A SCHEMATIC DESIGN AND STRUCTURAL ANALYSIS OF LEAF SPRING SUBJECTED TO DEFORMATION

P.RAVI KUMAR, M.Tech Student, Dept of Mechanical-CAD/CAM, Brilliant Grammar School Educational Institutions Group Of Institutions Integrated Campus, T.S, India

MR.SHYAM SUNDAR LUHA, Associate Professor, Dept of Mechanical-CAD/CAM, Brilliant Grammar School Educational Institutions Group Of Institutions Integrated Campus, T.S, India

ABSTRACT

A suspension system or shock absorber is a mechanical device designed to smooth out or damp shock impulse, and dissipate kinetic energy. The shock absorbers duty is to absorb or dissipate energy. In a vehicle, it reduces the effect of traveling over rough ground, leading to improved ride quality, and increase in comfort due to substantially reduced amplitude of disturbances. When a vehicle is traveling on a level road and the wheels strike a bump, the spring is compressed quickly. The compressed spring will attempt to return to its normal loaded length and, in so doing, will rebound past its normal height, causing the body to be lifted. The weight of the vehicle will then push the spring down below its normal loaded height. This, in turn, causes the spring to rebound again. This bouncing process is repeated over and over, a little less each time, until the up-and-down movement finally stops. If bouncing is allowed to go uncontrolled, it will not only cause an uncomfortable ride but will make handling of the vehicle very difficult. The design of spring in suspension system is very important.

The fundamental Objective of this project is to represent plan and exploratory examination of composite leaf spring made of glass fiber reinforced polymer. The intention is to look at the load carrying capacity, weight and stiffness effective of composite leaf spring with that of steel leaf spring. The design imperatives are stresses and deflections. The measurements of a current ordinary steel leaf spring of a light business vehicle are taken. Static investigation of leaf spring is likewise performed utilizing analysis software and compared with experimental results. Limited component investigation with full load on 3D model of composite multi leaf spring is done utilizing analysis software and the analytical results are compared with experimental results.

Keywords: *shock absorber, Leaf Spring, Steel 65Si7, E-Glass/Epoxy Material, Automobile,ANSYS.*

1.0 INRODUCTION:

Leaf springs are essentially utilized as a part of suspension systems to absorb shock loads in automobiles like light engine vehicles, Heavy trucks and SUV Cars. It conveys sidelong loads, brake torque, driving torque in addition to shock absorber. The benefit of leaf spring over helical spring is that the finishes of the spring might be guided along a positive way as it diverts to go about as an auxiliary part not withstanding vitality retaining tool. As indicated by the reviews made a material with greatest quality and least modulus of flexibility in the longitudinal course is the most reasonable material for a leaf spring. To address the issue of regular assets protection, car producers are endeavoring to diminish the heaviness of vehicles as of late. Weight lessening can be accomplished fundamentally by the presentation of better material, outline advancement and better assembling forms. The suspension leaf spring is one of the potential things for weight decrease in vehicles un-sprung weight. This accomplishes the vehicle with more fuel effectiveness and enhanced riding qualities. The presentation of composite materials was made it conceivable to lessen the heaviness of leaf spring with no decrease on load conveying limit and solidness. For weight diminishment in cars as it prompts to the decrease of un-sprung weight of car. The components whose weight is not transmitted to the suspension spring are known as the un-sprung components of the car.

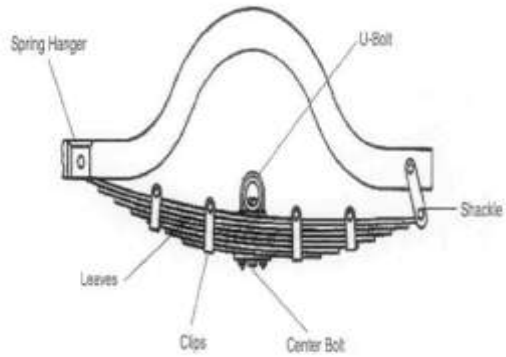


Fig.1.1 Leaf Spring

1.2 APPLICATIONS

Shock absorbers are an important part of automobile and motorcycle suspensions, aircraft landing gear, and the supports for many industrial machines. Large shock absorbers have also been used in structural engineering to reduce the susceptibility of structures toearthquake damage and resonance. A transverse mounted shock absorber, called a yaw damper, helps keep railcars from swaying excessively from side to side and are important in passenger railroads, commuter rail and rapid transit systems because they prevent railcars from damaging station platforms. The success of passive damping technologies in suppressing vibration amplitudes could be ascertained with the fact that it has a market size of around $ 4.5 billion.It is well known that springs, are designed to absorb and store energy and then release it. Hence, the strain energy of the material becomes a major factor in designing the springs. The leaf spring should absorb 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 released slowly.

