DESIGN AND FABRICATION AN ELECTRIC BUGGY FRAME

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ABSTRACT

Due to the large area of University Malaysia of Pahang factories especially the factory of Faculty of Mechanical Engineering, a problem arises that it takes quite a lot one's energy and time to move around the compound and also to carry or transporting small to medium-sized things that can be carried by a person. To encounter this problem, a small buggy frame will be build. This frame will acts as a foundation to the buggy that will be build for the purpose of carrying burden and load within the compound of University Malaysia Pahang factory. The buggy will be design to transport 2 persons in one time. In this project, there are three stages of development will be done which are designing the electric buggy frame by using CAD software, analyzing the stress distribution on the frame when the load is applied and fabricating the frame

ABSTRAK

Oleh kerana keluasan kawasan University Malaysia Pahang terutamanya keluasan kawasan makmal Fakulti Kejuruteraan Mekanikal yang terlalu besar, timbulnya satu masalah iaitu ia memakan banyak tenaga dan masa untuk bergerak di sekitar kawasan tersebut sambil membawa barang-barang dengan saiz yang sederhana. Ubtuk mengatasi masalah ini, sebuah rangka kecil 'buggy' akan dibina. Rangka ini akan menjadi asas kepada 'buggy' tersebut bagi tujuan mengangkat beban dan barang disekitar makmal Universiti Malaysia Pahang. 'Buggy' tersebut akan direka untuk mengangkat 2 orang serentak. Didalam projek ini, terdapat tiga tahap dimana yang pertama mereka rangka tersebut dengan menggunakan perisian CAD, menganalisa tekanan keatas rangka tersebut dan fabrikasi.

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CHAPTER 1

INTRODUCTION

1.1 Background of the Project

The area of University of Pahang factories compound are quite large especially for the factory of Faculty of Mechanical Engineering. Due to this size, a problem arises that it takes quite a lot one's energy and time to move around the compound and also to carry or transporting small to medium-sized things that can be carried by a person.

By looking on the transporting system used in most of golf courses and some of large industries, comes an idea of using a buggy as a transport to reduce this problem. A buggy is a small light weight vehicle that has been developed for the purpose of carrying load, burden and also transporting people.

In this project, a small buggy frame will be build. This frame will acts as a foundation to the buggy that will be build for the purpose of carrying burden and load within the compound of University Malaysia Pahang factory or indoor used. This buggy will be design to transport 2 persons in one time and it also will use electric motor instead of conventional engine. This also satisfied its objective which this buggy will be used within the University Malaysia Pahang compound and for indoor used because there are no pollution if electric motor is used.

By considering these needs, the frame for this buggy has to be designed to perfectly fit with all the parts and components that will be used like electric motor, electronic controller, brakes and etc. This frame also has to be designed to withstand the load from all the parts, the passengers and burden it carries.

1.2 Objective

The objectives for this project are:

i. To design an electric buggy frame
ii. To analyze the stress distribution on an electric buggy frame
iii. To fabricate an electric buggy frame

1.3 Scopes of Project

The scope for this project consists of:

i. Design a two seater electric buggy car frame.
ii. Analyzing the frame stress distribution by using Finite Element Analysis software.
iii. Test the frame with the weight of two average people.

CHAPTER 2

LITERATURE REVIEW

2.1 History and Overview of Vehicle Structure Types

Many different structures of cars have been used since the invention cars over the years. In the 1920s, the standard car configuration was the separate 'body-on-chassis'. The chassis frame was perfectly suited for mounting the semi-elliptic spring on the beam axle suspensions system. The structure of the car which is the underfloor chassis frame consisted of a more or less flat 'ladder frame' like as shown in Figure 1. Two open side frame with the full length of the vehicle is connected with the frame by open section cross-members and riveted at 90° joints.

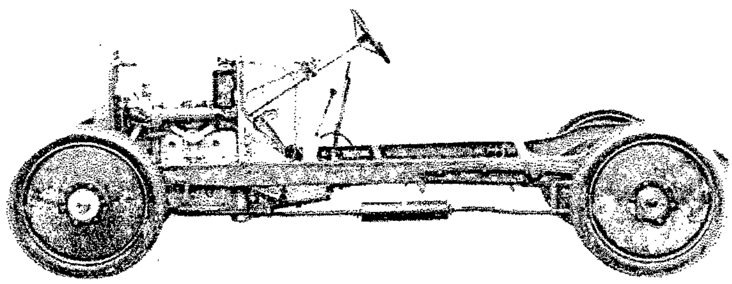

Figure 1: Open section ladder frame chassis of the1920s [1].

