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REDUCING THE IMPACT OF COLLISION ON A VEHICLE USING CONVENTIONAL SUSPENSION SYSTEM IN CRUMPLE ZONE

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Abstract*- Demand of transportation is increasing day by day as population is growing all over the world. Due to high population growth, more vehicles are getting on the road to meet their demand. Therefore, traffic congestion becomes more likely nowadays. And number of roads for transportation are not increasing at the required pace to meet those demands. Thus, rate of accidents and crashes is also increasing in Bangladesh, taking a lot of lives every year which is no doubt a big issue for us. In this paper, a specially designed suspension system is proposed which can be easily installed in front of current vehicle body and will reduce the impact of the accident or crash on the vehicle as much as possible. Though totally neutralizing the accident is impractical but this setup will minimize the loss as much as possible. The setup is designed using conventional automotive suspension devices to make it simple and cost effective. A simulation of the designed project was done using ANSYS software and compared with experimental data.*

Keywords: Transportation, Suspension System, Automotive, ANSYS.

1. INTRODUCTION

In a world where the transport systems are bound to be fast to travel anywhere, accidents are meant to be happened. The current road transport system has the most accidental rates for the past few years. A statistical data analysis shows that most of the accidents happens in roads in current world and billions per miles for the road vehicles it is 7.3. Whereas, the values are 3.2, 0.43 and 0.07 respectively for ferry, amtrak and airplane from year 2000 to 2009 [1]. Also, the cause of death at workplace is road accident in most cases. The total 1242 death at workplace of that year, 488 deaths are caused by transport accidents which is almost 40%. [2]. And in Bangladesh most of the road accidents are caused for hitting the trees which is about 33%, 21% for standing vehicles, 11% for bridge, 8% for electric poles and piling logs, 7% for animal and agricultural products and other barrier and other causes are of 7% [3].

Crumple system of a vehicle is designed to deform and crumple in a collision or crash. It helps to absorb most of the energy of the impact force which is made from the collision. This system works like a soft zone which deforms easily as this zone is made purposely weaker than all other areas of a vehicle. Though the use of a soft material would be much more efficient in this case. However, it will take a large amount of space in comparison of this system. Therefore, using crumple mechanism is much efficient as it absorbs more impact force using less area. A British Research Centre says that in case of crashes the impacts were 65% front, 25% rear, 5% at the left and rest 5% were at the right side [7]. Usually in modern vehicles, the crumple system is made of steels and other rigid materials like composite or carbon-fiber honeycomb, aluminum or other energy absorbing foam [8][9] which can act as an impact attenuator that dissipates the collision energy by using a lower weight and much smaller volume. These are always weaker than the other parts [10].

Previous studies on reducing the collision impact were done by several researchers. Lingyu Sun et al. [4] reported that an energy absorption device can ne used for protection from various types of car collision scenarios, which is able to adjust the stiffness and damping capacities of its own according to the situation. They developed a magnetorheological elastomer based adaptive energy absorption device called MREBEAD to work with its controllable characteristics for car bumper systems. A series of these devices were also installed behind a vehicle bumper. David C. Viano [5] shows that a lap-shoulder belts can be a very effective method in preventing the deaths of road collisions. It states that while the rest of the car is absorbing the instant impact of the collision force, this lap shoulder belt will give extra safety to the passengers inside. Mahmoud Shafik et al. [6] developed an intelligent fault monitoring and anti-collision system for electric vehicle industrial applications. It is mainly focused on the development of the vehicle anti-collision system. This system works as a network of sensors detecting the near real time embedded system. Total four operational conditions were considered it this research. Some activities also have been taken for controlling the speed and the steering system of the vehicle at an oncoming collision without causing additional problems to the driver. Some visual alerts such as LEDs were developed for indicating other vehicles around or obstacles along the path of this vehicle even if those are coming from opposite direction.

In this paper, a new design of a crumple system using coil springs and shock absorbers is proposed and evaluated experimentally, which will help to reduce the impact of the collision of a motor vehicle if the anti-collision systems fail to stop the vehicle from collision. The coil springs were used to absorb the impact force, whereas the dampers will help to bear the weight of the full setup. The uses of damper and coil spring make the system simple and durable with a very low maintenance.

