DESIGN AND ANALYSIS SOLAR CAR CHASSIS

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BORANG PENGESAHAN STATUS TESIS

JUDUL **DESIGN ANG ANALYSIS SOLAR CAR CHASSIS**

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DESIGN AND ANALYSIS SOLAR CAR CHASSIS

IDHAM ARIFF BIN MAT ALI

Report submitted in partial fulfillment of the requirements for the award of the Diploma of Mechanical Engineering

Faculty of Mechanical Engineering

UNIVERSITI MALAYSIA PAHANG

NOVEMBER 2010

SUPERVISOR DECLARATION

I hereby declare that I had read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the purpose of the granting of Diploma of Mechanical Engineering.

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I declare that this thesis entitled "Design and Analysis Solar Car Chassis" is the result of my own research except as cited in references. The thesis has not been accepted for any diploma and is not concurrently submitted in candidature of any other diploma.

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Date 24 NOVEMBER 2010

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ABSTRACT

A solar car is a specialized type of car designed for race and powered by sun energy (solar). This is obtained from solar panels on the surface of the vehicle. Photovoltaic (PV) cells convert the sun's energy directly into electric energy. Solar vehicles are not sold as practical day-to-day transportation devices at present, but are primarily demonstration vehicles and engineering exercises. It have limited seating (usually one, sometimes two people), it have very little cargo capacity, and only be driven during the day.

Chassis is one of the important parts and every car passenger has it. This structure was the biggest component in the car and car shape dependent on it. It has a considerable affected to the performance of the car. The primary challenge in developing an effective solar car chassis is to maximize the strength but minimize the weight. There are various types of chassis, each with its own advantages and disadvantages. Every extra pound requires more energy to move down the road. This means that chassis must strive to minimize weight and a key area is the chassis. However, safety is a primary concern and the chassis must meet stringent strength and safety requirements.

As the conclusion, this project had achieves its entire objective successfully. This project was done around twelve week included almost all steps of the report such as literature review, design, analysis process and others.

ABSTRAK

Kereta Solar adalah sejenis kenderaan yang direka khusus untuk perlumbaan dan dijana oleh tenaga matahari (solar). Tenaga solar ini diserap oleh panel suria pada permukaan kenderaan. Sel photovoltaic (PV) menukarkan tenaga solar menjadi tenaga elektrik.Ia tidak sesuai untuk dijadikan sebagai pengangkutan harian, tetapi ianya digunakan dalam bidang penyelidikan khususnya dalam bidang kejuruteraan mekanikal. Ini kerana kereta solar mempunyai tempat duduk yang terbatas kepada satu atau dua sahaja selain ruang kargo yang kecil dan paling utama ianya terhad untuk kegunaan pada waktu siang sahaja.

Casis merupakan salah satu bahagian terpenting setiap kenderaan. Struktur ini merupakan komponen terbesar sesebuah kenderaan.Casis mempunyai peranan yang penting terhadap prestasi kereta.Cabaran utama dalam menghasilkan casis kereta solar adalah untuk memaksimumkan kekuatan dan meminimumkan berat. Ada pelbagai jenis chassis dengan kelebihan dan kekurangan yang tersendiri. Setiap berat tambahan menyebabkan sesebuah kenderaan memerlukan lebih banyak tenaga untuk bergerak. Ini bermakna pakar automotif harus mengurangkan berat sesebuah kenderaan dan kunci utama dalam perkara ini adalah mencipta casis yang ringan dan efektif. Namun, keselamatan haruslah menjadi perhatian utama dan casis mesti memenuhi kekuatan dan ciri-ciri keselamatan yang telah ditetapkan.

Kesimpulan, projek ini telah mencapai semua tujuan berjaya. Projek ini dilakukan kira-kira dua belas minggu termasuk hampir semua langkah laporan seperti tinjauan literatur, rekabentuk, proses analisis dan lain-lain.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

For this chapter, we will discuss about the problem background, problem statement, objective of the project and lastly scope of the project.

1.2 Project Background

The purpose of this project is to designing and analysis solar car chassis. The chassis need to fulfill the scope of the project. In this project, the chassis has been design and analysis to be light in weight and safe to driver. As the Diploma Final Year Project allocates the duration of one semester, this project need combination of knowledge and skills of using several software like solidworks. In an excellent opportunity to develop future technologies especially in transportation and it can replace now days car. From this problem come out an idea to design a solar car chassis.

1.3 Problem statement

Most of the solar car chassis face same problem which is weight and safety. Every extra kilogram required more energy to move down the road and design of the chassis need to protect the driver if an accident happen.

1.4 Objectives

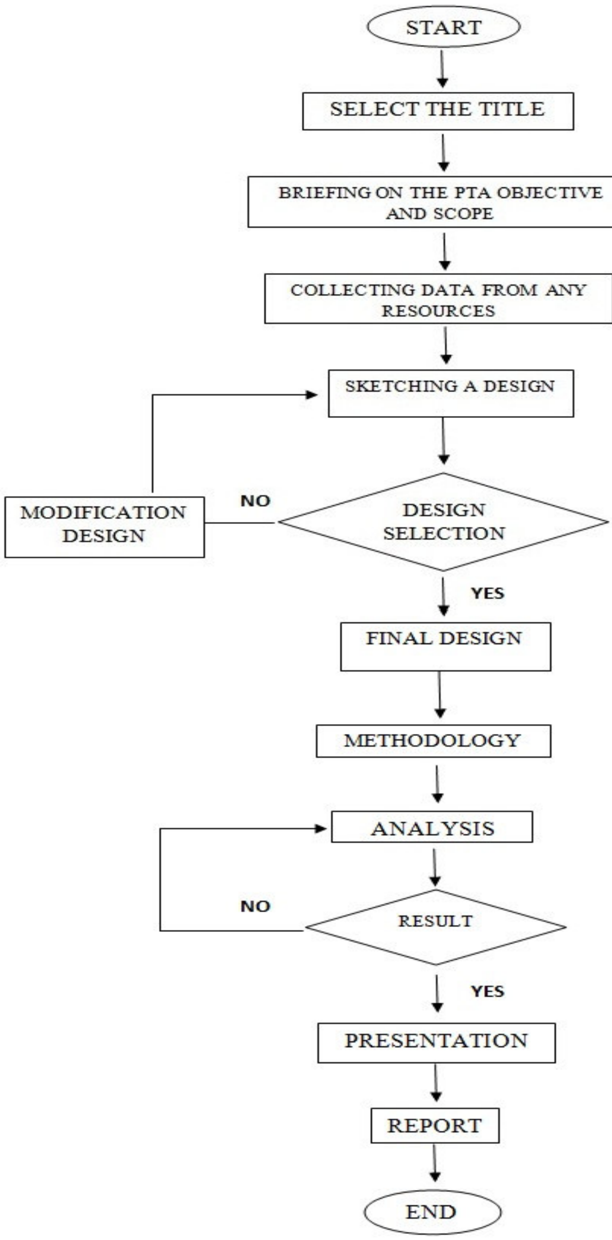
The main objectives of this project is to design and analysis solar car chassis.

1.5 Scope

i. Support maximum driver's weight up to 75Kg.
ii. Fix with 3 wheels.
iii. Chassis have safety features for driver.

1.6 Flow Chart

A flow chart is a graphical representation of a process or system that details the sequencing of steps required to create output.



CHAPTER 2

LITERATURE VIEW

2.1 Introduction

A literature review is a body of text that aims to review the critical points of current knowledge and or methodological approaches on a particular topic. Literature reviews are secondary sources, and as such, do not report any new or original experimental work.

