IMPROVING CHASSIS FRAME FOR EIMARACE 2014 TS131 RACING CAR BY USING HYPERMESH ANALYSIS

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Abstrak

Kertas kerja ini membentangkan peningkatan bingkai casis untuk kereta lumba *EIMARace 2014 Ts131* dengan menggunakan analisis HYPERMESH. Bingkai casis kereta lumba telah direka dan dibangunkan mengikut spesifikasi Inovasi Pendidikan Sukan Motor dan Automotif Race (*EIMARace 2014*). Casis kereta lumba dibangunkan dengan menggunakan bantuan komputer perisian reka bentuk (CAD) dan menganalisis menggunakan HYPERMESH. Matlamat dan sasaran projek ini adalah untuk mensimulasikan struktur kerangka, pengesahan kekuatan dan juga untuk meningkatkan kerangka casis apabila kilasan dan lenturan telah digunakan dengan menggunakan perisian analisis HYPERMESH. Untuk mencapai matlamat itu, dua jenis analisis (lenturan dan kilasan) dijalankan untuk menentukan ciri-ciri casis. Berdasarkan keputusan purata analisis, anjakan peningkatan casis menurun dengan ketara. Kesimpulannya, peningkatan baru kerangka casis adalah lebih serasi untuk perlumbaan yang boleh melalui permukaan jalan kasar tanpa sebarang kegagalan.

Kata Kunci: Kerangka casis, EIMARace 2014, analisis, HYPERMESH

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Abstract

This paper presents the improvement chassis frame for EIMARace 2014 Ts131 racing car using HYPERMESH analysis. A chassis frame of race car have been designed and developed according to the specifications of Educational Innovation of Motorsports and Automotive Race (EIMARace 2014). The race car chassis was developed using computer aided design (CAD) software and analysis using HYPERMESH. The goal and target of this project are to simulate frame structure, strength validation and also to improve chassis frame when torsion and bending are applied by using HYPERMESH analysis software. In order to achieve the objective, two types of analysis (bending and torsion) were being run to determine the characteristics of the chassis. Based on average analysis result, the displacements of the improvement chassis are significantly decreased. As conclusion, the new improvements of chassis frame are more compatible for racing which can through the rough surface of road without any failure.

Keywords: *Chassis frame, EIMARace 2014, Analysis, HYPERMESH*

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1.0 Introduction

The *EIMARace* competition requires the construction of a new car in every annual competition. Space frame chassis have been in use since the start of the motor sport scene (Ashari 2011). Basically chassis is considered as a framework to support body, engine and other parts of the vehicle and the chassis also lends the whole vehicle the support and rigidity (Daub 2012). A space frame consists of steel or aluminum tubular pipes placed in a triangulated format to support the loads from the vehicle caused by suspension, engine, driver and aerodynamics. 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. 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 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. For this paper, the objectives of this work are to simulate frame structure, strength validation and also to improve chassis frame when torsion and bending are applied by using HYPERMESH analysis software.

2.0 Literature review

Ideally, the purpose of a motor car chassis is to connect all four wheels with a structure which is rigid in bending and torsion, and will neither sag nor twist. It must be capable of supporting all components and occupants and should absorb all loads that feed into it without deflecting unduly (Costin & Phipps 1965). Considering the chassis in this way, its chief purpose is to provide suitable mountings for all components of the car. In descending order of magnitude, the major loads involved are: 1. rear suspension and final drive; 2. front suspension and steering; 3. engine and/or gearbox; 4. fuel tank; 5. seats (and occupants), steering column, pedals and other controls, including hydraulic cylinders; 6. radiator; 7. battery; 8. spare wheel (Costin & Phipps 1965).

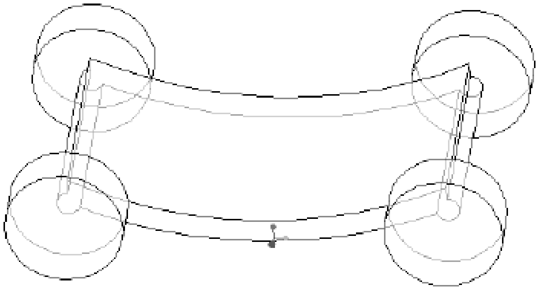


Figure 1: Vertical Bending Deformation Mode

2.1 Vertical Bending

The weight of the driver and components mounted to the frame, such as the engine and other parts, are carried in bending through the car frame. The reactions are taken up at the axles (Rileys & George 2002). Vertical accelerations can be raised or lowered in magnitude of these forces (Rileys & George 2002).