Fig.1.2 Leaf spring assembled at rear axle of automotive

OBJECTIVE OF SUSPENSION:-

i. To safeguard the occupants against road shocks and provide riding comfort.
ii. To keep the body of the motor vehicle while travelling over rough ground or when turning in orders to minimize the rolling, pitching, or vertical movement tendency.
iii. To minimize the effects of stresses due to road shock on the mechanism of the motor vehicle and provide the cushioning effect.
iv. To provide the requisite height to the body structure as well as to bear the torque and the braking reactions.
v. To keep the body perfectly in level while travelling over the rough uneven ground i.e. the up and down movement of the wheels should be relative to the body.
vi. To isolate the structure of the vehicle from shock loading and vibrations due to irregularities of the road surface without impairing its stability.

2 .LITERATURE REVIEW

HELICAL SPRINGS:

The helical springs are made up of a wire coiled in the form of a helix and are primarily intended for compressive or tensile loads. The cross-section of the wire from which the spring is made may be circular, square or rectangular. The two forms of helical springs are compression helical spring and tension helical spring.

CONICAL AND VOLUTE SPRINGS:

The conical and volute springs, are used in special applications where a telescoping spring or a spring with a spring rate that increases with the load is desired. The conical spring, is wound with a uniform pitch whereas the volute springs, are wound in the form of parabolic with constant pitch and lead angles.

TORSION SPRINGS:

These springs may be of helical or spiral type. The helical type may be used only in applications where the load tends to wind up the spring and are used in various electrical mechanisms. The spiral type is also used where the load tends to increase the number of coils and when made of flat strip are used in watches and clocks.

The major stresses produced in torsion springs are tensile and compressive due to bending.

- Helical torsion spring.
- Spiral torsion spring

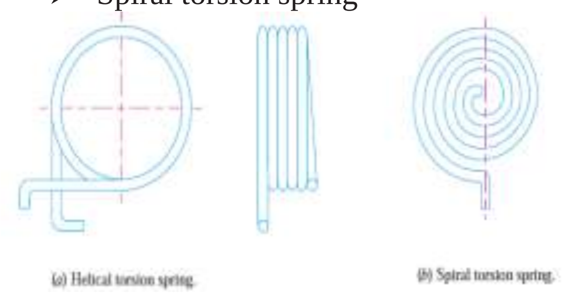


Fig 2.1 Torsion springs

LAMINATED OR LEAF SPRINGS:

The laminated or leaf spring (also known as flat spring or carriage spring) consists of a number of flat plates (known as leaves) of varying lengths held together by means of clamps and bolts. These are mostly used in automobiles.The major stresses produced in leaf springs are tensile and compressive stresses.

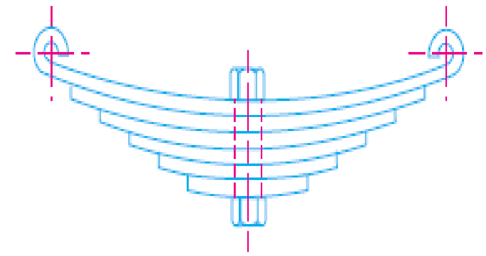


Fig 2.2 Laminated or leaf springs.

MATERIALS FOR LEAF SPRING

Materials for leaf spring are not as good as that for the helical spring. Plain carbon steel, Chromium vanadium steel, Chromium-Nickel- Molybdenum steel, Silicon- manganese steel, are the typical materials that are used in the design of leaf springs.

STANDARD SIZES OF LEAF SPRING

Width (mm) : 25-80 mm in steps of 5mm

Thickness (mm) : 2-8 mm in steps of 1mm, 10-16 mm in steps of 2mm

STRESSES DUE TO SUPPORT HINGES:

The master leaf of a laminated spring is hinged to the supports. The support forces induce, stresses due to longitudinal forces and stresses arising due to possible twist.