2.1.1 Grillage Frame

The previous explanation is belongs to a class of structures called 'grillages' A grillage is a flat structure which the loads is normal to its frame. The internal loads in the frame are:

i. Bending about the in-plane lateral axis of the member.
ii. Torsion about the longitudinal axis of the member in the plane of the frame.
iii. Shear force in a direction normal to the plane of the frame.

This chassis frames, are particularly flexible locally in torsion. But the transferred bending moments from the ends of members into torsion in the attached members are poor due to the riveted T-joints. Thus, the chassis frames had very low torsion stiffness and because of the importance of torsion, the situation is not very satisfactory. The depth of the structure was limited to a shallow frame underneath the body, so that the bending stiffness was also relatively low. Good torsional design is important to prevent the incapability between body and frame and the torsion stiffness is often used as one of the benchmarks of the structural competence of a vehicle structure. In the case of a flexible body on a flexible body on a relatively stiff chassis frame, most of the torsion load would pass through the chassis and if the body were stiff and the chassis flexible, then the body would carry a larger proportion of the torsional load. The major grillage member in the passenger compartment floor consists principally of 'transmission tunnel', one or more cross-members, the rockers (as part of the sideframe) and the bulkheads at the ends of the compartment [2]. These members, in idealized form are shown in Figure 2.

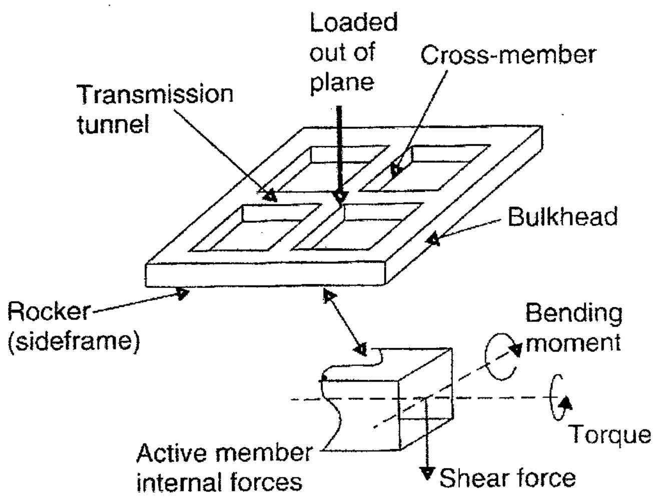

Figure 2: Grillage structure [3].

2.1.2 Backbone Structure

This is an example of the large section tube concept. It is used on specialists sport cars like Lotus as shown in Figure 3. It still amounts to a separate chassis frame. The large cross-sectional area of the backbone member derives the backbone chassis stiffness. A typical size might be around 200mm x 150mm. The walls of the tube are in shear when in tubular structures in torsion. In Lotus case, the wall of the tube consists of shear panels. However there are other ways of carrying in plane shear like a triangulated bay of welded or brazed can also form a very effective and efficient shear carrying structure. The combined stiffness of the chassis and the attached body together is greater than the sum of the stiffness of the individual items. This reflects the facts that the connection between the two merely at the ends, but is made at many points, giving a combined which is highly statically in determinate.

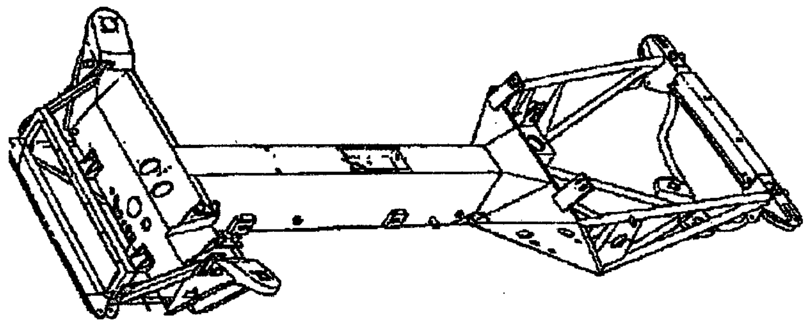

Figure 3: Sheet steel backbone chassis of Lotus car [2]

2.1.3 Triangulated Tube Structure

This tube arrangement is not limited to backbone structures only. A common approach which is using this principle is the bathtub layout in which the triangulated structure surrounds the outside of the body. This approach has the advantage that the coachwork can consist of thin sheet metal cladding, attached directly to the framework. This method is best suited to low volume production because of low tooling costs. It is not well suited to mass production due to complication and labors intensive maintenances. This type of chassis usually used in some specialist sports cars, such as the TVR as shown in Figure 4.

