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Leaf Spring Analysis with Eyes Using FEA

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ABSTRACT:

The objective of this present work is to estimate the deflection, stress and mode frequency induced in the leaf spring. The component chosen for analysis is a leaf spring which is an automotive component used to absorb vibrations induced during the motion of vehicle. It also acts as a structure to support vertical loading due to the weight of the vehicle and payload. Under operating conditions, the behaviour of the leaf spring complicated due to its clamping effects and interleaf contact, hence its analysis is essential to predict the displacement, mode frequency and stresses. The leaf spring, which we are analyzing, is a custom designed leaf spring with different eyes like viz., Berlin and upturned eyes with different materials at different sections. In analysis part the finite element of leaf spring is modelled. Appropriate boundary conditions, material properties and loads are applied selected as per intended performance. The resultant deformation, mode frequencies and stresses obtained are analyzed.

KEYWORDS: *ANSYS, Clamping effects, Leaf spring, Pro-E.*

I. INTRODUCTION

A spring is defined as an elastic body, whose function is to distort when loaded and to recovers its original shape when the load is removed. Semi- elliptic leaf springs are almost universally used for suspension in light and heavy commercial vehicles. For cars also, these are widely used in rear suspension. The spring consists of a number of leaves called blades. The blades are varying in length. The blades are us usually given an initial curvature or cambered so that they will tend to straighten under the load. The leaf spring is based upon the theory of a beam of uniform strength. The lengthiest blade has eyes on its ends. This blade is called main or master leaf, the remaining blades are called graduated leaves. All the blades are bound together by means of steel straps. The spring is mounted on the axle of the vehicle. The entire vehicle rests on the leaf spring. The front end of the spring is connected to the frame with a simple pin joint while the rear end of the spring is connected with a shackle. Shackle is the flexible link which connects between leaf spring rear eye and frame. When the vehicle comes across a projection on the road surface, the wheel moves up, leading to deflection of the spring. This changes the length between the spring eyes. If both the ends are fixed, the spring will not be able to accommodate this change of length. So, to accommodate this change in length shackle is provided as one end, which gives a flexible connection.Spring eyes for heavy vehicles are usually bushed with phosphor bronze bushes. However, for cars and light transport vehicles like vans, the use of rubber has also become a common practice. This obviates the necessity of lubrication as in the case of bronze bushes. The rubber bushes are quiet in operation and also the wear on pin or the bush is negligible. Moreover, they allow for slight assembly misalignment, "Silentbloc' is an example of this type of bushes.

II. OBJECTIVE OF THE PROJECT

The automobile industry is showing increased interest in the replacement of steel spring with fibreglass composite leaf spring due to high strength to weight ratio. Therefore; this project aims at comparative study of design parameters of a traditional steel leaf spring assembly and composite leaf spring with bonded end joints.
By performing dynamic analysis using ANSYS WORK BENCH software and mathematical calculations, the maximum bending stress and corresponding payload have to be determined by considering the factor of safety.Determining and assessing the behaviour of the different parametric combinations of the leaf spring, their natural frequencies are compared with the excitation frequencies at different speeds of the vehicle with the various widths of the road irregularity. These excitation frequencies are calculated mathematically.

III. Classification of Suspension springs

The Suspension springs may be classified as follows:

Steel Springs
(a) Leaf Spring
(b) Coil spring
(c) Torsion bar

Rubber Springs
(a) Compression spring
(b) Compression–shear spring
(c) Steel reinforced spring
(d) Progressive spring
(e) Face Shear Spring
(f) Torsion shear spring

IV. BENDING STRESS OF LEAF SPRING

Leaf springs (also known as flat springs) are made out of flat plates. The advantage of leaf spring over helical spring is that the ends of the spring may be guided along a definite path as it deflects to act as a structural member in addition to energy absorbing device. Thus the leaf springs may carry lateral loads, brake torque, driving torque etc., in addition to shocks.Consider a single plate fixed at one end and loaded at the other end. This plate may be used as a flat spring. Let t= thickness of plate
b= width of plate, and
L= length of plate or distance of the load W from the cantilever end.