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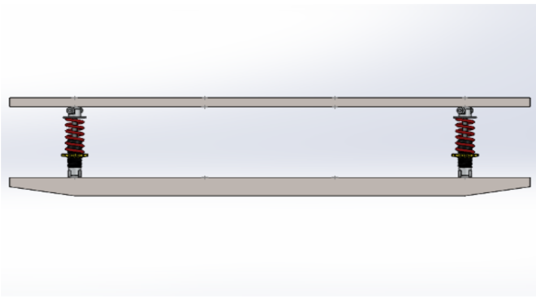
2. EXPERIMENTAL SETUP

The design of the setup was done considering the weight, size, cost and convenience of the user. The setup was made to fit in front of car quite easily without hampering mass balancing of the system. Also, the design was made keeping in mind that it should be cost effective and capable of being operated for a long time with less maintenance. The CAD design of the setup is shown in Figure 2.1, which was done using SOLIDWORKS.

It was fabricated using spring shock absorbers, thick steel bar, force measuring machine, screws and nuts etc. The setup is designed with a metal bar which is fixed with coil springs and shock absorbers with it. The coil spring and the shock absorbers are fitted vertically with the steel bar upon their working angles. Figure 2.2 shows the fabricated model of the setup.



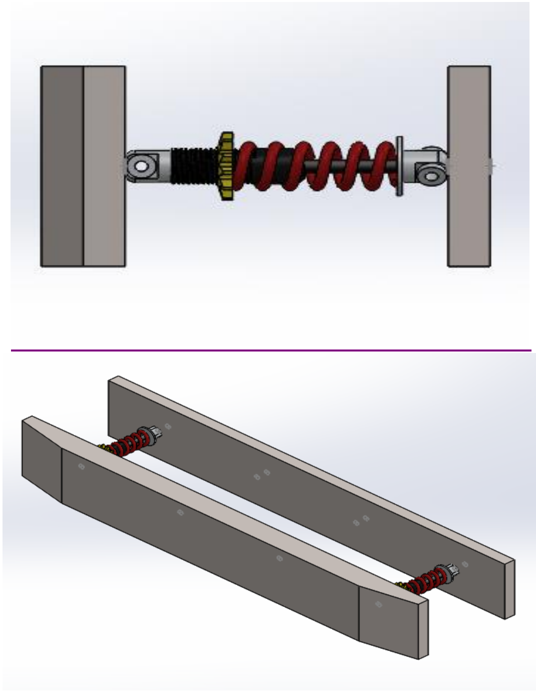


Fig. 2.1: The CAD model of the setup

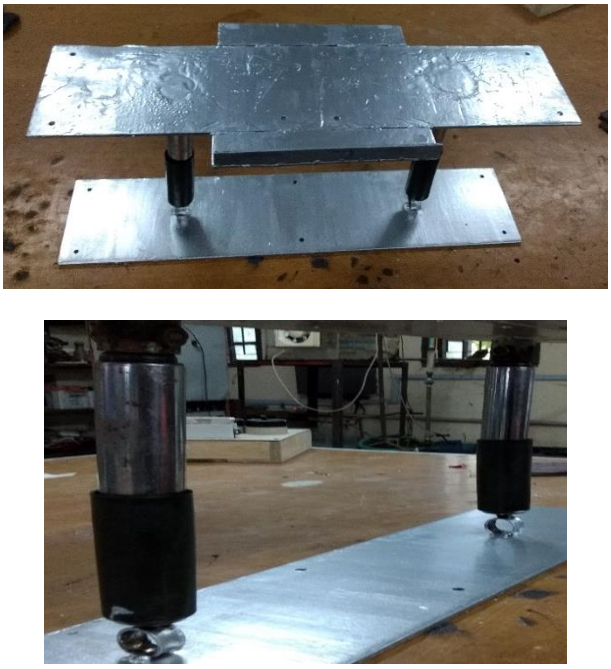


Fig. 2.2: The fabricated model of the setup

3. DATA COLLECTION

The experimental data collection method includes application of impact force on the setup and then the calculation of the absorbed force by the setup. The initial input force is measured by a weight machine which acted as a force calculating machine. The applied impact force travelled through the setup and then the output force which would act on the vehicle body is measured by another force calculating machine. Finally, the force which is absorbed by the designed setup is calculated. The data was collected by conducting 30 sets of experiments and it is quite obvious. The coil spring stiffness was evaluated by the equation 3.1.

