

DESIGN AND ANALYSIS OF CAR CHASSIS

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ABSTRACT

This project concerns on the assessment on making an analysis of the car chassis will fit all aspects and concepts according to the rules of Eco Marathon Challenge. The objective of this project to design and analyse of car chassis. To avoid any possibilities of failure of the structure and thus to provide enough supporting member to make the region stronger in term of deformation. Finite element analysis enables to predict the region that tends to fail due to loading. Besides that, need to utilize the feature of CAE software named as FEMPRO to get the distribution of stress and strain on the chassis, both component as well as the material costing. The main objective is to study the effect of load that applied in term of driver weight, the car body and the equipment.

ABSTRAK

Projek ini menekankan pembelajaran berkenaan dengan cara-cara menganalisa terhadap casis kereta berdasarkan undang-undang yang terdapat di dalam pertandingan Shell Eco Marathon. Objektif projek ini ada untuk membuat rekaan dan menganalisa casis kereta. Untuk menghindarkan sebarang kemungkinan kegagalan struktur casis kereta dan membrikan sokongan yang secukupnya kepada casis kereta. Analisa “Finite element” membantu untuk mengesan kawasan yang berkemungkinan akan gagal. Perisian CAE atau FEMPRO digunakan untuk mendapatkan taburan “stress” dan “strain”. Tambahan pula, tujuan utama adalah untuk menelaah kesan bebanan hasil daripada berat pemandu, berat body dan berat kelengkapan tambahan.

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LIST OF SYMBOLS, ABBREVIATIONS AND NOMENCLATURE

σ	True Stress, Local Stress
δ	Displacement Magnitude
ε	True Strain, Local Strain
%	Percent
K_B	Bending Stiffness
K_T	Torsion Stiffness
$^{\circ}\text{C}$	Degree Celsius
$^{\circ}\text{F}$	Degree Fahrenheit
Cr	Chromium
Fe	Iron
Mg	Magnesium
Mn	Manganese
Si	Silicon
Ti	Titanium
Cu	Copper
Al	Aluminium
Zn	Zinc
C	Carbon
S	Sulphur
θ	Angle
CAE	Computer-aided Engineering
FEA	Finite Element Analysis

FYP	Final Year Project
UMP	Universiti Malaysia Pahang
AA	Aluminium Alloy
SUV	Sport Utility Vehicle
USA	United States of America
3D	Three-dimensional

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Many types of pollution such as water pollution, noise pollution, thermal pollution and air pollution. Air pollution can be considered as one of the main hazard to the health of human being. The air pollution is due to the increasing number of vehicle use by human. When the number of vehicle increase, the usage of the petrol increase respectively. The lack of the source of the petrol makes the price increase by time to time. The emission from the vehicle makes the environment faces the air pollution that in critical level.

Many steps need to reduce the number of the vehicle in other side to reduce the price of the petrol. Besides that also use to reduce the air pollution. The big number of vehicles in each country makes the prevention to reduce the number of vehicle difficult. So, the other prevention is increase the efficiency of the vehicle's engine. When the engine at the efficient level, the emission is at the low level and the most important is the usage of petrol is low. The prevention is reducing the weight of the body and chassis of each vehicle.

This project focused to reduce the usage of petrol by design and analysis the chassis to reduce the weight of the chassis of vehicle. At the same time, the global usage of the petrol also reduced.

1.1 PROBLEM STATEMENT

Nowadays, the usage of transport increasing day to day on the road. The number increase due to those people that usually choose to use own vehicle than public transport. When the vehicle number increase, the price of petrol (fuel) also increase. At the same time, the emissions from the vehicles increase the air pollution. The prevention steps need to reduce the number of car and price of petrol. Cars emitted high emission and use high amount of petrol when the cars have bigger weight. Preventive step by reducing the weight of the body and chassis can reduce the usage of petrol.

1.2 OBJECTIVES

1.2.1 General Objectives

The objective of this project is to expose to the student on the process of design and analysis of a product. In addition, student also able to apply their knowledge and their skill that have learnt during class and outside class. Besides, student also can add their knowledge by make this project. The project challenge the student to do research and solving any problem that will be appeared towards a successful project.

Student able to practice his own soft skill on how to communicate well wit person to person by the presentation section. Besides, it can train student's capability in answering, questioning, researching, evaluating, data gathering, decision making, planning and problem solving by the research during this project.

From this project, student able to make a good research in technical writing. Furthermore, this project can encourage the student how to be more independent in searching, detailing, and expanding their knowledge and also have own experience under minimal supervisory.

1.2.2 Specific Objectives

The main objectives of this project are as follows:

- i. To evaluate current chassis
- ii. To redesign car chassis
- iii. To analyze in term of structure failure using Algor software

1.3 SCOPES

- i. This car is designed for Shell Eco Marathon Challenge (Asia) for 2012 in prototype category.
- ii. Design stage for this project using Solidworks software.
- iii. Algor software is used to analyze the stress at the car chassis.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Basically chassis is considered as a framework to support the body, engine and other parts which make up the vehicle. Chassis lends the whole vehicle support and rigidity. Chassis usually includes a pair of longitudinally extending channels and multiple transverse cross members that intersect the channels. The transverse members have a reduced cross section in order to allow for a longitudinally extending storage space. The chassis has to contain the various components required for the race car as well as being based around a driver's cockpit. The safety of the chassis is a major aspect in the design, and should be considered through all stages. Generally, the basic chassis types consist of backbone, ladder, spaceframe and monocoque. Different types of chassis design result the different performance.