Most often associated with academic-oriented literature, such as theses, a literature review usually precedes a research proposal and results section. Its ultimate goal is to bring the reader up to date with current literature on a topic and forms the basis for another goal, such as future research that may be needed in the area.

A well-structured literature review is characterized by a logical flow of ideas, current and relevant references with consistent, appropriate referencing style; proper use of terminology; and an unbiased and comprehensive view of the previous research on the topic.

2.2 Types of Frames

2.2.1 Space Frame

The spaceframe chassis is about as old as the motorsport scene. Its construction consists of steel or aluminum tubes placed in a triangulated format, to support the loads from suspension, engine, driver and aerodynamics.

Spaceframes are popular today in amateur motorsport because of their simplicity. Space frames, unlike the monocoque chassis used in modern Formula 1 or CART, are easily repaired and inspected for damage.

So how does triangulation work? The diagram below shows a box, with a top, bottom and two sides, but the box is missing the front and back. The box when pushed collapses easily because there is no support in the front or back.

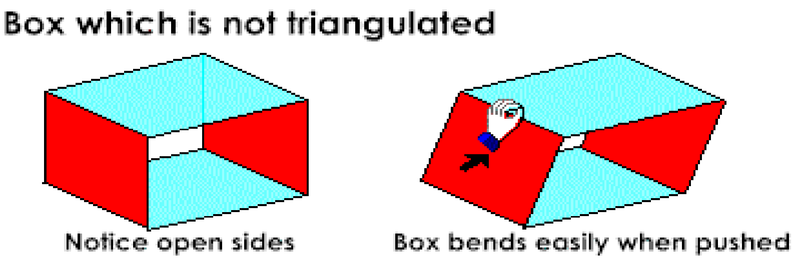


Figure 2.1: Box with open front and back

Of course, race cars need to be supported in order to operate properly, and so we triangulate the box by bracing it diagonally. This effectively adds the front and back which were missing, only instead of using panels, we use tubes to form the brace.

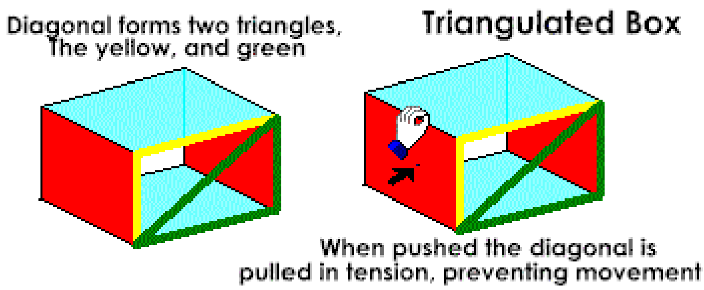


Figure 2.2: Box add with triangle at front

The triangulated box above imparts strength by stressing the green diagonal in **Tension**. Tension is the force trying to pull at both ends of the diagonal. Another force is called **Compression**. Compression tries to push at both ends of the diagonal (Shown above in the horizontal yellow tube). In a given size and diameter tube or diagonal, compression will always cause the tube to buckle long before the same force would cause the tube to pull apart in tension. As an experiment, try pulling on the ends of a pop can, one end in each hand. Then, try crushing the can by pushing on both ends. The crushing is much easier, or at least humanly possible, compared to pulling the can apart.

Spaceframes are really all about tubes held together in compression and tension using 3D pyramid-style structures, and diagonally braced tube boxes. A true space frame is capable of holding its shape, even if the joints between the tubes were hinges

In contrast to spaceframes, the monocoque chassis uses panels, just like the sides of the box pictured above. Instead of small tubes forming the shape of a box, an entire panel provides the strength for a given side.

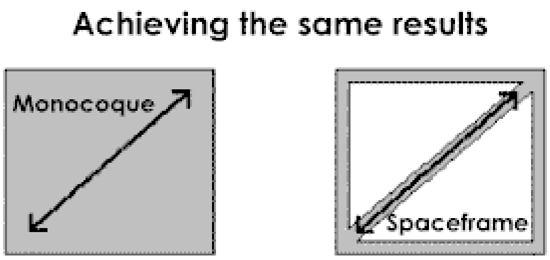


Figure 2.3: Different between monocoque and spaceframe

A common shape for 1960s cars of monocoque construction was the "cigar". The cylindrical shape helped impart something called **Tortional rigidity.** Tortional rigidity is the amount of twist in the chassis accompanying suspension movement.

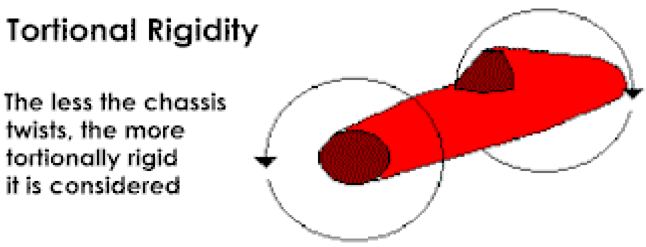


Figure 2.4: Shape of car 'cigar'

Tortional rigidity applies to space frames too, but because a space frame isn't made from continuous sheet metal or composite panels, the structure is used to approximate the same result as the difficult to twist "cigar car".

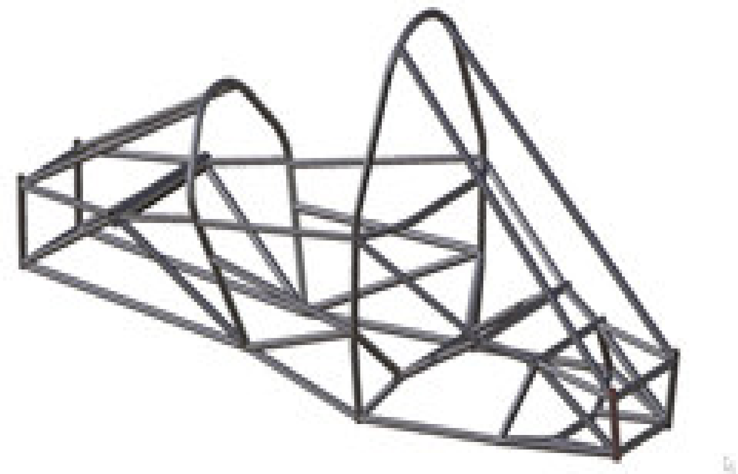


Figure 2.5: Spaceframe chassis

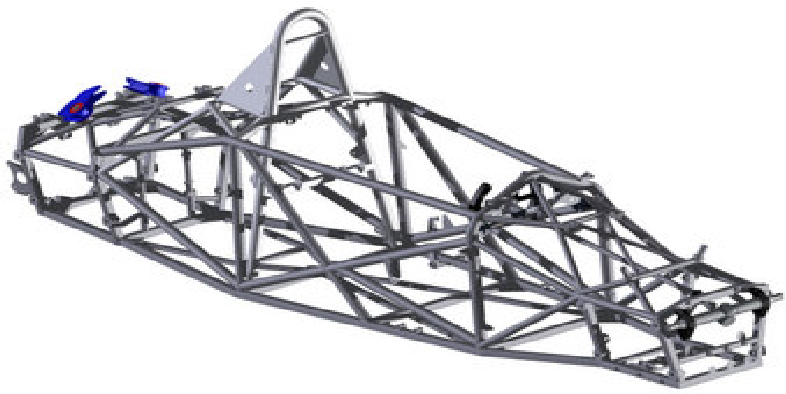


Figure 2.6: Spaceframe chassis

2.2.2 Semi-monocoque

The semi-monocoque or carbon beam chassis uses composite beams and bulkheads to support the loads and is integrated into a non-load bearing composite belly pan. The top sections of the car are often separate body pieces that are attached to the belly pan.