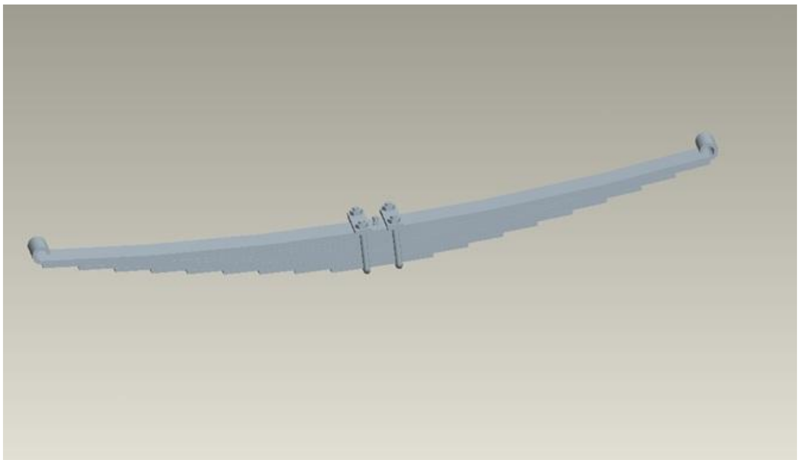


Fig. 1 Total Assembly of Leaf Spring

Bending stress = F= M/Z

V. MODELING OF ROAD IRREGULARITY

An automobile assumed as a single degree of freedom system traveling on a sine wave road having wavelength of L as shown in below Fig. 5.1. The contour of the road acts as a support excitation on the suspension system of an automobile. The period is related to ω by $t=2\pi/\omega$, ω and L is the distance travelled as the sine wave goes through one period.`

$L = v.t = 2\pi v/\omega$

So excitation frequency $\omega = 2\pi v/L$

L = Width of the road irregularity (WRI)

V = speed of the vehicle

The variation of road irregularities is highly random. However a range of values is assumed for the present analysis i.e. 1m to 5m for the width of the road irregularity (L)

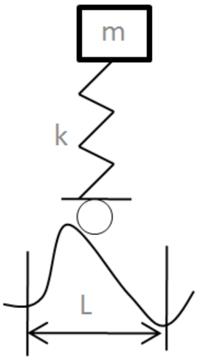
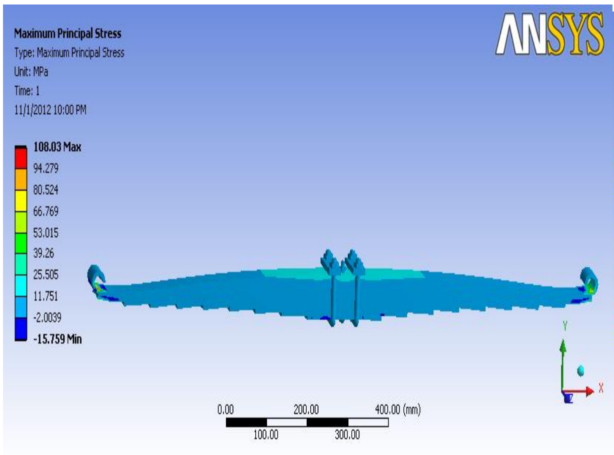