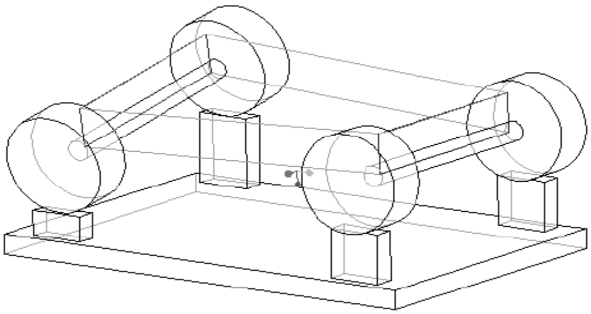


Figure 2: Longitudinal Torsion Deformation Mode

2.2 Longitudinal Torsion

Torsion loads resulted from applied loads act on one or two oppositely opposed corners of the car. The frame can be thought of as a torsion spring connecting the two ends where the suspension loads act. Torsional loading and accompanying deformation of the frame and suspension parts can affect the handling and performance of the car (Rileys & George 2002). The resistance to torsional deformation is often quoted as stiffness in foot-pounds per degree. This is generally thought to be the primary determinant of frame performance for a FSAE racecar (Rileys & George 2002).

3.0 Methodology

Figure 3 shows the flow chart of the project procedures consist of problems definition, conceptual design, preliminary design, design communication and detailed design.