DISC OR BELLEVILE SPRINGS:

These springs consist of a number of conical discs held together against slipping by a central bolt or tube. These springs are used in applications where high spring rates and compact spring units are required.The major stresses produced in disc or Belleville springs are tensile and compressive stresses.

SPECIAL PURPOSE SPRINGS:

These springs are air or liquid springs, rubber springs, ring springs etc. The fluids (air or liquid) can behave as a compression spring. These springs are used for special types of application only

SHOCK ABSORBER TYPES

There are a number of different methods of converting an impact /collision into relatively smooth cushioned contact..

- Metal Spring
- Rubber Buffer
- Hydraulic Dashpot
- Collapsing safety Shock Absorbers
- Pneumatic Cylinders
- Self compensating Hydraulic

METAL SPRINGS

Simply locating metal springs to absorb the impact loads are a low cost method of reducing the collision speed and reducing the shock loading. They are able to operate in very arduous conditions under a wide range of temperatures. These devices have high stopping forces at end of stroke. Metal springs store energy rather than dissipating it. If metal sprint type shock absorbers are used then measures should be provided to limit Oscillations. Metal springs are often used with viscous dampers. There are a number of different types of metal springs including helical springs, bevel washers(cone-springs), leaf springs, ring springs, mesh springs etc etc. Each spring type has its own operating characteristics.

DESIGN CALCULATIONS FOR HELICAL SPRINGS FOR SHOCK ABSORBERS

Material: Steel(modulus of rigidity) G = 41000

Mean diameter of a coil D=62mm

Diameter of wire d = 8mm

Total no of coils n1= 18

Height h = 220mm

Outer diameter of spring coil D0 = D +d =70mm

No of active turns n= 14

Weight of bike = 125kgs

Let weight of 1 person = 75Kgs

Weight of 2 persons = 75×2=150Kgs

Weight of bike + persons = 275Kgs

Rear suspension = 65%

65% of 275 = 165Kgs

Considering dynamic loads it will be double

W = 330Kgs = 3234N

For single shock absorber weight = w/2= 1617N = W

We Know that, compression of spring (δ) = × × /×

C = spring index = = = 7.75 = 8

(δ) = × × × /× = 282.698

Solid length, Ls=n1×d=18×8=144

Free length of spring,

Lf = solid length + maximum compression + clearance between adjustable coils

= + + 0.15 = 144 + 282.698 + 0.15 × 282.698 = 469.102

Spring rate, K = = . = 5.719

Pitch of coil, P = = . = 26

Stresses in helical springs: maximum shear stress induced in the wire

τ = K

K = + . =

+ . = 0.97

τ = K× = 0.97

× = 499.519

Buckling of compression springs, =

Values of buckling factor KB= 7.5

K = 0.05 (for hinged and spring)

The buckling factor for the hinged end and built-in end springs

Wcr=5.719×0.05×469.102=134.139N

3.METHODOLOGY

3.1 METHODOLOGY/ PLANNING OF WORK :

The whole analysis process shall begin with following steps: model definition, meshing, model analysis, validation of the Finite Element Analysis (FEA) model.The process is briefed stepwise.

1) **Design of leaf spring**: The first step in the process is to define the model geometry. This is done by prepare a 3D solid modeling through using a computer-aided engineering tool.

2) **Importing solid model data into mesh model**: The second step is to import the data from the 3D solid model to the mesh generation software. This is done by creating a mesh model of the solid model after importing all the data into advanced analysis software and mesh generating tool.

3) **Finite Element Analysis (FEA) starts**: The finite element analysis was carried out using a commercial finite element analysis software package.

4) **Evaluations of the post processed results**: The results are post processed into a form suitable for engineering assessment

Analysis using Steel 65Si7 :

Load is acting 2500N on leaf spring.

