

# DESIGN CRASH CUSHION USING WASTE TIRE FOR TOLL PLAZA BARRIER

**Dan, M.M.P., Fadhli Akmal, A.M.**

Faculty of Manufacturing Engineering  
Universiti Teknikal Malaysia Melaka (UTeM),  
Hang Tuah Jaya, 76100, Durian Tunggal,  
Melaka, Malaysia

Email: drdan@utem.edu.my

**ABSTRACT:** Nowadays, there are many victims of accidents at toll plazas spread in the daily newspaper. Based on the severed incident, there are many humans died and seriously injured. Thus, accidents at the toll plaza is the main cause of this study. Besides that, one of the factor that cause the accident is the barrier systems such as crash block that made from concrete preferred the safety of the workers where they protect the vulnerable from harm tollbooth violations from the vehicle. This study aimed to design a crash cushion to be placed in front of crash block. In this study, waste tires are used as material crash cushion. The waste tires is used in this study because its can reduced envirnmental pollution and its also can counter the requirements of rubber demand. Moreover, the waste tires has been cut and crushed into fine powder using a Crusher Machine. Then, the waste tires is routed to make the crash cushion. Actually, a main process of producing the crash cushion is injection moulding process. In addition, this process has been studied to get more information about the flow process in producing the crash cushion. Furthermore, samples of prototype will be made to show the real view crash cushion. Other than that, results from the test data will be recorded in order to make this study qualified in the future.

**KEYWORDS:** Plaza Toll Concrete Barrier, Design Crash Cushion, Waste Tires, Ansys Software, Car Impact, Finite Element Method, Simulation Xpress.

## 1.0 INTRODUCTION

Each year, many people are died on roads. This does not include those people that seriously injured and slightly injured. The average person in a metropolitan country has risk in one of hundred lifetimes being killed in road traffic accident and one in three lifetime risk of being injured (Rodger and Grary, 2003). Accident affect not only toward to the driver but also to the passenger.

There are many accident cases in Malaysia that related to the crash at toll plaza. In Star Publications news paper on Thursday, February 10, 2011 has reported that mechanic killed in crash at toll plaza. He is 38 year old died instantly after his car rammed into the concrete safety wall at Sungai Dua toll plaza. This is because he has lost his control of his car which rammed into the wall of smart Tag booth. Same in The Star News paper on Tuesday, January 08, 2010 has reported siblings die in toll plaza crash. In this case, their three children of multinational company's vice-president were killed when the car they were travelling was rammed into a safety wall at Sungai Dua toll plaza and burst into fire.

Thus, this would require changes in design to lessen injury to user road. Now, car technologies have used bumpers that contain an extra layer of energy absorbing material to reduce the impact force. In other way, engineers was design many kind of barrier like we can see on the road. Currently, there are many kind of barrier. Some of these are roadside barriers, median barriers, bridge barrier and work zone barriers. This all barrier are making from different material. They have come with metal, plastic and concrete material. This depends on what function and where the barrier was placed.

This focused to design the crash cushion by recycle waste tire for make the toll wall barrier can perform better than the existing crash cushion. The material should contain of energy absorbing material to reduce the impact force of crash. In this research, the toll concrete barrier is focus from other kinds of barriers. This is because these researches have to find the way to reduce the crash accidents at toll plaza. The materials that have been research will be apply at the barrier or the barrier will be redesign with using the new material.

## **1.1 Problem Statement**

The amount of accident on the road increases every year and many people died and injured. There are many reports about accidents that can see in news paper today. Even engineers trying their best for reducing the accidents by designing product safety like design the bumper car, road safety system, barrier, etc. As what we can see, system barrier at toll plaza (crash block) do not have a safety for absorbing crash impact. This is dangerous if there is any accident. Besides that, there is too much environmental pollution from the waste tires that are not used. Quantity of recycled tires is only a few then the overall waste tires in producing the crash cushion.

## **1.2 Objectives**

The objectives is to study the existing concrete barrier at toll booth. Design, developed and propose new design of crash cushion using waste tire for apply at concrete barrier. Then, testing and analyses using ANSYS software and fabricate the sample crash cushion.