2.2 Terminology

The propose of car chassis is to maintain the shape of the vehicle and to support the various loads applied to it. The structure usually accounts for a large proportion of the development and manufacturing cost in new vehicle programme and many different structural concepts are available to the designer. It is essential that the best one is chosen to ensure acceptable structural performance within other design constraints such as cost, volume and method of production, product application and many more. Assessments of the performance of a vehicle structure are related to its strength and stiffness. A design aim is to achieve sufficient levels of these with as little mass as possible. (Jason, 2002)

2.2.1 Strength

The strength requirement implies that no part of the shape will lose its function when it is subjected to road loads. Loss of function may be caused by instantaneous overloads due to extreme load cases, or by material fatigue. Instantaneous failure may be caused by either overstressing of components beyond the elastic limit, or by buckling of items in compression or shear stress, or by failure of the joints.

The life to initiation of fatigue cracks is highly dependent on design detail, and can only be assessed when a detailed knowledge of the component is available. For this reason assessment of fatigue strength is usually deferred until after the conceptual design stage.

The strength may be alternatively defined as the maximum force which the structure can withstand. Different load cases different local component loads, but the structure must have sufficient strength for all load cases. (Jason, 2002)

2.2.2 Stiffness

The stiffness of the structure relates the deflection produced when load is applied. It applies only to structures in the elastic range and is the slope of the load versus deflection graph.

The stiffness of a vehicle structure has important influence on its handling and vibrational behaviour. It is important to ensure that deflection due to extreme loads is not so large to impair the function of the vehicle, for an example so that the doors will not close, or suspension geometry is altered. Low stiffness are lead to unacceptable vibrations, such as 'scuttle shake'. (Jason, 2002)

Again different load cases require different stiffness definitions, and some of these are often used as ‘benchmarks’ of vehicle structural performance. The two most commonly used in this way are (Jason, 2002):

- a) Bending stiffness K_B , which relates the symmetrical vertical deflection of a point near the centre of the wheelbase to multiples of the total static loads on the vehicle. A simplified version of this to relate the deflection to a single, symmetrically applied load near the centre of the wheelbase.
- b) Torsion stiffness K_T , relates the torsional deflection θ of the structure to an applied pure torque T about the longitudinal axis of the vehicle. The vehicle is subjected to the ‘pure torsion load case’. Twist angle is measured between the front and rear suspension mountings. Twist at intermediate points along the wheelbase is sometimes also measured in order to highlight regions of the structure needing stiffening.

The two cases apply completely different local loads to individual components within the vehicle. It is usually found that the torsion case is the most difficult to design for, so that the torsion stiffness is often used as a benchmark to indicate the effectiveness of the vehicle structure. (Jason, 2002)

2.2.3 Vibrational behaviour

The global vibrational characteristics of a vehicle are related to both its stiffness and mass distribution. The frequencies of the global bending and torsional vibration modes are commonly used as benchmarks for vehicle structural performance. These are not discussed in this book. However, bending and torsion stiffness K_B and K_T influence the vibrational behaviour of the structure, particularly its first natural frequency. (Jason, 2002)

2.2.4 Selection of vehicle type and concept

In order to achieve a satisfactory structure, the following must be selected (Jason, 2002):

- a) The most appropriate structural type for the intended application.
- b) The correct layout of structural elements to ensure satisfactory load paths, without discontinuities, through the vehicle structure.
- c) Appropriate sizing of panels and sections, and good detail design of joints.

An assumption made in this book is that is satisfactory load path (i.e. if the equilibrium of edge forces between simple structural surfaces) are achieved, then the vehicle is likely to have the foundation for sufficient structural (and especially torsion) stiffness. Estimate of interface loads between major body components calculated by the simplified methods described are assumed to be sufficiently accurate for conceptual design although the structural members comprising load paths must still be sized appropriately for satisfactory results. Early estimates of stiffness can be obtained using the finite element method, but the results should be treated with caution because of simplifications in the idealization of the structure at this stage. (Jason, 2002)

2.3 TYPE OF CHASSIS

Chassis is considered to be one of the significant structures of an automobile. It is usually made of a steel frame, which holds the body and motor of an automotive vehicle. To be precise, car chassis or automobile chassis is a skeletal frame which bolts various mechanical parts like engine, tires, brakes, steering and axle assemblies. Chassis usually made of light metal or composite plastic which provides strength needed for supporting vehicle components and load into it. Here I listed several different types of automotive chassis which include ladder chassis, backbone chassis, monocoque chassis and tubular space frame chassis (Wakeham, 2009).

Ladder chassis is considered to be one of the oldest forms of automotive chassis or automobile chassis that is still been used by most of the SUVs till today. It is also resembles a shape of a ladder which having two longitudinal rails inter linked by several lateral and cross braces. The lateral and cross members provide rigidity to the structure (Wakeham, 2009).

