DESIGN AND DEVELOPMENT OF INTEGRATED CHASSIS OF ONE SEATED URBAN CAR USING EMBEDDED ALUMINIUM AND FRP

NOOR AKMAL BIN ZOLKIFLI

BACHELOR OF ENGINEERING

UNIVERSITI MALAYSIA PAHANG

2010

UNIVERSITI MALAYSIA PAHANG

FACULTY OF MECHANICAL ENGINEERING

I certify that the project entitled "*Design and Development of Integrated Chassis of One Seated Urban Car Using Embedded Aluminium and FRP* "is written by *Noor Akmal Bin Zolkifli*. I have examined the final copy of this project and in our opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. I herewith recommend that it be accepted in partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering.

TUAN HAJI AMIRRUDDIN BIN ABDUL KADIR --------------------------------

Examiner Signature

DESIGN AND DEVELOPMENT OF INTEGRATED CHASSIS OF ONE SEATED URBAN CAR USING EMBEDDED ALUMINIUM AND FRP

NOOR AKMAL BIN ZOLKIFLI

Thesis submitted in partial fulfilment of the requirements
for the award of the degree of
Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

DECEMBER 2010

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

Signature	---------------------------------
Name of Supervisor:	DR SUGENG ARIYONO
Position:	LECTURER OF MECHANICAL ENGINEERING
Date:	6 DECEMBER 2010

STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature ....

Name: NOOR AKMAL BIN ZOLKIFLI

ID Number: MH07024

Date: 6 DECEMBER 2010

Dedicated,

encouragements and always be there during hard times,

my beloved family and friends,

ACKNOWLEDGEMENT

I am very grateful and I would like to express my gratitude especially to my supervisor, Dr. Sugeng Ariyono for his guidance, direction and assistance. In particular, Dr. Sugeng Ariyono recommendations and suggestions have been invaluable for the project and the improvement. With his professional conduct and guide, his knowledge in engineering software, he has always impressed me. My interaction with him generates a fundamental role in development of this thesis. I also sincerely thanks for the time spent proofreading and correcting my mistakes.

I also would like to thank my family and all my friends for their blessings and supporting me throughout my education. My sincere thanks to the Department of Mechanical Engineering at Universiti Malaysia Pahang who helped me in many ways and made me stay at this university pleasant and memorable. Thanks also to Dr. Daw Thet Thet Mon which guides me in order to able to use FEMPRO software for my thesis.

Special thanks should be given to my friends in SAE UMP Chapter member especially UMP SAE Team which joined the Shell Eco Marathon Asia 2010, that always help me throughout the designing of the car in the same time help me for my thesis development. I would like to acknowledge their comments and suggestions which was crucial for the successful completion of the study.

ABSTRACT

This thesis deals with propose of new design of urban concept car chassis which are to improve the existing design of chassis for Shell Eco Marathon Asia 2010, UMP SAE Team Urban Car Concept, Elaion Kratos. The existing design is analyzed to spot the value of chassis displacement due to driver and engine load. The chassis has to be strong enough with combination of good design and material used. The chassis will act as suspensions which absorb the load and vibration due to weight of driver and engine. Three designs are proposed to be compared with the previous one as the improvement in chassis displacement and weight of the chassis. In order to analyze the designs, wireframe model are built in FEMPRO software and the model are analyzed due to driver and engine load to see the displacement and weight of the new designs. The parameters that vary among the model are the design and parameters that vary the models with the existing chassis are the materials. Aluminium and fiberglass are used in new design as to improve the strength and weight of the chassis. Analyses are made and based on the simulation, the three design improve and succeeded and the best which is design 1 is applicable as replacement for the new chassis.

ABSTRAK

Tesis ini berkaitan dengan cadangan rekabentuk baru casis kereta berkonsepkan urban untuk memperbaiki rekabentuk casis yang sedia ada iaitu Elaion Kratos, kereta berkonsepkan urban yang mewakili Pasukan SAE UMP Chapter untuk Shell Eco Marathon Asia 2010. Rekabentuk sedia ada dianalisis untuk mencari nilai perbezaan pada casis akibat beban dari pemandu dan enjin. Casis haruslah cukup kuat dengan kombinasi rekabentuk yang baik dan bahan yang digunakan. Casis bertindak sebagai suspensi yang menyerap beban dari pemandu dan enjin. Tiga rekabentuk baru diusulkan untuk dibandingkan dengan rekabentuk asal untuk meningkatkan kekuatan casis dari segi pertukaran nilai pada casis dan berat. Untuk menganalisis rekabentuk, model bingkai wayar dibina dalam perisian FEMPRO dan model dianalisis berdasarkan beban pemandu dan enjin untuk mendapatkan pertukaran nilai pada casis rekabentuk baru. Parameter yang berbeza antara model baru ialah rekabentuk, dan parameter yang berbeza antara model baru dan casis lama adalah bahan dan rekabentuk. Aluminium dan serat kaca digunakan dalam rekabentuk baru untuk meningkatkan kekuatan casis dalam masa yang sama mengurangkan beratnya. Analisis dijalankan dan hasil daripada simulasi, rekabentuk baru mepunyai peningkatan dari casis lama dan rekabentuk 1 adalah yang terbaik dan boleh digunakan sebagai pengganti casis lama.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

AISI	American Iron and Steel Institute
Al-Mg	Aluminium magnesium
Al-Mg-Si	Aluminium magnesium silicon
BMC	British Motor Corporation
FRP	Fiber reinforced plastic
GM	General Motors
GTAW	Gas tungsten arc welding
SAE	Society of Automotive Engineers
TIG	Tungsten inert gas

CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

An urban car is a term for a car intended for use primarily in an urban area. City cars are sold worldwide and most automotive industry manufacturers have one or two in their line-up. In North-America city cars have are often referred to simply as subcompact alongside the superminis. In Japan the “kei” car is a similar concept, although the car must be very small in physical dimensions and engine capacity, for city cars the definition is imprecise (Ruppert, 1998).

Urban car nowaday are widely used especially in city. Urban car was first introduced in the late 1980's when people wanted to buy a smaller 4 seated car. The example of the car is Honda Today and the Honda Acty, Subaru Sambar and Subaru Vivio, Daihatsu Atrai and Daihatsu Mira, Mitsubishi Minica and Mitsubishi Minicab, and the Suzuki Fronte and Suzuki Wagon R in Japan and Renault Twingo in Europe (Ruppert, 1998).

Urban cars are often hailed as the answer to the escalating levels of air pollution and traffic congestion that result from increases in numbers of larger personal vehicles. They are intended for use exclusively in or near cities and towns, and are not suited to long journeys or fast travel on highways. They are very light, pollute little, take up a fraction of the space required by most vehicles cost much less than most cars and trucks and can be effectively recycled.

In the case of vehicles, the term chassis means the frame plus the "running gear" like engine, transmission, driveshaft, differential, and suspension. A body, which is usually not necessary for integrity of the structure, is built on the chassis to complete the vehicle.

Aluminum property can be enhanced by some of the treatment which can improve its strength and give it more advantages. Aluminium is a very light metal with a specific weight of 2.7 g/cm^3, about a third that of steel. For example, the use of aluminium in vehicles reduces dead-weight and energy consumption while increasing load capacity. Its strength can be adapted to the application required by modifying the composition of its alloys (Kaufman, Rooy, 2004).

They include the use of extrusion tooling, which is all efficient technique of working the alloys into very long complex geometry, for an acceptable cost. Also the benefits of the alloy's lightweight and corrosion-resistant properties, as well as the value of aluminium waste due to its 100% recyclability. Most auto manufacturers however, have far more experience in using steel over aluminium in their product assembly. This has led to problems when these manufacturers have attempted to use aluminium in the same ways that they have utilised steel. The properties of aluminium therefore are not maximised in terms of the engineering performance and cost. Since the use of aluminium is so attractive, various plans are underway to improve its presence in the industry. Future goals are to develop new alloys in order to improve formability and reduce thickness; to develop new techniques for manufacturing, and addressing the concerns on how end of life vehicles would be recycled. Although the use of aluminium is not yet optimised, the trend of use is steadily increasing with major automotive manufacturers such as Ford, Renault, Audi and Volvo.

Nowadays, the use of fiber-reinforced plastic (FRP), such as fiberglass is widely use as reinforce agent. Fiber glass is formed when thin stranded of silica-based glass is extruded into many fibers with a small diameter which depends on textile processing. The fiberglass can be used to be embedded with the metal as to enhance the properties of the chassis for example.

1.2 PROBLEM STATEMENT

The major problem that automobile industry faced nowadays is in chassis design. Most of the industry wants to find the lightest with high strength material. The problem has been revised and the some material has been improved to achieve that target. The car industry faces a crucial weight problem resulting from increasing customer demands in terms of safety and performance. This trend leads to fully equipped cars in all classes getting more luxurious and comfortable. At present even small cars often have, for example, power steering or air conditioning as standard fittings. Also, customers pay increasingly more attention to occupant safety calling once again for stronger, more rigid bodies. This in turn requires a stronger engine and power train to keep the performance of the car. A stronger engine requires a heavier chassis and again this leads to a larger fuel tank and ends up in a car body with higher rigidity. As a result in any automobile class, each new model becomes heavier.

To escape from this vicious circle car manufacturers are forced to take action in the form of lightweight concepts. Car bodies contribute 25% to the total weight of a car and offer an appropriate way of breaking this circle. Light metals are seen as a promising opportunity to decrease the body in white weight decisively. An increasing use of metals such as aluminium and magnesium in the automotive industry shows that there is still large scope for improvements. Predictions estimate a rise in aluminium's contribution to the total vehicle weight from 6% to more than 10% after the turn of the millennium. The main application areas at present are the chassis and hang-on parts. Some car manufacturers have even taken the plunge and have designed full aluminium car bodies such as Audi's A8, Honda's NSX or the Lotus Elise. To enhance the strength of the chassis, the aluminium chassis has to be modified such as embedded with other material. This is because of the aluminium is a soft material. Fiberglass is one of the materials that can enhance the properties of the chassis. Although choosing the material is important, the design of the car has to be considered too. If not, there will be some part that failed due to weak spot of connection especially in chassis. The design must be analyzed as it will be used to build vehicles especially and will be used by people. So, the design and material has to be really considered as to build the best car.

1.3 OBJECTIVE

There are some objectives to be achieved in this project:

1) To study the chassis of Shell Eco-Marathon Urban Car Concept

2) To design a new 1-seated urban car chassis

3) To analyze the strength and deformation of the chassis

1.4 PROJECT SCOPES

This project is run by focusing on development of urban car which consists of studying and designing an urban car. This focus area is done based on the following aspects:

1) Based on regulations in Shell Eco Marathon Urban Car Concept

2) Study the concept of urban car.

3) Analyze the chassis using FEMPRO (Algor).

1.5 PROJECT METHODOLOGY

1.5.1 Flow Chart

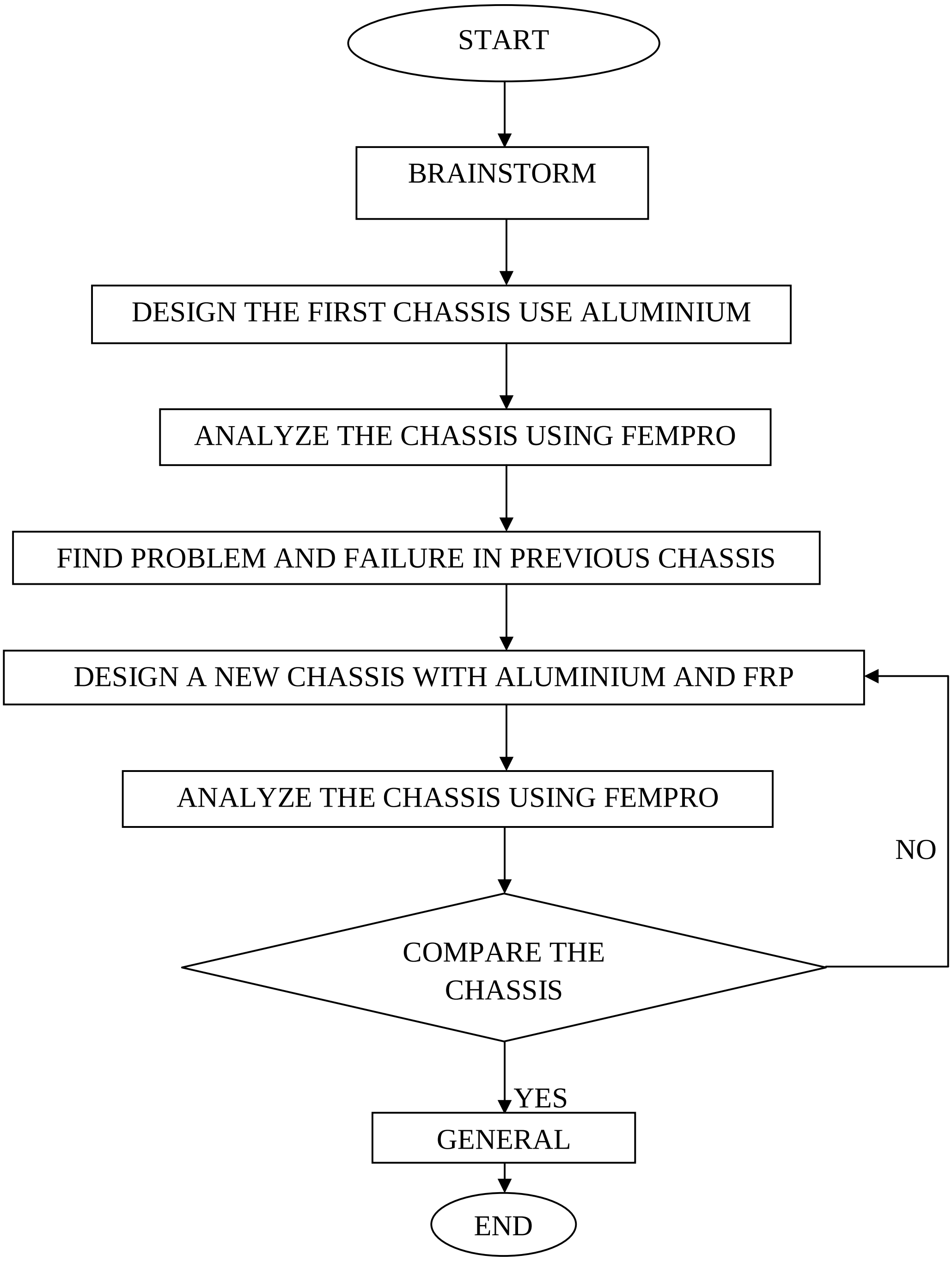

Figure 1.5 : Flow Chart

The first step starts with the brainstorm to choose the design of the body. The design of the body will leads to the design of the chassis. There are several designs that have been proposed for the Shell Eco Marathon Urban Concept Car and after several discussions the best design for the project is decided.