A fuselage(spindle-shaped) structure in which longitudinal members (stringers) as well as rings or frames which run circumferentially around the fuselage reinforce the skin and help carry the stress. Also known as stiffened-shell fuselage

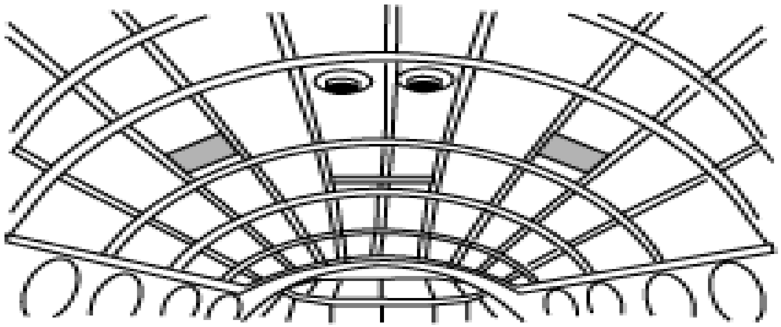


Figure 2.7 : Semi-monocoque fuselage construction

Semi-monocoque are referred to as "stressed skin" structures as all or a portion of the external load (i.e. from wings and empennage, and from discrete masses such as the engine) is taken by the surface covering. In addition, the entire load from internal pressurization is carried (as *skin tension*) by the external skin.Semimonocoque design overcomes the strength-to-weight problem of monocoque construction in addition to having formers, frame assemblies, and bulkheads, the semimonocoque construction has the skin reinforced by longitudinal member.

The semimonocoque fuselage is constructed primarily of aluminum alloy, although steel and titanium The original GT40 - and our ERA GT - have a semi-monocoque chassis. The heaviest (steel) main panel on our ERA GT is only .045" thick, and most panels are only .032"! Reinforcements are required at the suspension points where there are local high loads. With the rockers 10" high x 9" wide, the net result is an incredibly stiff structure. But you can't build a classic roadster like this.

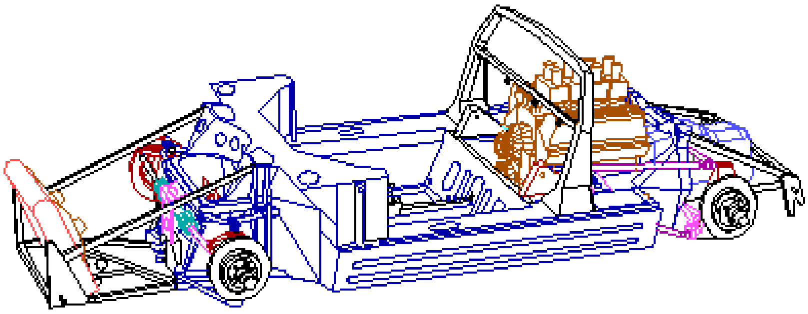


Figure 2.8 : ERA GT Chassis

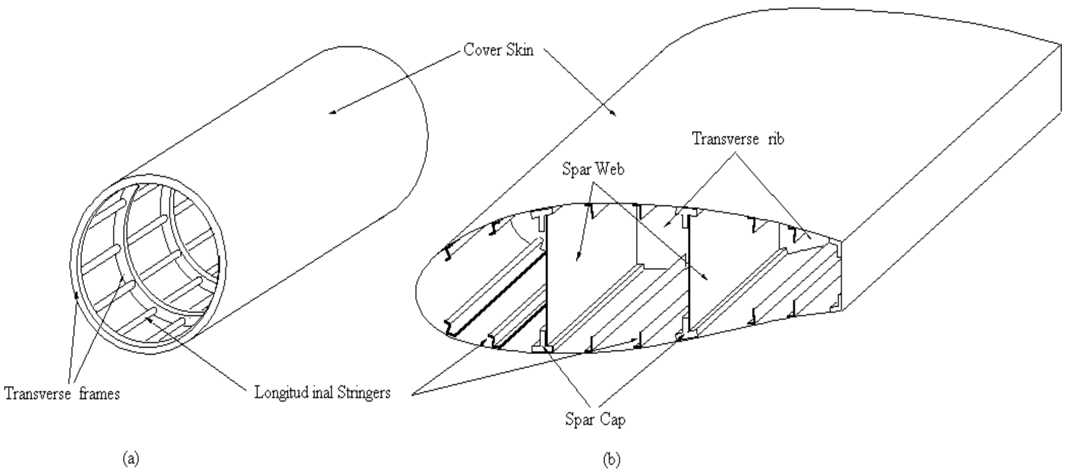


Figure 2.9 : Semi-monocoque structural component (body)

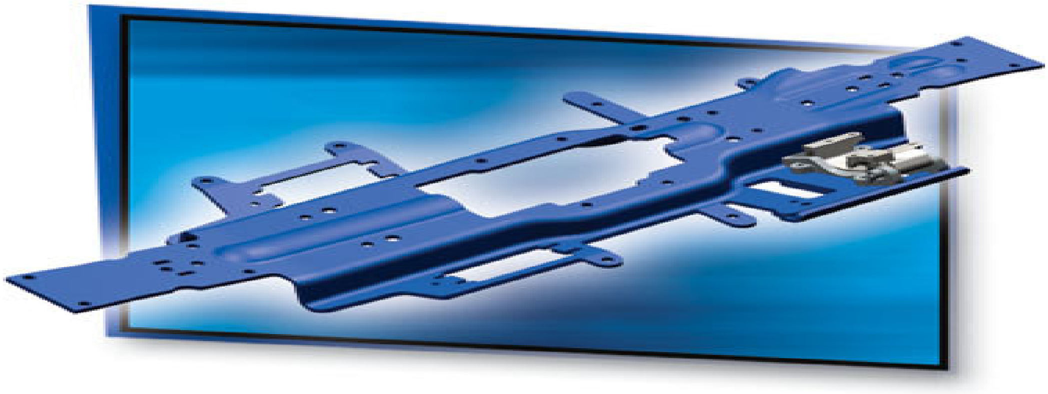


Figure 2.10 : Extended 3D semi-monocoque chassis

Some criteria of this chassis, it has been extended by 30mm for improved stability, cut and formed 3mm, 6061-T6 aluminum and integrated engine cradle and deep channel design to provide superior strength without adding unnecessary weight.

2.2.3 Monocoque

The monocoque design may be divided into three classes—monocoque, semimonocoque, and reinforced shell. A monocoque chassis uses the body structure to support the loads. Today, 99% cars produced made of steel monocoque chassis because its low production cost and suitability to robotized production. Monocoque is a one-piece structure which defines the overall shape of the car. While ladder, tubular space frame and backbone chassis provides only the stress members and need to build the body around them, monoque chassis is already incorporated with the body in a single piece,

Figure 2.11: Volvo V70

Monocoque chassis also benefit crash protection. Because it uses a lot of metal, crumple zone can be built into the structure. Another advantage is space efficiency and cheap for mass production.

There are many disadvantages as well. It's very heavy. As the shell is shaped to benefit space efficiency rather than strength, and the pressed sheet metal is not as strong as metal tubes or extruded metal, the rigidity-to-weight ratio is also the lowest among all kinds of chassis bar the ancient ladder chassis. Moreover, as the whole monocoque is made of steel, unlike some other chassis which combine steel chassis and a body made of aluminium or glass-fiber, monocoque is hopelessly heavier than others.