The study is purpose for implement a new material (waste tire) on a concrete barrier at the toll plaza. The idea stated after see many accidents that crashing the concrete barrier at toll plaza. In this case, the study needs to reduce the maximum crash impact on the concrete barrier and inferior the risk of accident. Researcher need to putting the waste tire material as a crash cushion in front the barrier. Before that, some design and concept of crash cushion are needed. Drawings have to analyses using the finite element method of CAD software. Then, the best result or one of option from the design concept will be taking to fabricate the prototype of crash cushion for the view sample.

## **2.0 LITERATURE REVIEW**

### **2.1 Crash Cushions System**

On road there are many kind of crash cushions barrier for absorbing the crash impact. Many options that have used for made the crash cushions. Most of it's from zinc and plastic material. Hirsch et al. (2000), state that apparatus and methods are described relating to barrel crash cushions. There is readily collapse when impacted from a substantially end-on direction. There are also more capable than conventional designs of substantially redirecting vehicles impacting from non-end-on directions. There reducing the chance of these vehicles tearing through the crash cushion. The described configurations also substantially reduce the harm associated with "coffin corner" impacts through a structurally reinforced portion that increases the ability of the barrel cushion to withstand impacts from directions other than substantially end-on.

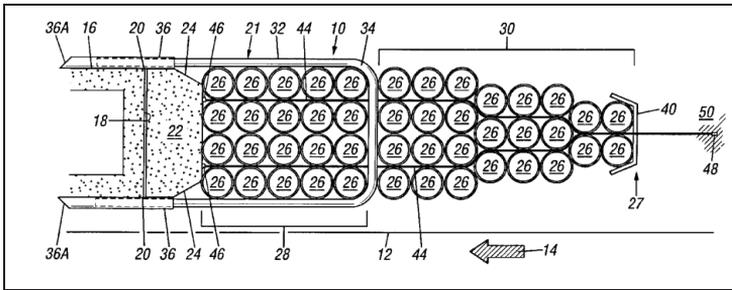


Figure 2.1: Drawing sheet of barrel crash cushion  
(United State Patent: Hirsch *et.al.*, 2000).

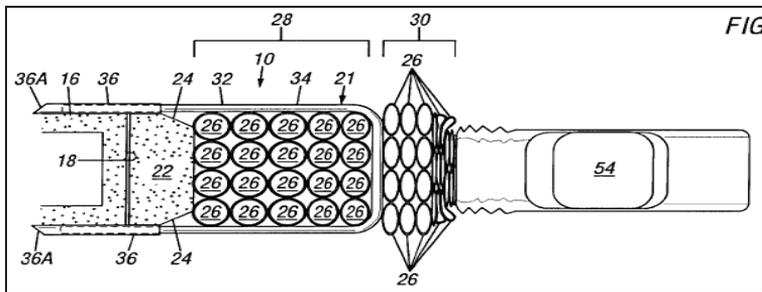


Figure 2.2: Absorbed after car crashing  
(United State Patent: Hirsch *et.al.*, 2000).

A common highway crash cushion device is created by lining up a number of barrels. There are formed of either metal or plastic. The lines of barrels are then positioned upstream of a fixed structure which is located in or adjacent to a roadway. The fixed structure representing a potential impact hazard to vehicles traveling along the roadway. The fixed structure is typically a concrete object, such as a bridge abutment or a median. In this discussion, the term “upstream” refers to the direction along the roadway from which traffic is expected to approach the fixed structure and, hence, is the direction from which a vehicle is most likely to impact the fixed structure. Conversely, “downstream” refers to the direction along the roadway which is generally opposite the upstream direction (Hirsch *et.al.*, 2000a).

In conventional designs, barrels of a desired resistance to crushing are welded together at contact points. The metal bands may be used to surround the barrels and band them together. Spacer bars or steel straps may also be tack welded to portions of the barrels. Screw eyes are screwed into the barrels so that wire rope or cables can be passed through the eyes and anchor the lines of barrels in position. It has also been known to place within the barrels filler such as sand, sawdust and

so forth, although normally the barrels remain unfilled. The barrels themselves are sometimes placed atop chair assemblies so that they remain above the ground. The upstream end of the lines of barrels is often covered by a reflectorize nose cover (Hirsch *et.al.*, 2000b).