After the design of the body complete, then the design for the chassis begin. The design of the chassis is based on the rule and regulation of the Shell Eco Marathon Urban Car Concept. The chassis is design for one seated urban car and aluminium as the material.

The chassis design will be built on FemPro software and then will be ready for analysis. Based on the analysis, the weak point of the chassis can be determined and the point that will lead to failure can be found.

The next design will be based on alumunium and fiberglass as the material. The design will be made as to improve the previous design. The new design is analyzed and compare to previous design. When the new design is better than the previous one, the new chassis will be ready for the blueprint.

The first step starts with the brainstorm to choose the design of the body. The design of the body will leads to the design of the chassis. There are several designs that have been proposed for the Shell Eco Marathon Urban Concept Car and after several discussions the best design for the project is decided.

After the design of the body complete, then the design for the chassis begin. The design of the chassis is based on the rule and regulation of the Shell Eco Marathon

Urban Car Concept. The chassis is design for one seated urban car and aluminium as the material.

The chassis design will be built on FemPro software and then will be ready for analysis. Based on the analysis, the weak point of the chassis can be determined and the point that will lead to failure can be found.

The next design will be based on alumunium and fiberglass as the material. The design will be made as to improve the previous design. The new design is analyzed and compare to previous design. When the new design is better than the previous one, the new chassis will be ready for the blueprint.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The aim of this chapter is to give the information about the urban car in terms of the design and development. The history of urban car and material of the chassis are explained in detail in this chapter. Various sources including journals, thesis, reference books and literature reviews have been carried out and revised in writing this chapter.

2.2 History of Urban Car

An urban car is a car designed to be used in city traffic. Normally urban car is small in size and not very powerful, but very fuel efficient. Urban cars are often hailed as the answer to the escalating levels of air pollution and traffic congestion that result from increases in numbers of larger personal vehicles. They are intended for use exclusively in or near cities and towns, and are not suited to long journeys or fast travel on highways. They are very light, pollute little, take up a fraction of the space required by most vehicles, cost much less than most cars and trucks, and can be effectively recycled (Northey, 1974).

One of the first urban cars was the American-made Crosleywhich is a four passenger vehicle from the late 1940s. A number of makers introduced microcars, the precursors to the modern city car after the Second World War,. These included the Bond Minicar and AC Petite in Britain, the Iso Isetta in Italy in 1953, the Fulda, Messerschmitt Kabinenroller, and Brütsh in Germany in 1954 (all two-seaters with a Fulda and Sachs two-stroke engine; the Goggomobil Isard (a 2+2, rather than a true four-seater) and the Gutbrod Superior. There was also the Dornier-designed Zündapp Janus, which placed passengers back to back, and the Riley Reliant (Northey, 1974).

When the European economy improved, all but the Riley disappeared. BMC would introduce the best-known and most-successful urban car, the Mini in 1959. The concept see a revival at the 1967 Turin Motor Show, where battery-driven Fiat 500s were shown by both Giannini and Moretti, and de Tomaso showed an electric four-seater. In 1972, Daihatsu proffered an electric model, while Toyota showed the Town Spider, with a choice of petrol or electric power, and General Motors displayed three two-seaters, one electric, one gasoline, and one (unfortunately for GM, not a precursor) hybrid (Northey, 1974).

While many of these cars can be considered city cars today, these cars have been replaced by larger cars with each passing generation. Exceptions are the smaller Fiats, especially the 1957 500 and 126. They were in the region of 3.0 metres (9 ft 10 in) in length, but had seating for four people, putting them outside the microcar category (Northey, 1974).

The replacement for the 126, the Cinquecento was presented in 1991 as a true urban car. At only 3,200 millimetres (10 ft 6 in) long, it had room for four and entry-level prices (Ruppert ,1998).

In Japan, urban car regulations were established on 8 July 1949, where they were known as "kei cars" or keijidōsha manufactured by Daihatsu, Mitsubishi, Subaru, and Suzuki starting around 1955-1958 (Ruppert,1998).

2.3 Previous Design of Shell Eco Marathon before 2010

Figure 2.1: DNV Fuel Fighter designed by Ole-Andreas Fagertun, Arnstein Johannes Syltern and Arne Magnus Mykkelbost

Source : http://blog.evaria.com/2009/05/

Figure 2.2 : M-112 designed by Ignacio Garcia

Source : www.technama.com/2009/shell-eco-marathon-pakistani-universities-to-participate

Figure 2.3 : KRUCE (Kent Ridge Urban Concept Ecocar) designed and built by the NUS School of Design and Environment's Design Incubation Centre (DIC)

Source: http://blog.nus.edu.sg/nusid/2009/04/27/design-incubation-centre-launched-latest-eco-friendly-urban-concept-car

Figure 2.4 : NUS-ECO1 designed and built by the NUS School of Design and Environment's Design Incubation Centre (DIC)

Source : http://www.eng.nus.edu.sg/EResnews/0806/hightlight.html

Under the Urban Concept, Shell offers an opportunity to design and build fuel economy vehicles that are close in appearance to today's production type passenger cars. Urban car concept must have four wheels, which under normal running conditions must be continuously in contact with the road.

For the chassis aspects, the vehicle must be equipped with an effective roll bar that can capable of withstanding a static vertical and horizontal load of 700 N without deforming. The vehicles chassis must be wide and long enough to protect the driver body in case of a frontal or lateral collision.

The chassis specification for urban car concept has to be followed to fulfill the rule and regulation as to pass for the competition. The regulations are including the vehicle's height, wide, length, wheelbase, driver compartment and others.

2.4 Automotive Trends in Aluminium

Due to its low weight, good formability and corrosion resistance, aluminium is the material of choice for many automotive applications such as chassis, autobody and many structural components.

Aluminum alloys tailored by suitable variations in chemical composition and processing best fit many requirements, like the non-heat treatable Al-Mg alloys used in chassis optimized for superb resistance against intercrystalline corrosion and concurrent high strength or the heat treatable AlMgSi alloys for extrusions and autobody sheet modified for improved age hardening response (Hirsc, 2004).

With a sound knowledge about the specific material properties and effects excellent light weight solutions for automotive applications have been successfully applied by the European automobile industries (Hirsc, 2004).

It is expected that in the near future the use of aluminium with specifically improved properties will grow in many automobile applications due to the increased economical and ecological pressure and due to the positive experience gained from many successful applications and current developments and that it will multiply its volume fraction used in cars of all classes and all sizes (Hirsc, 2004).

2.5 FRP Chassis

McLaren Automotive has launched its new high performance sports car, the McLaren MP4-12C which is based around a carbon fiber composite chassis as known as the Carbon MonoCell (Raynal, 2009).

The heart of the new car is the Carbon MonoCell. McLaren pioneered carbon composite construction in the 1981 Formula 1 MP4/1 race car. It brought carbon fiber technology to road cars with the 1993 McLaren F1 supercar and then built on this experience with a carbon fiber chassis and body on the Mercedes-Benz SLR McLaren between 2003 and 2009. The 12C MonoCell weighs less than 80 kg. Its torsion rigidity is considerably stiffer than a comparable alloy structure. This inherent lack of flex means the front suspension system, which is mounted directly onto the MonoCell, requires less compromise for flex of the suspension itself. The MonoCell also acts as a safety survival cell, as it does in a Formula 1 car (Raynal, 2009).

In the case of an accident, the aluminium alloy front and rear structures are designed to absorb impact forces in a crash and can be replaced relatively easily. Aluminium extrusions and castings are jig welded into the finished assembly and bolted directly to the Mono-Cell which uses their structure to absorb and crumple on impact, which implies more fundamental damage to the whole structure in a major accident (Raynal, 2009).

McLaren reports that it has developed a new carbon fibre production process that allows the hollow MonoCell to be produced to exacting quality standards, in a single piece, in only four hours. Typically, dozens of carbon components (and dozens of production hours) feature in a carbon fibre chassis structure. The Carbon MonoCell reduces the weight of the structure and also allows for the use of much lighter weight body panels (Raynal, 2009).

2.6 Summary

Based on the urban car concept is applied as to build a new chassis. The chassis will be based on aluminium and FRP as the material. The materials are widely use in automotive industry nowadays. Aluminium chassis is used in Audi R8 and FRP is used in Mercedes-Benz SLR McLaren. With the material, the project will be proceeded as to improve the previous design of the chassis. The criteria of urban car are followed as to build it due to its concept.

CHAPTER 3

ANALYSIS OF EXISTING DESIGN

3.1 Introduction

In this chapter, aluminium and fiberglass are analyzed and the last step is analyzes the previous chassis design. The analysis will be made by using FemPro software. The material is analyzed under certain load and the displacement magnitude will be observed.

3.2 Existing of Shell Eco-marathon Asia 2010

The previous design of Shell Eco Marathon Urban Concept chassis is not a perfect chassis with none exact analysis done. The chassis is based on aluminium pipe. For the improvement for the chassis, the fiberglass is embedded with the aluminium. This step is used to enhance the strength of the chassis.

3.2.1 Design of Shell Eco Marathon Urban Car Concept

The previous design of the urban car was the design of the Universiti Malaysia Pahang SAE Team, for Shell Eco Marathon Urban Car Concept. The car was design by Noor Akmal Bin Zolkifli, Head Designer of the team. The design will be analyzed using FemPro software under certain condition to see the where the part that can be improved. The design will be compared to the new design later on.

3.3 The Design

3.3.1 Existing Design

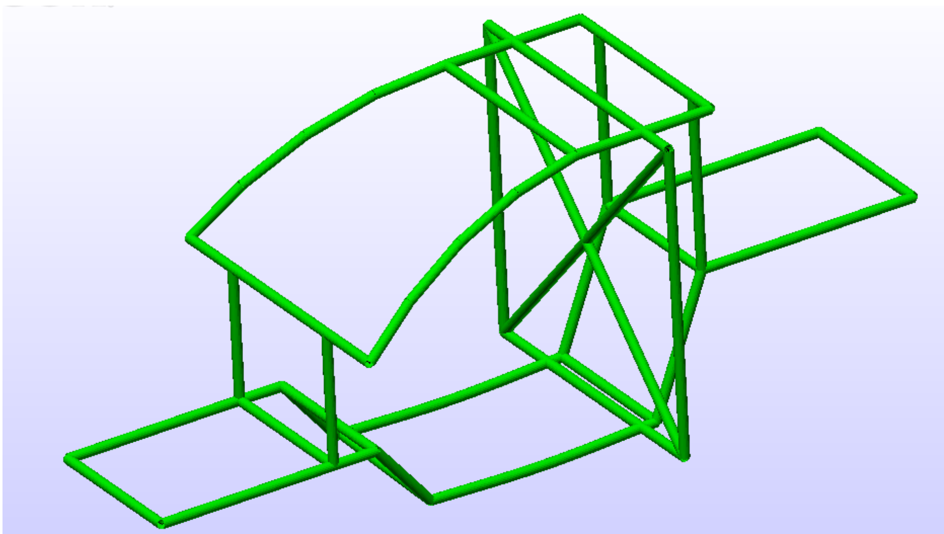

Figure 3.1 : Existing Chassis using FEMPRO (ALGOR Software)

This design was built based on the rules and regulation of Shell Eco Marathon 2010. The dimension of the chassis considers the driver compartment, luggage compartment, wheel base, height and wide of the car.

3.3.2 Design 1

Figure 3.2 shows the new first design. This design is based on the existing design. The chassis is simplified to decrease the part that is used. The chassis is analyzed to find the weight and displacement.

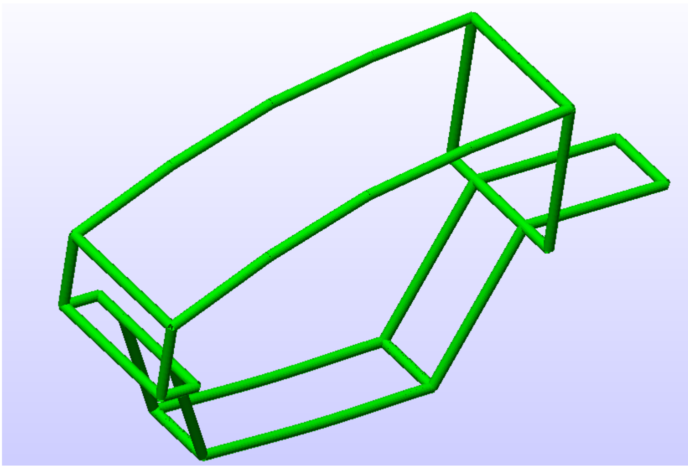

Figure 3.2 : Chassis Design 1

3.3.3 Design 2

Figure 3.3 shows the new second design. This design is made simple to decrease the weight. the chassis is analyzed to find the weight and displacement.