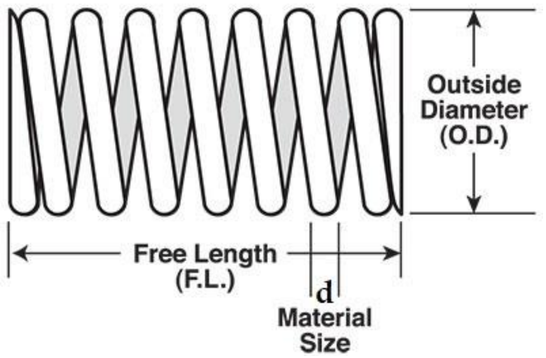


Fig.3.1: Spring measurement parameters [11]

$$\text{Spring Stiffness} = \frac{9913 \text{ x } d^4}{\text{n x } D^3} \qquad (3.1)$$

Where, d is the Coil diameter, OD is the outer diameter of spring, and n is the number of active coils.

4. NUMERICAL SIMULATION

The numerical simulation was done by ANSYS. Global coordinate was used to analysis the setup where Newton-Raphson residuals was zero. The CAD model of the setup was used in ANSYS and meshed afterwards. After a successful mesh, the analysis was done by getting the result of equivalent stress (von misses), normal stress, total deformation and stress probe by acting a force upon the front surface of the design making the output surface fixed. Results from the simulation and comparison with experiment will be shown in the later sections.

5. RESULTS

The experimental applied load on the fabricated setup vs the output load is depicted in the Figure 5.1. The relation between them is proportional.

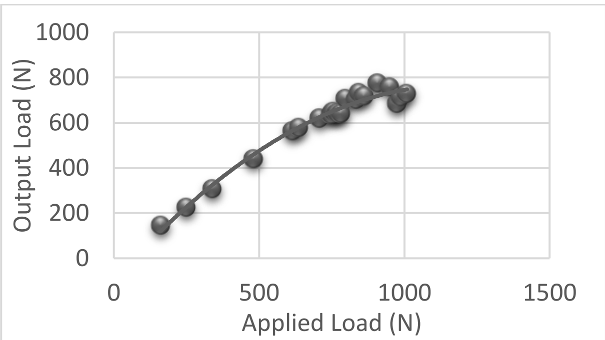


Fig. 5.1: Experimental Applied load vs Output load

Then, the absorbed load by the fabricated setup is shown in Figure 5.2 with applied load on it. It is clearly shown from the figure that the load absorption of the system increases with the increment of the applied load.

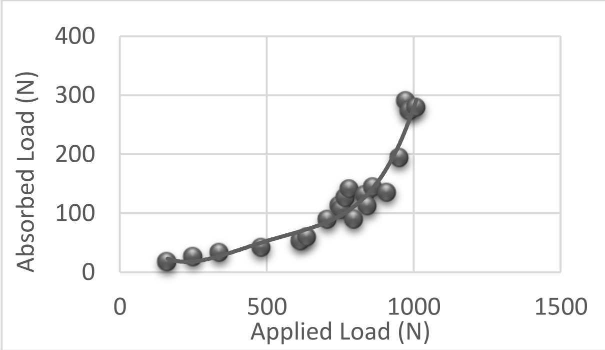


Fig. 5.2: Experimental Applied load vs Absorbed load by the setup

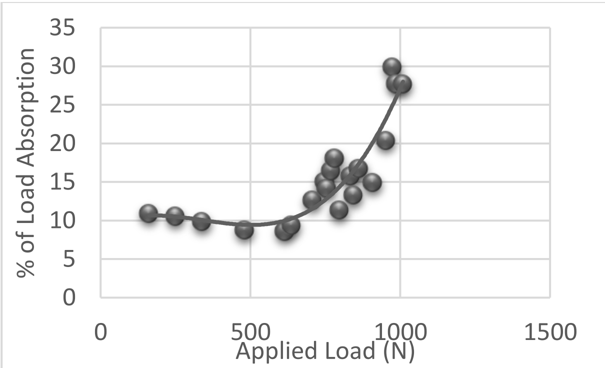


Fig. 5.3: Experimental Applied load vs Percentage of load absorption by the system

The percentage of load absorption by the designed setup is shown in Figure 5.3 along with applied load. It shows the positive result.

Now, Figure 5.4, 5.5 and 5.6 depicts simulation results of the stress analysis and deformation of the designed setup.