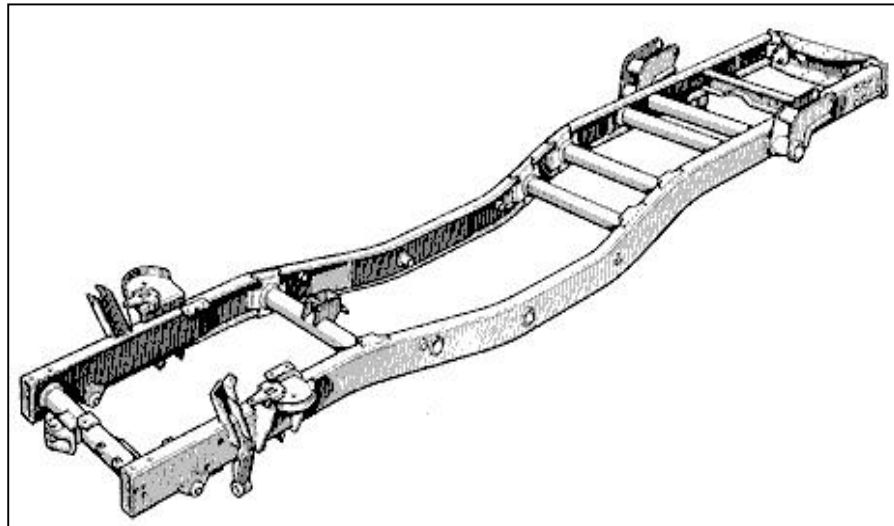


Figure 2.1: Ladder chassis

Source: (Moginalong, 2010)

The other type of chassis is backbone chassis which has a rectangular tube like backbone and simple in structure. It usually made up of glass fiber that is used for joining front and rear axle together and responsible for most of the mechanical strength of the framework. The space within the structure is used for positioning the drive shaft in case a rear-wheel drive. Furthermore, the drive train, engine and suspensions are all connected to each of the ends of the chassis. This type of chassis is strong enough to provide support smaller sports car besides it is easy to make and cost effective (Wakeham, 2009).

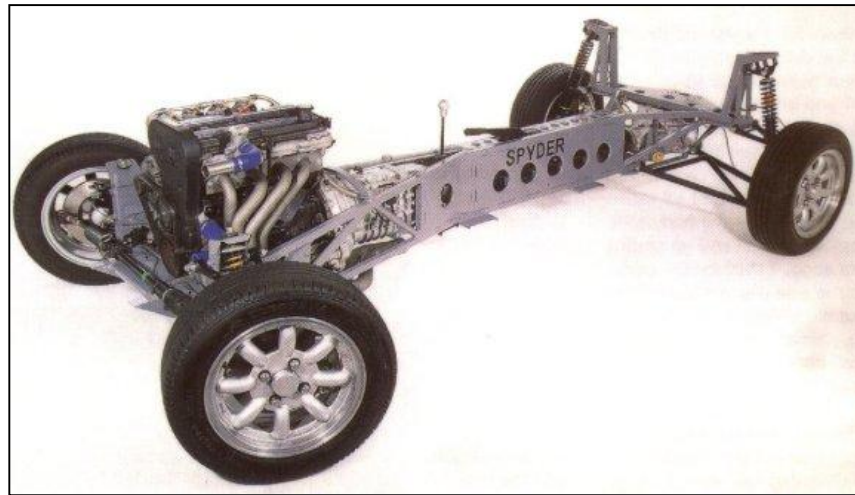


Figure 2.2: Backbone chassis

Source: (Which K, 2002)

As for monocoque chassis, most modern cars nowadays use this type of chassis. A monocoque chassis is a single piece of framework that gives shape to the car. A one-piece chassis is built by welding several pieces together. It is different from the ladder and backbone chassis as unlike them incorporated with the body in a single piece, whereas the former only support the stress members. The demanding of a monocoque chassis highly increased since it is cost effective and suitable for robotized production (Christopher, 2004).



Figure 2.3: Monocoque chassis

Source: (Mark Wan, 2000)

In this study, it is decided that tubular space frame chassis is used for the urban car. Since ladder chassis is not strong enough, motor racing engineers have developed a 3-dimensional design which known as tubular space frame. Tubular space frame chassis employs dozens of circular-section tubes (some may use square-section tubes for easier connection to the body panels though circular section provides the maximum strength), position in different directions to provide mechanical strength against forces from anywhere. These tubes are welded together and form a complex structure. For higher strength required by high performance sports cars, tubular space frame chassis usually incorporate a strong structure under both doors. Tubular space frame chassis also very strong in any direction compared with ladder chassis and monocoque chassis of the same weight.



