UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF THIN FLAT CHASSIS OF MULTIPURPOSE REMOTE CONTROLLED POWERED PLATFORM

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Mechanical Engineering Technology (Automotive Technology) with Honours.

by

AHMAD DANIAL BIN ZAKARIA
B071210506
900422-03-5427

FACULTY OF ENGINEERING TECHNOLOGY
2015

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Development of thin flat chassis of multipurpose remote controlled powered platform.**
SESI PENGAJIAN: **2015/16 Semester 1.**
Saya **AHMAD DANIAL BIN ZAKARIA**
mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

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

Alamat Tetap:
Lot 3764 Taman Harmoni,
Berangan.
16200 Tumpat,
Kelantan Darul Naim.
Tarikh: _____

Disahkan oleh:

_____
Cop Rasmi:

Tarikh:

** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared this report entitled "Development of Thin Flat Chassis of Multipurpose Remote Controlled Powered Platform" is the results of my own research except as cited in references.

Signature	:	…….
Author's Name	:	AHMAD DANIAL BIN ZAKARIA
Date	:	…….

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor's Degree in Mechanical Engineering Technology (Automotive Technology) with Honours.The member of the supervisory is as follow:

MUHAMMAD ZAIDAN BIN ABDUL MANAF
(Project Supervisor)

ABSTRAK

Laporan ini memperkenalkan kerangka nipis dan rata untuk kenderaan kawalan jauh. Kerangka ini akan diaplikasikan pada kenderaan Formula Varsity (FV). Rekabentuk kerangka keluli dilaksanakan menggunakan perisian CAD iaitu CATIA V5R20. Dua kes agihan beban ke atas galang, kerosakan dan daya telah dianalisa. Kesemua tiga paksi; paksi-x, paksi-y, dan paksi-z terlibat dalam analisis-analisis itu. Keputusan dari analisis-analisis tersebut termasuklah tekanan Von Mises, sesaran, dan tekanan utama tensor. Selain itu, analisis-analisis yang dilakukan adalah untuk mengkaji kesesuaian kerangka tersebut dengan konsep kereta lumba. Dari analisa-analisa yang telah dijalankan, kajian menunjukkan tekanan Von Mises maksima ialah 6.79 x 10^6 N/m² *dan pemesongan maksima ialah 0.00356mm untuk pemesongan pulasan longitude. Kerangka tersebut mengalami tekanan ketegangan pada paksi x, y, dan z dengan nilai 1.07 x 10^6* N/m², *5.82 x 10^6* N/m², *and 7.48 x 10^5* N/m² *masing-masing. Kajian selanjutnya dengan membina prototaip sebenar dan menjalankan uji kaji terhadap rolling, yawing dan pitching untuk kestabilan kenderaan apabila menggunakan kenderaan itu telah dicadangkan.*

ABSTRACT

This report introduces thin flat chassis of multipurpose remote controlled powered platform. The chassis will be implemented in Formula Varsity (FV) vehicle. The steel chassis design was conducted by using CAD software namely CATIA V5R20. Two cases of beam load distribution; deformation and force were analysed. All of three axes; longitudinal (x-axis), lateral (y-axis), and vertical (z-axis) were involved in the analyses. Results from the analyses including Von Mises stress, translational displacement and stress principal tensor. Besides, analyses which have been done is to study the suitability of the chassis design with a racing car concept. From the analyses, the study reveals that the maximum Von misses stress value to be 6.79 x 10^6 N/m² and a maximum deflection to be 0.00356mm for longitudinal torsion deformation. The chassis experienced tensile stress in x-axis, y-axis, as well as in z-axis with a value of 1.07 x 10^6 N/m², 5.82 x 10^6 N/m², and 7.48 x 10^5 N/m² respectively. Further study by developing actual prototype and conduct testing on rolling, yawing, and pitching for vehicle's stability when using that chassis is recommended.

DEDICATION

To my beloved wife Adibah binti Razali, my son Ahmad Adwa,
my kind parents Zakaria bin Seman and Anita binti Ahmad,
my mother in law Ruslah Binti Omar,
and my supportive family members.
I love you all.

