STUDIES AND DESIGN OF CARBON FIBER MONOCOQUE CHASSIS FOR FORMULA SAE RACING CAR

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Laporan ini dikemukakan sebagai memenuhi sebahagian daripada syarat penganugerahan Ijazah Sarjana Muda Kejuruteraan Mekanikal (Automotif)

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"I admit that this report is from my own work and idea except for the summary and a few section which were extracted from other resources as being mention"

SIGNATURE :…….....

WRITER NAME :……

DATE :……

DEDICATION

For My Lovely Mother,
Friend and Family

ACKNOWLEDGEMENT

I would like to acknowledge and extend my heartfelt gratitude to the following persons who have made the completion of this project possible. In preparations of this project, I have benefited from the guidance and advice from my supervisor Mr Razali bin Mohd Tihth who successfully kept me all focused on where that wanted this project go and fully managed the development of this project, the print supplements, keeping communication lines open and ensuring the highest quality at every stage. I am really appreciate that. I also like to acknowledge my entire friend whose comments and suggestions provide insight and remind me the requirement. I am also deeply appreciate my family who has provided invaluable support throughout the writing process. And to God, who made all things possible.

ABSTRACT

Formula SAE (FSAE) is a student design competition organized by the Society of Automotive Engineers (SAE). The competition is to offer students a chance to design, build, and race a formula-style race car. As a main component in a vehicle, chassis need adequate strength to encounter a lot of challenges especially during the competition. The main material of the chassis directly influences the performance and properties of the chassis in term of strength, reliability and stiffness. Therefore, the purpose of this project is to design and analyze the Carbon Fiber Monocoque Chassis for FSAE. The main objective of this project is to design the chassis with high strength and stiffness. The objective is achieved by collected all the necessary informations through the research related to undergo an accurate database of methodology. The methodology then allowed the design process to be derived. By using the O'Neill spaceframe chassis as a model for dimension, three concept designs are developed by using CAD software and later the Finite Element Analysis (FEA) software to analyze the torsional stiffness and longitudinal rigidity of the chassis. By given a minimum target of 300N.m/Degree of torsional stiffness of the chassis, the chassis undergo the analysis level in order to accomplish the minimum target. The longitudinal rigidity test will be applied on the final design only. Once the final design has been selected, the final refinements of the chassis need to carry out to ensure the chassis follow all the technical requirement and rules of the FSAE competition.

ABSTRAK

Formula SAE (FSAE) adalah pertandingan rekabentuk antara pelajar yang dianjurkan oleh *Society of Automotive Engineers* (SAE). Pertandingan ini memberi peluang kepada pelajar untuk mereka bentuk,membina dan berlumba dengan mengunakan kereta lumba ala Formula. Sebagai komponen penting di dalam kenderaan, casis memerlukan kekuatan yang mencukupi untuk menghadapi banyak cabaran terutama semasa pertandingan. Bahan utama casis sangat mempengaruhi prestasi dan ciri-ciri casis berdasarkan kekuatan, kebolehanharapan dan kekerasan. Oleh itu, tujuan projek ini adalah untuk merekabentuk dan menganalisis casis *monocoque* gentian karbon. Objektif utama untuk projek ini adalah merekebentuk casis dengan kekuatan dan kekerasan yang tinggi. Objektif ini dapat dicapai dengan mengumpulkan semua maklumat yang penting dan kajian yang berkaitan untuk mendapat fakta asas kaedah yang tepat. Kaedah ini membenarkan proses reka bentuk ini diperoleh. Dengan menggunakan ukuran daripada O'Neill spaceframe casis, tiga konsep rekabentuk dibina dengan menggunakan perisian CAD dan kemudian perisian FEA(*finite element analysis*) digunakan untuk menganalisis kekerasan daya kilas dan *longitudinal rigidity*. Dengan menetapkan kekerasan daya kilas minimum sebanyak 300 N.m/Darjah, casis tersebut menjalani proses analisis untuk mencapai sasaran minimum. *Longitudinal rigidity* hanya dijalankan pada konsep rekabentuk terakhir. Setelah rekabentuk casis dipilih, pemerhatian terakhir perlu dijalankan untuk memastikan casis tersebut mengikut semua keperluan teknikal dan peraturan pertandingan FSAE.

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C	=	Torsional Stiffness in N/Mm
c	=	Spring Rate
d	=	Road Wheel Deflection
D	=	Torsional Deflection of Chassis
P_c	=	Load Composite
P_f	=	Load Fiber
P_m	=	Load Matrix
A_c	=	Cross-Sectional Areas of Composite
A_f	=	Cross-Sectional Areas of Fiber
A_m	=	Cross-Sectional Areas of Matrix

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

1.1 Background of Project

Chassis plays a large role in the handling of the vehicle. It must be designed to connect suspensions and support the entire load. It also must be tough enough to resist fatigue loads that are produced due to the interaction happened between driver, engine power, transmission and road. The major aspect in the design of chassis is the safety which is must be considered through all the design stages. The design also has to meet the requirement and regulations set by Formula SAE (FSAE) organizers. The racer in FSAE usually used two main types of chassis; steel space frames and composite monocoque. Many of the competitive teams with more experience will use a composite monocoque chassis due to of its weight and performance properties. In this project, the monocoque chassis which used carbon fiber as a main material will be designed. A good knowledge of proven designs or extensive analysis and testing is required to design a competent and reliable monocoque chassis.