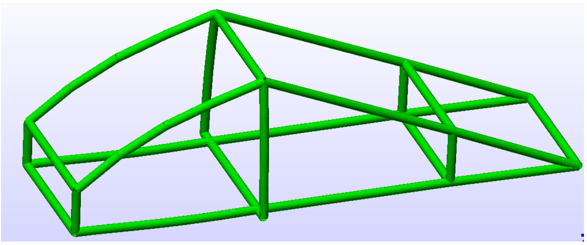

Figure 3.3 : Chassis Design 2

3.3.4 Design 3

Figure 3.4 shows the new third design. The design is for compact and lighter car for 1 seat urban car type which is in the regulation of Shell Eco Marathon.

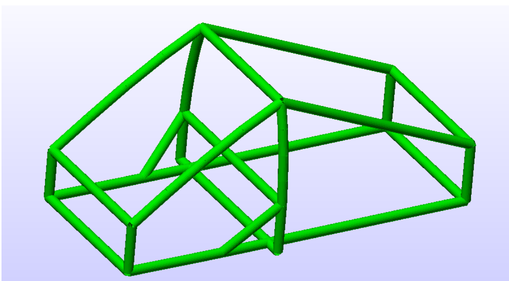

Figure 3.4 : Chassis Design 3

3.4 Analysis

3.4.1 Chassis and material analysis

The analysis was done by using FEMPRO software to check the displacement of the chassis when it is loaded with engine and driver. The driver weight is stated 700N which is based on the Rules and Regulation of Shell Eco Marathon Asia. The engine weight is 340N which is located at the back of the chassis.

First, the dimension of the chassis is drawn in the FEMPRO software. The element type used is beam. After that, the element definition is edited. The beam type is pipe and the outer diameter and thickness is inserted. Then, the material of the chassis is selected. For the existing chassis, the material used is Stainless Steel AISI Type 304.

When the design is completed, the several point is fixed based on the part that not moved during loading analysis. The load is located at the driver compartment and engine compartment as to see the displacement of the chassis.

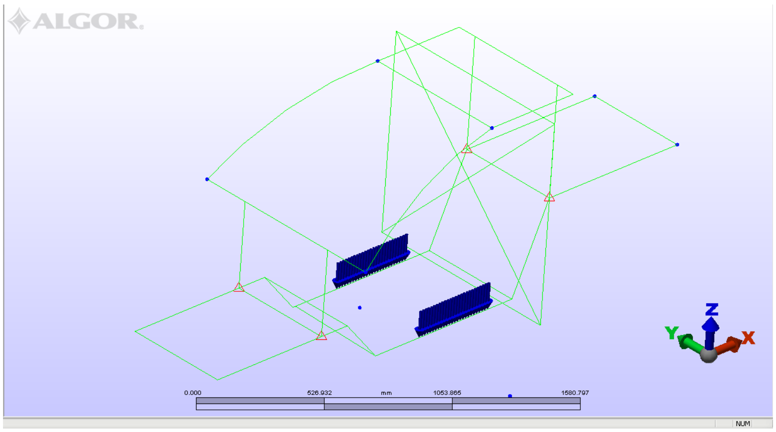

Figure 3.5 : Chassis Wireframe

3.4.2 Chassis embedded with E-Glass Fiber

Based on the 3 new designs, the part that has the high displacement at the chassis is embedded with fiber. This is done to strengthen the part as to improve the chassis profile. The fiber is laminated around the specific part of chassis using beam type. At Figure 3.6, 3.7 and 3.8, the chassis is embedded with fiberglass as to strengthen the part that has the biggest displacement.

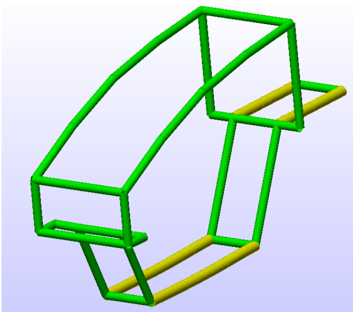

Figure 3.6 : Design 1 (Embedded with Fiber)

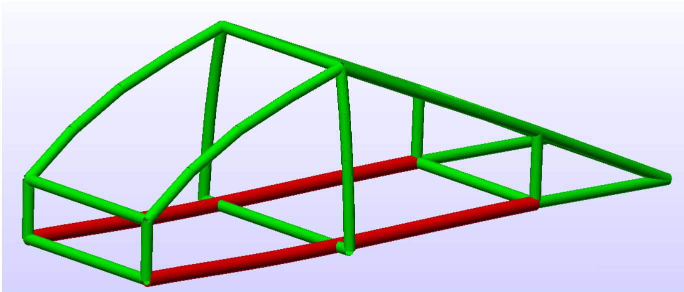

Figure 3.7 : Design 2 (Embedded with Fiber)

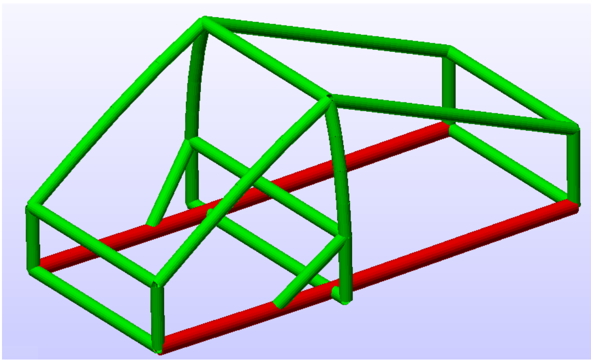

Figure 3.8 : Design 3 (Embedded with Fiber)

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter is about the results obtained from the analysis using FEMPRO software. The analysis is based on 3 new models and the existing model. The designs are compared as to find the best chassis with low displacements and lightweight. There are five point of displacement for each data for chassis displacement which was used to get the accurate data as to found the value as small as can be. The data is important as it determined the safety of the chassis and also the improvement than being done.

4.2 Results on driver load

From the analysis, existing chassis using Stainless Steel AISI Type 304 has a lower displacement which is 0.46993mm but the weight is 2.4301 x 10^2 N. The material of the existing chassis then been changed to Aluminium 6063-T6. After analysis, the displacement is 1.31892 but with the lighter weight which is 8.2016 x 10^1 N. From this analysis, aluminium can giv lighter weight. With lighter weight, the analysis is continued using variable diameter of aluminium which is available in market.

Based on the local market for aluminium 6063-T6 round tubes, the diameter of the pipes are stated as table 4.1.

Table 4.1 : Diameter and Thickness of Aluminium 6063-T6 Round Tube

Diameter (mm)	**Thickness (mm)**
15.88	1.57
19.05	1.00
25.40	1.00
31.75	1.40
38.10	1.20

4.2.1 Existing Design Using Stainless Steel AISI Type 304

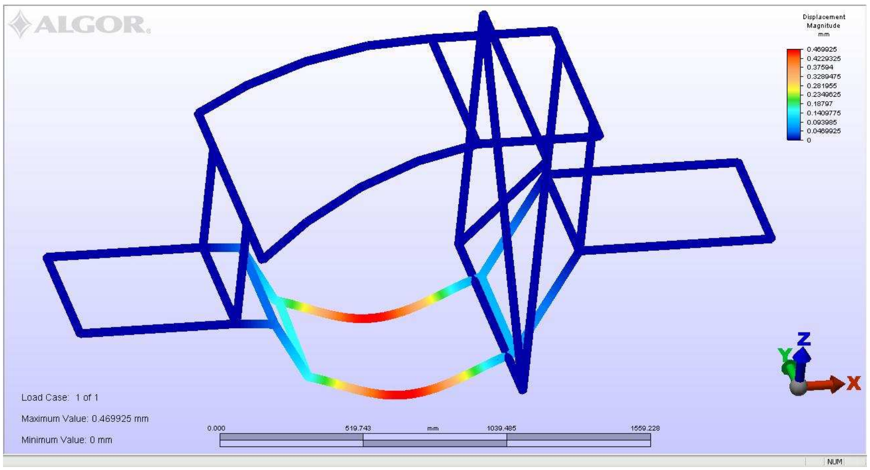

Figure 4.1 : Chassis Displacement Stainless Steel AISI Type 304

The existing design of the chassis using Stainless Steel AISI Type 304 is analyze and the data is taken. From table 4.2, the weight is 2.4302 x 10^2 N with displacement of 0.46993 mm.

Table 4.2 : Data Analysis of Existing Design Using Stainless Steel AISI Type 304

Diameter (mm)	**Thickness (mm)**	**Weight (N)**	**Displacement (mm)**
31.75	1.4	2.4301 x 10^2	0.46993

4.2.2 Existing Design Using Aluminium 6063-T6

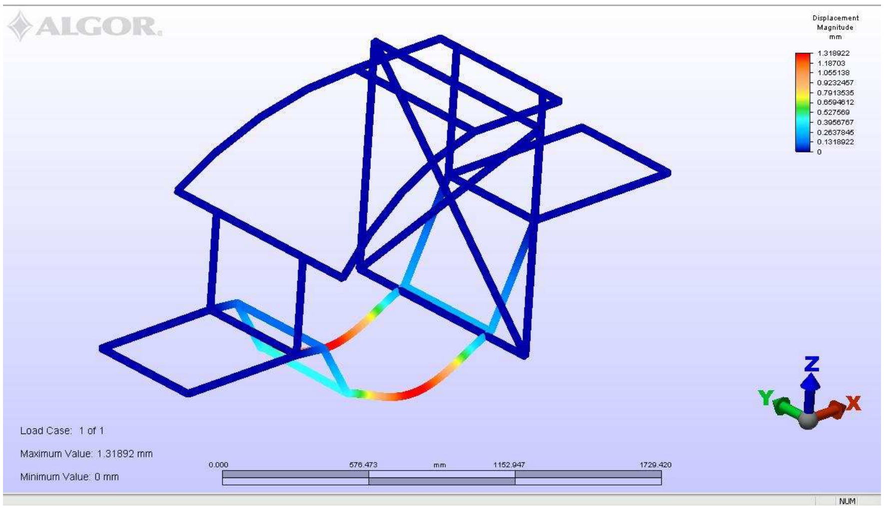

Figure 4.2 : Chassis Displacement Aluminium 6063-T6

The existing design of the chassis using Aluminium 6063-T6 is analyze and the data is taken. From table 4.3, the weight is 8.2016 x 10^1 N with displacement of 1.31892 mm.

Table 4.3 : Data Analysis of Existing Design Using Aluminium 6063-T6

Diameter	**Thickness**	**Weight (N)**	**Displacement (mm)**
31.75	1.4	8.2016×10^{1}	1.31892

4.2.3 Design 1 using Aluminium 6063-T6

For Figure 4.3, using Aluminium 6063-T6 round tube with diameter of 15.88 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 5.82877 mm.

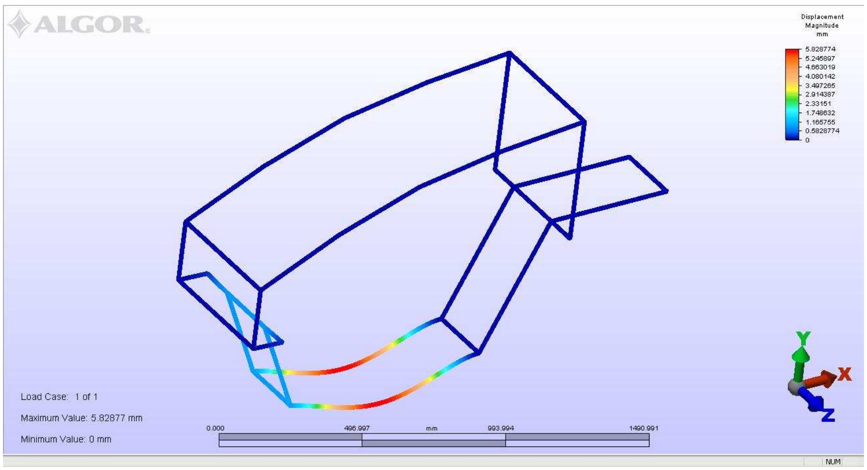

Figure 4.3 : Round Tube Diameter 15.88mm

For Figure 4.4, using Aluminium 6063-T6 round tube with diameter of 19.05 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 4.66474 mm.

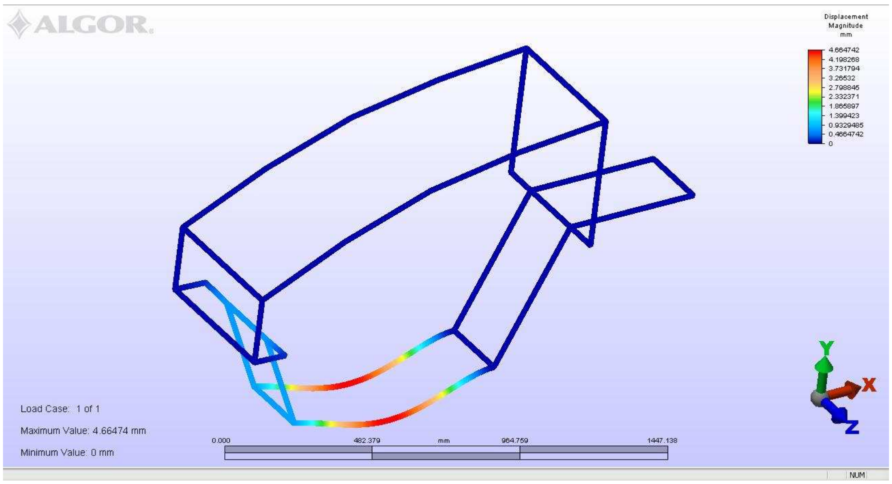

Figure 4.4 : Round Tube Diameter 19.05 mm

For Figure 4.5, using Aluminium 6063-T6 round tube with diameter of 25.40 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 1.94894 mm.

