SIMULATION ANALYSIS OF AN IMPROVED DESIGN FOR TEMPORARY CRASH BARRIER USING PLASTIC RECYCLE MATERIAL

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To my beloved mother **Sarah Binti Abdul Manaf**

To my beloved wife **Mizan Musfirah Binti Mustapha**

To my beloved princess **Nur Syauqina Mawaddah**

To my beloved princess **Nur Syauqina Mardhiyya**

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ABSTRACT

Plastic temporary barrier acts as a road safety device for protecting or minimizing the risk of workers exposed to traffic flows as well as minimizing the risk of injury to vehicle occupants in the event of collision. Plastic temporary barrier is one of road safety device application which capable of absorbing the impact energy during collision with errant vehicles, thus minimize the severity of injury upon impact. Currently, all plastic temporary barriers were developed using Virgin High Density Polyethylene (V-HDPE) material. Currently, most of production defect and destruction temporary barrier will be scrapping which mean contributes into plastic waste. Therefore, releasing on this situation, by implementing plastic recycle material as alternative to control the plastic waste. Comprehending on this situation; the study was conducted to identify the potential of using Recycled High Density Polyethylene (R-HDPE) for road safety barrier application through make an improvement design based on selected temporary barrier which have better energy absorption and complies with road safety regulation.

In order to analyze the energy absorption capability of the recycled plastic, a finite element method using Abaqus/Explicit was used to simulate a car impacting a series of assembled temporary barrier at 90˚ and 20 ˚degrees angle following the Test Level 0 (TL-0) of standard impact test regulation. Three types of conceptual designs of the temporary barrier were proposed to improve the current barrier design. The capabilities of all the barrier designs in terms of their internal energy, kinetic energy, total energy, stress and displacement were analyzed. The tests were conducted using both plastic material properties of primary recycle R-HDPE and V-HDPE from. The

output results of both materials were compared to distinguish whether R-HDPE can provide acceptable absorption capability as compared to V-HDPE. Overall results showed a similar pattern of R-HDPE and V-HDPE materials in terms of energy absorption regardless of any types of barrier design. However, Conceptual Design 2 (CD2) based on R-HDPE material that includes external ribs along the outer structure of the barrier provides better energy absorption compared to the other two of barrier designs. These show that the improvement design provide an influence to the ability of R-HDPE as temporary barrier.

In conclusion, analysis of the simulated results on the primary recycled R-HDPE temporary barrier showed a good potential of how this material can be an alternative as a road safety device material. With the use of such recycled materials, the amount of plastic waste can be controlled as well as supporting sustainable manufacturing environment.

ABSTRAK

Halangan sementara plastik bertindak sebagai alat keselamatan jalan raya untuk melindungi atau mengurangkan risiko pekerja terdedah kepada aliran trafik serta mengurangkan risiko kecederaan kepada penghuni kenderaan sekiranya berlaku perlanggaran. Halangan sementara plastik adalah salah satu peranti keselamatan jalan raya permohonan yang boleh menyerap tenaga kesan semasa perlanggaran dengan kenderaan ingkar, sekali gus mengurangkan keterukan kecederaan apabila kesan. Pada masa ini, semua halangan sementara plastik dibangunkan menggunakan bahan baru 'High Density Polyethylene (V-HDPE)' yang ketara. Pada masa ini, kebanyakan kecacatan pengeluaran dan kemusnahan halangan sementara akan pelupusan yang bererti menyumbang ke dalam sisa plastik. Oleh itu, melepaskan kepada keadaan ini, dengan melaksanakan bahan kitar semula plastik sebagai alternatif untuk mengawal sisa plastik. Memahami keadaan ini; kajian ini dijalankan untuk mengenal pasti potensi menggunakan dikitar semula 'High Density Polyethylene (R-HDPE)' untuk keselamatan jalan raya melalui permohonan halangan membuat reka bentuk penambahbaikan berdasarkan halangan sementara dipilih yang mempunyai penyerapan tenaga yang lebih baik dan mematuhi peraturan keselamatan jalan raya.

Untuk menganalisis keupayaan penyerapan tenaga plastik dikitar semula, kaedah unsur terhingga menggunakan Abaqus/Explicit telah digunakan untuk mensimulasikan sebuah kereta yang memberi kesan satu siri halangan sementara dipasang pada 90 ˚ dan 20 ˚ darjah sudut berikut Ujian Level 0 (TL-0) standard peraturan ujian kesan. Tiga jenis reka bentuk konsep halangan sementara telah

dicadangkan untuk meningkatkan reka bentuk halangan semasa. Keupayaan semua reka bentuk halangan dari segi tenaga mereka dalaman, tenaga kinetik, jumlah tenaga, tekanan dan anjakan telah dianalisis. Ujian telah dijalankan menggunakan kedua-dua sifat bahan plastik kitar semula utama R-HDPE dan V-HDPE dari. Keputusan pengeluaran kedua-dua bahan dibandingkan untuk membezakan sama ada 'R-HDPE' boleh menyediakan keupayaan penyerapan boleh diterima berbanding dengan 'V-HDPE'. Keputusan keseluruhan menunjukkan corak yang sama iaitu 'R-HDPE' dan 'V-HDPE' bahan dari segi penyerapan tenaga tanpa mengira apa-apa jenis reka bentuk halangan. Walau bagaimanapun, Rekabentuk Konseptual 2 (CD2) berdasarkan bahan R-HDPE yang termasuk tulang rusuk luar bersama-sama struktur luar halangan menyediakan penyerapan tenaga yang lebih baik berbanding dua yang lain reka bentuk halangan. Ini menunjukkan bahawa penambahbaikkan reka bentuk memberi pengaruh kepada keupayaan R-HDPE sebagai penghalang sementara.