Figure 2.4: Spaceframe chassis

Source: (Wan, 2000)

2.4 CHASSIS DESIGN PRINCIPLE

The fundamental principle of a chassis design states that the chassis is to be designed to achieve the torsional rigidity and light weight in order to achieve good handling performance of a race car. By the definition, torsional rigidity is refers to the ability of chassis to resist twisting force or torque. In the other words, torsional

rigidity is the amount of torque required to twist the frame by one degree. These parameters also applied to spaceframe chassis. Generally, the effect of the torsional rigidity on spaceframe is different to the monocoque due to their construction format, but the structure is used to approximate the same results as the difficult to twist monocoque chassis. Figure 2.5 shows the torsional rigidity applies to race car chassis. (Matt, 1999).

According to the statement above, chassis designed must have high torsional rigidity in order against the twisting force or torque. In order to increase torsional rigidity on the chassis, the format of tube pipes arrangement must be considered. By strategically positioning a frame member, torsional rigidity increase significantly.

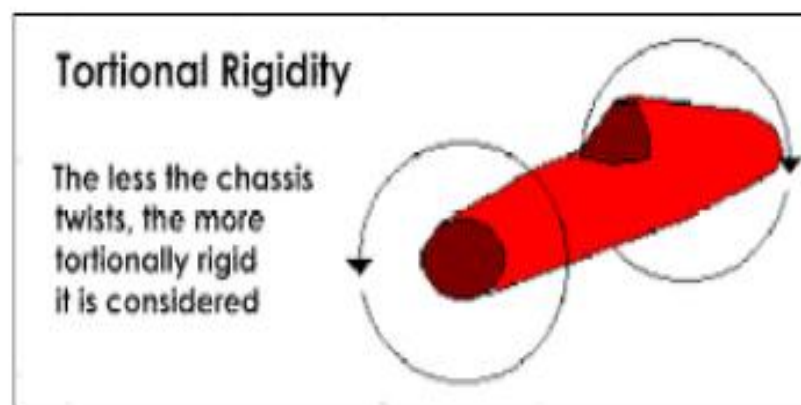


Figure 2.5: Torsional rigid of car chassis

Source: (Matt, 1999)

The triangulated box imparts strength by stressing the diagonal in tension and compression. As shown, the box will not easily deformed by bending force due to the triangulated format of frame. Hence, most race car chassis today designed in triangulated format as shown in Figure 2.6 below. (Matt, 1999).

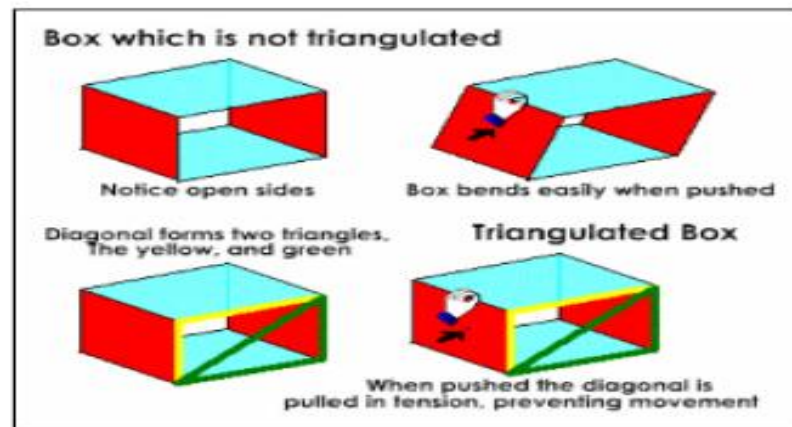


Figure 2.6: The strategy on positioning spaceframe number

Source: (Matt, 1999)

2.5 MATERIALS

Different chassis materials can reduce the weight of the vehicle, improving the vehicle power to weight ratio. Material selection can also provide advantages by reducing member deflection, increasing chassis strength and can determine the amount of reinforcement required.

2.5.1 STAINLESS STEEL

Stainless steel is selected as engineering material mainly because of their excellent corrosion resistance in many environments. The corrosion resistance of stainless steel is due to their high chromium contents. In order to make a “stainless steel” stainless, there must be at least 12 percent chromium (Cr) in the steel. According to the classical theory, chromium forms a surface oxide that protects the underlying iron-chromium alloy from corroding. To produce the protective oxide, the stainless steel must be exposed to oxidizing agents. (William, 2006). In the design principles, 317 is a higher chromium, nickel and molybdenum version of 316 stainless designed principally for increased strength and corrosion resistance. Machinability for this type of stainless steel is Low speeds and constant feeds will minimize this alloy's tendency to work hardens. Tougher than 304 stainless with a

long stringy chip, the use of chip breakers is recommended. Welding process can be using all common fusion and resistance methods except oxyacetylene welding have proven successful. Use AWS E/ER317 or 317L filler metal for best results. All common hot working processes are possible with this alloy. Heat to 2100-2300°F (1149-1260°C). Avoid working this material below 1700°F (927°C). For optimum corrosion resistance, a post-work annealing is recommended and Shearing, stamping, heading and drawing can be successfully performed. To remove internal stresses, a post-work annealing is recommended. Mechanical properties and typical composition of Stainless Steel (AISI 317) is shown in Table 2.1 and Table 2.2.