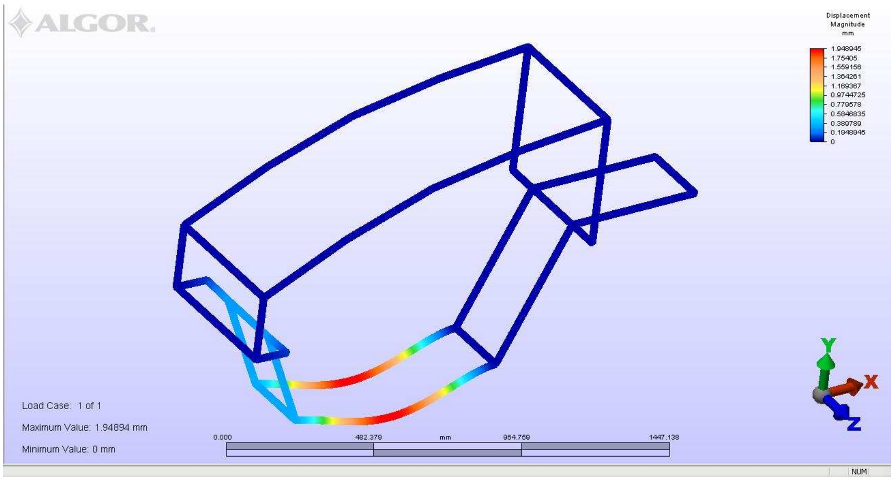

Figure 4.5 : Round Tube Diameter 25.40 mm

For Figure 4.6, using Aluminium 6063-T6 round tube with diameter of 31.75 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 0.74880 mm.

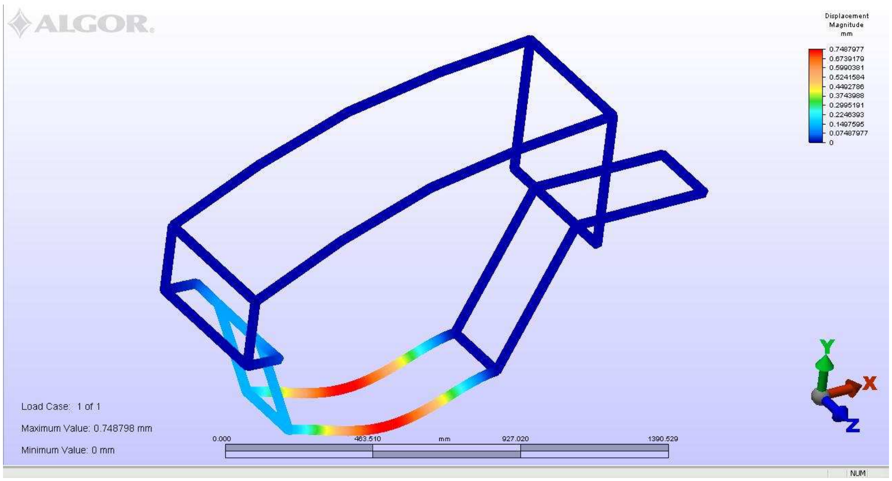

Figure 4.6 : Round Tube Diameter 31.75 mm

For Figure 4.7, using Aluminium 6063-T6 round tube with diameter of 38.10 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 0.50885 mm.

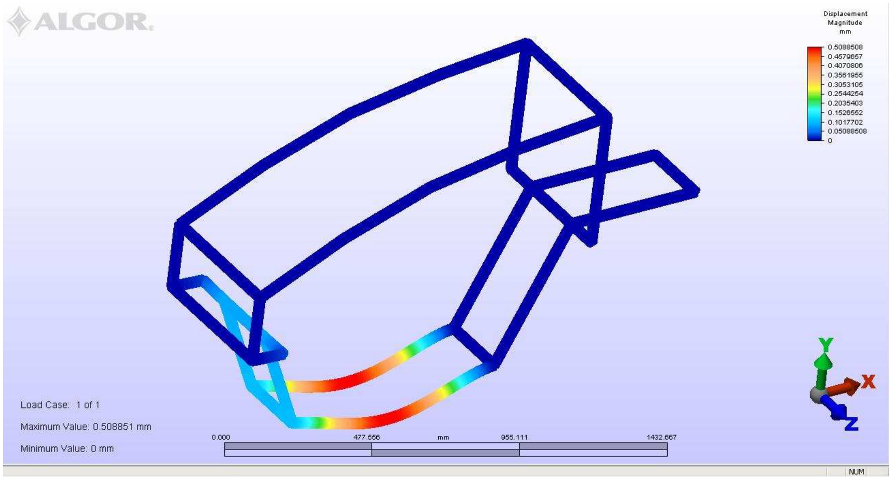

Figure 4.7 : Round Tube Diameter 38.10 mm

Based on the analysis on design 1 referring table 4.4, the best diameter of the round tube with a light weight and low displacement is Aluminium 6063-T6 38.10 mm diameter with 4.3884 x 10^1 N weight and 0.50885 mm displacement.

Table 4.4 : Data Analysis on Design 1 Aluminium 6063-T6 (Driver Load)

Diameter (mm)	**Thickness (mm)**	**Weight (N)**	**Displacement (mm)**
15.88	1.57	2.2265×10^{1}	5.82877
19.05	1.00	1.7888×10^{1}	4.66474
25.40	1.00	2.4181×10^{1}	1.94894
31.75	1.40	4.2109×10^{1}	0.74880
38.10	1.20	4.3884×10^{1}	0.50885

4.2.4 Design 2 Using Aluminium 6063-T6

For Figure 4.8, using Aluminium 6063-T6 round tube with diameter of 15.88 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 8.19982 mm.

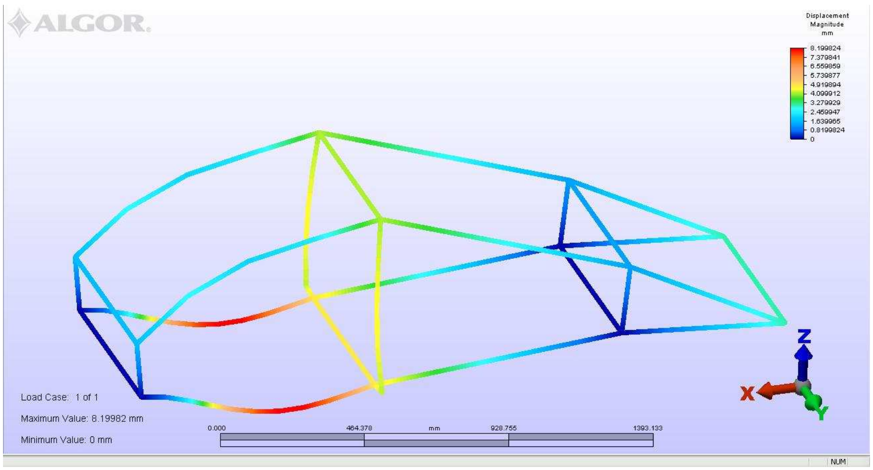

Figure 4.8 : Round Tube Diameter 15.88 mm

For Figure 4.9, using Aluminium 6063-T6 round tube with diameter of 19.05 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 6.54715 mm.

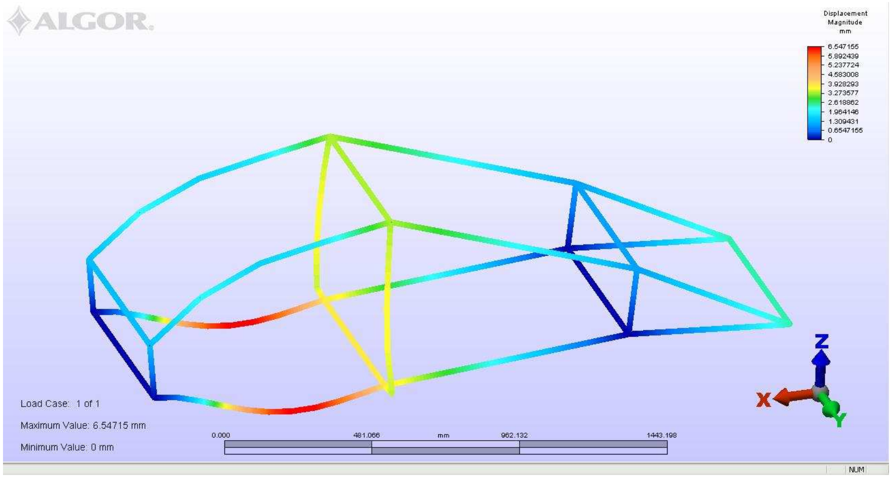

Figure 4.9 : Round Tube Diameter 19.05 mm

For Figure 4.10, using Aluminium 6063-T6 round tube with diameter of 25.40 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 2.72183 mm.

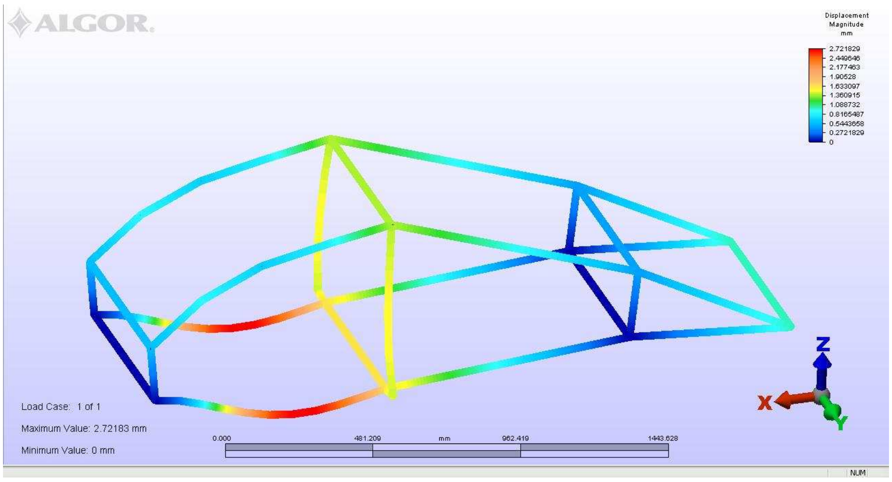

Figure 4.10 : Round Tube Diameter 25.40 mm

For Figure 4.11, using Aluminium 6063-T6 round tube with diameter of 31.75 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 1.04000 mm.

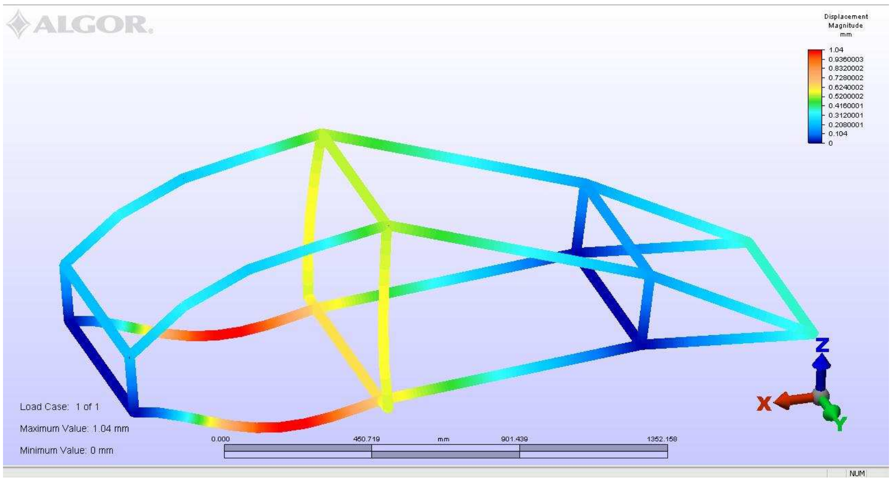

Figure 4.11 : Round Tube Diameter 31.75 mm

For Figure 4.12, using Aluminium 6063-T6 round tube with diameter of 38.10 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 0.70196 mm.

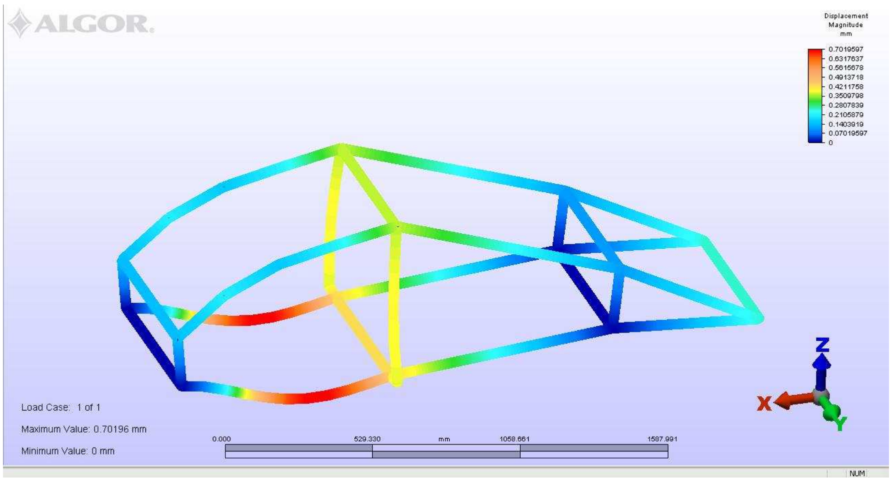

Figure 4.12 : Round Tube Diameter 38.10 mm

Based on the analysis on design 2 referring to table 4.5, the best diameter of the round tube with a light weight and low displacement is Aluminium 6063-T6 38.10 mm diameter with 5.7796 x 10^1 N weight and 0.70196 mm displacement.

Table 4.5 : Data Analysis of Design 2 Aluminium 6063-T6 (Driver Load)

Diameter (mm)	Thickness (mm)	Weight (N)	Displacement (mm)
15.88	1.57	2.9325×10^{1}	8.19982
19.05	1.00	2.3560×10^{1}	6.54715
25.40	1.00	3.1848×10^{1}	2.72183
31.75	1.40	5.5460×10^{1}	1.04000
38.10	1.20	5.7796×10^{1}	0.70196

4.2.5 Design 3 Using Aluminium 6063-T6

For Figure 4.13, using Aluminium 6063-T6 round tube with diameter of 15.88 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 3.67683 mm.