ACKNOWLEDGEMENT

I would like to express my utmost appreciation to Mr. Muhammad Zaidan bin Abdul Manaf who is my final year project supervisor. The supervision and support that he gave truly help the progression and smoothness of completing this project. The co-operation is much indeed appreciated.

My grateful thanks also go to all lecturers who always give advices and motivate me to work harder and smarter. I believe that success is not a dime a dozen.

I am also heartily thankful my wife for her endless support and encouragement. She made me agree that verily with every hardship, there is relief.

I would like to thank all my friends for their help. Also, to who are directly or indirectly involved in completing this thesis.

TABLE OF CONTENTS

DECLARATION **II**

APPROVAL **III**

ABSTRAK **IV**

ABSTRACT **V**

DEDICATION **VI**

ACKNOWLEDGEMENT **VII**

TABLE OF CONTENTS **VIII**

LIST OF TABLES **XI**

LIST OF FIGURES **XII**

LIST OF ABBREVIATIONS **XIV**

CHAPTER 1 **1**

1.1 Project Background 1

1.2 Problem Statement 2

1.3 Objectives 2

1.4 Scope and Limitations 3

1.5 Structure of the Report 4

CHAPTER 2 **5**

2.1 Introduction 5

2.2 Chassis System 5

2.2.1 Definition of Chassis 5

2.2.2 Chassis Structures 6

2.2.3 Functions of Chassis 6

2.3 Chassis Design 6

2.3.1 Types of Chassis 7

2.3.2 Comparison Between Different Types of Chassis 11

2.3.3 Requirements of the Chassis Design 13

2.4 Materials for Chassis 13

2.4.1 Types of Materials for the Chassis 13

2.4.2 Materials Selection 16

2.5 Chassis Operating Conditions 20

2.5.1 Global Load Cases 20
2.5.2 Local Load Cases 23
2.6 Load Cases 24
2.6.1 Bending 24
2.6.2 Torsion 25
2.6.3 Combined Bending and Torsion 26
2.6.4 Lateral Loading 26
CHAPTER 3 **28**
3.0 Introduction 28
3.1 Project Steps 28
3.2 Phase 1: Identifying Customer Needs 30
3.2.1 Define the Vehicle Purpose 30
3.2.2 Define the Size and Configurations 31
3.2.3 Define the Load for Components and System 33
3.3 Design Base Structure 36
3.4 Phase 2: Topology (remove material) 37
3.4.1 Using topology method to remove, unnecessary material. (Objective: light weight). 37
3.5 Phase 3: Analysis structure (base run) 39
3.5.1 Realization concept using CAD software. 39
3.5.2 Analysis model 41
CHAPTER 4 **49**
4.1 Introduction 49
4.2 Analysis for Deformation 49
4.2.1 Vertical Bending Deformation 50
4.2.2 Logitudinal Torsion Deformation 53
4.2.3 Lateral Bending Deformation 56
4.3 Analysis for Force 59
4.3.1 Vertical Force 59
4.3.2 Longitudinal Force 61
4.3.3 Lateral Force 63
4.4 Summary of Results 66

CHAPTER 5 **67**
5.1 Conclusion 67
5.2 Significance of the Study 67
5.3 Recommendations 68
REFERENCES **69**
APPENDIX **71**
A: Gantt Chart 71
B: Executive Summary 72
C: Research Framework on Template 78

LIST OF TABLES

TABLE	TITLE	PAGE
2.1	Advantages, disadvantages and application of chassis	11
2.2	Elements involved in translation step	17
3.1	Criteria and specification	32
3.2	Information for the short item	34
3.3	Component and mass	35
3.4	Information for the short item	37
4.1	Description of analysis results	49
4.2	Summary Results of Analyses	66