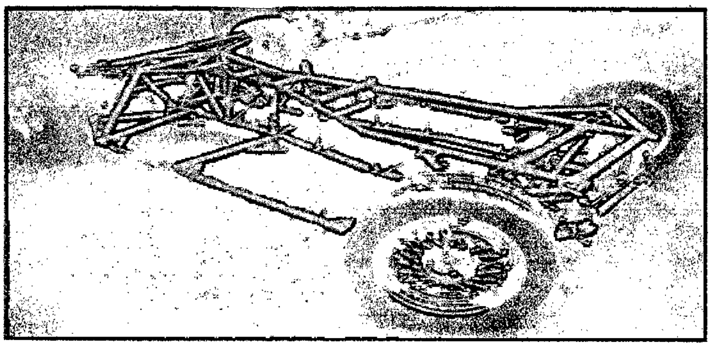

Figure 4: Backbone chassis made of triangulated tubes [2]

2.1.4 Incorporation of Roll Cage into Structure

The best way of using the tube principle is to make the tube encompass the whole car body. This is shown in Figure 5. The triangulated roll cage extends to the passengers compartment. This make the cross-sectional area of the body very large hence the torsion constant is large also. The contribution of the roll cage depended on:

i. The degree of triangulation in the roll cage
ii. On how well the roll cage was connected to the rest of the structure.

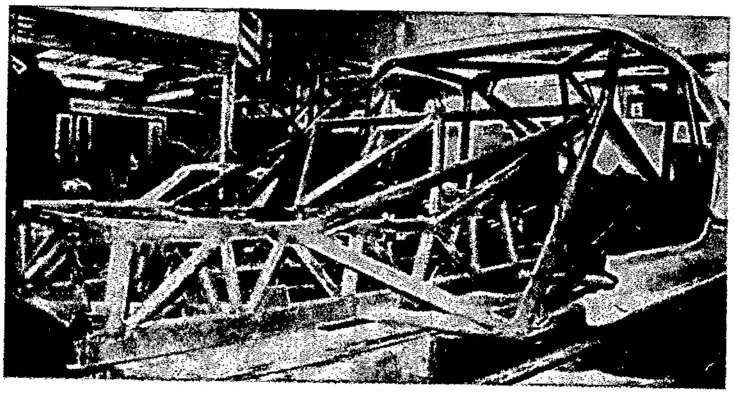

Figure 5: Triangulated sports car structure with integrated roll cage [2].

2.1.5 Pure Monoque

Monoque in French means single shell. In this structure, the outer skin performs the dual role of the body surface and structure. This type of structures is very rare compare to other structures. The used is restricted to racing cars only as shown in Figure 6. This is because of certain reasons which are:

i. It requires a totally closed tube to work efficiently. Because of this, the normal vehicle will have an opening for passengers entry thus it will be an interruption to single shell which then lowering the torsion stiffness.

ii. The shell requires reinforcement to prevent buckling and to carry-out-plane loads.

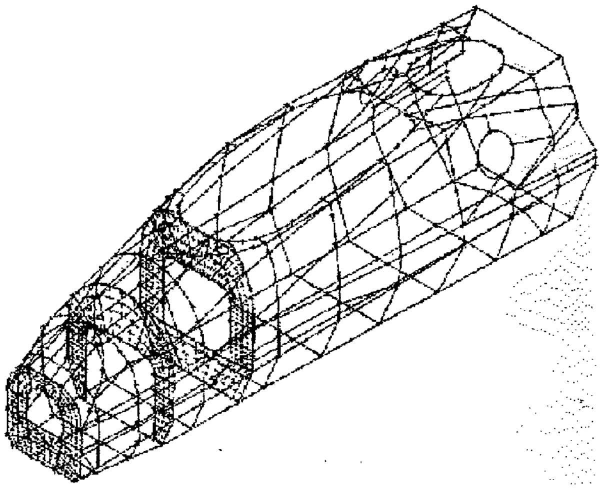

Figure 6: Monocoque structure [2].