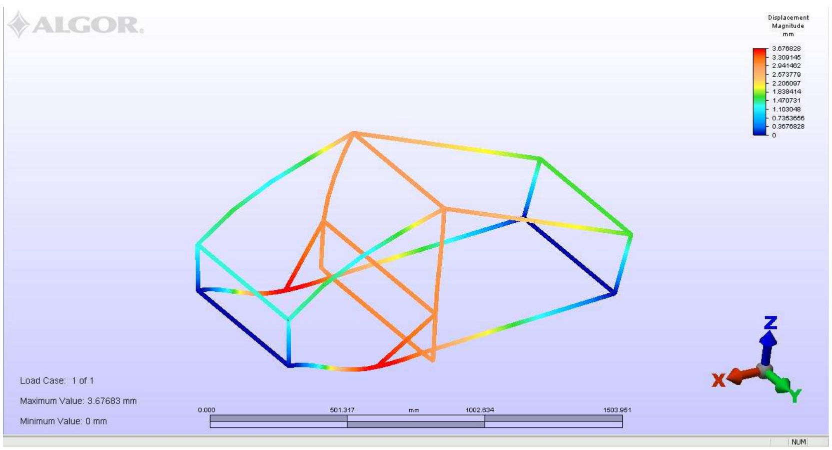

Figure 4.13 : Round Tube Diameter 15.88 mm

For Figure 4.14, using Aluminium 6063-T6 round tube with diameter of 19.05 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 2.95748 mm.

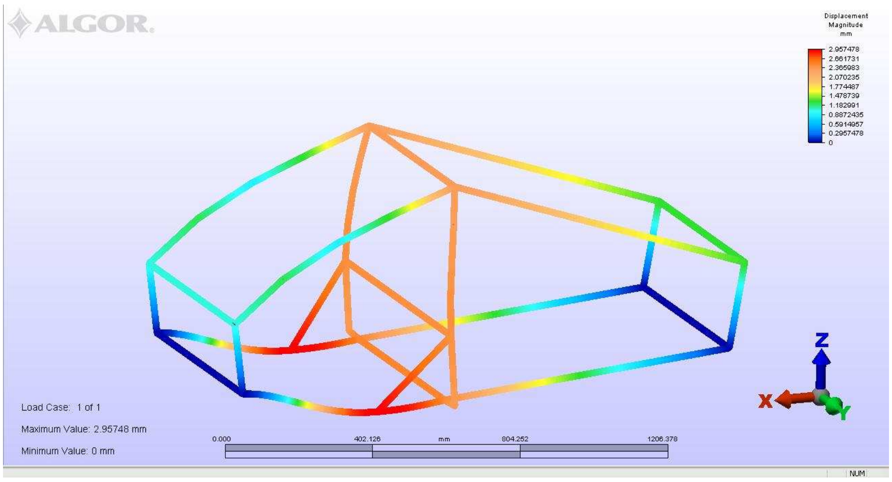

Figure 4.14 : Round Tube Diameter 19.05 mm

For Figure 4.15, using Aluminium 6063-T6 round tube with diameter of 25.40 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 1.25010 mm.

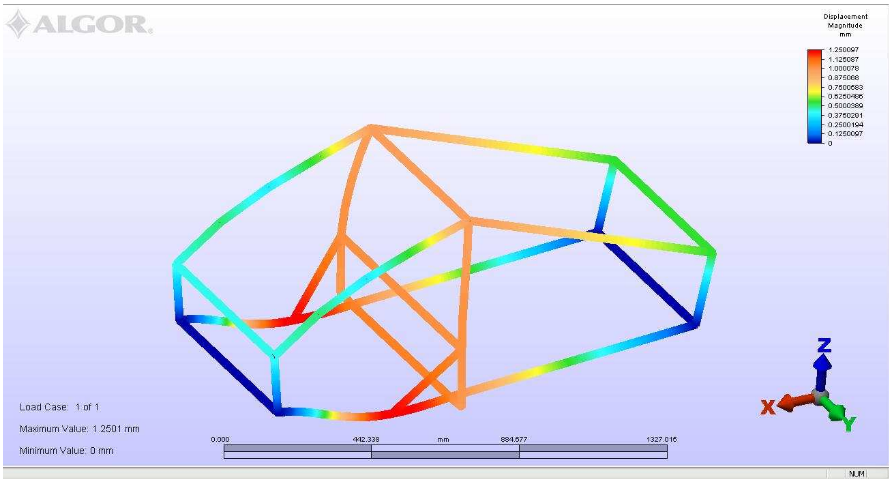

Figure 4.15 : Round Tube Diameter 25.40 mm

For Figure 4.16, using Aluminium 6063-T6 round tube with diameter of 31.75 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 0.48679 mm.

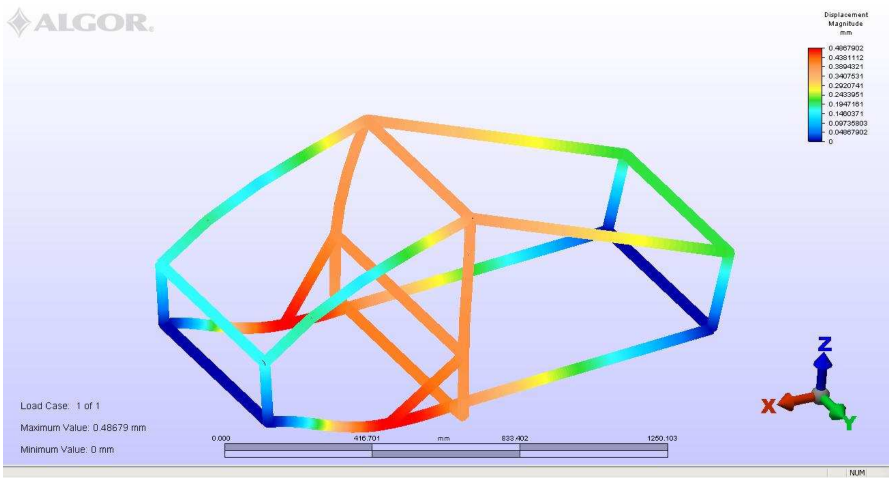

Figure 4.16 : Round Tube Diameter 31.75 mm

For Figure 4.17, using Aluminium 6063-T6 round tube with diameter of 38.10 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 0.33616 mm.

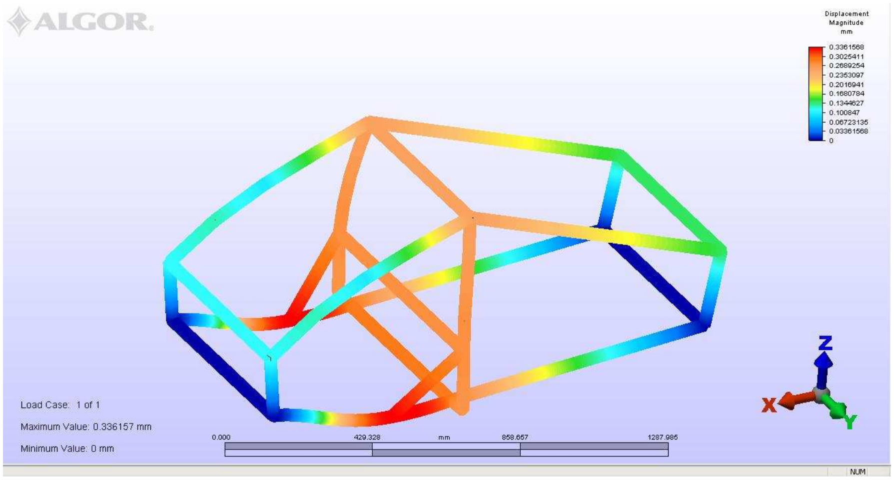

Figure 4.17 : Round Tube Diameter 38.10 mm

Based on the analysis on design 3 referring to table 4.6, the best diameter of the round tube with a light weight and low displacement is Aluminium 6063-T6 38.10 mm diameter with 4.9062 x 10^1 N weights and 0.33616 mm displacement.

Table 4.6 : Data Analysis on Design 3 Aluminium 6063-T6 (Driver Load)

Diameter (mm)	**Thickness (mm)**	**Weight (N)**	**Displacement (mm)**
15.88	1.57	2.4893×10^1	3.67683
19.05	1.00	1.9999×10^1	2.95748
25.40	1.00	2.7035×10^1	1.25010
31.75	1.40	4.7079×10^1	0.48679
38.10	1.20	4.9062×10^1	0.33616

4.3 Results on Engine Load

4.3.1 Design 1 Using Aluminium 6063

For Figure 4.18, using Aluminium 6063-T6 round tube with diameter of 15.88 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 19.21455 mm.

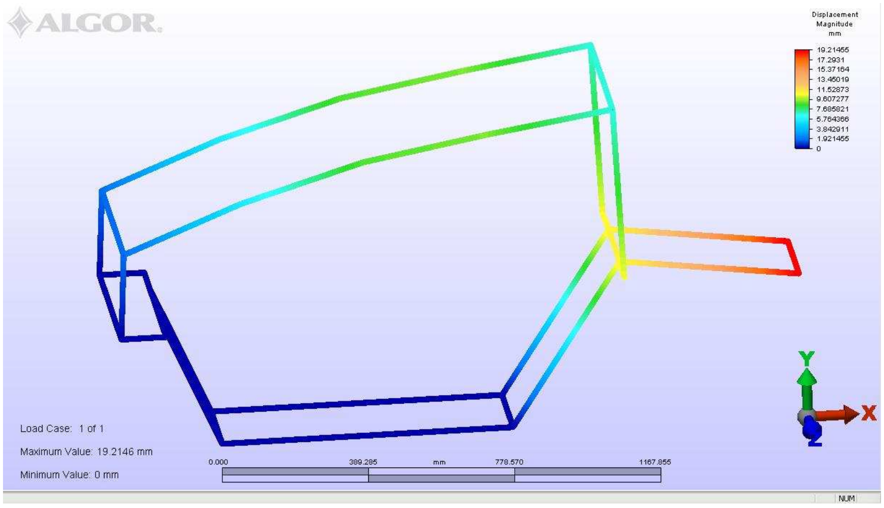

Figure 4.18 : Round Tube Diameter 15.88 mm

For Figure 4.19, using Aluminium 6063-T6 round tube with diameter of 19.05 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 15.69153 mm.

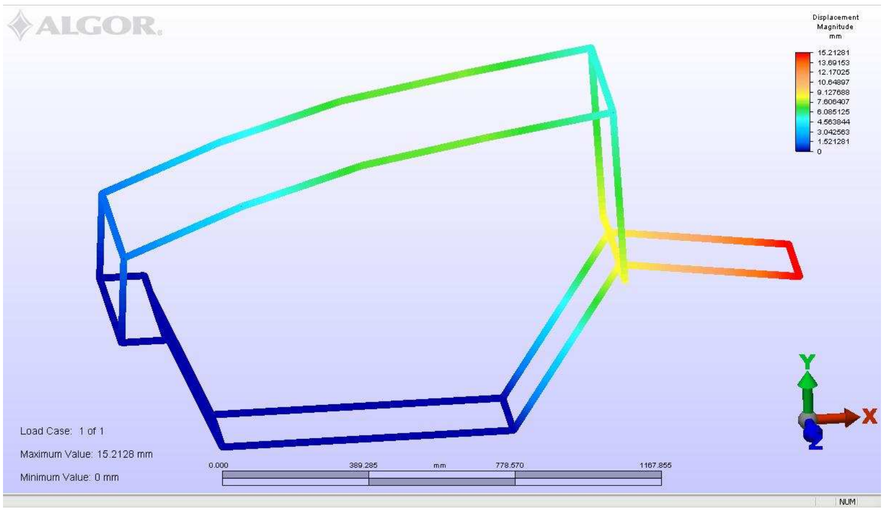

Figure 4.19 : Round Tube Diameter 19.05 mm

For Figure 4.20, using Aluminium 6063-T6 round tube with diameter of 25.40 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 6.20940 mm.

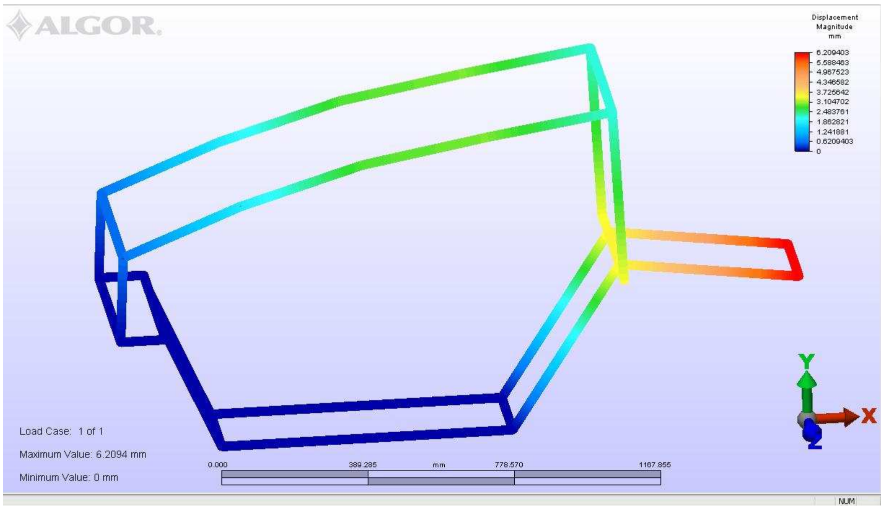

Figure 4.20 : Round Tube Diameter 25.40 mm

For Figure 4.21, using Aluminium 6063-T6 round tube with diameter of 31.75 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 2.32271 mm.