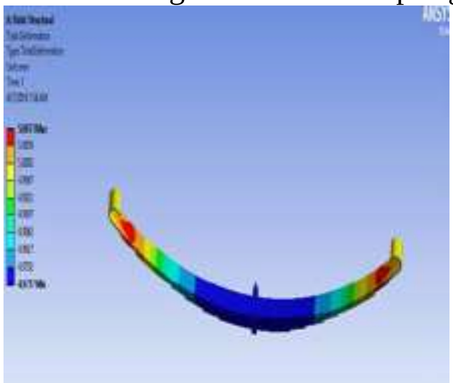


FIGURE 3.1 TOTAL DEFORMATION

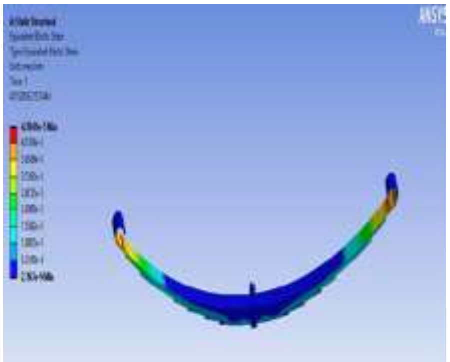


FIGURE 3.2 EQUIVALENT ELASTIC STRAIN

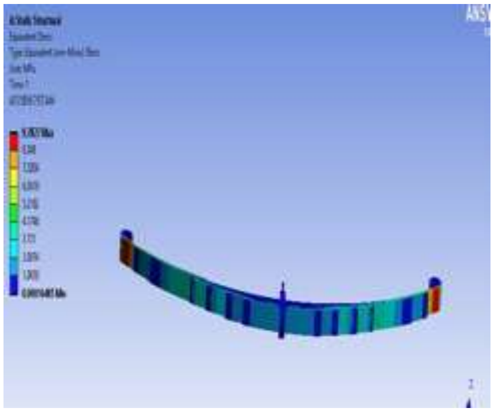


FIGURE 3.3 EQUIVALENT STRESS

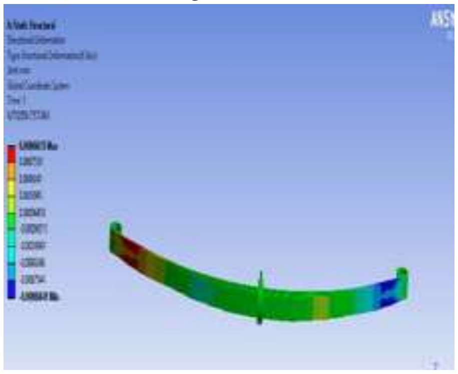
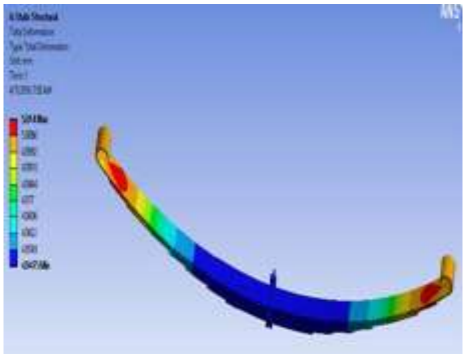
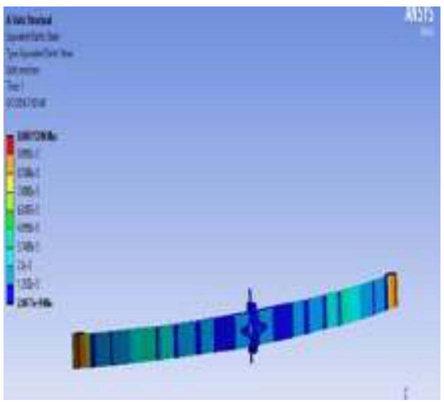


FIGURE 3.4DEFORMATION

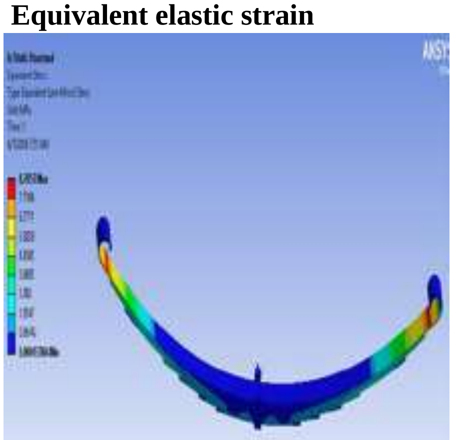
3.2 ANALYSIS USING COMPOSITE MATERIAL "E-GLASS/EPOXY



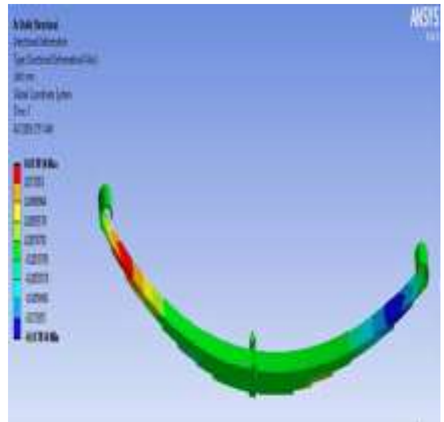
Total deformation



Equivalent elastic strain



Equivalent stress



Total deformation

DESIGN & ANALYSIS

In order to research relationship between stiffness, mass and design variables, and common batch file is built by 3D modeling software and analysis is done in Analysis / simulation Software.