2.1.6 Punt or Platform Structure

This structure usually is from sheet metal construction which the floor members are large closed section and with a good joint between members. It is like a grillage structure of members with high torsion and bending properties. This structure always used for low production volume vehicles which the body styles or rapid model are required. Figure 7 is an example of Punt chassis.

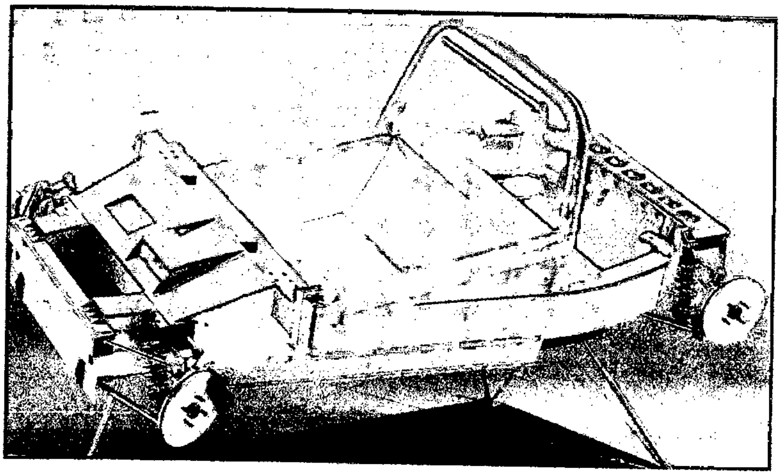

Figure 7: Punt chassis [2].

2.1.7 Perimeter Space Frame or Birdcage Frame

In this structure, relatively small section tubular members are built into stiff jointed ring beam bays welded together at joints or nodes. The individual open bay ring frames is not weight efficient shear structure. If the shear stiffness of the skin panels is incorporated into this type of body, it becomes integral structure and a considerable increase in torsional rigidity is usually observed, depending on the stiffness of the attachment. An example of perimeter or birdcage frame is the Audi A2 aluminum vehicle as shown in Figure 8.

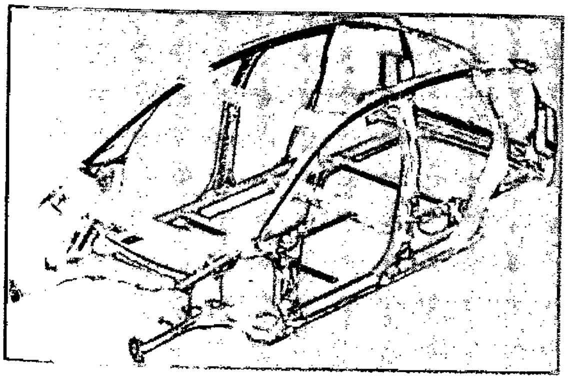

Figure 8: Perimeter space frame [2].

2.1.8 Integral or Unitary Body Structure

This type of structure is the most widely used in modern car structure type. The body is self supporting so that the separate chassis omitted with a saving in weight. The first integral car bodies were introduced in the 1930s. The integral body is a mixture of the monocoque and the birdcage types. The body forms a closed box torsion structure which results in high stiffness. The panels and body components in this structure are stamped from sheet metal and fixed together mostly by spot welding, clinching, laser welding or other methods. The beam members are formed out of folded or pressed sheet steel shapes and welded together. A notable example was the Citroen 11 CV, shown in Figure 9.

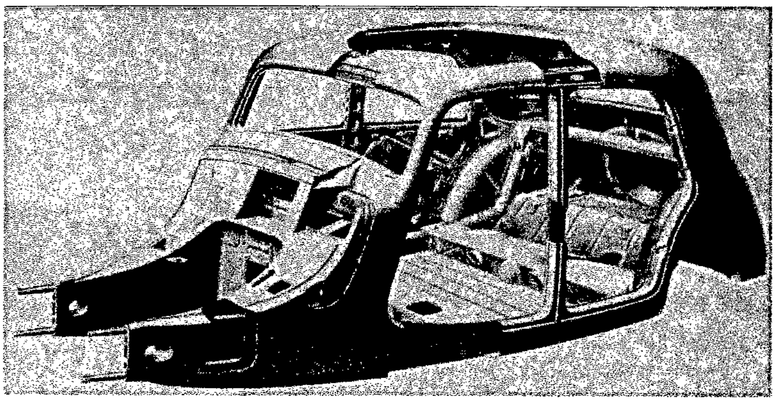

Figure 9: Integral body structure [2].