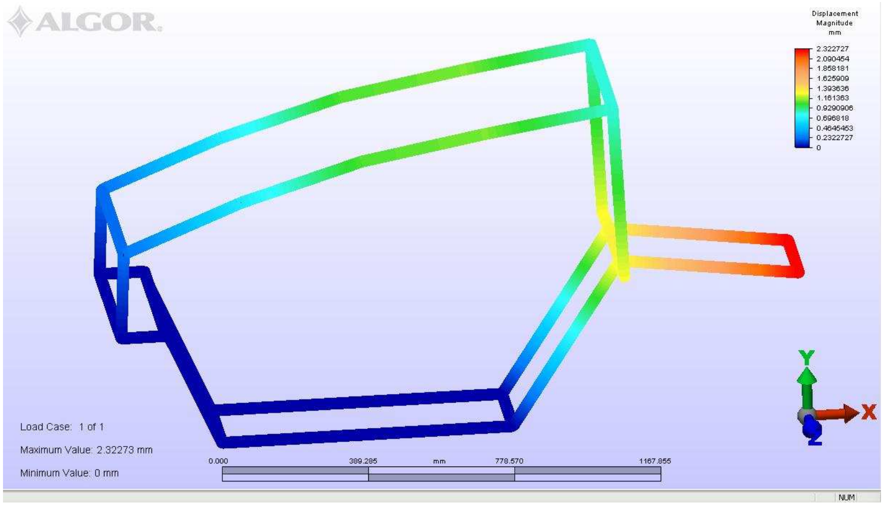

Figure 4.21 : Round Tube Diameter 31.75 mm

For Figure 4.22, using Aluminium 6063-T6 round tube with diameter of 38.10 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 1.52605 mm.

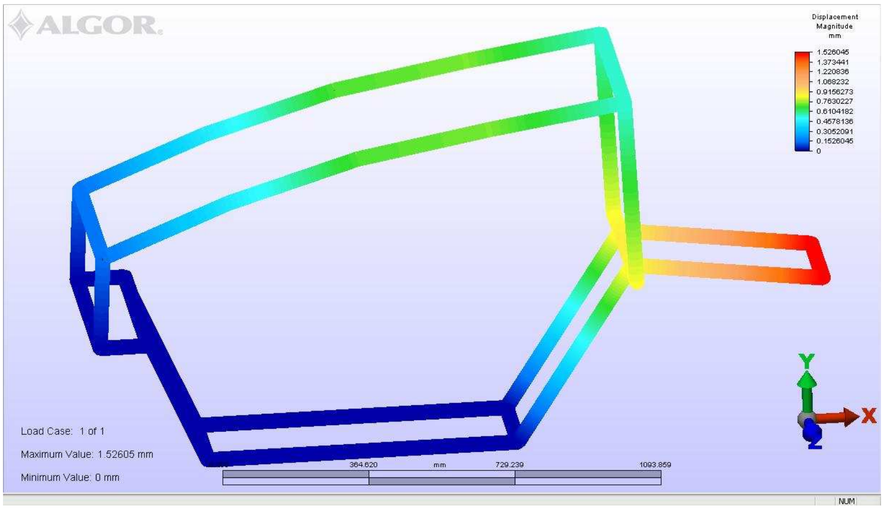

Figure 4.22 : Round Tube Diameter 38.10 mm

Based on the analysis on design 1 referring to table 4.7, the best diameter of the round tube with a light weight and low displacement is Aluminium 6063-T6 38.10 mm diameter with 4.3884×10^{1} N weights and 1.52605 mm displacement.

Table 4.7 : Data Analysis on Design 1 Aluminium 6063-T6 (Engine Load)

Diameter (mm)	Thickness (mm)	Weight (N)	Displacement (mm)
15.88	1.57	2.2265×10^{1}	19.21455
19.05	1.00	1.7888×10^{1}	15.69153
25.40	1.00	2.4181×10^{1}	6.20940
31.75	1.40	4.2109×10^{1}	2.32271
38.10	1.20	4.3884×10^{1}	1.52605

4.3.2 Design 2 Using Aluminium 6063-T6

For Figure 4.23, using Aluminium 6063-T6 round tube with diameter of 15.88 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 3.73711 mm.

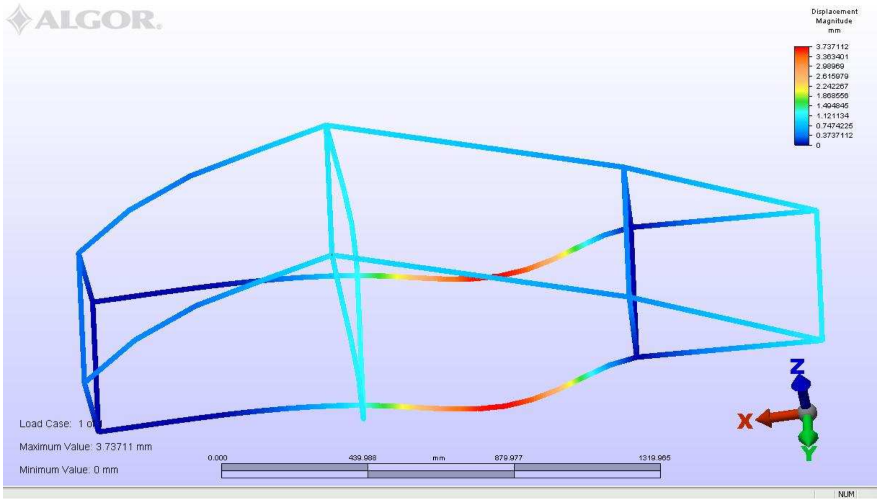

Figure 4.23 : Round Tube Diameter 15.88 mm

For Figure 4.24, using Aluminium 6063-T6 round tube with diameter of 19.05 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 2.98156 mm.

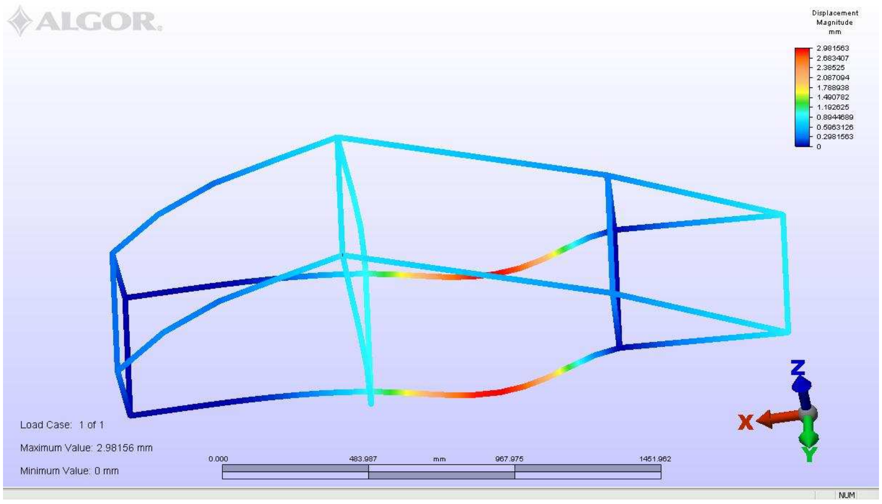

Figure 4.24 : Round Tube Diameter 19.05 mm

For Figure 4.25, using Aluminium 6063-T6 round tube with diameter of 25.40 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 1.23763 mm.

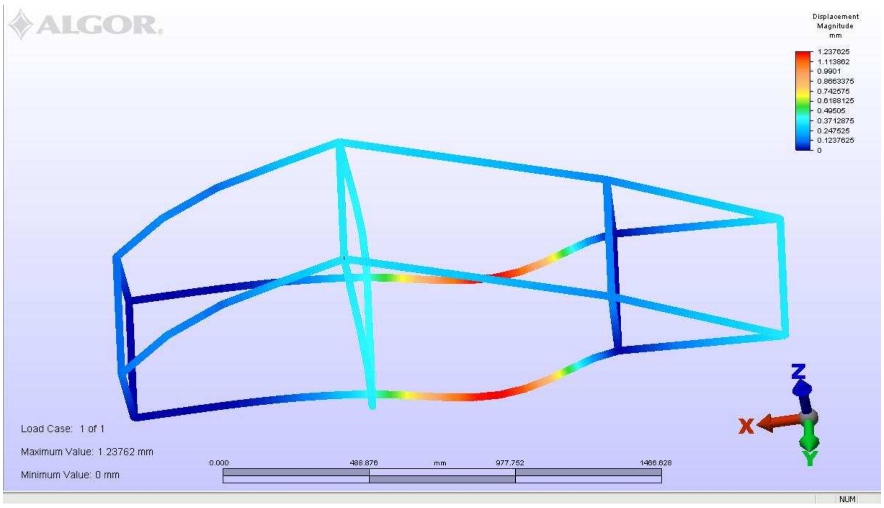

Figure 4.25 : Round Tube Diameter 25.40 mm

For Figure 4.26, using Aluminium 6063-T6 round tube with diameter of 31.75 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 0.47212 mm.

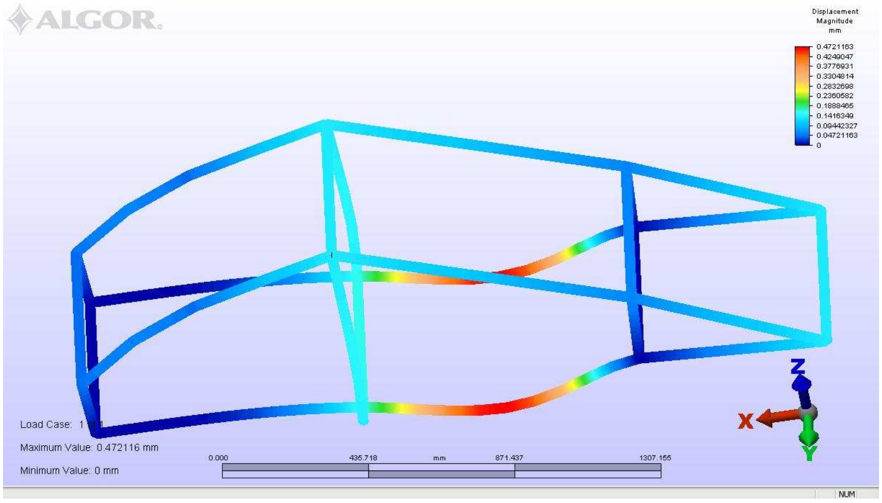

Figure 4.26 : Round Tube Diameter 31.75 mm

For Figure 4.27, using Aluminium 6063-T6 round tube with diameter of 38.10 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 0.31808 mm.

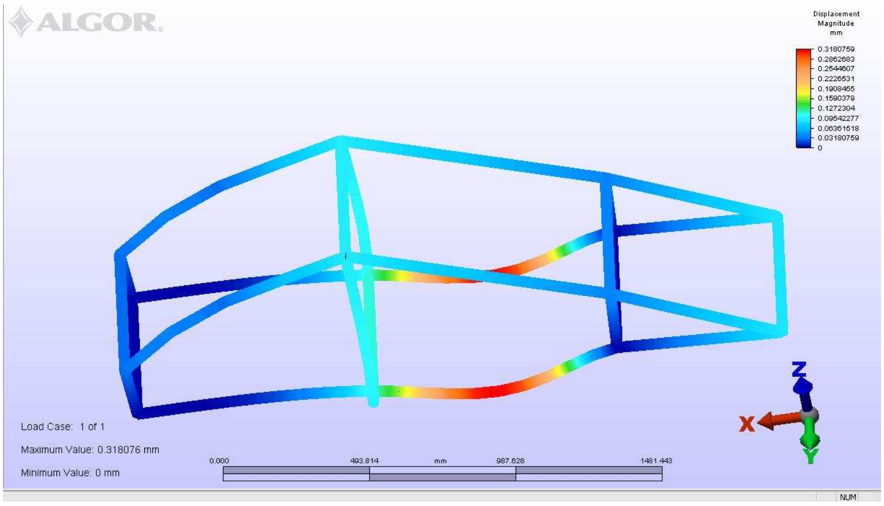

Figure 4.27 : Round Tube Diameter 38.10 mm

Based on the analysis on design 2 referring to table 4.8, the best diameter of the round tube with a light weight and low displacement is Aluminium 6063-T6 38.10 mm diameter with 4.3884×10^1 N weights and 0.31808 mm displacement.

Table 4.8 : Data Analysis on Design 2 Aluminium 6063-T6 (Engine Load)

Diameter (mm)	**Thickness**	**Weight (N)**	**Displacement (mm)**
15.88	1.57	2.9325×10^1	3.73711
19.05	1.00	2.3560×10^1	2.98156
25.40	1.00	3.1848×10^1	1.23763
31.75	1.40	5.5460×10^1	0.47212
38.10	1.20	5.7796×10^1	0.31808

4.3.3 Design 3 Aluminium 6063-T6

For Figure 4.28, using Aluminium 6063-T6 round tube with diameter of 15.88 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 3.47753 mm.

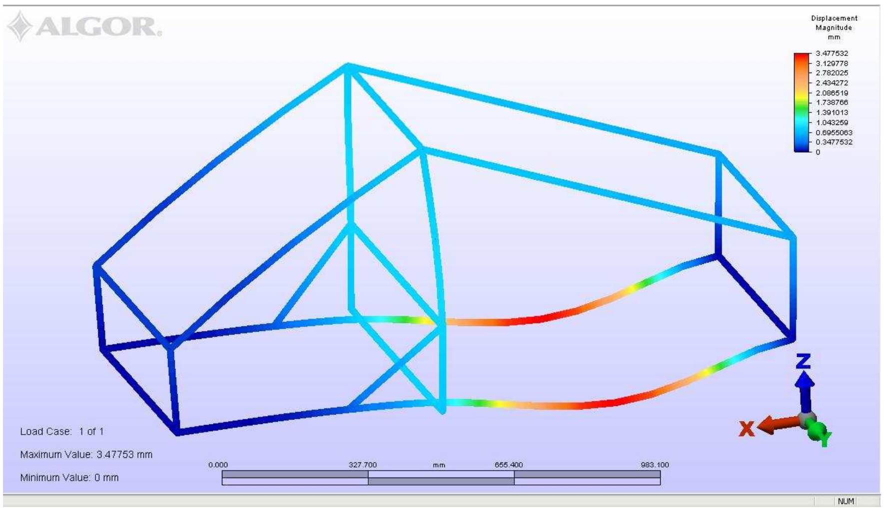

Figure 4.28 : Round Tube Diameter 15.88 mm

For Figure 4.29, using Aluminium 6063-T6 round tube with diameter of 19.05 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 2.77888 mm.

