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Design and Testing of Energy Absorbing System Avoiding Car Crashing with Lighting Poles

Elfetori F. Abdewi
elfetori.abdewi@academy.edu.ly
School of Engineering and Applied Science, Libyan Academy, Tripoli, Libya

Abstract

This paper is devoted to study the effect of crashing of vehicles with concrete blocks that placed around lighting poles. Unexpected dangers takes place if crashing occurs. It may cause death of the driver and passengers, or severe injuries. In order to minimize or eliminate this risk, a system made of corrugated composite material plates have been designed to replace the concrete blocks around lighting poles. This system is made of reinforced fiber glass and it is modeled to crash with a model of car exactly similar to the real one, forming a simulation of car accident. Modeling process takes place using Finite Element Analysis (FEA). ANSYS software utilized for this purpose. Simulation was performed at three different speeds of the vehicle. Results obtained have been recorded in a form of deformed mesh, and contours. The results proved that the new designed system is working perfectly and it has the ability to absorb impact energy caused by car accident. Therefore, by using composite material instead of concrete, risk of death and injuries will minimized or completely eliminated.

Keywords: Car crashing, Energy absorber, Composite material, lighting poles.

1. Introduction

The dangers resulting from car accidents to which humans are exposed every day are not only caused by speed and recklessness, but also have many reasons, including the presence of concrete blocks to close the entrances to some roads, as well as breaks between parallel roads and around lighting poles to protect them and others.

When cars collide with these concrete blocks, severe damage occurs, sometimes leading to the death of the driver and passengers, and sometimes to deep wounds and severe injuries that may result in disabilities or loss of some body parts (hands, legs, or …etc), in addition to the material damage represented by the loss of the car and other goods around the area of the accident.

All this is due to the collision of the vehicles with the concrete block that crosses a very solid, durable and heavy-weight object that cannot be easily displaced. If these concrete blocks are replaced by blocks made of composite materials that have the characteristics of absorbing impact energy, there is no doubt that these alternative blocks will reduce the risk very significantly, or it may completely eliminate the risk.

Composite materials are the best alternative to metals and other materials because of their distinctive properties [1-3]. Nowadays, it is widely used in various applications such as aircraft cars, motorcycles, ships and boats as well as furniture, sports goods and more.

Based on this recital. This paper focusing in design and testing a new system made of composite materials aims to minimize or eliminate the dangers caused by car crushing with concrete blocks. The system has the ability and effectiveness to absorb impact energy. This system is made of composite plates with square corrugated profile. The shape and geometry of tested material was chosen based on previous researches [4-11] that proved its effectiveness on crashworthiness.

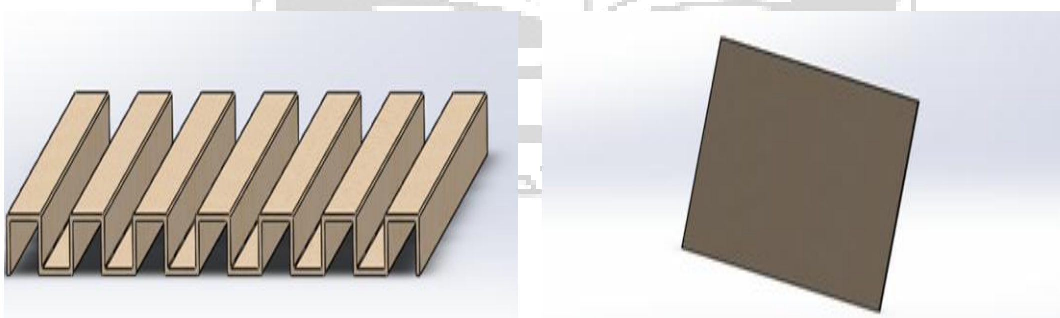
Designed model placed around lighting poles and a car with real specifications was designed to crash with the designed system placed instead of the concrete block around the lighting poles. The study was conducted theoretically using Finite Element Method (FEM), using ANSYS code.

2. Modeling Process

The experimental setup carried out consists of three main elements: designed absorbing system, lighting pole, and simulated car which will crash with a lighting pole in a presence of absorbing system around the lighting pole. Detail description will be illustrated for each element.