LIST OF FIGURES

FIGURE	TITLE	PAGE
1.1	Arrangements of the report	4
2.1	Ladder chassis	7
2.2	Twin tube chassis	8
2.3	Four tube chassis	9
2.4	Monocoque chassis.	9
2.5	Lotus Elan backbone chassis.	10
2.6	Example of space frame chassis structure for race car	11
2.7	Steps for materials selection	17
2.8	Automobile life cycle	20
2.9	Vertical bending deformation mode	21
2.10	Longitudinal torsion deformation mode	22
2.11	Lateral bending deformation mode	23
2.12	Horizontal lozenging deformation mode	23
2.13	Bending load case	25
2.14	Torsion load case	26
2.15	Combined bending and torsion load case	26
2.16	Lateral loading case	27
3.1	Project flowchart	29
3.2	Top view of the thin flat chassis	32
3.3	Side view of the thin flat chassis	32
3.4	Front view of the thin flat chassis	33
3.5	Direction of static loads	35
3.6	Direction of dynamic loads	35
3.7	Design base structure	37
3.8	Topology method to remove unnecessary material	38
3.9	Concept using CATIA software	39

FIGURE	TITLE	PAGE
3.10	Manikin concept using CATIA software	41
3.11	Arrow for the analysis tests	42
3.12	Material Properties Data	42
3.13	Vertical Bending Deformation (load applied at equally in driver cabin)	43
3.14	Longitudinal Torsion Deformation (load applied at equally in driver cabin)	44
3.15	Lateral Bending Deformation (load applied at equally in driver cabin)	45
3.16	Longitudinal force (load applied at bulk head front suspension)	46
3.17	Vertical force (load applied at lower front suspension)	47
3.18	Lateral force (load applied at right side front suspension)	48
4.1	Translational Displacement of Vertical Bending Deformation	50
4.2	Von-Mises stress distribution for a side members center force	51
4.3	Maximum Principal Stress Vertical Bending Deformation	52
4.4	Displacement Longitudinal Torsion Deformation	53
4.5	Von Mises stresses during Torsional Test	54
4.6	Maximum Principal Stress Longitudinal Torsion Deformation	55
4.7	Displacement Lateral Bending Deformation	56
4.8	Von Misses stresses during Side Impact Test	57
4.9	Maximum Principal Stress Lateral Bending Deformation	58
4.10	Von Mises stress during vertical force analysis (load applied at lower front suspension)	59
4.11	Maximum Principal Stress Vertical Force	60
4.12	Von Mises stress during longitudinal force (load applied at bulk head front suspension)	61
4.13	Maximum Principal Stress Longitudinal Force	62
4.14	Von Mises stress during lateral force	64
4.15	Maximum Principal Stress Lateral Force	65

LIST OF ABBREVIATIONS

2D	-	Two Dimession
2WD	-	Two Wheel Drive
CAD	-	Computer-Aided Design
CAE	-	Computer-Aided Engineering
CG	-	Center Gravity
FEA	-	Finite Element Analysis
FV	-	Formula Varcity

CHAPTER 1
INTRODUCTION

1.1 Project Background

This project focused on the multipurpose powered platform and design of new vehicle chassis that used the electric motor power supply alternative as it main energy. Chassis is one of the main components for the new vehicle. Chassis is a structural system that supports other components of a physical construction. Design is one of the main processes in producing the new vehicle. This will help to make a new vehicle that follows the criteria needed by the designer and the customer. Design, usually considered in the context of applied arts, engineering, architecture, and other creative endeavors, is used both as a noun and a verb. As a verb, to design refers to the process of originating and developing a plan for a product, structure, system, or component. As a noun, a design is used for either the final solution plan, for example proposal, drawing, model, description or the result of implementing that plan, for example object produced, result of the process. More recently, processes in general have also been treated as products of design, giving new meaning to the term process design. There are three main sections in the frame such as body-on-frame, chassis and sub frame. All of these sections are important to support the entire body of the new Vehicle. The design and the analysis of these three sections will be done based on the criteria of the new vehicle.

These sections will carry certain components such as the motor, drive train, and suspension. These sections will be welded and or bolted to the vehicle. Beside that the chassis is the central frame of a vehicle which has to carry all the components and support all the loads. These loads include the weight of each component and the forces which manifest during acceleration, deceleration and cornering. Therefore the chassis is considered as the most important element of the vehicle as it holds all the

parts and components together. Having a well-designed chassis is important to ensure the safety, performance and any the place.