Figure 2.3: Crash block make from smart plastic (HMW/HDPE) (Google.com, 2011).

## 2.2 Waste Tire

Each year more than 250 million used tyres are stockpiled in the United States, Rma, (2004) and Canada generates over 28 millions of passenger tires per year, O'shoughnessy & Garga, (2000). At Korea, there has generated approximately 20 millions of waste tires per year since 1998 (Figure 2.4.) and some of the tires are utilized for rubber tiles, blocks or for cements material. Sandra (2006) has say in his thesis that in Malaysia, the number of motorcar waste tires generated annually was estimated to be 8.2 million or approximately 57,391 tones. About 60% of the waste tires are disposed via unknown routes.



Figure 2.4. Waste tires. (Google.com, 2011)

With the concept of reuse and recycling, waste collectors roam residential areas in major cities and towns to search the articles that can be reused. Some of the products resulting from reprocessing wastes are attractive and level of skills and high intelligence. Recycles artisan

themselves into the traditional markets and have created a viable life for themselves in this sector. Tire collection process and the collection and reuse are a task carried out mainly by the information. The tires are seen too valuable to enter the waste stream and collected and put to be used (Gards, M. 2002).

### **3.0 METHODOLOGY**

Methodology is a procedure that used to attainment the objectives of the study that was prescribed. Methodology also can be a guideline which is very important where it can arranged the steps that be conducted to seek a method that most suitable to be used. In Figure 3.1: show framework of the project research.

Generally, new materials been applied with toll barrier. Materials have been screening and ranking by using the CES Edupack 2010 software. After the materials have been ranking, the material will be design with the barrier. Here, the final material choice is carbon black reinforced styrene butadiene rubber. The typical uses of this material are car and truck tires, belt, hose and footwear. So, the wastes tire can be use by recycle it back. This also can help reduce the environmental pollution.

Sketched the idea generation of the research products are needed. There are three option designs have been selected and it's have a three concept of design that will applies to toll barrier. By using CAD software, the hand sketch will be applied to realize the design. The design will be analysis with finite element method to know the result of impact crash on the product. After all result have been collected, the best result will be selected and proceed to the next process.

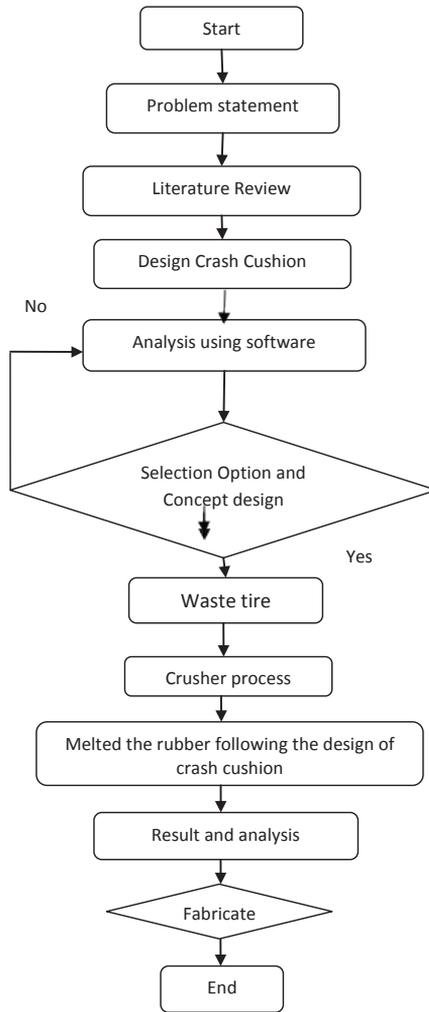


Figure 3.1: Framework of the Project

Analysis software has been used to analysis the impact process of the project. Ansys 13 software is choosing in this project for testing the explicit dynamics of the crash car at crash block and crash cushion. For fabricate, the waste tires have be processed in different stage until it is forming granules. Then, the materials are used as a sample before in managing to the further process. The granules rubber will be heated to form new material by following the design of rubber sheet.