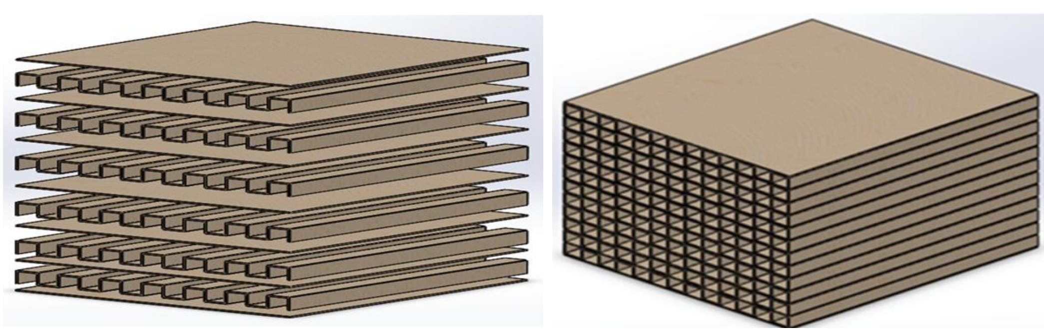
2.1. Designed Absorbing System

The system being designed made of several corrugated composite plates with square profile. Each plate fabricated by reinforced fiber glass using hand lay-up technique. The plate has four layers with a dimension of 60 cm x 60 cm (see Figure 1 a). A flat composite plate with a same dimensions have been fabricated using same technique (hand lay-up process) as shown in Figure 1 b. Designed model is formed by attaching flat composite plates with corrugated composite plates in a form of alternative sequence, means that each flat plate was placed in-between two corrugated composite plates as shown in Figure 2 a. A total ofTwelve corrugated composite plates and Twelve flat composite plates have been attached together by adhesive glue forming a designed absorbing system being tested as shown in Figure 2 b.



(a)(b)

Fig.1 (a) Corrugated composite plate with square profile, (b) Flat composite plate



(a)(b)

Fig.2 Designed system for absorbing crushing energy (a) separated plates, (b) combined plates

2.2. Lighting Pole

Lighting pole was designed similar to the real life one with respect to dimensions and type of material. As shown in Figure 3, the lighting pole has a length of 6.8 m, and a diameter of 200 mm, 110 mm at a base side and top side respectively. Lighting pole shell has a thickness of 4 mm. Regarding the material, it is assumed that the lighting pole is made of steel AISI 1020, and its weight is found to be 112 Kg.

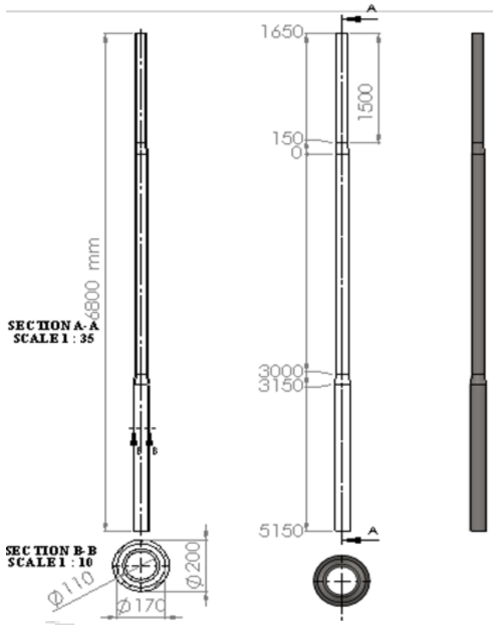


Fig.3 Model of Lighting Pole

2.3. Model of the Car

The car being tested have been modeled to reflect exactly the real case. The car chosen to perform the test is TOYOTA Corolla 2013 as shown in Figure 4. However, the model of designed car has a specification almost closed to the real one. In order to simplify modeling process, designed car was drawn as a car body without motor, wheels, and other parts. While the main specifications including: size, weight, shape, and type of material. Table 1, records specifications of real car and its similarity car model.

Fig.4 Photo of real car TOYOTA Corolla 2013

Table 1 Specifications of real car and model of the car being tested

Dimension	**Value**	
	Real Car	**Model**
Height	1465mm	1125 mm
Length	4540mm	3850mm
Width	1760mm	1400mm
Weight	1695kg	1503.2kg