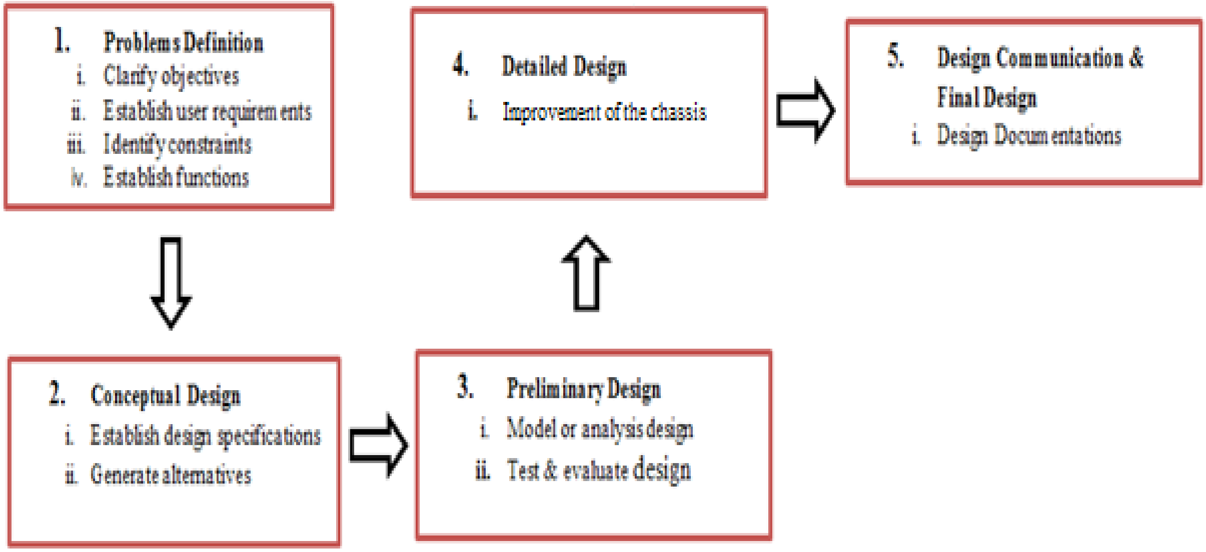


Figure 3: Flowchart of the project procedures

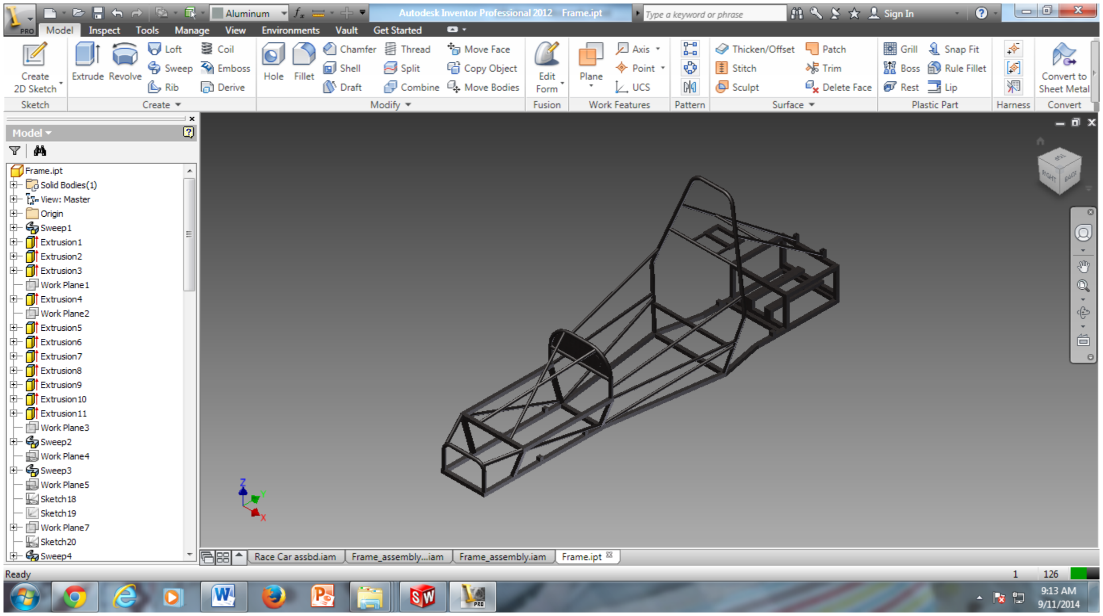
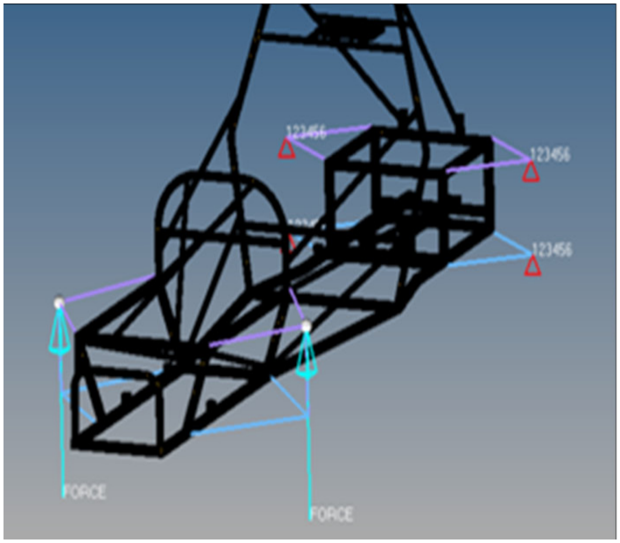


Figure 4: Free body diagram of chassis

In order to achieve the objective, two types of analysis were being run to determine the characteristics of the chassis. Below methods were used in this analysis:

1. Apply load with bending load 2000N (200kg)
2. Apply load with torsion load 2000N (200kg)

Figure 5(a) and 5(b) shows the pictures of bending and torsion force that has been applied to the chassis. The chassis before and after the improvement has been shown in figure 6(a) and 6(b). The added link joint (blue color) in chassis, figure 6(b), is to add more strength to the chassis.