### 4.0 RESULT ANALYSIS

Because one of the objectives of this study is to analysis the impact car to the crash cushion. Ansys 13 have been use for generate the result. In progress of using the software, there are several technical problems that have been identified. Ansys 13 software is the sensitive software and need a long period time to gate the result. In this study case, for obtain one result their need to wait three hour to ten hour or more. It is depended what kind of the analysis. Table 4.1 showed the maximum shear, maximum deformation and maximum acceleration for the result from analysis.

Table 4.1: All result of current design and options.

Design Concept	Parameter		
	Maximum Shear Stress (m)	Deformation (m)	Total Acceleration (m/s <sup>2</sup> )
Current Design	1.4838e9	0.94002	5.3383e5
Option 1	1.7082e7	0.90314	8.0932e5
Option 2	7.6131e8	0.90314	8.0932e5
Option 3	6.4305e7	14.097	1.9252e7

From the data and graph that showed before, crash cushion from option 1 is the more effective in absorbing the impact. The different of the crashing can be see from the analysis movement on software. Option 1 showed that it make the movement of the object that crashing the crash cushion been slower and do not give the suddenly big impact for driver compared with other option. Figure 4.1 showed the absorbing of crash cushion on option 1 design. The same speed (30m/s = 108km/h) have been applied to all option.

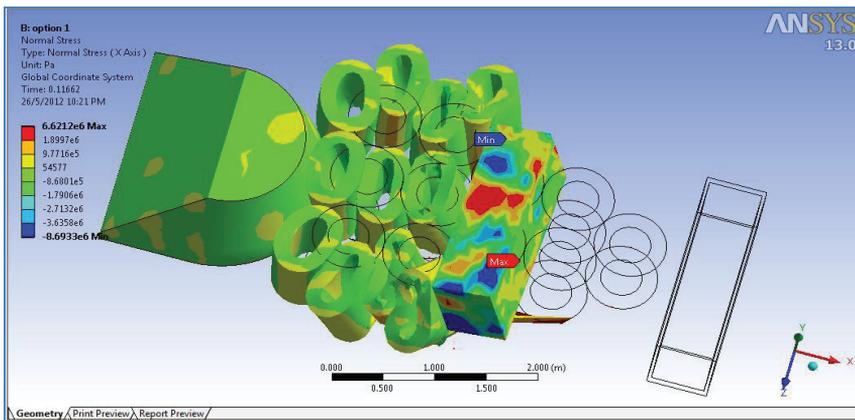


Figure 4.1: Absorbing of crash cushion for option 1.

## 4.1 Analysis Maximum Shear Stress

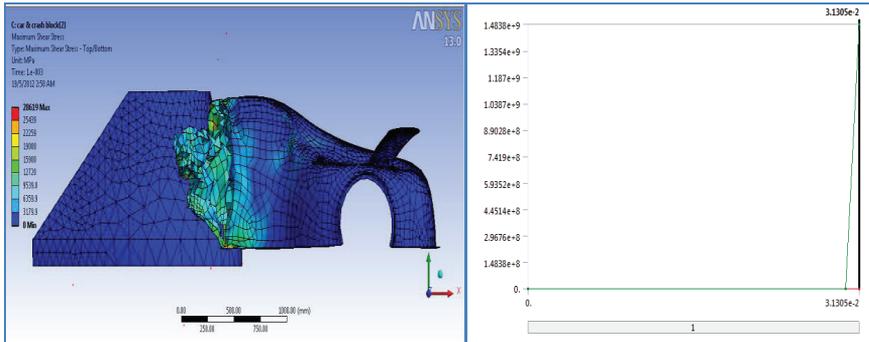


Figure 4.2: Contour of maximum shear stress for crashing car at crash block.