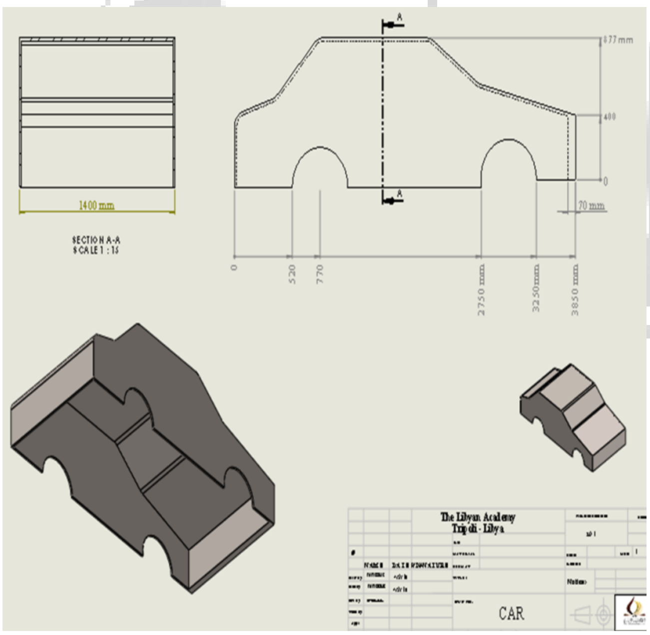


Fig.5 Engineering drawing of car model being tested

2.4. Modeling methodology

Modeling process carried out perfectly similar to a real life. As shown in Figure 6, the process involved a car making an accident with a lighting pole surrounded by a designed system which should serve as energy absorber. The test will be run three times with three different speeds. The car will crash designed composite block around the lighting pole firstly with a low speed of 36 Km/h, then medium speed of 54 Km/h, and finally with relatively high speed of 72 Km/h. response of

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crashing will be observed, analyzed, and then recorded in a form of deformed mesh and contours. Finite Element code have been used for modeling and analysis process.

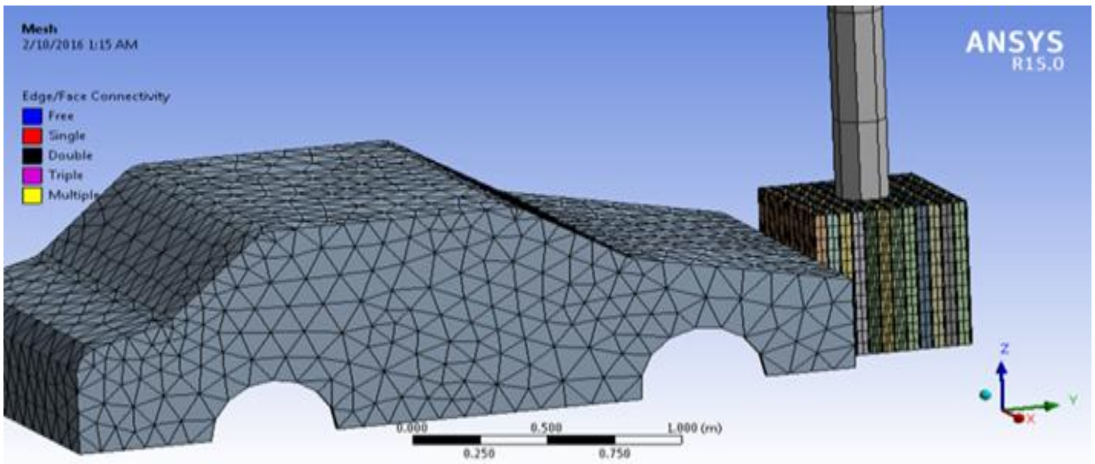

Fig.6 Modeling of Crushing Process

3. Results and Discussion

The objectives of the tests were to study the crushing behavior and to investigate the effect of design parameters on energy absorption capabilities. In order to achieve this goal, dynamic impact tests have been carried out. The tests were simulated and modeled using Finite Element Analysis. ANSYS software was used for this purpose. The tests were conducted three times at low, medium, and relatively high speed. Results of crushing tests have been plotted in a form of contours. Deformation at each crushing speed was clearly observed as shown in Figures 7 – 9. However, other obtained parameters are recorded in Table 2.