Table 2.1: Mechanical properties of Stainless Steel (AISI 317)

Properties	Value and unit
Ultimate tensile strength	70 MPa
Density	8.0 g/cm ³
Modulus of elasticity	200 GPa
Shear strength	152 MPa
Yield strength (0.2% offset)	205 MPa
Melting point	1454 °C
Elongation	35%

Table 2.2: Typical composition of Stainless Steel (AISI 317)

Element	Value
Ni	11-14
Cr	18-20
C	0.08 max
Mo	3-4
Fe	Balance
Mn	2 max
Si	1 max
S	0.03 max
P	0.04 max

2.5.2 ALUMINIUM

Aluminium is a nonferrous material with very high corrosion resistance and very light material compared to steels. Aluminium cannot match the strength of steel but its strength-to-weight ratio can make it competitive in certain stress application. Aluminium can also be alloyed and heat treated to improve its mechanical properties, which then makes it much more competitive with steels however the cost increases dramatically. Pure aluminium is also a possible material and is reasonably affordable and very light but it is the weakest and requires extra reinforcement to produce a rigid chassis. Aluminium is very hard to work with as it requires very skilled welding and is an overall softer metal. Basically there are several types of aluminium. For this project, decide to test with Aluminium Alloy 6063-T6. Aluminium alloy 6063 is one of the most extensively used of the 6000 series aluminium alloys.

Aluminium Alloy 6063 is the least expensive and most versatile of the heat treatable aluminium alloys. It has most of the good qualities of aluminium. It offers a range of good mechanical properties and good corrosion resistance. It can be fabricated by most of the commonly used techniques. In the annealed condition it has good workability. The typical properties of aluminium alloy 6063 include medium to high strength, good toughness, good surface finishing, excellent corrosion resistance to atmospheric conditions, good workability and widely available. It is welded by all methods and can be furnace brazed. It is available in the clad form ("Alclad") with a thin surface layer of high purity aluminum to improve both appearance and corrosion resistance. This aluminum type is used for a wide variety of products and applications from truck bodies and frames to screw machine parts and structural components. 6063 is used where appearance and better corrosion resistance with good strength are required. Mechanical properties and typical composition of Aluminium Alloy 6063-T6 is shown in Table 2.3 and Table 2.4.

Table 2.3: Mechanical properties of Aluminium Alloy 6063-T6

Properties	Value and unit
Ultimate tensile strength	195MPa
Density	2.7 g/cm ³
Modulus of elasticity	69.5GPa
Shear strength	150 MPa
Yield strength (0.2% offset)	160 MPa
Melting point	600 °C
Elongation	14%

Table 2.4: Typical composition of Aluminium Alloy 6063-T6

Element	Value
Cr	0.1
Fe	0.35 max
Mg	0.45 - 0.9
Mn	0.1 max
Si	0.2
Ti	0.1 max
Cu	0.1max
Al	Balance
Zn	0.1 max

2.5.3 IRON

Iron is a lustrous, ductile, malleable, silver-gray metal (group VIII of the periodic table). It is known to exist in four distinct crystalline forms. Iron rusts in damp air, but not in dry air. It dissolves readily in dilute acids. Iron is chemically active and forms two major series of chemical compounds, the bivalent iron (II), or ferrous, compounds and the trivalent iron (III), or ferric, compounds. Iron is the most used of all the metals, including 95 % of all the metal tonnage produced worldwide. Thanks to the combination of low cost and high strength it is indispensable. Its applications go from food containers to family cars, from screwdrivers to washing machines, from cargo ships to paper staples.

Steel is the best known alloy of iron, and some of the forms that iron takes include: pig iron, cast iron, and carbon steel, and wrought iron, alloy steels, iron oxides. Iron is believed to be the tenth most abundant element in the universe. Iron is also the most abundant (by mass, 34.6%) element making up the Earth; the concentration of iron in the various layers of the Earth ranges from high at the inner core to about 5% in the outer crust. Most of this iron is found in various iron oxides, such as the minerals hematite, magnetite, and taconite.

The earth's core is believed to consist largely of a metallic iron-nickel alloy. Iron is essential to almost living things, from micro-organisms to humans. World production of new iron is over 500 million tonnes a year, and recycled iron adds other 300 million tonnes. Economically workable reserves of iron ores exceed 100 billion tonnes. The main mining areas are China, Brazil, Australia, Russia and Ukraine, with sizeable amounts mined in the USA, Canada, Venezuela, Sweden and India. Mechanical properties and typical composition of Iron (Fe) is shown in Table 2.3 and Table 2.4.

Table 2.5: Mechanical properties of Iron, Fe

Properties	Value and unit
Ultimate tensile strength	70 MPa
Density	7.9 g/cm ³
Shear strength	45 MPa
Yield strength (0.2% offset)	53 MPa
Melting point	1538°C
Young's modulus	211 GPa

Table 2.6: Typical composition of Iron, Fe

Element	Value
C	3.4
Mg	0.06
Mn	0.4 max
Ni	1.0
P	0.1 max

2.6 MATERIAL MECHANICAL CONCEPT

Many materials display linear elastic behaviour, defined by a linear stress-strain relationship, as shown in the figure up to point 2, in which deformations are completely recoverable upon removal of the load that is, a specimen loaded elastically in tension elongates, but it returns to its original shape and size when unloaded. Beyond this linear region, for ductile materials, such as steel, deformations are plastic. A plastically deformed specimen not returns to its original size and shape when unloaded. Note that there is elastic recovery of a portion of the deformation. For many applications, plastic deformation is unacceptable, and is used as the design limitation.