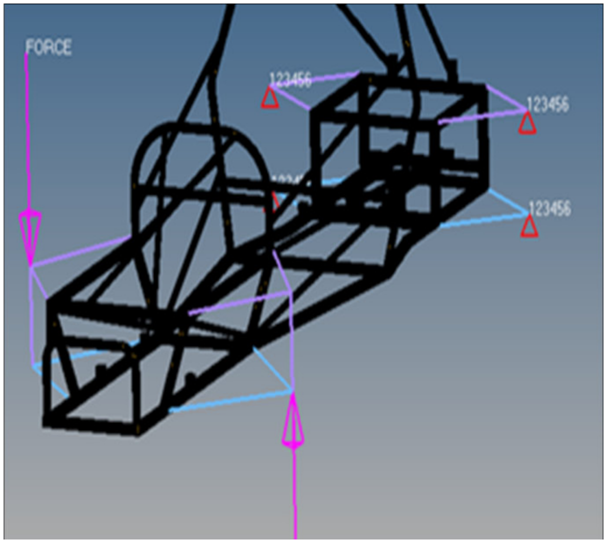
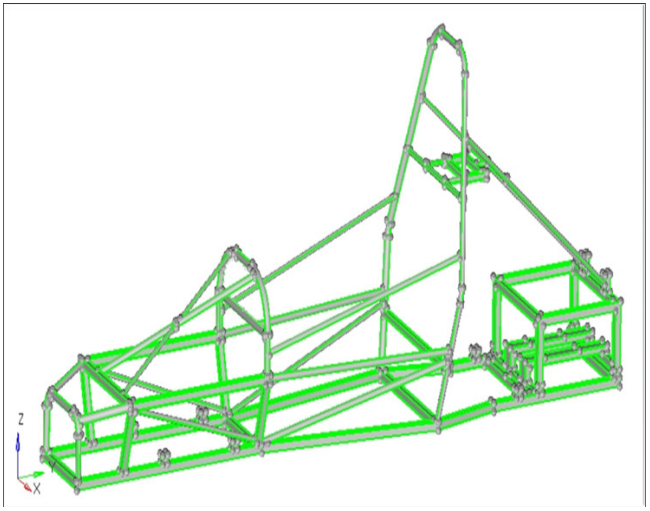


Figure 5(a): Load case 1 (Bending)

Figure 5(b): Load case 2 (Torsion)



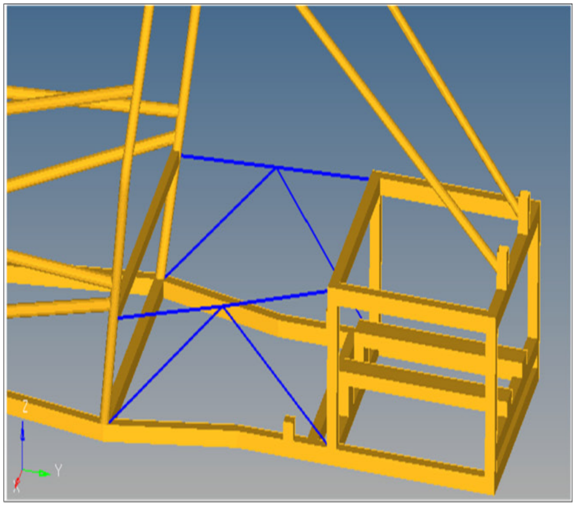
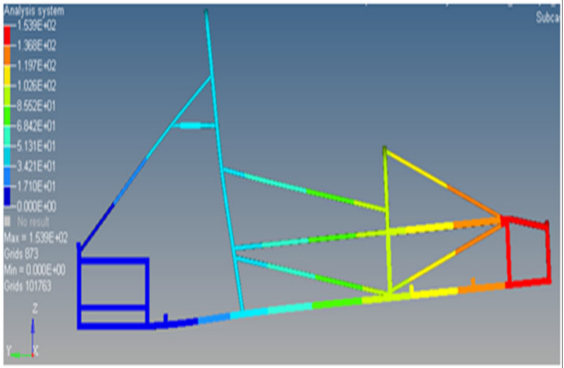


Figure 6(a):Chassis before Improvement

Figure 6(b): Chassis after Improvement

4.0 Results and Discussion

a) Load case 1 (Bending)



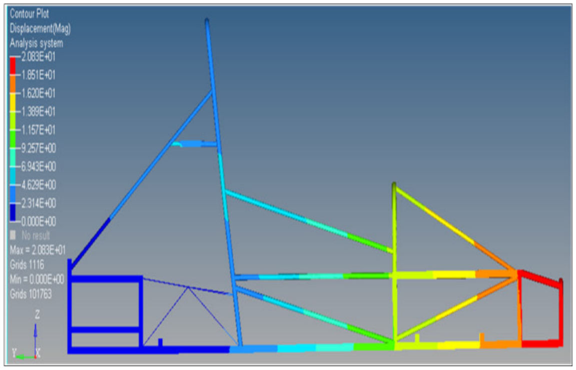
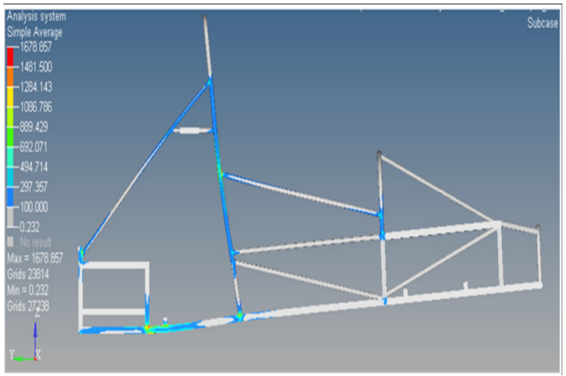