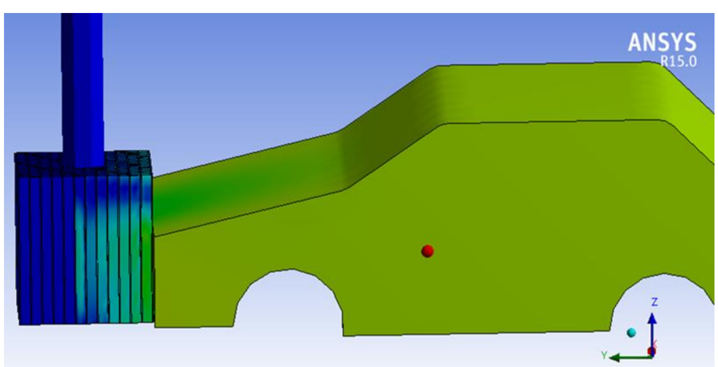

Fig.7 Modeling of Crushing Test at a Speed of 36 Km/h

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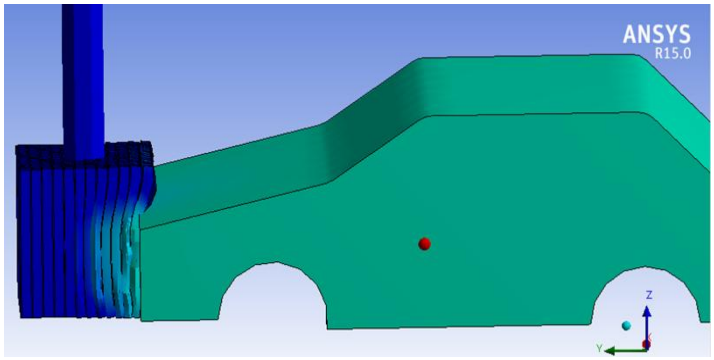

Fig.8 Modeling of Crushing Test at a Speed of 54 Km/h

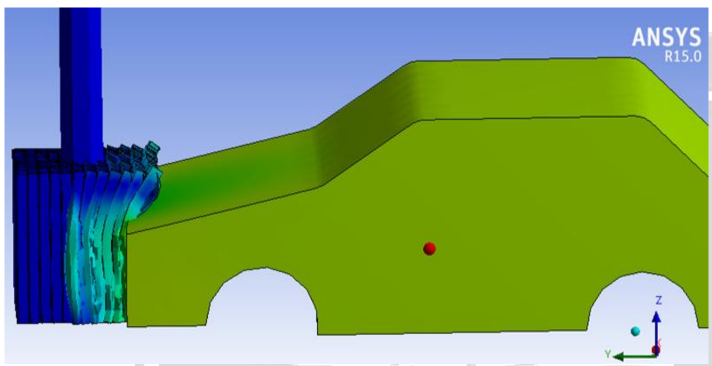

Fig.9 Modeling of Crushing Test at a Speed of 72 Km/h

As shown in figures above, the effect of accidents is mainly related to the speed of the car. As a speed increases, crushing becomes more worse. It is also observed that, the designed system plays a valuable role with respect to safety of driver and passengers. Moreover, the car body as well as the lighting pole is not affected in presence of designed composite absorbing system. It is found that, designed system works perfectly in case of car accident with lighting pole. The mechanism occurred while accident takes place is at the contact of the front side of the car body with the designed system, shattering starts in first layers of the absorbing system. The number of layers shattered depends on the speed of the car. If the speed of the car is low, crashing may not occur. However, if the speed is high, the first layers of the absorbing system will be destroyed. For the current test, results showed that no distortion observed in the car body and lighting pole. Regarding the designed absorbing system,

There was no shatters at the accidents of low speed (36 Km/h), just a contact between the car and absorbing system. When the speed of the car was 54 Km/h, the accident cause a medium shattering of the first few composite layers of the absorbing system. However, at a relatively high speed of the car (72 Km/h), more composite layers have been destroyed, but the lighting pole still safe. Meanwhile, deformation have been recorded at three cases. The deformation occurred was 16 mm, 156 mm, and 193 mm at a car speed of 36 Km/h, 54 Km/h, and 72 Km/h respectively. Main parameters obtained are summarized in Table 2.

Table 2 Obtained parameters for car crash modeling at different speed

Speed of the car (Km/h)	**Deformation** (mm)	**Max. stress** (MPa)	**Mean stress** (MPa)	**Energy absorption** (K j)
36	16	635.24	299.19	0.245
54	156	768.24	608.3	0.88
72	193	1021.7	811.39	1.703

4. Conclusion

The objectives of the paper have been achieved. An absorption system have been designed, modeled and analyzed using finite element method.Based on results obtained, it can be concluded that modeling process reflecting real case action, and finite element method proved that it is a power full tool in in design, analysis, and testing. Simulation showed that composite materials exhibit an excellent response in terms of energy absorption capability. It is found that designed system is able to absorb impact energy exerted by crushing. Hence, dangers caused by crushing can be completely eliminated, or minimized. Therefore, it is strongly recommended that solid blocks such as concrete should be replaced by similar size composite blocks.

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