7	**55Cr5**	**H.C.S.**
Load (N)	10000	10000	10000

Deflection (mm)	29.43	28.947	31.865
Maximum Stress (MPa)	287.89	278.88	296.53
Elastic Strain (mm/mm)	0.0013692	0.0013474	0.0014828

These works involves a comparison of conventional H.C.S, 55Si7 and 55Cr5 material leaf spring under static loading conditions the model is preferred of in Pro-E Wildfire 5.0 and then analysis is performed through ANSYS 16.0 from the result obtained. The conclusion of the result is as follows:

1. Variation of 1.67% is observed in deflection among 55Si7 and 55Cr5 material, variation of 9.16% is observed in deflection among 55Cr5 and H.C.S. and variation of 7.64% is observed in deflection among 55Si7 and H.C.S. material.
2. Variation of 3.13% is observed in maximum stress among 55Si7 and 55Cr5 material, variation of 5.95% is observed in maximum stress among 55Cr5 and H.C.S. and variation of 2.91% is observed in maximum stress among 55Si7 and H.C.S. material.
3. Variation of 1.59% is observed in elastic strain among 55Si7 and 55Cr5 material, variation of 9.13% is observed in elastic strain among 55Cr5 and H.C.S. and variation of 7.66% is observed in elastic strain among 55Si7 and H.C.S. material.

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Under the same static load conditions the stress and deflection in 55Cr5 material leaf springs are lower than 55Si7 and H.C.S. material leaf spring.

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