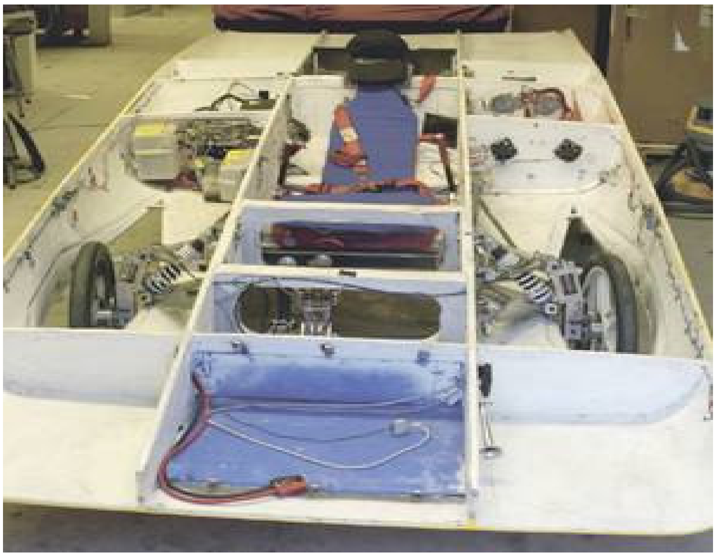


Figure 2.12: Monocoque chassis

Although monocoque is suitable for mass production by robots, it is nearly impossible for small-scale production. The setup cost for the tooling is too expensive - big stamping machines and expensive mouldings. I believe Porsche is the only sports car specialist has the production volume to afford that. Rust is also more of a problem, since the structural metal is part of the load bearing structure making it more vulnerable, and must be repaired by cutting-out and welding rather than by simply bolting on new parts.

2.3 Material selection

2.3.1 Carbon Fiber

Carbon fiber is a material consisting of extremely thin fibers about 0.005–0.010 mm in diameter and composed mostly of carbon atoms. The carbon atoms are bonded together in microscopic crystals that are more or less aligned parallel to the long axis of the fiber. The crystal alignment makes the fiber very strong for its size. Carbon fiber has many different weave patterns and can be combined with a plastic resin and wound or molded to form composite materials such as carbon fiber reinforced plastic (also referenced as carbon fiber) to provide a high strength-to-weight ratio material. The density of carbon fiber is also considerably lower than the density of steel, making it ideal for applications requiring low weight.

The properties of carbon fiber are high tensile, strength, low weight, and low thermal expansion. Carbon fiber is very strong when stretched or bent, but weak when compressed or exposed to high shock. In the early 1980s, Formula 1 use carbon composite materials to build the chassis. Today, most of the racing car chassis - the monocoque, suspension, wings and engine cover - is built with carbon fiber. This material has four advantages over every other kind of material for racing car construction is super lightweight, super strong, and super stiff and it can be easily molded into all kinds of different shapes.

Figure 2.13: Chassis using carbon fibre

2.3.2 Graphite

The mineral graphite is one of the carbons. Graphite is an electrical conductor, a semimetal. Graphite is the most stable form of carbon under standard conditions. Therefore, it is used in thermo chemistry as the standard state for defining the heat of formation of carbon compounds. Graphite may be considered the highest grade of coal, although it is not normally used as fuel because it is hard to ignite. The Advantage using graphite is it light in weight and stiffer, in theory, the lighter weight and stiffness of the graphite will allow your car to be faster and more responsive

Figure 2.14: Carbon fibre chassis

2.3.3 Aluminium

Aluminium is a silvery white member of the boron group of chemical elements. Aluminium is the most abundant metal in the Earth's crust. Aluminium is remarkable for the metal's low density and for its ability to resist corrosion due to the phenomenon of passivation. Structural components made from aluminium and its alloys are vital to the aerospace industry and are very important in other areas of transportation and building. Its reactive nature makes it useful as a catalyst or additive in chemical mixtures, including ammonium nitrate explosives, to enhance blast power.

The exceptionally sturdy body shell and high proportion of aluminium components provide the foundation for the supreme sporting performance of the chassis. The even distribution of weight between the front and rear axles maintains maximum traction for all wheels to ensure optimum performance. Aluminium has excellent corrosion resistance. This is due to our experience with very weak sheet materials used for body work or anodized parts. Using Aluminium (to an identical design) the weight will be reduced to one third compare to stell.

The main problem with Aluminium is that it has relatively low fatigue strength and unlike most ferritic steels it does not have an "endurance limit". The endurance limit is the stress at which fatigue failure will never occur. Aluminium will always fatigue even if stresses are very low. In practice it may take millions of cycles for this to occur and it may not be of any practical significance but you would need to consider the fatigue loading of every critical chassis joint and pick-up point to be confident.

Figure 2.15: Aluminium chassis

CHAPTER 3

METHODOLOGY

3.1 Introduction

Methodology can properly refer to the theoretical analysis of the methods appropriate to a field of study or to the body of methods and principles particular to a branch of knowledge. In this sense, one may speak of objections to the methodology of a geographic survey (that is, objections dealing with the appropriateness of the methods used) or of the methodology of modern cognitive psychology (that is, the principles and practices that underlie research in the field). In recent years, however, methodology has been increasingly used as a pretentious substitute for method in scientific and technical contexts, as in the oil company have not yet decided on a methodology for restoring the beaches. People may have taken to this practice by influence of the adjective methodological to mean "pertaining to methods." Methodological may have acquired this meaning because people had already been using the more ordinary adjective methodical to mean "orderly, systematic." But the misuse of methodology obscures an important conceptual distinction between the tools of scientific investigation (properly methods) and the principles that determine how such tools are deployed and interpreted.

3.2.1 First design

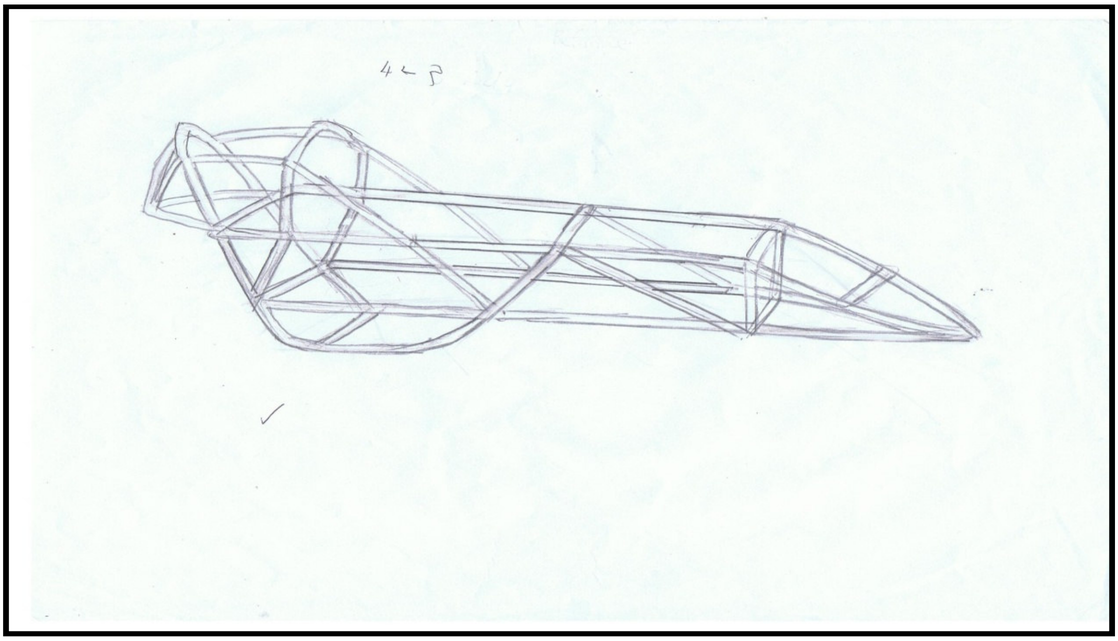


Figure 3.1:First design

Advantages :

The rounded portion above the driver’s head would protect the driver.