After the yield point, ductile metals undergo a period of strain hardening, in which the stress increases again with increasing strain, and they begin to neck, as the cross-sectional area of the specimen decreases due to plastic flow. In a sufficiently ductile material, when necking becomes substantial, it causes a reversal of the engineering stress-strain curve (curve A); this is because the engineering stress is calculated assuming the original cross-sectional area before necking. The reversal point is the maximum stress on the engineering stress-strain curve, and the engineering stress coordinate of this point is the tensile ultimate strength, given by point 1. The ultimate tensile strength is not used in the design of ductile static members because design practices dictate the use of the yield stress. It is, however, used for quality control, because of the ease of testing. It is also used to roughly determine material types for unknown samples.

In Figure 2.7 shows the stress vs. strain curve of a ductile material, at point number one (1) is the ultimate tensile strength, refer to the maximum stress that a material can withstand while being stretched or pulled before necking, which is when the specimen's cross section starts to significantly contract. At point number two (2) is yield strength, explained that the boundary between elastic region and plastic region. At the point number three (3) is point for the proportional limit stress, at this point explained that the amount of stress increasing proportional to the increasing of strain. Fracture occurred at the point number four (4). Fracture is the local separation of an object or material into two, or more, pieces under the action of stress. Lastly at point number five (5) is the offset strain (typically 0.2), this offset use in order to find the yield strength of material.

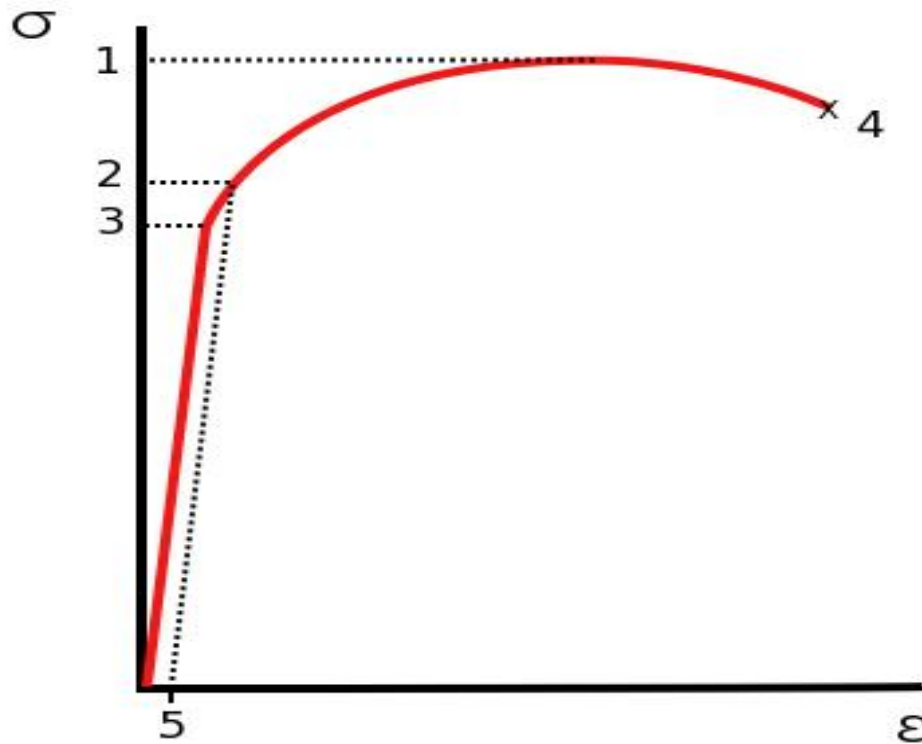


Figure 2.7: Stress vs. strain curve of ductile material

2.7 FINITE ELEMENT ANALYSIS (FEA) USING ALGOR

Finite Element Analysis (FEA) was first developed by R. Courant in 1943, who utilized the Ritz method of numerical analysis and minimization of variation calculus to obtain approximate solutions to vibration systems. FEA consists of a computer model of a material or design that is stressed and analyzed for specific results. It is used in new product design, and existing product refinement. A company is able to verify a proposed design will be able to perform to the client's specifications prior to manufacturing or construction. Modifying an existing product or structure is utilized to qualify the product or structure for a new service condition. In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition (Widas, 1997).

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Methodology can properly refer to the theoretical analysis of the methods appropriate to the field of study or to the body of methods and also principles particular to the 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 (the principles and practices that underlie research in the field).

Spaceframe more rigid to other chassis type, this is the reason race car usually use spaceframe chassis. The chassis not absolutely just a spaceframe chassis, but the combination between the monocoque and also the spaceframe chassis. As the result, driver and engine compartment, the combination reduces the weight of the car.