Kesimpulannya, analisis keputusan simulasi di kitar semula 'R-HDPE' halangan sementara yang utama menunjukkan potensi yang baik bagaimana bahan ini boleh menjadi alternatif sebagai bahan peranti keselamatan jalan raya. Dengan menggunakan bahan-bahan kitar semula itu, jumlah sisa plastik boleh dikawal dan juga menyokong persekitaran pembuatan mampan.

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R-HDPE	Recycle High Density Polyethylene
V-HDPE	Recycle High Density Polyethylene
HDPE	High Density Polyethylene
LDPE	Low Density Polyethylene
s	Second
m	meter
mm	Millimetre
m^3	Volume
^{0}	Degree
kg	Kilogram
%	Percentage
^0C	Degree Celsius
J	Joule
Pa	Pascal
ρ	Density
ASTM	American Society for Testing and Materials
CAE	Computer Aided Engineering

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CHAPTER 1

INTRODUCTION

1.1 Background

Plastic is widely produced as consumer products, especially in food industries, transportation, and communication, medical, electronic and many other engineering applications. With high human usage of plastic material and the fact that the world's population has reached 7 billion, the garbage or waste material is also increasing at a high rate every day. The increasing use of plastics has contributes concerns among scientists and researchers regarding its disposal. Notably, plastic is non-biodegradable and its existence will remain forever. Nearly every single plastic-based item that was ever created, will still exists on the planet, and will for thousands of years. Recycling plastics might be one possible solution but requires extensive analysis before it can be fully utilized for its functionalities. Furthermore, previous research concluded that the rate of recycle plastic is still not able to compete with the rate of virgin plastic that has long been produced.

Realising such situation, many countries nowadays undergo research and development on plastic recyclability and reusability. There is several high education institutions conducting a research to study the possibilities on using plastic recycle in daily life. Through technology and research advancement, nowadays, there many types of recycle product that has been developed such as plastic bottle, food container, equipment container and other types of simple product which can be used by consumer. By implementing recycle and reuse of plastic products, reduction on the amount of plastic waste can be greatly reduced. Comprehended on the effect of plastic in human life, perhaps the application of recycle material can be extended to road safety barrier application. All current road safety barriers which are using plastic material had preferred to use virgin plastic material for their product.

Realizing that plastic recycle applications are still not widely used in road safety barrier, therefore, this research aims to use plastic recycle material as an alternative material for road safety barrier. There are many types of plastic which can be recycled. Most of plastic recycle is widely used as simple product application. Therefore, in selection for road safety barrier, the selection of recycle plastic material must able to meet the standard requirement and specification as road safety device. Most of road safety barrier manufacture was using virgin High Density Polyethylene (HDPE) and virgin Low Density Polyethylene (LDPE) as road safety barrier. Therefore, Recycled High Density Polyethylene (R-HDPE) was selected based on the current application and performance as road safety device. Furthermore, these selections also are supported by previous research; where they had done a study of recycle material as road safety device using R-HDPE material [5], W-beam guardrail post [6] and barricades [4].

This study utilized the R-HDPE as the material of a road safety barrier. The behaviour of the recycled material was then tested using simulation software analysis. Simulation analysis was selected rather than performing the actual testing since full scale testing will incur high setup cost and very time consuming. In addition, using simulation may inject new insights into simulation technology and estimation on the performance of crash scenes that are too complex can be analysed. Over the years, finite element analysis has also rapidly become a fundamental part of the analysis and design of roadside hardware because of its reliable results and relatively inexpensive means of analysing and simulating impact events.

Moreover, a simulation test analysis can give results that are not experimentally measurable with the current level of technology. Simulation test also able to support the test sample since the differentiate result of simulation test and actual simulation is around 5%. Consequently, the simulation test is one method which simplifies the actual testing and produce result which considerably same to actual test results.

Simulation test data were used in order to compare between R-HDPE based barrier designs sample with virgin HDPE based safety barrier.

1.2 Research Aims

The aim of the study is to perform simulation analysis on plastic recycle material based on current road safety barrier design and to propose an improved barrier design in terms of its performance. This study focuses on using R-HDPE plastic as temporary road safety barrier.

1.3 Objectives of the Study

The objectives of the study are:

i. To determine potential usage of recycle plastic material for road safety barrier application
ii. To improve the design of current roadside crash barrier for better absorption characteristic using simulation analysis
iii. To propose feasible crash barrier design that complies with the road safety regulation.

1.4 Scopes of the Study

The scopes of the study are**:**

i. The material will be focused only to use recycled HDPE plastic
ii. Identify the guideline and specification of current crash barrier design
iii. Conduct computer simulation analysis on the crash barrier model based on potential of recycles HDPE plastic using Abacus simulation software
iv. Determine the most feasible design by referring the result analysis.

1.5 Outline of the Thesis

The thesis is divided into six chapters; Chapter 1 is to introduction the research which explains the overview about the recycle material of HDPE, simulation test analysis as well as the objectives and scopes of the study. Chapter 2 is literature review which explains about the method of analysis, standard test specification, and data collection of previous research regarding the recycle HDPE and types of temporary barrier. Chapter 3 elaborates about the method to conduct the analysis using Abaqus simulation software and explains about conceptual design of temporary barrier. Two methods of analysis were analysed looking at90^0 impact angle and 20^0 impact angle. Chapter 4 explains about the results and data analysis covering all the analysis conducted on the temporary barrier. All the data were evaluated in the data analysis comparing the virgin HDPE and recycled HDPE. Chapter 5 discusses on the overall data analysis conducted on the temporary barrier and all factors that affect the data analysis were identified. Chapter 6 concludes the thesis and highlights the recommendation for future improvement.

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