Have arodynamics shape

Disadvantages :

The frame leaves plenty of open room in front of where the driver sits so that driver can throughout if accidents happen.

3.2.2 Second design

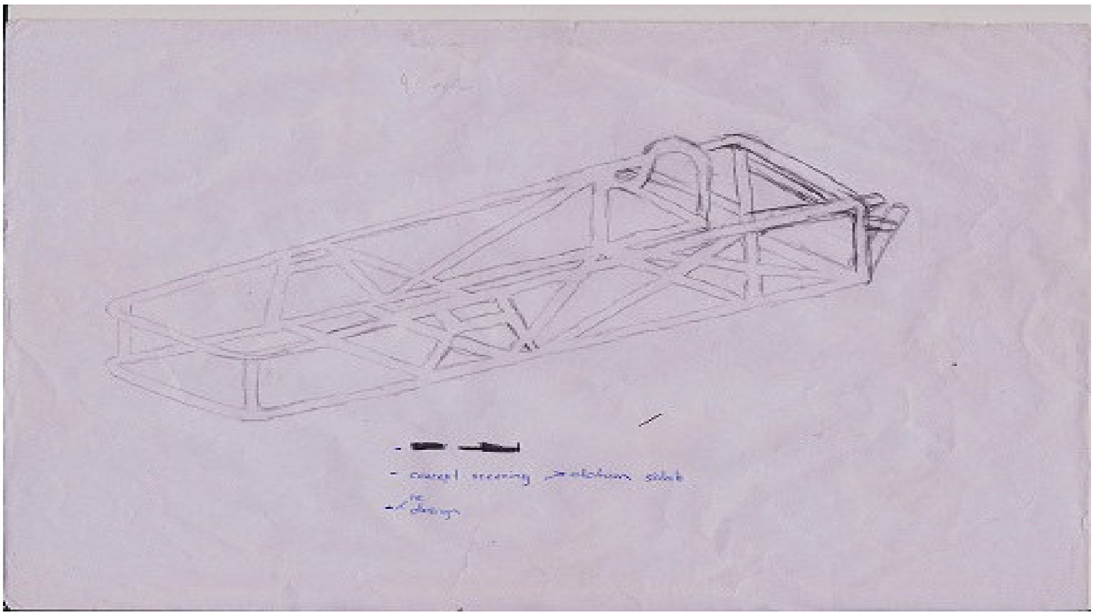


Figure 3.2:second design

Advantages :

Driver would be left untouched inside

Enough room for other parts.

Disadvantages :

Shape do not have aerodynamics.

Too much bars and need accurate dimension.

3.2.3 Third design

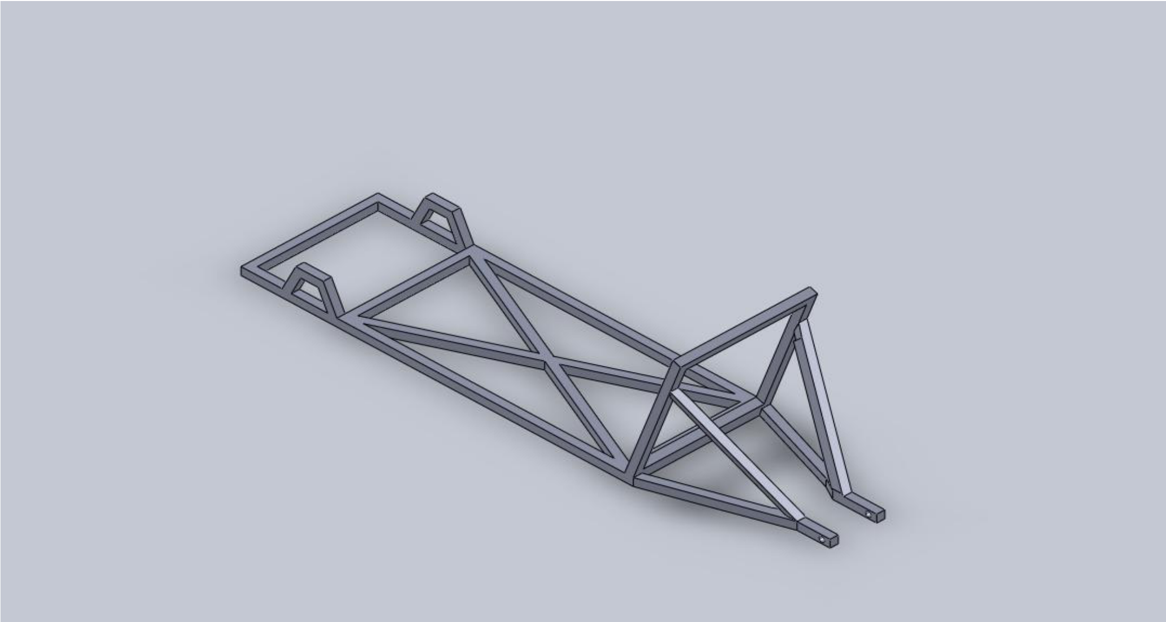


Figure 3.3:Third design

Advantages :

Enough room space for driver.

Side bar will protect driver from side impact.

Disadvantages :

Have sharp edge.

3.2.4 Fourth design

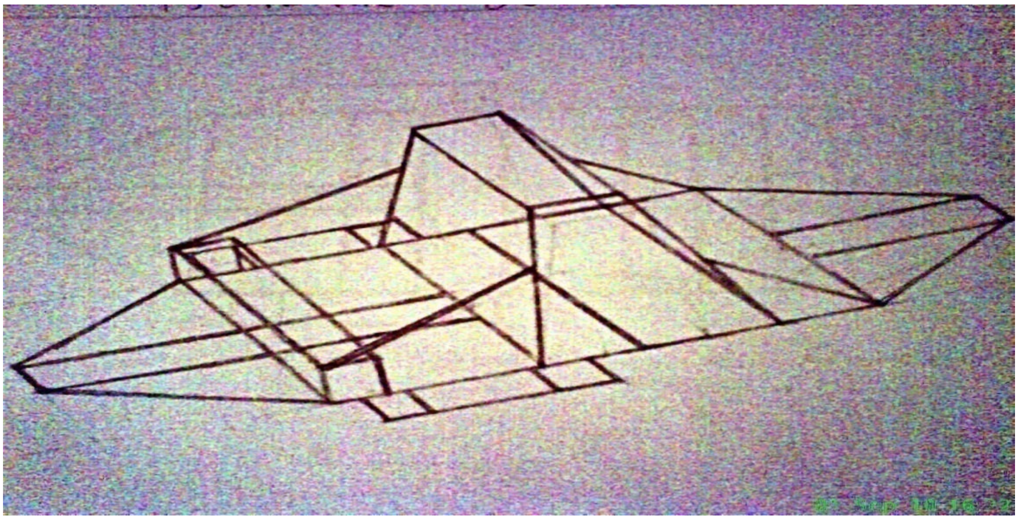


Figure 3.4:fourth design

Advantages :

Driver room can enter by any size of person

Disadvantages :

To simple.