Fig .2 An automobile travelling on a sine wave road

VI. RESULTS & DISCUSSION



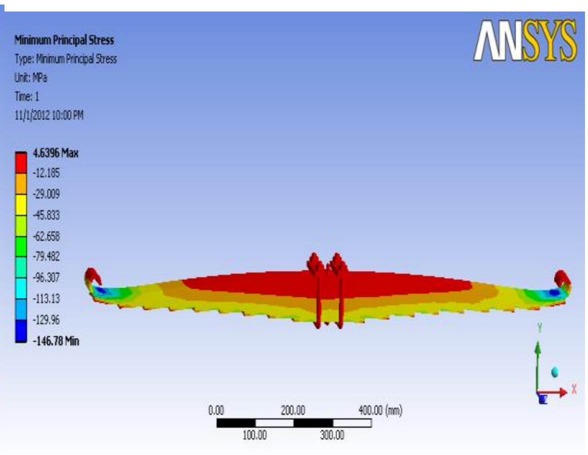


Fig.3 Maximum Principal Stress

Fig.4 Minimum Principal Stress

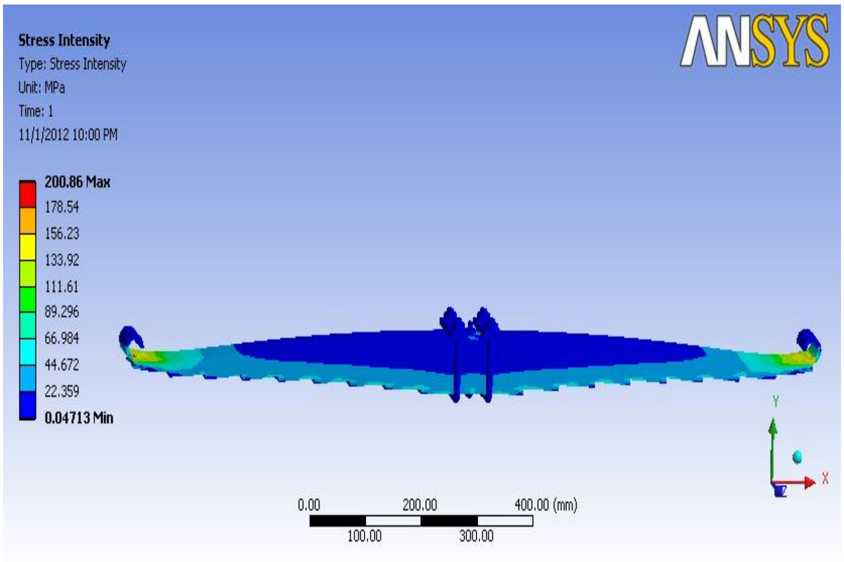
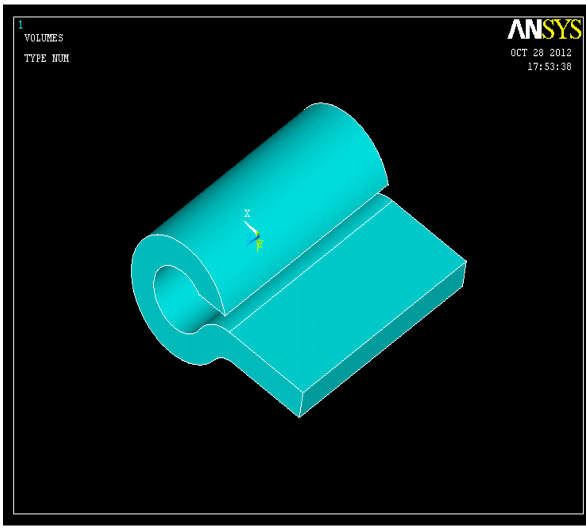


Fig.5 Stress Intensity



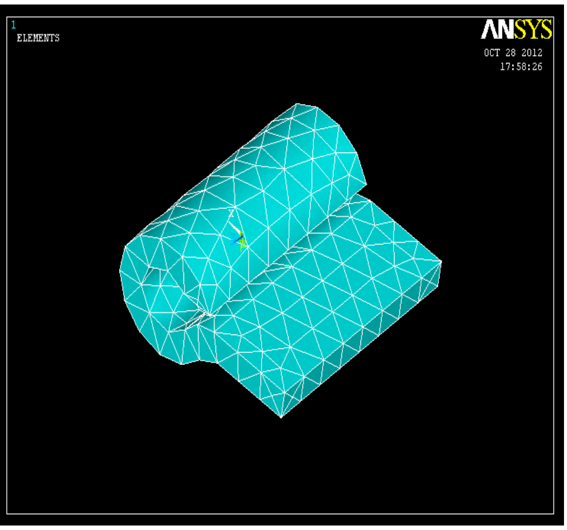
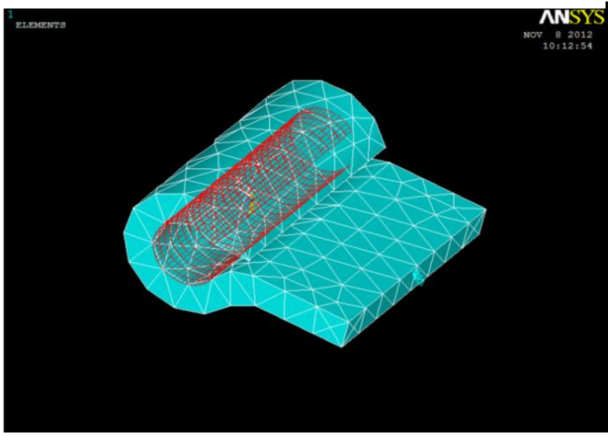