Theoretically, the chassis design concept state that the chassis designed must have the triangulated format of tubular pipes in order to increase the torsional rigidity of the chassis. But for the designing of the prototype car using spaceframe chassis for car, it is not important to follow this concept because the goals of the design is to have a lightweight car which can cruise further by using less amount of energy. It's mean that, the car will not go faster and not facing the twisting force or torque. The designer will ignore about the principle which is to place the frame members in a triangulated format as mentioned before.

3.2 THE DESIGN PROCESS

The engineering design process is the steps of chassis design construction process . In this chapter explain how chassis was designed and how stimulation of the chassis was performed. In this part, explained how chassis is performed. Before the last chassis design got, there are several steps must be considered to make the last result bring the best design. In this part, start from the sketching process, the n use SOLIDWORKS 2008 is used in order to create the model of the chassis. The analysis stage used ALGOR 23.1 to analyze the, model of chassis.

3.2.1 EVALUATING

Before start the projects, rough ideas and the steps proposed must be drafted to ensure the project within the planned steps. Evaluation process is important to ensure that the design needed have advantages guided from the current design. The ideas or steps can be gained from the evaluation of the current design (2011). The current design has square shape; square shape is not very good aerodynamic shape. The cockpit or driver compartment is not in sleep position. As shown in Figure 3.1.



Figure 3.1: Current design of Eco Marathon Challenge (2011)

The rough idea of the chassis designed is described by sketching the chassis as shown in Figure 3.2. The sketch describes more about monocoque type chassis. The sketch consist driver and engine compartments. Sketch describe the chassis have two tire for front and one tire of rear.

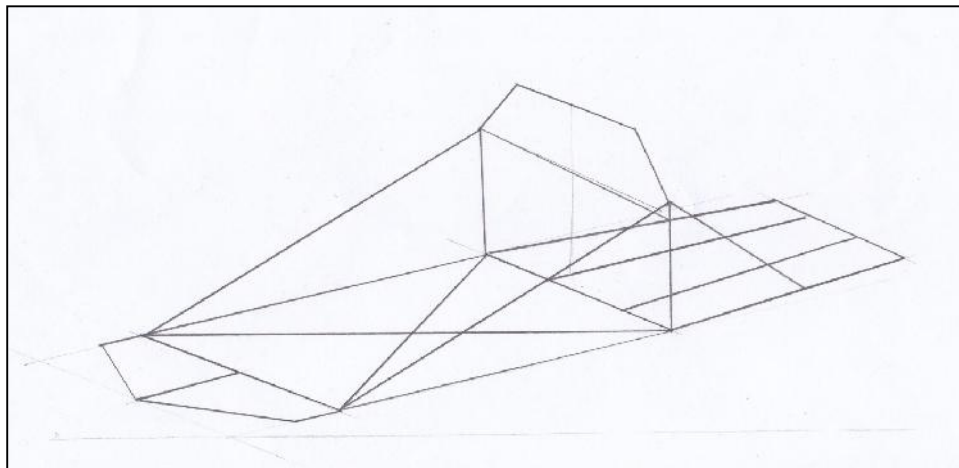


Figure 3.2: Sketch of Design A

The rough idea of the chassis designed is described by sketching the chassis as shown in Figure 3.3. The sketch describes more about frame type chassis. The sketch consist driver and engine compartments. Sketch describe the chassis have two tire for front and one tire of rear.

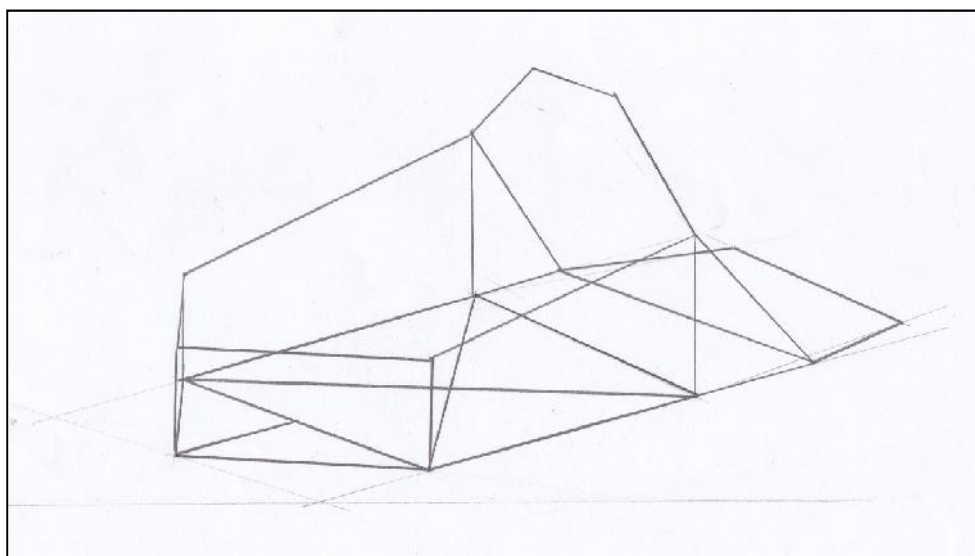


Figure 3.3: Sketch of Design B

The rough idea of the chassis designed is described by sketching the chassis as shown in Figure 3.4. The sketch describes more about frame type chassis. Sketch describe the chassis have two tire for front and one tire of rear.