Room for parts to small

3.3 Concept Screening

When making decisions about alternatives systems that may be used in various situations in the workplace, a problem that is often faced is that there are many different opinions. This can result in long meetings and protracted arguments that lead to unsatisfactory or compromise choices.

Invented by Stuart Pugh the decision-matrix method, also Pugh method is a quantitative technique used to rank the multi-dimensional options of an option set. Each option then has its score totaled to show its overall score relative to the base option (datum). It is frequently used in engineering for making design decisions but can also be used to rank investments options, vendor options, product options or any other set of multi dimensional entities.

The advantage of this concept is that subjective opinions about one alternative versus another can be made more objective. An example of this might be to see how much your opinion would have to change in order for a lower ranked alternative to out rank a competing alternative.

Characteristic	Design			
	1(datum)	2	3	4
Lightweight	0	+	+	+
Size	0	-	-	0
Driver's seat space	0	-	+	+
Driver's protection	0	-	0	-
No. of bars	0	+	+	0
Room for parts	0	-	-	+
Shape (aerodynamics)	0	+	+	-
Sum of (+)	0	3	4	3
Sum of (0)	3	0	1	2
Sum of (-)	0	4	2	2
Net Score	0	-1	2	1
Rank	3	4	1	2

Notes:
+= Better than
- = Worse than
0 = Same as

Table 3.1: Concept Screening

3.4 Finalize design

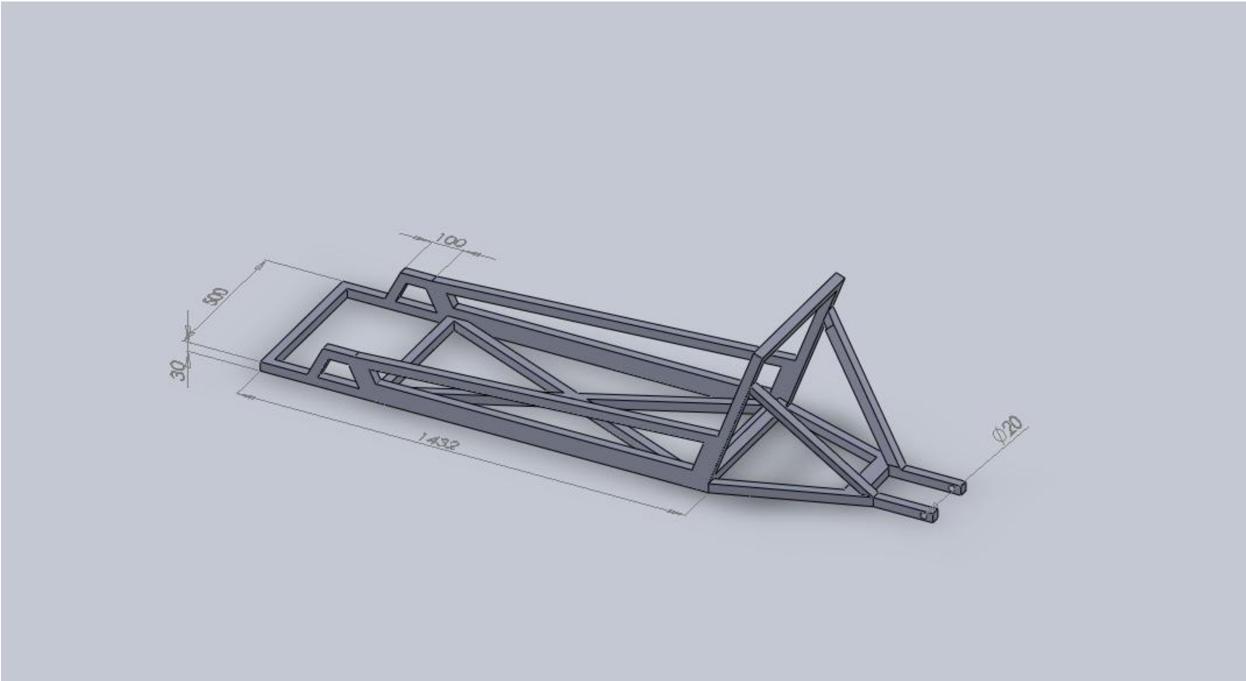


Figure 3.5 : Design selected in Solid Work drawing

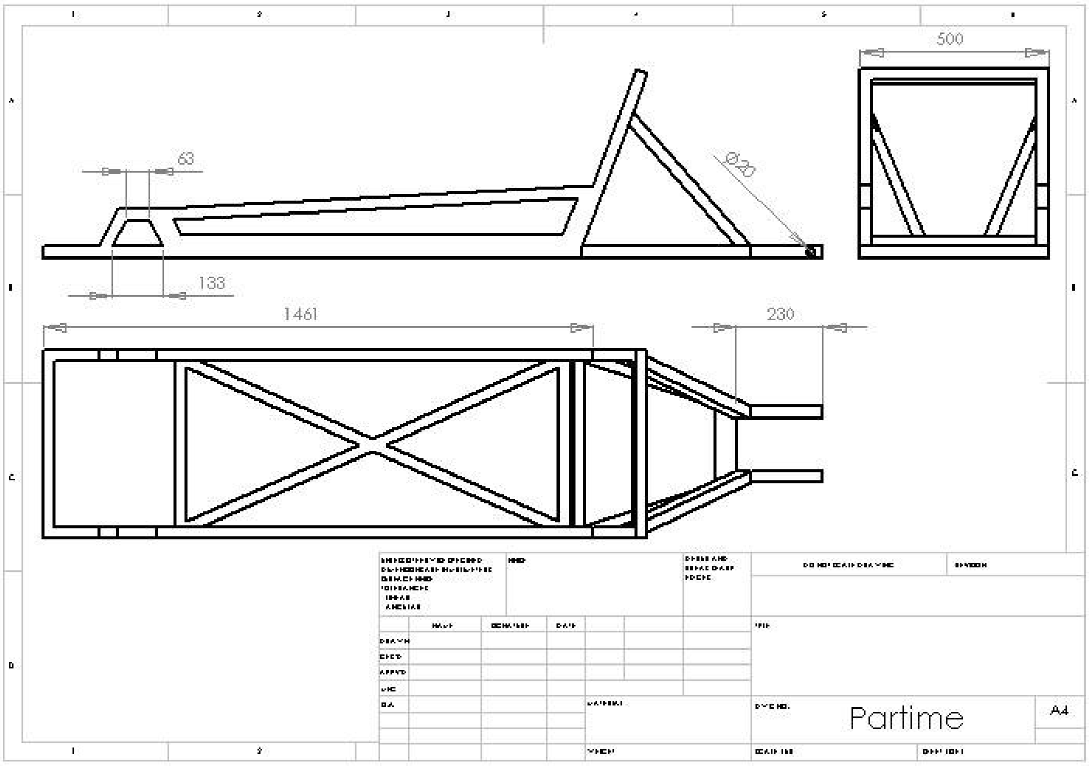


Figure 3.6 : Design selected in 2D drawing

3.5 Product Design Specification

(a) Product title

Solar car chassis

(b) Purpose

To support load of driver and other parts.

(c) New or special features

- Safety requirement installed.
- Light in weight.
- Strong enough to support load that applied.

(d) Competition.

Will compete against other chassis.

(e) Relationship to existing products line.

Generate from existing product.