Figure 7(a): Displacement before an improvement

Figure 7(b): Displacement after an improvement



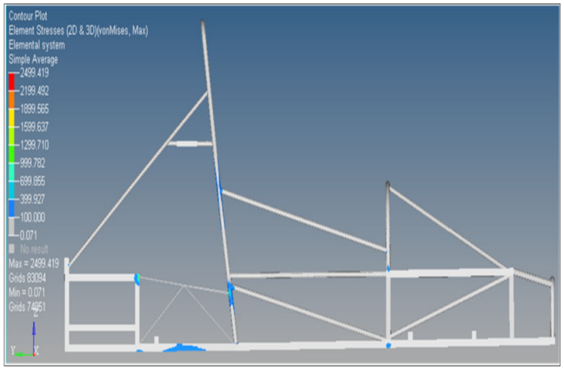


Figure 8(a): Analysis of Stress before an improvement

Figure 8(b): Analysis of Stress after an improvement

Table 1: Maximum displacement and maximum stress result before and after improvement

Load Case 1	Before Improvement	After Improvement
Max. Displacement	153mm	20.8mm
Max. Stress	1678MPa	2499MPa

The figures 7(a) and 7(b) show the displacements before and after an improvement. Its shows a comparison between the bending force between the two case studies. For the figures 8(a) and 8(b), they clearly show that the bending force before an improvement is greater than the torsion stress when both rear wheels get over the ramp. Also, it presents the maximum torsion stress of the two case studies. The analytical result in table 1, before an improvement, the maximum displacement during application of bending force is 153mm and, after an improvement, the maximum displacement when bending force being applied is 20.8mm. While, for the displacement of the bending force before improvement, the maximum stress when bending force being applied is 1678MPa and after improvement, maximum stress is 2499MPa. For the chassis improvement, the values of the maximum displacement are half of non-improvement chassis.

a) Load case 2 (Torsion)