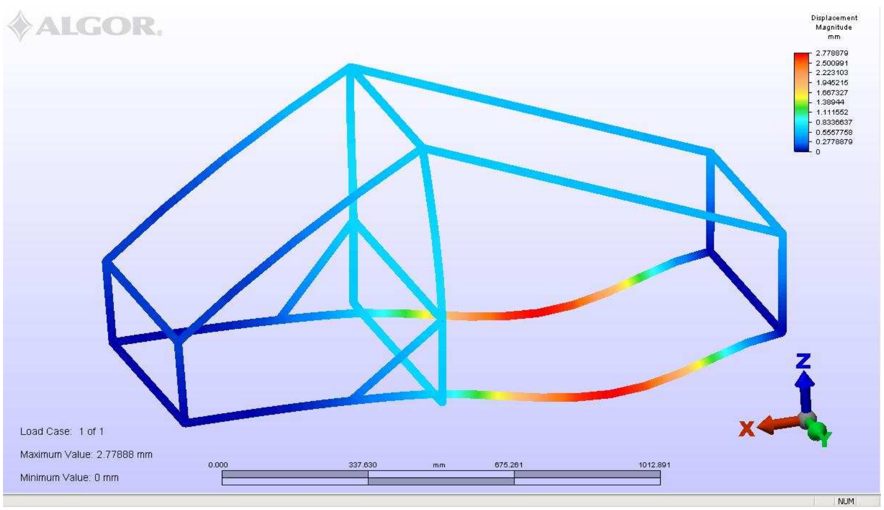

Figure 4.29 : Round Tube Diameter 19.05 mm

For Figure 4.30, using Aluminium 6063-T6 round tube with diameter of 25.40 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 1.15727 mm.

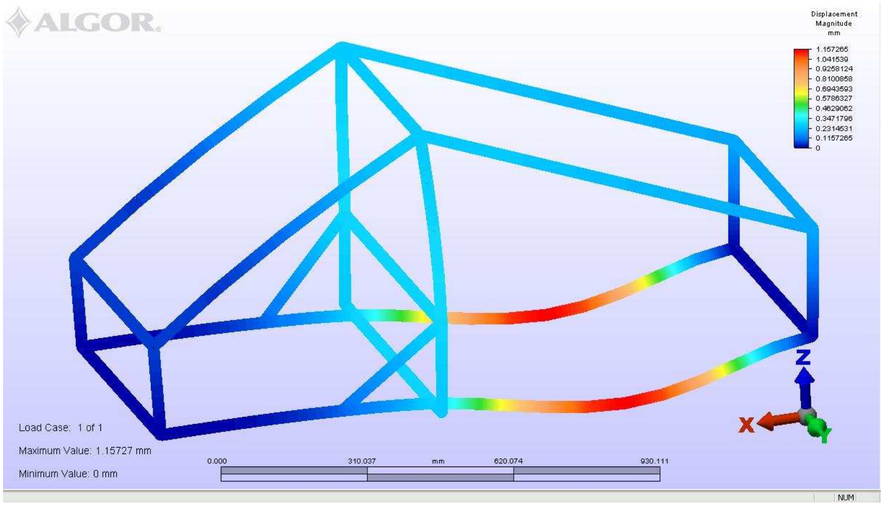

Figure 4.30 : Round Tube Diameter 25.40 mm

For Figure 4.31, using Aluminium 6063-T6 round tube with diameter of 31.75 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 0.44297 mm.

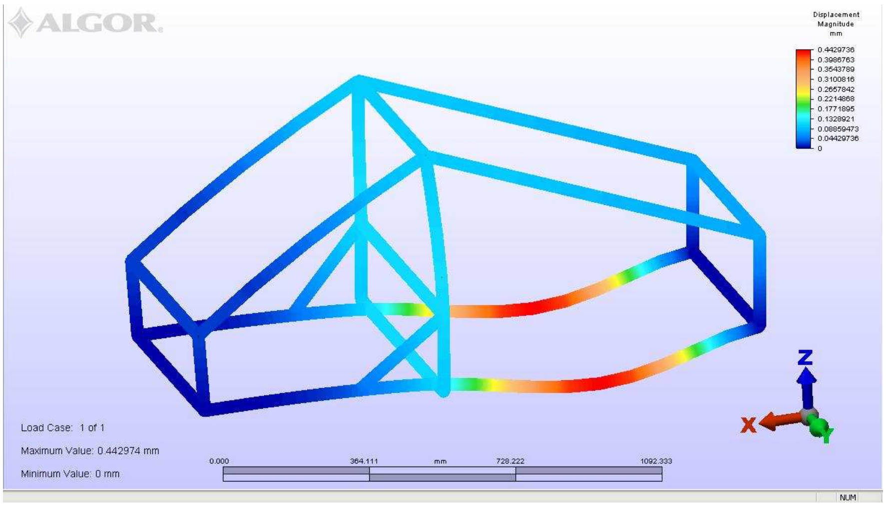

Figure 4.31 : Round Tube Diameter 31.75 mm

For Figure 4.32, using Aluminium 6063-T6 round tube with diameter of 38.10 mm, the minimum value which is area of blue colour is 0 mm and the highest displacement which is shown with red colour is 0.29960 mm.

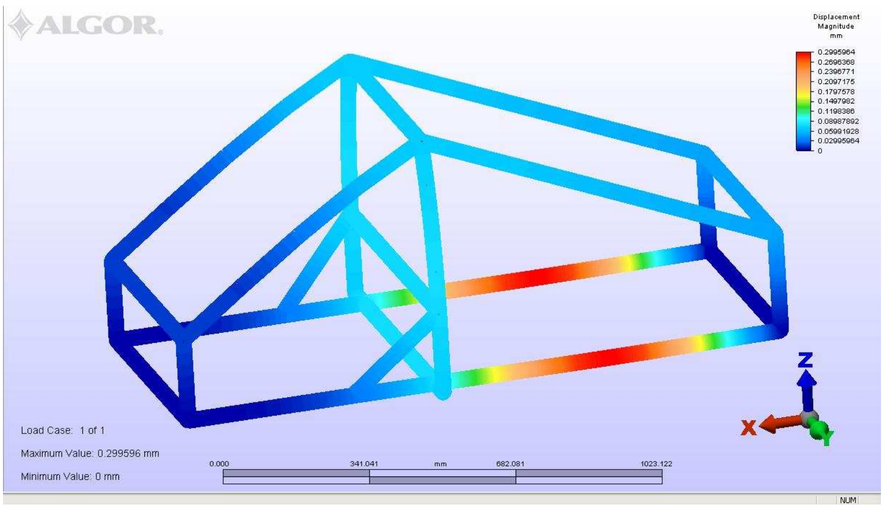

Figure 4.32 : Round Tube Diameter 38.10 mm

Based on the analysis on design 3 referring to table 4.9, the best diameter of the round tube with a light weight and low displacement is Aluminium 6063-T6 38.10 mm diameter with 4.3884×10^{1} N weights and 0.29960 mm displacement.

Table 4.9 : Data Analysis on Design 3 Aluminium 6063-T6 (Engine Load)

Diameter (mm)	Thickness (mm)	Weight (N)	Displacement (mm)
15.88	1.57	2.4893×10^{1}	3.47753
19.05	1.00	1.9999×10^{1}	2.77888
25.40	1.00	2.7035×10^{1}	1.15727
31.75	1.40	4.7079×10^{1}	0.44297
38.10	1.20	4.9062×10^{1}	0.29960

4.4 Aluminium 6063-T6 Diameter 38.1mm Embedded with E-Glass Fiber 5mm Thickness

Data from table 4.10 show that design 1 has the lightest weight and lowest driver load displacement and design 3 has the lowest engine load displacement.

Table 4.10 : Data Analysis After Embedded with Fiber

Design	Weight (N)	Driver Load Displacement (mm)	Engine Load Displacement (mm)
1	8.6414×10^{1}	0.08155	1.44825
2	1.1315×10^{2}	0.19466	0.06309
3	9.7669×10^{1}	0.12214	0.05528

4.5 Analysis Comparison Results

Based on the result**,** graph of weight versus diameter, figure 4.33, and graph displacement versus diameter, figure 4.34 can be made.

The relation of the graph mostly show that the weight increase when the diameter is increase.

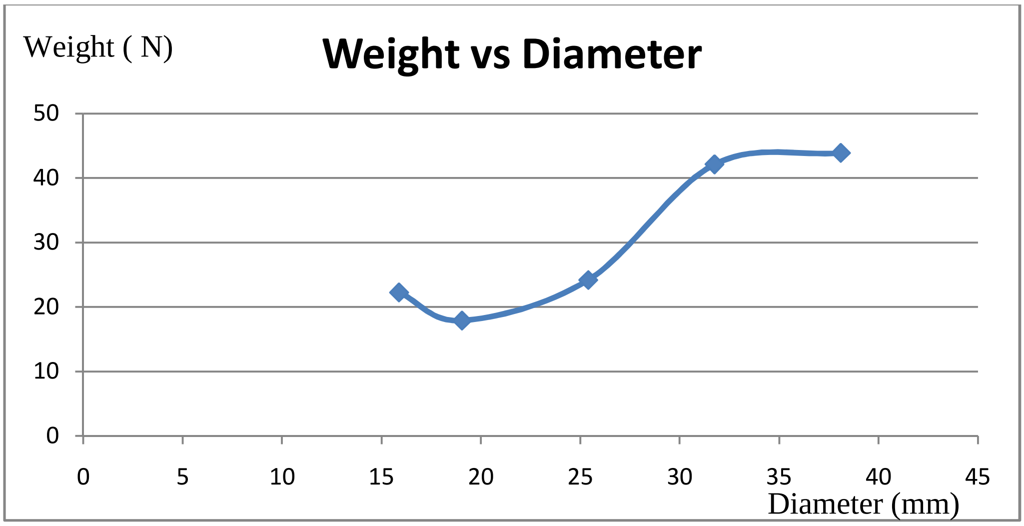

Figure 4.33 : Weight versus Diameter

Based on figure 4.34, Design 3 has the lowest displacement comparing to the other two designs. Design 2 has the largest displacement due to driver load.

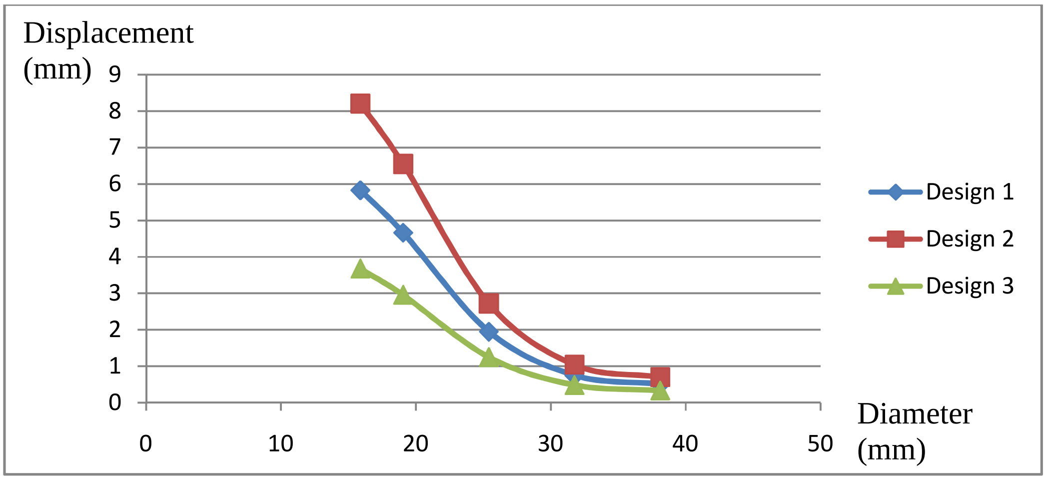

Figure 4.34 : Displacement versus Diameter for Driver Load

Based on figure 4.35, Design 3 has the lowest displacement comparing to the other two designs. Design 1 has the largest displacement due to engine load.