(f) Functional performance

- Safe to driver
- Can support heavy load

3.6 Parts Weight

Parts	Weight	Type
Batery	25 Kg	Kokam Lithium Polymer, 130 volts 6P31S,
Seat	8 Kg	Molded fiberglass
Motor + controller	35Kg	Permanent magnet brushless DC (PM-BLDC) motor
Pilot	50Kg	-

Table 3.2: Parts weight

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

The final design was selected. This chapter will discuss mainly about the analysis of the project and the result. I am using Algor 2009 for analysis the design. The design test with load applied including pilot, seat and battery. The result is it maximum stress and strain and also the displacement for each load.

4.2 RESULT

After apply 75 Kg loads for the driver, the result shown as the figure above:

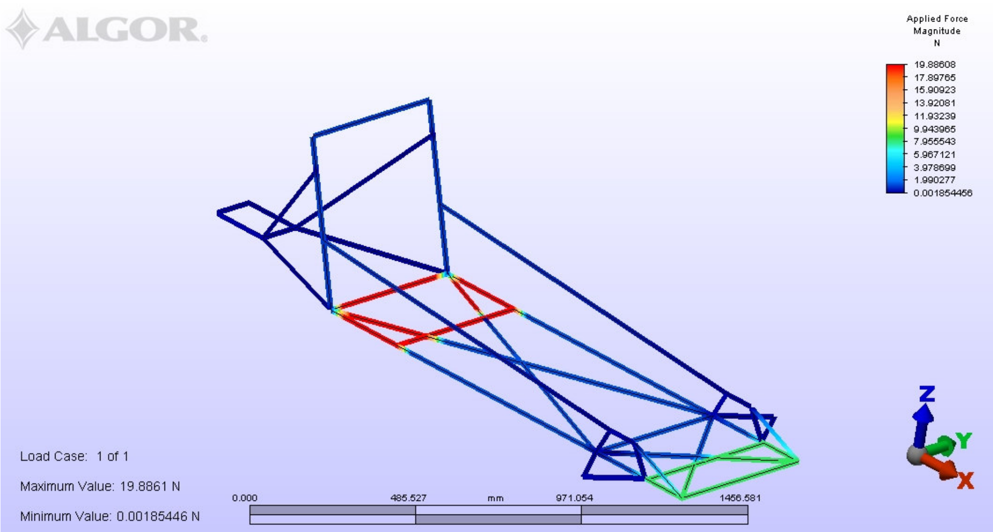


Figure 4.1: Applied force magnitude (N)

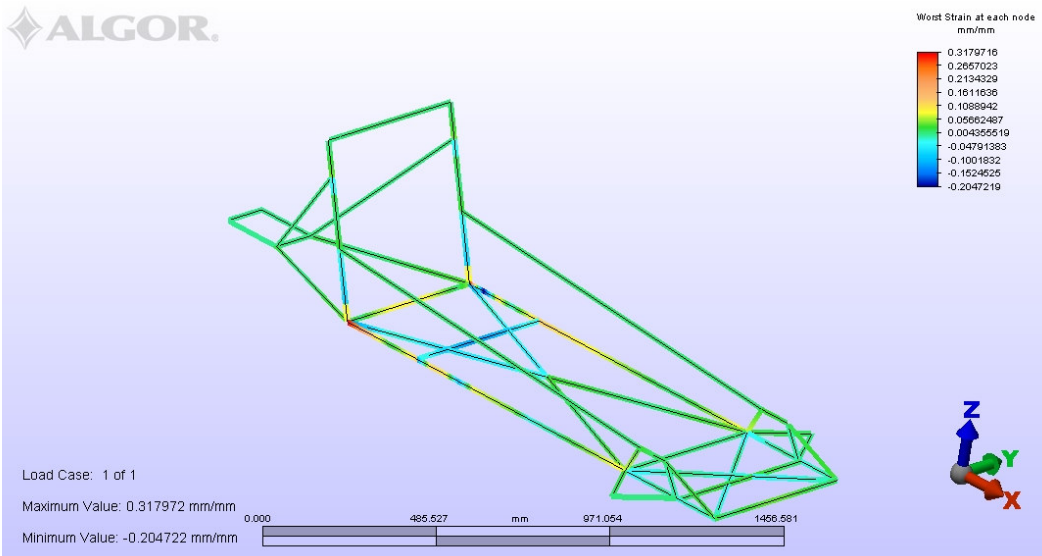


Figure 4.2: Worst strain (mm)

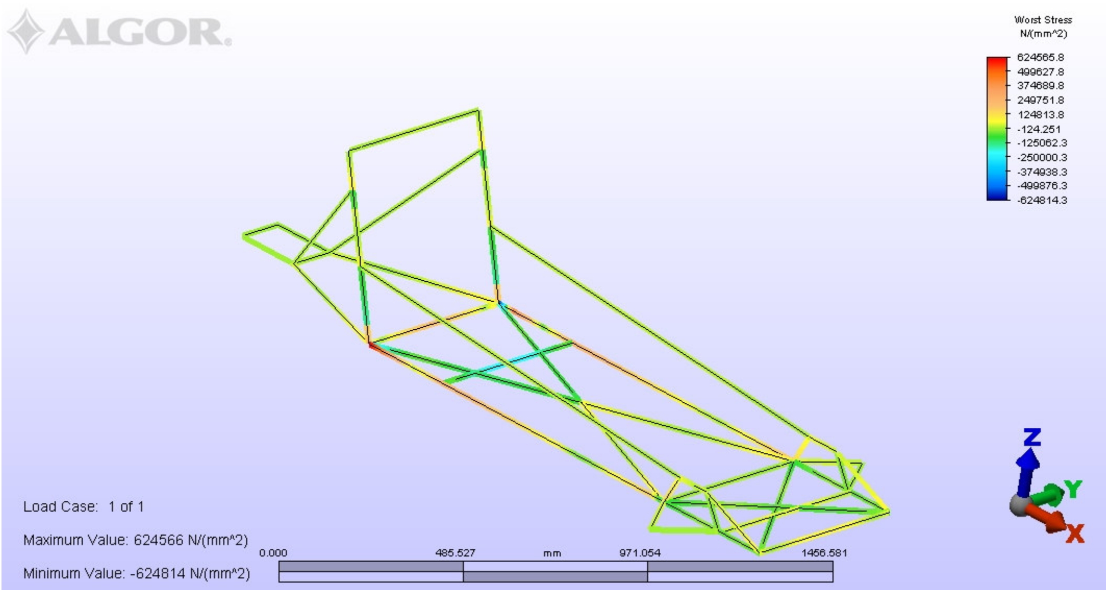


Figure 4.3: Worst stress (N/mm^2)