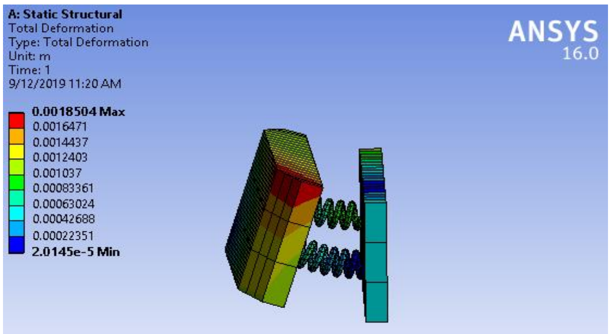


Fig. 5.4: Numerical simulation (Total Deformation)

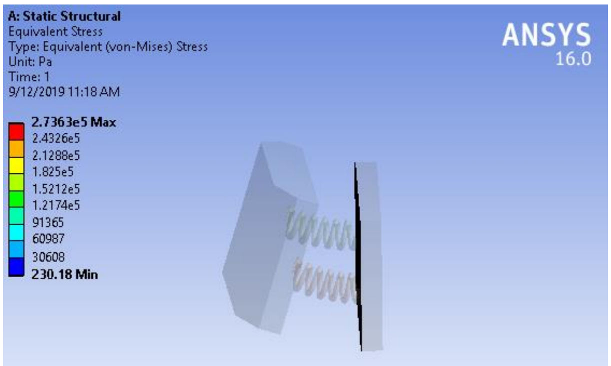


Fig. 5.5: Numerical Simulation (Equivalent Stress)

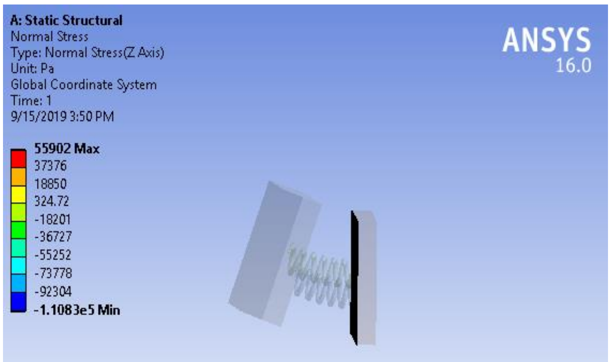


Fig. 5.6: Numerical Simulation (Normal Stress)

Then, a same sort of plotting like experimental data was done with the simulated data to show the comparison in between them. Figure 5.7 and 5.8 shows the comparison between experimental and simulation data analysis. The agreement between them is quite acceptable.

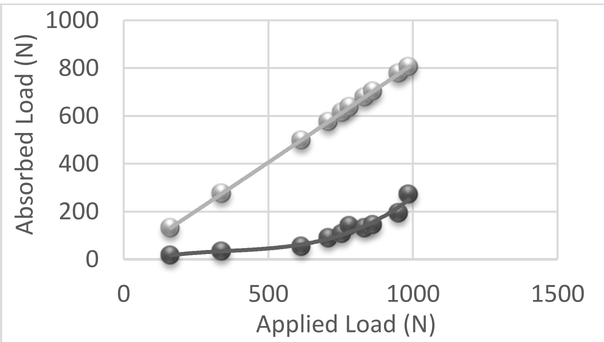


Fig. 5.7: Comparison between experimental and simulation results (Absorbed load)

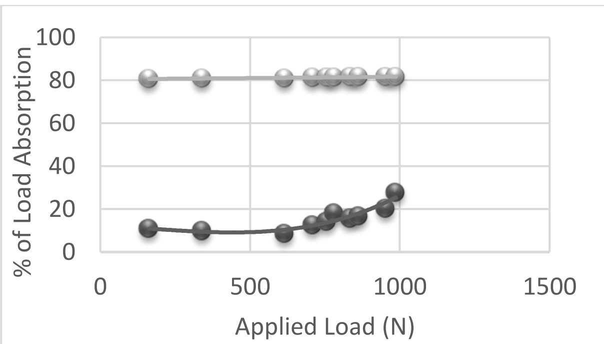


Fig. 5.8: Comparison between experimental and simulation results (Percentage of load absorption)

Therefore, it is clearly depicted that the outcome of experimental analysis is successful enough to use it in future purposes. The comparison between the experiment and simulation are also admissible.

6. CONCLUSION

The impact force of collision on the body of the vehicle was reduced by around 30% by using the setup and comparison with simulation results is satisfactory. The setup is quite simple, easy to fit and replace, cheap and requires less maintenance. It would very useful for current road vehicles in Bangladesh. A multiple combination of springs and dampers of different stiffness could be used to compare their effectiveness for the further research and improvement.

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7. NOMENCLATURE

Symbol	Meaning	Unit
D	diameter	(mm)
n	Active number of coils	------