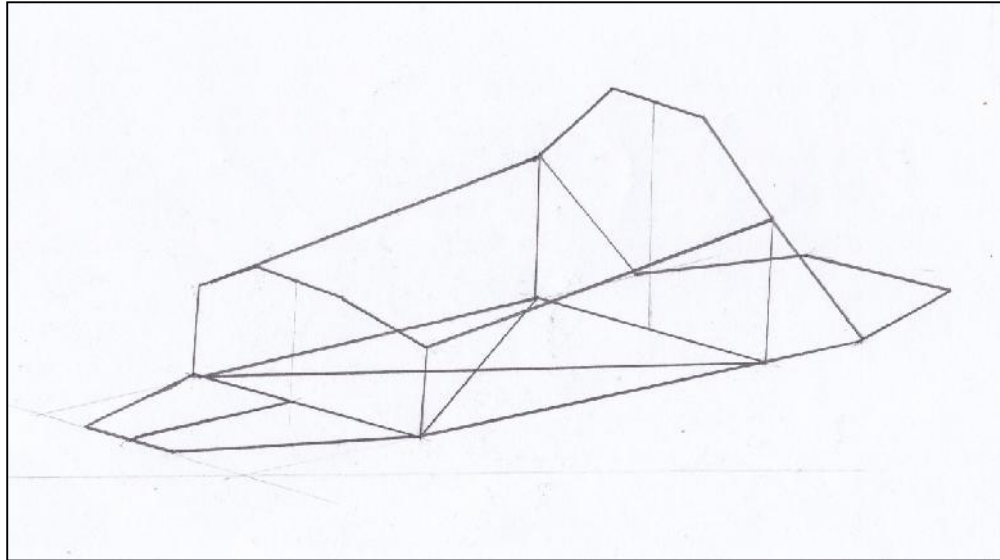


Figure 3.4: Sketch of Design C

3.2.2 CONCEPTUAL DESIGN

By using previous sketches in Figure 3.2, Figure 3.3, and Figure 3.4 as a guideline, the conceptual chassis design can be using SOLIDWORKS 2008. In this step, the best dimensions need to make the design to be draw symmetry and have logic concept. Shown in Figure 3.5, Figure 3.6 and Figure 3.7.

Figure 3.5 shown drawing perform using SOLIDWORKS. The design shown that the design shape is monocoque type. Consist cross shape beam under the driver compartment to support weight of driver and the chassis designed with tow tire at front and one tire at the rear or back.

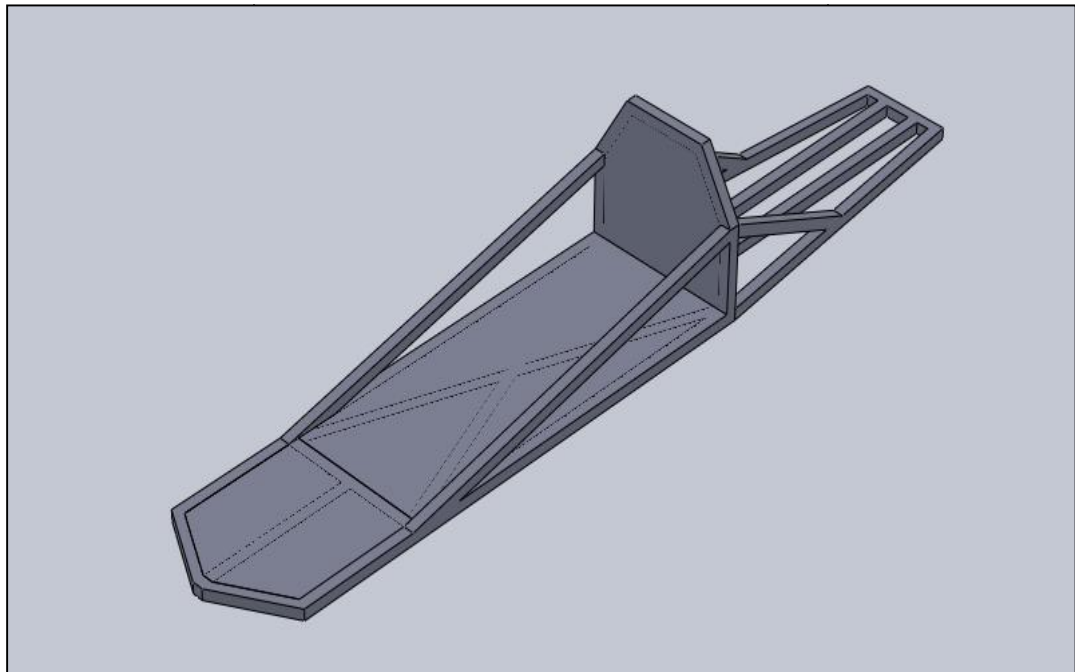


Figure 3.5: Conceptual design of Design A

Figure 3.6 shown drawing perform using SOLIDWORKS. The drawing shown that the design shape is frame type chassis. Consist cross shape beam under the driver compartment to support weight of driver and the chassis designed with tow tire at front and one tire at the rear or back.