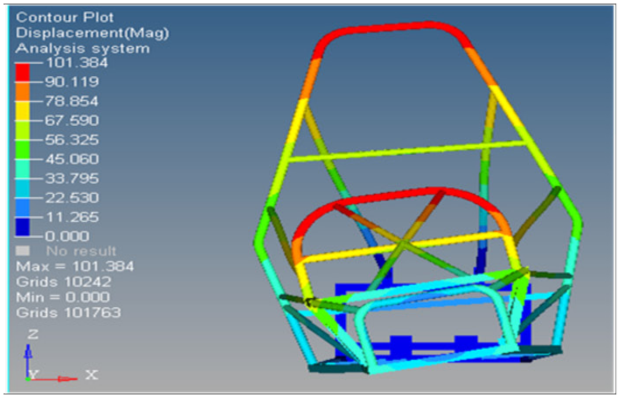


Figure 9: Displacement before an improvement

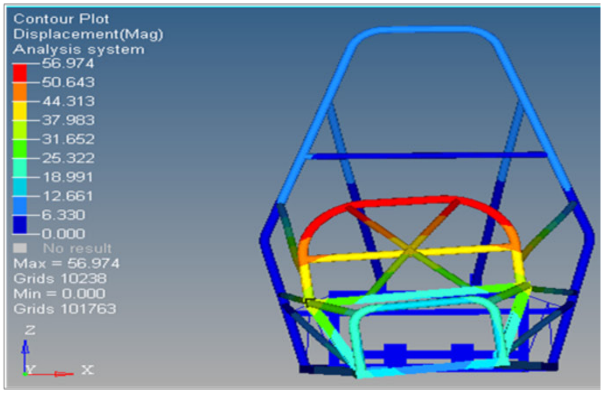


Figure 10: Displacement before an improvement

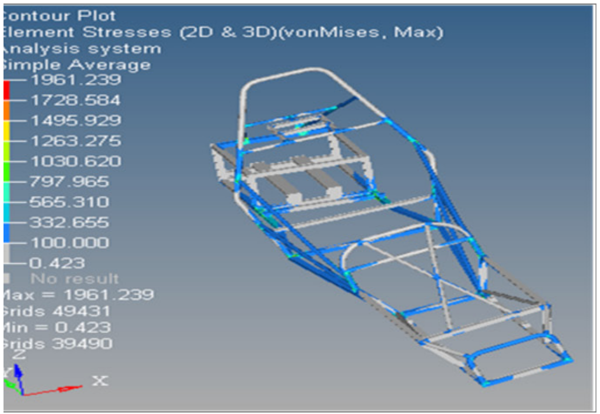


Figure 11: Stress before an improvement

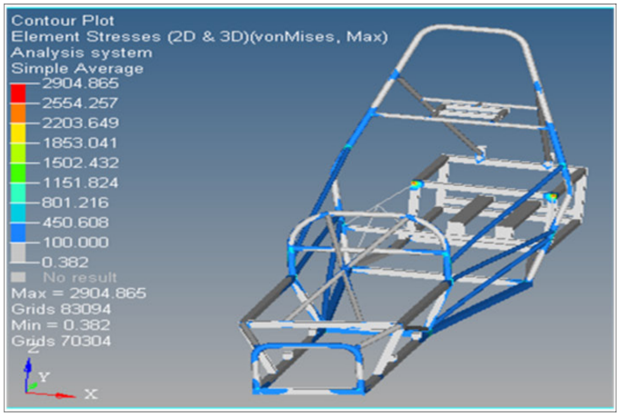


Figure 12: Stress after an improvement

Table 2: Maximum displacement and maximum stress results before and after improvement

Load Case 1	Before Improvement	After Improvement
Max. Displacement	101mm	56.97mm
Max. Stress	1961MPa2904MPa	

From the Table 2, before improvement, the maximum displacement when torsion was applied is 101mm and after improvement, maximum displacement is 56.97mm. While, the maximum stress when torsion was applied is 1961MPa and after improvement, the maximum stress when torsion was applied is 2904MPa. It shows that the improvements make a difference in the result. For the chassis improvement, the values of the maximum displacement are half of non-improvement chassis.

5.0 Conclusion

The chassis frame was successfully designed and analysed. After making some improvements to the chassis frame, maximum displacement decreases by 132.2mm and maximum stress increases by 821MPa when bending force was applied. For load case 2, the maximum displacement decreases by 44.03mm and the maximum stress increases by 943MPa. From the result, with the additional support, the natural frequency for the first mode of vibration was increased and resulted in torsion in place of the bending mode seen without any support (Ryan 2008). As conclusion, the new improvement of chassis frame is much more compatible for racing.

References

Abrams, Ryan, 2008. "*Formula SAE Race Car Analysis: Simulation & Testing of the Engine As a Structural Member*", The University of Western Ontario, Canada, 2008.

David A. Crolla, 2009. "*Automotive Engineering: Power train, Chassis System and Vehicle Body"*, Butterworth-Heinemann, pp233.

Educational Innovation of Motorsports & Automotive Race (EIMARace) 2014. Rules *and Regulation Universiti Teknologi Malaysia (UTM).*

Michael Costin and David Phipps 1965. "*Racing and Sports Car Chassis Design*", B.T. Batsford Ltd.

Muhamad Hafizul Ashari, 2011. "*Design and Fabrication of Space Frame Chassis for UteM Formula Style Race Car*", *B. Eng (Automotive) Thesis,* Universiti Teknikal Malaysia Melaka, Malaysia.

Muhamad Solehin Daub 2012. Design and Analysis of Urban Concept Car Chassis for Shell Eco-Marathon Challenge, *B. Eng (Automotive) Thesis,* Universiti Malaysia Pahang, Malaysia.

Tim Gilles, 2005. "*Automotive Chassis: Brakes, Suspension, and Steering",* Thomson Delmar Learning, pp. 462-466

William B. Riley and Albert R. George 2002. "*Design, Analysis and Testing of a Formula SAE Car Chassis*", Motorsports Engineering Conference & Exhibition Indianapolis, Indiana December 2-5, 2002.

Yusoff F, and Hameedullah M., 2004. "*The Automotive Chassis: Engineering Principles*", Butterworth-Heinemann, pp 844-850.