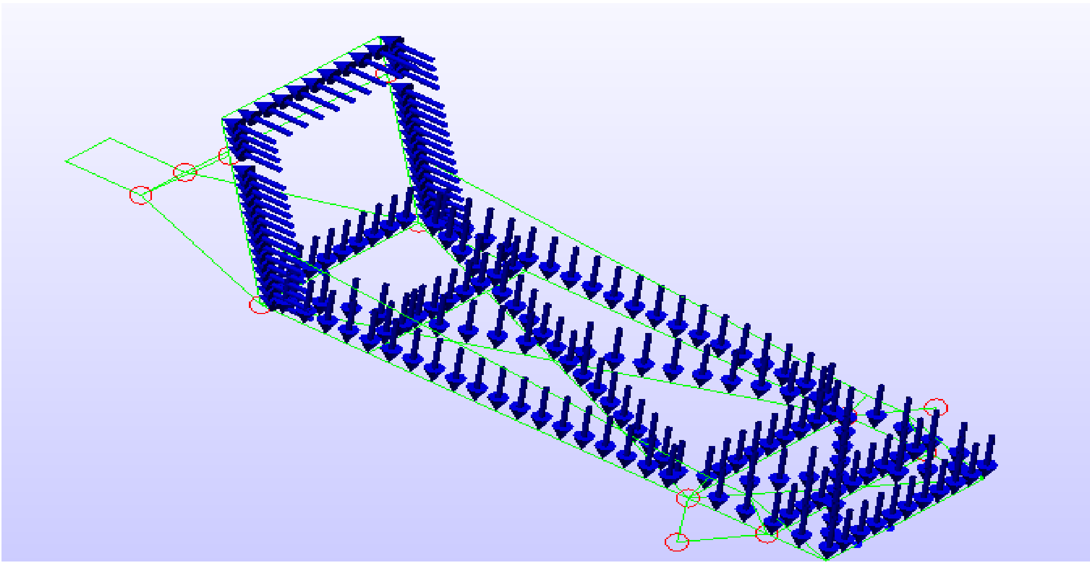


Figure 4.4: Nodal Force

4.2.1 Design Specification

The design specification is shown on the table below

CATEGORIES	DIMENSION
Length	2094mm
Width	720mm
Height	500mm
Weight	35 Kg
Type of material	Aluminium 6061-T6; 6061-T651

Table 4.1**:** Design Specification

4.3 DISCUSSION

In this analysis, several issues have been done with respect to the analysis of the solar car chassis. The outcome analysis was achieving the objective of this project. The Solar car chassis can hold driver's maximum weight at 75 Kg.

Result of the analysis show below:

DRIVER WEIGHT	MAX STRESS	MAX STRAIN	MAX FORCE APPLIED
50 Kg	428862 N/mm^2	0.218 mm	13.25 N
55 Kg	468171 N/mm^2	0.238 mm	14.58 N
60 Kg	507184 N/mm^2	0.258 mm	15.90 N
65 Kg	546492 N/mm^2	0.278 mm	17.23 N
70 Kg	585506 N/mm^2	0.297 mm	18.55 N
75 Kg	624566 N/mm^2	0.3179 mm	19.88 N

Table 4.2: Result of analysis

During analysis process, there are so many things happen such as error. This error happens because lacks of skill using this software. Although this problem happened, I take that as challenge for me to doing well at next time.

4.3.1 Material

From the analysis, maximum stress for 75 Kg driver's weight is 624566 N/mm^2 and it quite higher for small chassis. My suggestion is to reselect the material for the chassis. Using strong material such as stainless steel but it increase the total weight of the chassis. This chassis using aluminium 6061.Aluminium will always fatigue even if stresses are very low. In practice it may take millions of cycles for this to occur and it may not be of any practical significance but it would need to consider the fatigue loading of every critical chassis joint and pick-up point to be confident.

It's been called the automotive engineer's dream material. Able to assume any shape while delivering stiffness, strength and light weight, carbon fiber has been the material of choice for years in structural components and stylishly aerodynamic exterior panels on race cars and exotic supercars costing more. Yet carbon's use in production vehicles still appears to be a long way off, given high fiber prices and relatively slow production rates.

Material	Yield strength (MPa)	Ultimate strength (MPa)	Density (g/cm³)	free breaking length (km)
ASTM A36 steel	250	400	7.8	3.2
Steel, API 5L X65[8]	448	531	7.8	5.8
Steel, high strength alloy ASTM A514	690	760	7.8	9.0
Steel, prestressing strands	1650	1860	7.8	21.6
Piano wire		2200–2482 [9]	7.8	28.7
Carbon Fiber (CF, CFK)		5650 [10]	1.75	
High density polyethylene (HDPE)	26-33	37	0.95	2.8
Polypropylene	12-43	19.7-80	0.91	1.3
Stainless steel AISI 302 - Cold-rolled	520	860		
Cast iron 4.5% C, ASTM A-48[11]	*	172	7.20	2.4
Titanium alloy (6% Al, 4% V)	830	900	4.51	18.8
Aluminium alloy 2014-T6	400	455	2.7	15.1

Table 4.3: Typical yield and ultimate strengths

Based on the table, titanium alloy have higher ultimate strength. It can support load better than aluminium but it will increase the cost of the chassis

4.3.2 Bars

4.3.2.1 Lower Arm Bars

The lower arm bar is designed to reduce the flex of the vehicle chassis where it is connected by the Lower wishbone of the suspension system, thus to lessen the distortion of the vehicle lower suspension when it is under load, especially during hard cornering. It is installed at the lower mounting points between the left and right suspension and the vehicle chassis. Tremendously improving the stiffness at the area where the lower arm is connected to the vehicle chassis. The lower arm bar also keeps camber accurate during hard cornering.

4.3.2.2 Front Fender Bars

As most of the vehicle's front chassis over hanging is designated to carry the vertical loads from the front suspensions, it is vital that this part of the chassis is strong enough to take the bounce and rebound force of the suspension. Else, the effort of a good suspension will lose its meaning if the chassis absorbs all the forces from the suspension and not letting the suspension does what it suppose to do.

Therefore, these high quality 3-Point Fender Bars strengthen and reinforce these essential areas of your car and help maintain the suspension in position from all kind of vertical loads so this chassis need to add more bars in order for load not focus to one point.

Advantages of the fender bar:

- Improve handling, stability at high speed and cornering, hence safer driving.
- Provide a better braking and stopping performance.
- Reduce NVH (Noise, Vibration and Harshness).
- Increase stiffness of vehicle front chassis.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

As conclusion, I have achieved both design and analysis the solar car chassis. I manege to fullfill the scope of the project by designing the solar car chassis that light in weight but strong enough to withstand the load and it come with safety requirement for the driver.

The main objectives of this study which is to design and analysis solar car chassis is accived.

5.2 Recommendation

5.2.1 Future project

Firstly, I would like to recommend to University authority whereby they should continues this project in developing solar car. It an excellent opportunity to develop future technologies especially in transpotation and it can replace nowdays car that using fuel. It also for the better environment. Setup a team with experient people in automotive may became the first step.

5.2.2 Group Project

Solar car chassis is not just ordinary project.It require more time and experience to finish it.This project need to do in group in order to get better result.I suggest Faculty to select more suitable project title for Diploma student.It must suit with our learning outcome.

5.2.3 Time Frame

The time frame completing this project is very short. This could be avoided if the management had completing the setup of computer for analysis at the lab. In this case, students would have to search for the own software by downloading at internet or bought the DVD. So, the managemant had to be prepare the computer with that software instaled.

REFERENCES

Available from en.wikipedia.org/wiki/Carbon_fiber- reinforced_polymer

Available from en.wikipedia.org/wiki/Monocoque.

Available from en.wikipedia.org/wiki/Space_frame

Available from calfeedesign.com/whitepaper4.html

Available from erareplicas.com/misc/stress/deslogic.htm

Available from mycyclingsource.com/advantages-carbon-fiber-road-bikes.html

Available from speedace.info/solar_car_anatomy.htm

John, C. (2009) Gideon's torch vehicle impact analysis. Available from cse.taylor.edu/~physics/solarcar/structrep/report.html

Mybeck, I. (2010) Principia Solar Car. Available from principiasolarcar.com/the-car/chassis

Nelson, K. (2005) Solar Car Anatomy – The Chassis or Frame. Available from speedace.info/solar_car_anatomy.htm

APPENDIX A

Gantt Chart

ACTIVITIES	WEEK														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Title Selection, Scope, Objective															
Literature Review and Identify Problem															
Sketching Design And Select Final Design															
1st Draft Summation															
Pre-Presentation															
Analysis															
Final Presentation															
Final report															

Planning

Actual

APPENDIX B

DRAWING