1.2 Problem Statement

This study is conducted to seek a solution regarding car chassis which powered by electric motor system. The limitation for that particular chassis design is it uses more space to locate electric motor, battery, and other components related to electric system. Therefore, development of thin flat chassis will enable all components in the electric system utilize the chassis space. Other than that, electrical components such as electric motor, battery, and other components can be located in their specific yet the most suitable area.

The current available chassis is heavy when all components are joined together is the other problem which drives to realization of this study. In fact, mass is the most important point to be considered in determining the vehicle's performance. Therefore, this project is done to design and develop lighter chassis which provides equivalent strength with the heavier one when dealing with specified amount of loads.

1.3 Objectives

The main goal of this project is to develop the chassis system for multipurpose remote controlled powered platform. In order to achieve this aim, this study is conducted based on these specific objectives:

i. To design the thin flat ladder chassis concept.
ii. To reduce the weight of chassis using topology optimization method.
iii. To analyse the chassis structure performance in term of stress, displacement and vibration.

1.4 Scope and Limitations

The project scope of the chassis system for the thin flat chassis of multipurpose remote controlled powered platform are limited to the several process and equipment that have been provided. Hence, a few scope have been drawn and they are;

a) To study about the design of the chassis of current vehicle.
b) Conceptual design.
c) Develop designs for the thin flat ladder chassis of multipurpose remote controlled powered platform.
d) Analyze the performance using CAE of the new designs that follow the requirements of the new vehicle.
e) Propose the new design of the thin flat ladder chassis based on the analyses that have been done.