2.2 Computer modeling

2.2.1 Solid Model

Final chassis geometry that resulted from sketch and analysis was used to produce a solid model constructed by using Solidworks. This solid model represents what the chassis will look like when it is constructed which was useful for surfacing the body shell, checking components clearances and spacing, verifying vision requirements, and deciding mounting locations. All major components to be mounted in the chassis were meticulously created to give an accurate picture of spacing and clearance concerns [3].

2.2.2 Finite Element Analysis

The computerized structural analysis techniques have become the key link between structural design and computer-aided drafting. However because the small size of the elements usually prevents an overall view, the automation of the analysis tend to mask the significance of the major structural scantlings. A series of finite element analyses ensued after the creation of preliminary model. Excessive high local stresses and deflections were reduced and material thicknesses were optimized in an iterative manner which was especially helpful in optimizing the front and rear space frame [3]. A fine mesh analysis will give an accurate stress and deflection prediction, course mesh can give a degree in structural feel useful in the later stage of conceptual design. The principal steps in the FEA process are:

i. idealization of the structure
ii. evaluation of stiffness matrices element groups
iii. assembly these matrices into a supermatrix
iv. application of constraint and loads
v. solving equation for nodal displacement
vi. finding member loading

The first stage is getting the static and dynamic stiffness and from here, comes structural refinement and optimization based on load inputs and also projected torsional and bending stiffness. The key factor in a vehicle body analysis and modeling is joint stiffness which involves in modifying the local properties of the main beam elements of a structural frame.

2.3 Chassis Design

The vehicle chassis links the mounting points for vehicle's front suspension, steering, engine, transmission, rear suspension, final drive, fuel tank, seat for occupants, and in this case, motor controller, electric motor and batteries[3]. The chassis requires toughness to sustain punishing fatigue loads from the road, power unit and the driver. There are several parameters needs to be considered during the chassis phase design. These parameters include:

i. Passenger Accommodation
ii. Materials for fabrication
iii. Battery Housings
iv. Packaging

2.3.1 Passenger Accommodation

Ergonomics play a vital role in the design and to accommodate the needs of the passengers, the chassis' mid-monoque was designed to provide ample space for comfort and clear visibility [3]. Rough passenger compartment dimensions and measurement are taken followed by the measurements for the seat car and this will be used as a general layout for compartment of the car. This also will help in deciding the distance between the front tires to the rear tire beside the distance from front to rear firewall.

2.3.2 Material for Fabrications

Choice of materials decided upon considering manufacturability, recyclability, material properties, safety, and ability to model accurately finite element analysis and availability. Square steels were choosing to construct the chassis because of their toughness and simpler computer modeling advantages. It is recyclable and easy to manufacture with the available tools and machinery. This material has exceptional versatility in terms of formability, strength and cost.

Advantages of steel:

i. -low cost
ii. -Ease of forming
iii. -Consistency of supply
iv. -Corrosion resistance with zinc coatings
v. -Ease of joining
vi. -Recyclable
vii. -Good crash energy absorption

Disadvantages

i. -Heavier than alternative material
ii. -corrosion if uncoated

Higher strength steel with wide range of yield strength values can to 1200Mpa. Designs can be suitably modified to either improve performance at existing thickness or down gauge with strength related parts. Although stiffness remains unaltered it is possible to offset decreased torsional rigidity. The full range of steels used in automotive design from the forming grades with a minimum yield of 140N/mm2.

2.3.2.1 Square Frame Rails

Under pure vertical bending load, square tube is stiffer than round tube. This is important because this design does not have a roof to stiffen the passenger's compartment. By using the rectangular tubing, we can add an X member acting as additional longitudinal beam reinforcement and as two transverse members. This is hard to be done if the round tube is used.

2.4 Structural Integrity

2.4.1 Stiffness

The stiffness of a vehicle structure has important influences on its handling and vibrational behaviors. The deflections due to extreme loads have to be ensured not so large.

2.4.1.1 Torsional Stiffness

The torsional stiffness of the chassis was determined by using rigid beams to conservatively model all suspension geometry while the rear wheels were held fixed. The angle difference between the front and rear axles is determined by using the displacement results. An over designed chassis is acceptable but an under designed chassis could be devastating. The stiffness of an ideal unitized structure is proportional to the square of the distance of the components from the centerline [6].

2.4.1.2 Bending Stiffness

Bending stiffness is a measure of an individual chassis to resist deflection due to a vertical load. It is measured in pounds per inch of deflection. It relates the