1.2 Objective and Scope

a) Objective:

The main objectives of this project were:

a) To design the FSAE monocoque chassis by going through all the important related processes and regulations;
b) To design the monocoque chassis using carbon fiber as main material;
c) To develop the concept of chassis and its application, and discover CAD and CAE tools. On the other hand, the production process and performance of carbon fiber also need to be taken into account;
d) To perform a torsion test on the chassis to determine its torsional stiffness.

Scope:

a) To study the information related to the carbon fiber monocoque chassis of FSAE;
b) To design the chassis of FSAE racing car by considering the input gained during the literature stage, in term of strength requirements and reliability requirements;
c) To analyze the designed chassis base on the technical and strength requirement been gained during the literature stage.

1.3 Problem Statement

During the event of an FSAE competition, every racecar that are involve in the competition will be subjected to a variety of performance challenges, in which the chassis of the car will be a key factor in the success of the vehicle. As a chassis is the most important component in a vehicle, it must have high strength and stiffness to support all the loads of the vehicle. In this project, a research regarding the chassis of the formula racing car have to be done in order to achieve the objective. Due to a good characteristics, the monocoque chassis been used widely in the automotive industries and this type of chassis will be used to achieve the main objective. On the way to have a reliable FSAE monocoque, this project will concentrate on the development of the monocoque chassis with high strength and stiffness. In the future research, it is recommended; the designed chassis to be fabricate and use as UTeM FSAE racing car backbone.

1.4 Project Schedule

Action / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Title Selection & Working Plan															
Definition of Objectives & Scopes															
Literature on Chassis Technology, Monocoque Technology & Carbon															
Literature on Formula SAE, Application of Chassis, CAD, CAE &															
Concept Design Developtment															
Documentation															

Figure 1.1: Project Schedule for PSM I

Action / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Design Process																
Analysis Process																
Result and Discussion																
Report Writing																
Documentation																

Figure 1.2: Project Schedule for PSM II

CHAPTER 2

LITERATURE REVIEW

2.1 Chassis Technology

Brown et al. (2005) stated that the chassis is the framework which provides mounting points for the suspensions systems, steering mechanism, engine and gearbox, the final drive, the fuel tank and the seating for the occupants. A body is built on the chassis to complete the vehicle. Chassis has to provide sufficient rigidity for accurate handling, absorb crash energy for the safety of the occupants, and resist torsional and bending deflection. It also needs to be light enough to increase fuel economy and speed and to reduce inertia, thereby increasing the performance of car.

There are many different types of chassis have been designed and tested due to the development of the motor vehicle. The basic types which were or are in common use are ladder chassis, tubular space frame, backbone chassis, glass fiber body, space frame chassis and monocoque chassis.

2.2 Overview of Chassis Types

2.2.1 Ladder Chassis

Ladder Chassis is the earliest kind of chassis. It's have a good isolation between passenger cabin and road vibration making its still used in trucks and SUVs. It has two longitudinal rails interconnected by several lateral and cross braces. The advantages of this type of chassis are its easy and cheap hands build. However, Brown et al. (2005) stated that since it is a 2 dimensional structure, torsional rigidity is very much lower than other chassis, especially when dealing with vertical load or bumps.

Figure 2.1: Chevy Ladder Chassis
(Source: www.autoweldchassis.com)

2.2.2 Tubular Chassis

Tubular space frame often used in race cars and ultra high performance sports car. Tubular space frame chassis employs dozens of circular-section tubes, which are welded together, position in different directions to provide mechanical strength against forces from anywhere. It is very strong in any direction but its structure is very complex, costly, and time consuming to be built. It's also used a lot of space, raise the door sill and result in difficult access to the cabin.

Figure 2.2: The tubular chassis of the 3500 GT

(Source: www.maserati-alfieri.co.uk)

2.2.3 Backbone Chassis

Backbone chassis is a simple chassis with a strong tubular backbone (usually in rectangular section) connects the front and rear axle. There is space for the drive shaft in case of front-engine, rear-wheel drive layout. The whole drivetrain, engine and suspensions are connected to both ends of the backbone. Brown et al. (2005) agreed that this chassis provides nearly all the mechanical strength and strong enough for smaller sports cars. It is also easy to be made by hand thus cheap for low-volume production. With its simple structure, it is become the most space-saving other than monocoque chassis. The disadvantages are it is not strong enough for high-end sports cars. The backbone does not provide protection against side impact or off-set crash. It is also cost ineffective for mass production.

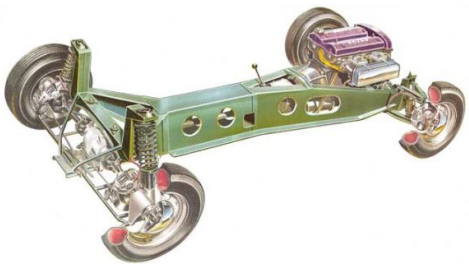

Figure 2.3: 1962 Lotus Elan backbone chassis

(Source: www.carbodydesign.com)