For multi leaf spring:

MATHEMATICAL FORMULATION

For the purpose of analysis, the leaves are divided in two groups as master leaf along with graduatedlength
leaves forming one group and the extra full-length leaves forming the other group.

Let,

nf = number of extra full-length leaves,

ng = number of graduated-length leaves including the master leaf,

n = nf + ng =Total number of leaves present in the multi-leaf spring,

b = width of each leaf (mm),

t = thickness of each leaf (mm),

L = half the length of the semi-elliptic spring or the length of the cantilever (mm),

P = force applied at the end of the spring (N),

Pf = portion of P taken by the extra full-length leaves (N),

Pg = portion of P taken by the graduated-length leaves (N),

So, P = Pf + Pg .

Now, from practical considerations for an automobile leaf spring, that is of semi-elliptical shape usually, for a length of 2L and a load of 2P acting at the centre, the entire beam can be considered as a Static Analysis of Multi-Leaf Spring Using Ansys Workbench 16.0 double cantilever. If the leaves are cut into two equal halves in longitudinal plane and then combined accordingly, to form almost a triangular plate then, The maximum bending stress is given by [6].

(sb)max = 6P.L/n.b.t2 (1)

4. RESULTS

First the material selected for leaf spring is Steel 65Si7. The design parameters selected for steel leaf are listed in table 1 & 2. The normal static loading is 2500 N and Number of leaves are 7 which is clamped with rectangular clamp

MATERIALS FOR COMPOSITE LEAF SPRING:

The greatest advantage, be that as it may, is mass decrease: Composite leaf springs are up to five circumstances more strong than a steel spring, A transverse composite leaf spring presses against the lower arm and traverses the width of theauto. Truth be told, the spring is constantly stacked against the sub outline. Composites additionally can possibly supplant steel and spare weight in longitudinal leaf springs.