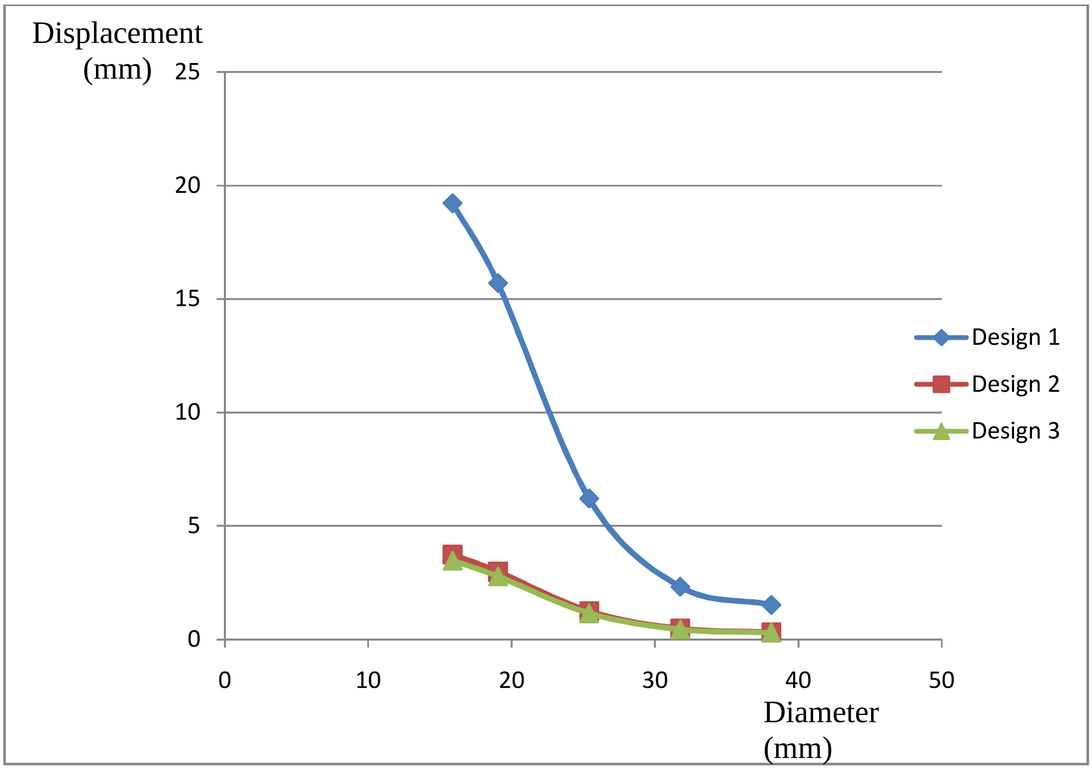

Figure 4.35 : Displacement versus Diameter for Engine Load

When aluminium is embedded with fiber, the displacement is decrease, which reinforced the chassis to become stronger. The figure 4.36 shows that every design improved with the embedded fiber.

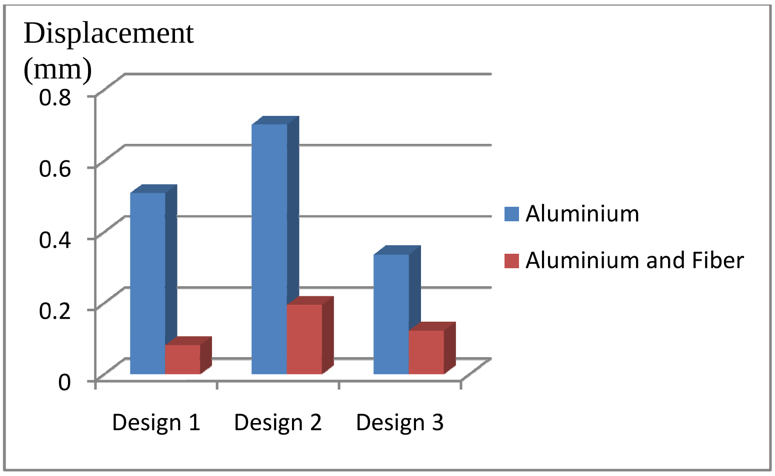

Figure 4.36 : Displacement of chassis after embed with Fiber for Driver Load

The data from the graph shows when the diameter of the material is increasing, the weight also increase but the increasing of the diameter decrease the value of displacement.

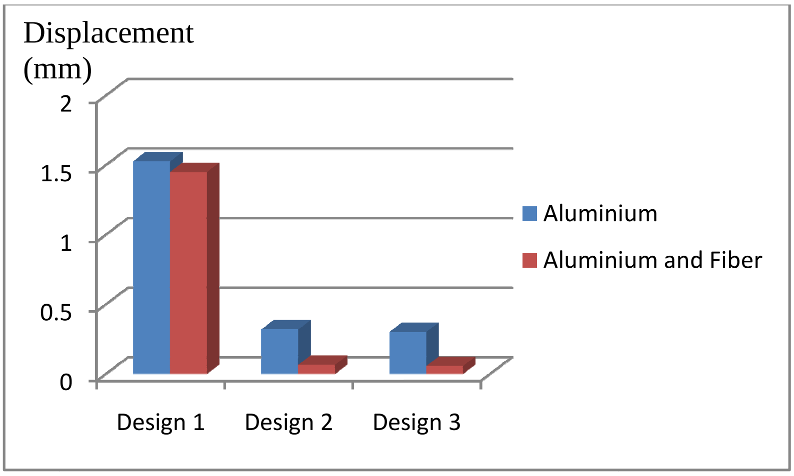

Figure 4.37 : Displacement of chassis after embed with fiber for engine load

From table 4.11, the lightest design weight is Design 1 which has 64.44% of weight reduction from the existing chassis. It also has the highest percentage of displacement reduction which is 82.65%. For the engine load displacement, Design 3 has the lowest value which is 0.055276mm. From the result, the best chassis design is Design 1 with lighter weight and less displacement of chassis to use in the next project.

Table 4.11 : Data Comparison

Design	**1**	**2**	**3**
% Weight Reduction	64.44	53.44	59.81
% Displacement Reduction for Driver load	82.65	58.58	74.01
Engine Load Displacement (mm)	1.44825	0.06309	0.05528

CHAPTER 5

CONCLUSION

5.1 Conclusion

In industry especially, the cost is one of the important factor in produce the product. Automotive industry is seeking for low cost material, light weight and best material properties. This is needed to improve the design and performance of the vehicles they produce.

The stainless steel has better strength compared to aluminium but the weight is heavier. Stainless steel is also expensive than aluminium which is in a cost factor. Base on market price, aluminium is cheaper than stainless steel. Aluminium 6063-T6 is widely used as pipe and chassis (Zeguer, 2009).

The design must be suitable as to get the better result and less displacement. If the design is lightweight, but the displacement of the chassis is big, there is no safety for the user. The best design must be lightweight but also has less displacement and better material properties.

The design 1 is base on the existing design which is improved in weight and displacement. The cost is also cheaper because the non-use part is removed and the material used is cheaper. The Design 3 is the second option which also improved than the existing design. Design 2 is the third option which has improvement but lower than Design 1 and Design 3. Design 1 is the best design to be use for next project.

5.2 Recommendation

The design of the chassis that has been analyzed should be fabricated for the next urban concept car. This analysis has ensured that it is safe enough to be used. The best way to weld it is by using gas tungsten arc welding (GTAW) or also known as tungsten inert gas (TIG) welding. It is the best method to weld aluminium. The used of fiber also can be applied for body of the car embedded directly to the chassis as to strengthen the structure of the chassis (Armao, 2001).

REFERENCES

Aluminium Alloy 6063-T6, Aalco Metals Ltd.

Armao F. (2001). Preparing for aluminum GTAW. Retrieved from http://www.thefabricator.com/article/aluminumwelding/preparing-for-aluminum-gtaw

Advance Fibreglass & Composites. Retrieved March 29, 2010, from http://www.fiberglasssales.com/index.php/why_use_fiberglass/

AutoZine Technical School. Retrieved March 29, 2010, from http://www.autozine.org/technical_school/tech_index.html#Chassis-and-Body

Christoper, S. (2004). Technical Paper. FoES Formula SAE-A Spaceframe Chassis Design. University of Southern Queensland

Different Types of Chassis. Retrieved March 29, 2010, from http://www.autozine.org/technical_school/chassis/tech_chassis2.htm

DNV Fuel Fighter designed by Ole-Andreas Fagertun, Arnstein Johannes Syltern and Arne Magnus Mykkelbost, from http://blog.evaria.com/2009/05/

FEMPRO V22, (2008) Algor, Inc

Feraboli, P., & Masini A. (2003). Development of carbon/epoxy structural components for a high performance vehicles

General Spaceframe Chassis Principals. Retrieved March 29, 2010, from http://www.gmecca.com/byorc/dtipschassis.html#ChasisGeneral

Henningsgraad, A., & Yanchar, C. (1998). Technical Paper. Carbon Fiber Reinforced Steel Spaceframe Techniques. University of Minnesota, Twin Cities

Hirsch J. (2004). Automotive Trends in Aluminium - The European Perspective

Kaufman J.G., Rooy E.L. (2004). Aluminum Alloy Castings: Properties, Processes, and Applications. ASM International

Keith, J. (2009). Introduction to Chassis Design. Memorial University of Newfoundland And Labrador

KRUCE (Kent Ridge Urban Concept Ecocar) designed and built by the NUS School of Design and Environment’s Design Incubation Centre (DIC) from http://blog.nus.edu.sg/nusid/2009/04/27/design-incubation-centre-launched-latest-eco-friendly-urban-concept-car

M-112 designed by Ignacio Garcia, from www.technama.com/2009/shell-eco-marathon-pakistani-universities-to- participate

Northey T. (1974). World of Automobiles Volume 4

NUS-ECO1 designed and built by the NUS School of Design and Environment’s Design Incubation Centre (DIC) from http://www.eng.nus.edu.sg/EResnews/0806/hightlight.html

Raynal W. (2009). “McLaren unveils new supercar”. Reinforced Plastic

Reimpell J. (2001). The Automotive Chassis. Reed Educational Publishing Ltd

Ruppert J. (October 10,1998). “Motoring: The City car to be Seen in”. The Independent

Schmid S., & Kalpakjian S. (2006). Manufacturing Engineering and Technology. Singapore: Prentice Hall

Staley J.T., & Lege D.J. (1993). Advances in aluminium alloy products for structural applications in transportation

Zeguer T. (2009). The Development of The New XJ Jaguar in Advanced Aluminium; Opportunities and Challenges

6061 aluminum material property data sheet. Retrieved March 29, 2010, from http://www.suppliersonline.com/propertypages/6061.asp

APPENDIXES

APPENDIX A1

Table A1 : Material properties of AISI Type 304 Stainless Steel

Mechanical Properties	Value
Yield strength	290 Mpa
Ultimate strength	580 Mpa
Modulus of Elasticity	193 Gpa
Poisson's ratio	0.29
Density	8000 kg/m^3

APPENDIX A2

Table A2: Mechanical properties based on AA standard

Alloy	Temper	Thickness (mm)	Tensile Strength (Mpa)				Elongation % min in 50 mm
			Ultimate		Yield, 0.2% offset		
			Min	Max	Min	Max	
1060	0	All	60	95	15	-	25
6060	T51	Up thru 3.20	150	-	110	-	8
6061	0	All	-	150	-	110	16
	T4	All	180	-	110	-	16
	T6	Up thru 6.3	260	-	240	-	8
6063	T5	Up thru 12.50	150	-	110	-	8
	T52	Up thru 25.00	150	205	110	170	8
	T6	Up thru 3.20	205	-	170	-	8

APPENDIX A3

Table A3: Typical Composition of Aluminum Alloys

Component	Amount (wt.%)
Aluminium	Balance
Magnesium	0.8-1.2
Silicon	0.4 – 0.8
Iron	Max. 0.7
Copper	0.15-0.40
Zinc	Max. 0.25
Titanium	Max. 0.15
Manganese	Max. 0.15
Chromium	0.04-0.35
Others	0.05

APPENDIX A4

Table A4 : Mechanical Properties of Aluminium

Temper	Ultimate Tensile Strength (MPa)	0.2% Proof Stress (MPa)	Brinell Hardness (500kg load, 10mm ball)	Elongation 50mm dia (%)
0	110-152	65-110	30-33	14-16
T1	180	95-96		16
T4	179 min	110 min		
T6	260-310	240-276	95-97	9-13

APPENDIX A5

Table A5: Typical properties and the mechanical properties of some common fiber.

Materials	Density (g/cm^3)	Tensile Strength (MPa)	Young modulus (GPa)
E-Glass	2.55	2000	80
S-Glass	2.49	4750	89
Alumina (Saffil)	3.28	1950	297
Carbon	2.00	2900	525
Kevlar 29	1.44	2860	64
Kevlar 49	1.44	3750	136

APPENDIX B1

Gantt Chart Final Year Project 1

Week / Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Discuss with supervisor about the thesis title															
Study regulation for the chassis															
Design the body of the car based on regulation															
Search for information and data about the chassis, material and urban car concept															
Discuss with supervisor about the data and information															
Design the chassis of the car based on regulation															
Submit chapter 1 to chapter 3 To supervisor															
Presentation slide preparation based on chapter 1 to chapter 3															
Presentation Final Year Project 1															
Discuss with supervisor about panel comment and improvement for Final Year Project 2															

APPENDIX B2

Gantt Chart Final Year Project 2

Task \ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Discuss with supervisor about the improvement of chassis															
Study of the material replacement															
Analyze the existing chassis															
Design 3 new chassis															
Discuss with supervisor of displacement of the chassis															
Simulate the new design															
Discuss with lecturer about finite element analysis for two material															
Analyze the design															
Report writing															
Submitting drafts															
Presentation															

UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS♦

JUDUL: **DESIGN AND DEVELOPMENT OF INTEGRATED CHASSIS OF ONE SEATED URBAN CAR USING EMBEDDED ALUMINIUM AND FRP**

SESI PENGAJIAN: **2010/2011**

Saya **NOOR AKMAL BIN ZOLKIFLI (880515045135)**
(HURUF BESAR)

mengaku membenarkan tesis (Sarjana Muda/~~Sarjana~~ /~~Doktor Falsafah~~)* ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hakmilik Universiti Malaysia Pahang (UMP).
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (√)

	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
√	**TIDAK TERHAD**	

Disahkan oleh:

(TANDATANGAN PENULIS) (TANDATANGAN PENYELIA)

Alamat Tetap:

NO 26, TAMAN INTAN MAS 3,
JALAN KAMPUNG BANJAR,
36000 TELUK INTAN,
PERAK

DR. SUGENG ARIYONO
(Nama Penyelia)

Tarikh: **6 DISEMBER 2010**

Tarikh: : **6 DISEMBER 2010**

CATATAN:
* Potong yang tidak berkenaan.
** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh tesis ini perlu dikelaskan sebagai atau TERHAD.
♦ Tesis dimaksudkan sebagai tesis bagi Ijazah doktor Falsafah dan Sarjana secara Penyelidikan, atau disertasi bagi pengajian secara kerja kursus dan penyelidikan, atau Laporan Projek Sarjana Muda (PSM).