Fig.6 Ansys Geometric model

Fig .7 Ansys Finite element model



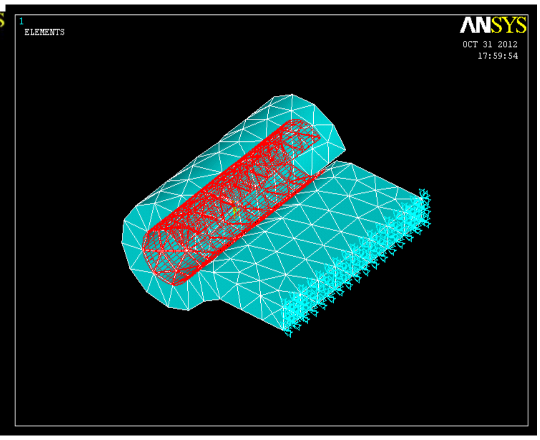
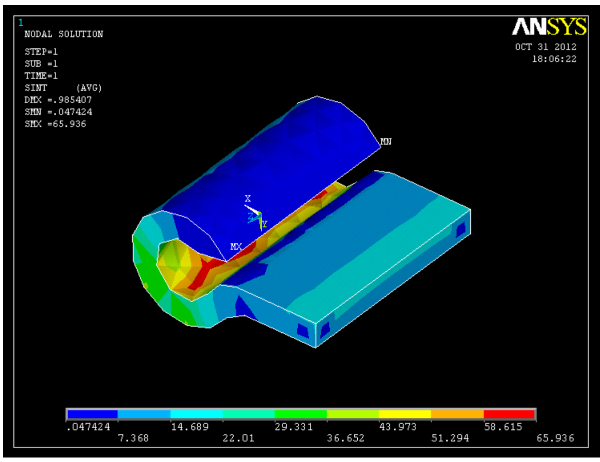


Fig .8 Boundary conditions and pressure

Fig.9 Boundary conditions and pressure



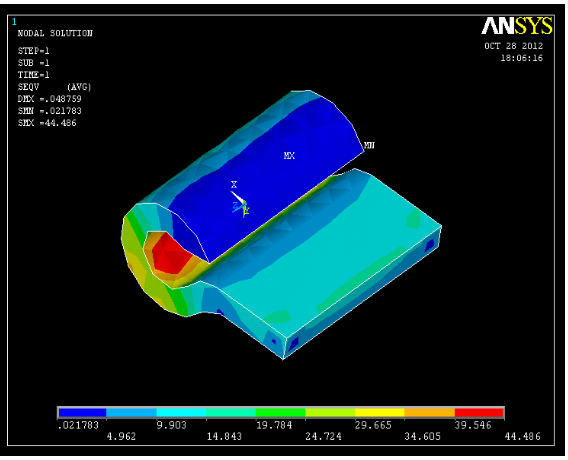


Fig.10 Stress intensity

Fig.11 Von-Mises Stress

Span	Frequency (Hz at Modes)									
mm	1	2	3	4	5	6	7	8	9	10
1120	3.896	6.281	9.803	15.423	17.617	19.471	27.401	28.192	31.062	42.924
1220	2.180	3.113	6.189	12.134	14.532	15.534	23.581	26.895	27.450	36.484
1320	2.126	3.012	4.509	11.643	12.625	13.925	21.420	23.920	25.102	27.959
1420	2.126	2.891	3.941	9.899	11.962	13.491	18.462	21.270	24.952	26.152

Table.1 Variation of natural frequency with span

VII. CONCLUSION

The steel leaf spring width is kept constant and variation of natural frequency with leaf thickness, span, camber and numbers of leaves are studied. It is observed from the present work that the natural frequency increases with increase of camber and almost constant with number of leaves, but natural frequency decreases with increase of span. The natural frequencies of various parametric combinations are compared with the excitation frequency for different road irregularities. The values of natural frequencies and excitation frequencies are the same for both the springs as the geometric parameters of the spring are almost same except for number of leaves. study of this nature by varying the layer configuration higher strengths can be achieved. Replacing the conventional leaf spring by composite leaf spring can be considered from strength, stiffness and vehicle stability point of view in vehicle stability. Instead of mono composite material, multi composite materials with multiple layers can be considered for study. An efficient design and manufacturing process of composite material leaf spring can reduce the cost and weight of the vehicle.

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