1.5 Structure of the Report

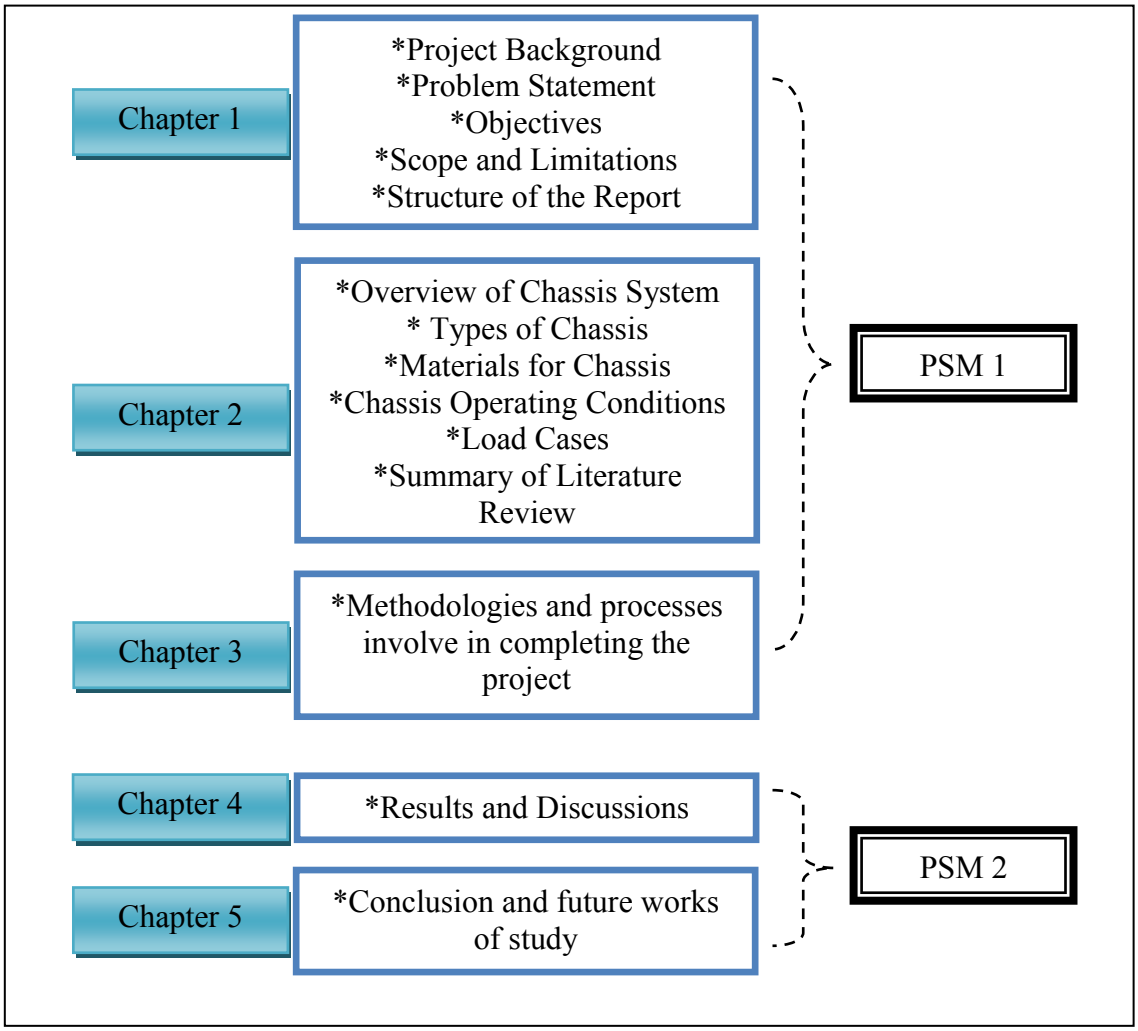

Figure 1.1: Arrangements of the report.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This chapter will be focused on the research information and the outcome of the study. This information then will be used as the guideline to find the most suitable material and design based on the factor and the supported theory to finalize the design of the development of thin flat chassis of multipurpose remote controlled powered platform.

2.2 Chassis System

This section discusses on several issues related to the chassis system such as its definition, functions, requirements of its design, and also types of the chassis. These basic information will provide an overview for the project.

2.2.1 Definition of Chassis

Chassis is a French term which provides two distinct definitions according to vehicle category (H. Crouse & Rajput, 2008):

i. Heavy vehicle - the overall shape of the vehicle except the body.
ii. Light vehicle of mono construction – the entire body except additional fittings in the body.

The chassis is a skeletal frame which all mechanical parts such as engine, suspension, tires, axle, assemblies, brakes, steering and others are fixed in a vehicle. As the definition itself, the chassis is the most important element to provide strength

and stability to the vehicle under various conditions. The rigidity, stiffness, and bending of the vehicle is thus highly depending on the chassis (Linton, 2002).

2.2.2 Chassis Structures

Chassis structures are categorized into 3 prime categories (Demir, 2012):

i. Frame – separated from the body
ii. Underbody – unitized body
iii. Sub-frame – auxiliary structure

2.2.3 Functions of Chassis

Generally, functions that are expected to be fulfilled by an automobile chassis are as follows (Linton, 2002):

i. provide mounting points for the mechanical parts
ii. carry the maximum load safely
iii. provide rigidity for accurate handling
iv. protect the occupants against external impact
v. hold all components together while driving
vi. endure shock loading
vii. accommodate twisting on even road surface

2.3 Chassis Design

Types of chassis and requirements of the chassis design are explained in this section.

2.3.1 Types of Chassis

Different types of the chassis are including:

i. Ladder
ii. Twin tube
iii. Four tube
iv. Monocoque
v. Backbone
vi. Spaceframe

2.3.1.1 Ladder

As the name implies, it is a ladder-like shape with two longitudinal rails as depicted by Figure 2.1 below. Several lateral and cross braces are connected to those rails. In this chassis design, large diameter tubes are used. Weight of the vehicle uses ladder chassis is sustained by the axles. The ladder chassis is one of the oldest forms of the automobile chassis which used in car construction until 1950's. It was also applied for racing until the mid of 1930's (Linton, 2002). Ability to resist the bending is taking into account for its design. However, torsional stiffness is not considered for this type of chassis (Linton, 2002). In the 1930s, additional cruciform bracing was helpful in increasing the torsional stiffness to the chassis. It is still be used in some Sports Utility Vehicles (SUV) available in today's market.