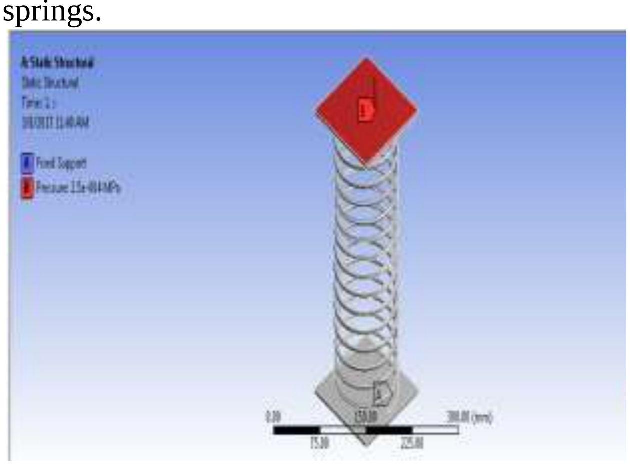


FIGURE4.1: SHOWS THE STATIC STRUCTURAL

SUSPENSION SPRING IN WHICH ONE END IS FIXED AND AT OTHER END PRESSURE IS APPLIED

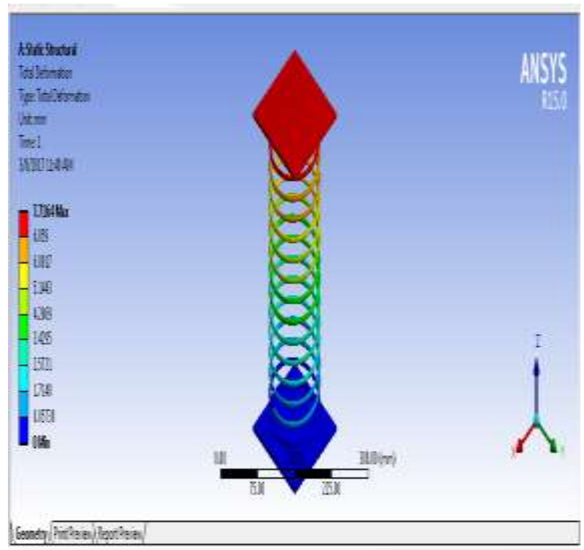


FIGURE 4.2: SHOWS THE TOTAL DEFORMATION OF THE SUSPENSION SPRING WHEN A PRESSURE OF 20P IS APPLIED

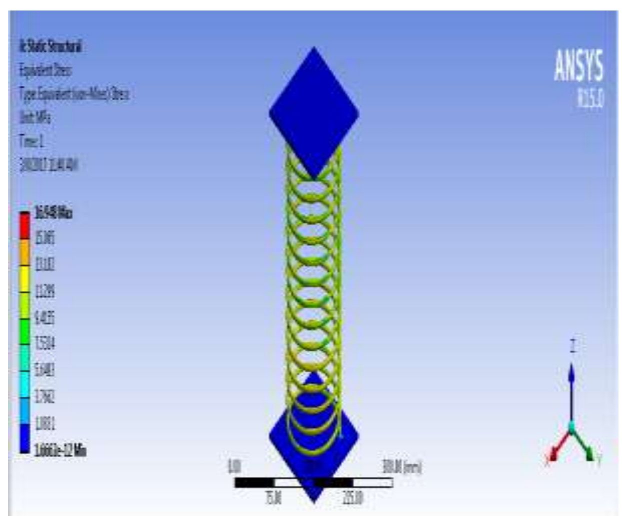


FIGURE 4.3 SHOWS THE EQUIVALENT STRESS ANALYSIS ON THE SUSPENSION SPRING AT AN APPLIED PRESSURE OF 20P.

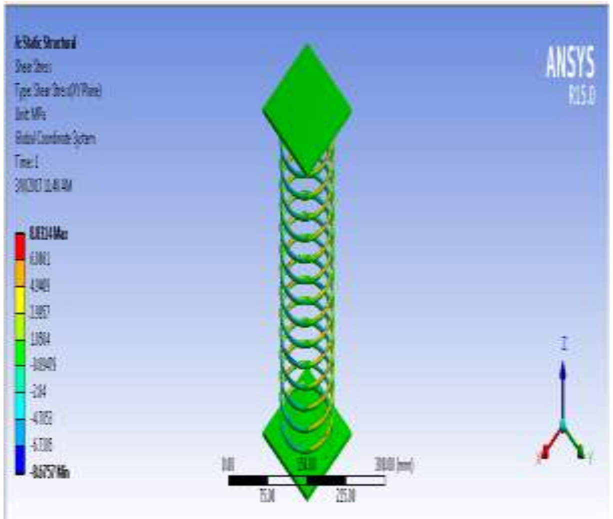


FIGURE 4.4 SHOWS THE SHEAR STRESS ANALYSIS ON SUSPENSION SPRING AT AN APPLIED PRESSURE OF 20P

CONCLUSION:

Design & Analysis of both steel and material is done Analysis and simulation software. It observe that steel leaf springs are approximate 70% heavier as compare to composite springs. A comparative study on both analysis & focusing on its equivalent Strain, von- misses Stress and its total deformation we get the results that composite spring is lighter and more economical as compare to steel spring on a same design.

FUTURE SCOPE & BENEFITS

1. Automobile industries research on reducing weight and increasing strength of products, so they were using such type of spring.
2. By design, leaf springs absorb vertical vibrations caused by irregularities in the road.
3. Weight saving as compare to Aluminum, Steel leaf springs.
4. Internal damping in the composite material leads to better vibration energy absorption within the material, resulting in reduced transmission of vibration noise to neighboring structures.

REFERENCES:

[1]. in this project we have designed a shock absorber used in a 150cc bike. We have modeled the shock absorber by using 3D parametric software Uni-Graphics.

[2]. To validate the strength of our design, we have done structural analysis and modal analysis on the shock absorber. We have done analysis by varying spring material Spring Steel and aluminum

[3] By observing the analysis results, the analyzed stress values are less than their respective yield stress values. So our design is safe.

[4] By comparing the results for both materials, the stress value is less for Spring Steel than Beryllium Copper.