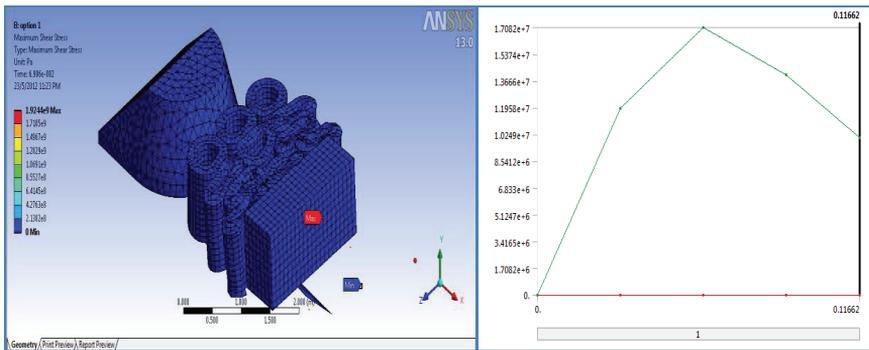


Figure 4.3: Contour result of maximum shear stress for option 1.

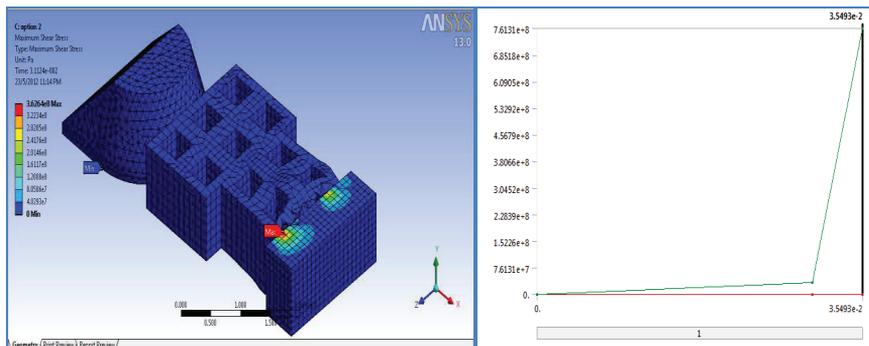


Figure 4.4: Contour result of maximum shear stress for option 2.

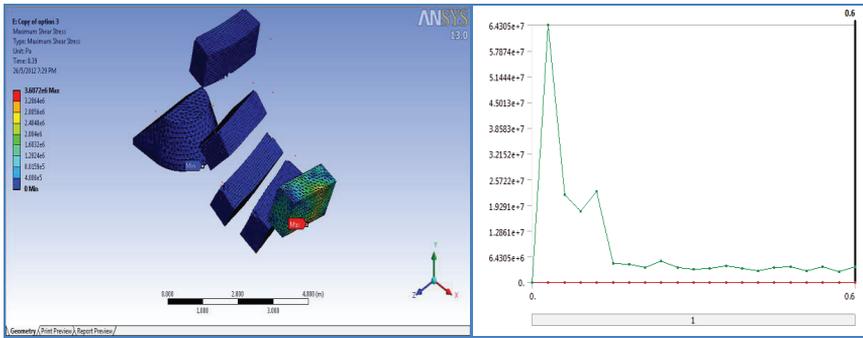


Figure 4.5: Contour result of maximum shear stress for Option 3.

## 5.0. CONCLUSION

For the conclusion, the overall objective of this project had been achieved. The existing of concrete at toll booth has been study. The result show that the concrete barrier or crash block is too hard and not safety too driver if had any accident. For the solution of the problem, second objective have been made. By using the waste tires, crash cushion was design to apply at crash block. There are three options that have been choosing from all design having made. The chosen are depend on the better design and logical. From three options that have been chose, there have been analyses to choose the best adsorb impact. In this objective, Ansys Implicit Dynamics have been used to analysis the impact of product to the crash block and three designs of crash cushion. From the result analysis, showed that option 1 is the best absorbing from the other. Figure 4.1 above show the view of option 1 that after crashing the crash cushion.

However, the using of Ansys Explicit Dynamic software is been many problem. The problem is about the period of getting the result analysis. Time for get a result of analysis is up to 15 hour and more. So user has to wait the result for long dateline.

## 6.0 ACKNOWLEDGEMENT

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