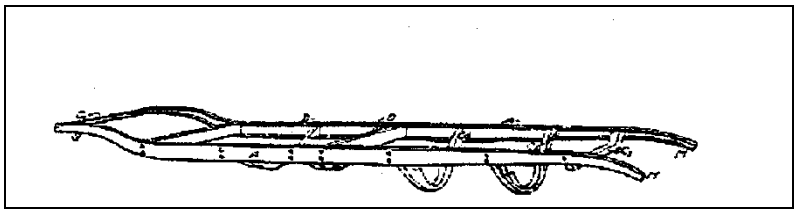

Figure 2.1: Ladder chassis.

2.3.1.2 Twin Tube

In the mid 1930's, the ladder frame chassis was modified to enhance its operation's efficiency by improving torsional stiffness. It is known as 'twin tube' chassis which shown by Figure 2.2. Design of side rails of the ladder chassis is made deeper and boxed. Through the improved design, torsional stiffness is approximated to be thousand times greater than an open section as before. Disadvantage of twin tube chassis is low efficiency due to the weight of the large tubes. Some examples of twin tube chassis are:

i. Mercedes – first use rectangular section, then change to oval section which has high torsional stiffness as well as high bending stiffness due to increased section depth

ii. "Twin Tube" Chassis Frame

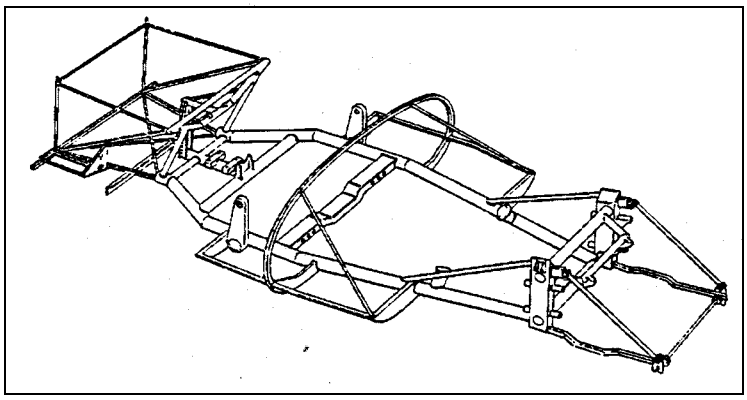

Figure 2.2: Twin tube chassis.

2.3.1.3 Four Tube

Designers sought for improvement of the bending stiffness provides by twin tube chassis, therefore, it was transformed into four tube chassis (Figure 2.3). A modification on existing tube was made by adding two more longitudinal tubes that ran from the front of the car, around the cockpit opening and on to the rear of the car. Bending characteristics are improved by a very deep side rails which are formed connecting top and bottom side rails with vertical or diagonal members.

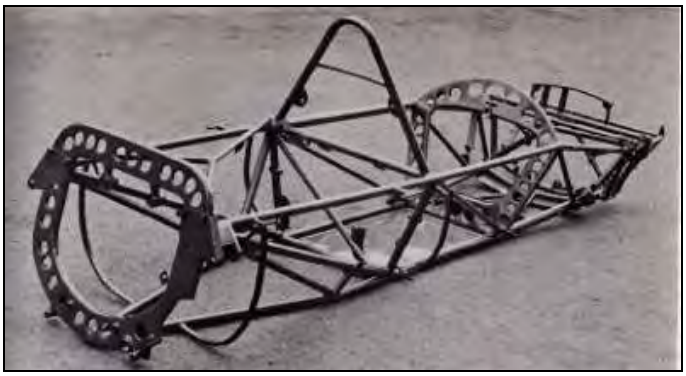

Figure 2.3: Four tube chassis

2.3.1.4 Monocoque

Monocoque chassis is best to be described as a single piece structure which defines the final shape of an automobile. Example of monoque chassis is illustrated in Figure 2.4. Steel plated monocoque chassis are used for 99% of vehicles produced today due to the low cost and suitability for robotized production offered (Chandra, Sreenivasulu, & Hussain, 2012).

Figure 2.4: Monocoque chassis.

It is manufactured through sequence of processes as follows:

i. Pressing of metal sheets using big stamping machines.
ii. Welding of pressed sheets using spot welding process or riveting the pressed sheet together to form the chassis.