BORANG PENGESAHAN STATUS TESIS

JUDUL: EVALUATION OF NATIONAL CAR SEAT BELT'S DESIGN FOR THE COMFORT OF SMALL SIZE DRIVER

SESI PENGAJIAN: 2012/2013

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EVALUATION OF NATIONAL CAR SEAT BELT'S FOR THE COMFORT OF SMALL SIZE DRIVER

ROS ARIANTY BINTI MOHAMAD GHAZALI

Thesis submitted in fulfillment of the requirements
for the award of the degree of
Bachelor of Manufacturing Engineering

Faculty of Manufacturing Engineering
UNIVERSITI MALAYSIA PAHANG

JUNE 2013

EXAMINER'S APPROVAL DOCUMENT

We certify that the thesis entitled "Evaluation of National Car's Seat Belt Design For The Comfort of Small Size Driver" by Ros Arianty Binti Mohamad Ghazali. We have examined the final copy of this thesis and in our opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Manufacturing Engineering. We herewith recommend that it be accepted in fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering.

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SUPERVISOR'S DECLARATION

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STUDENT'S DECLARATION

I declare that this thesis entitled "Evaluation of the national car's seat belt design for the comfort of small size driver" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any degree.

Signature :

Name : ROS ARIANTY BINTI MOHAMAD GHAZALI

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Name : ROS ARIANTY BINTI MOHAMAD GHAZALI

Date : 19 JUNE 2013

To my beloved parents

My husband

My family

Fellow friends

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Alhamdulillah, thanks to GOD for giving me the strength to finish this Final Year Project. Firstly, I would like to express my gratitude to my supervisor Madam Munira bt Mohd Ali for her advice and support throughout this project. Special thanks to my assessor Madam Mazni, and not forget to Mr. Mazwan from PERODUA and Mr. Nasir from AUTOLIV for their help and cooperation during this study.

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ABSTRACT

National car seat belts design has been evaluated for the comfort of small size driver. Copies of a questionnaire were distributed to 30 participant undergraduate engineering students studying at the University Malaysia Pahang. The participant only female and 5th percentile of Malaysian that represent the small size driver. The variables used to investigate this were based upon those found to predict engagement in self-protective behaviors by previous researchers and included: comfort, perception of risk, perception of safety, belief about the effectiveness of using a seat belt, beliefs about the seriousness of having a crash, and concern about having a traffic accident or being fined for not using a seat belt. There are many consideration should be cautioned to design and produce a national car's seat belt that have ergonomics and more safety characteristic. Thus, to create an ergonomic product anthropometry data is plays a main role in the design development. Anthropometry refers to the measurement of humans. Anthropometry has been considered as the very basic core of ergonomics in an attempt to resolve the dilemma of "fitting people to machine. The anthropometric data of American Male (AM) at 95th percentile and the anthropometric data of Malaysian Male (MM) at 95th percentile will be compared and at the same time the focus is more towards the 5th percentile of Malaysian that represent the small size driver as another design requirement for the seat belt.

ABSTRAK

Reka bentuk tali pinggang keledar untuk kereta nasional telah dinilai untuk keselesaan pemandu saiz kecil. Salinan soal selidik telah diedarkan kepada 30 orang peserta terdiri daripada pelajar Sarjana Muda Kejuruteraan yang belajar di Universiti Malaysia Pahang. Hanya peserta wanita (5 persentil) yang mewakili pemandu bersaiz kecil. Pemboleh ubah yang digunakan untuk menyiasat ini adalah berdasarkan kepada mereka yang didapati meramalkan penglibatan dalam tingkah laku diri perlindungan oleh penyelidik sebelum ini dan termasuk: keselesaan, persepsi risiko, persepsi awam tentang keselamatan, kepercayaan tentang keberkesanan menggunakan tali pinggang keledar, kepercayaan tentang betapa seriusnya mempunyai kemalangan, dan kebimbangan mengenai mempunyai kemalangan jalan raya atau yang didenda kerana tidak menggunakan tali pinggang keledar. Terdapat banyak pertimbangan perlu diingatkan untuk merekabentuk dan menghasilkan tali pinggang keledar kereta nasional yang lebih ergonomik dan mempunyai ciri-ciri keselamatan. Oleh itu, untuk mempunyai ciri-ciri ergonomic, antropometri data produk ini memainkan peranan utama dalam pembangunan reka bentuk. Antropometri merujuk kepada ukuran manusia. Antropometri telah dianggap sebagai teras yang sangat asas ergonomik dalam usaha untuk menyelesaikan dilema "menyesuaikan orang kepada mesin”. Data antropometri Lelaki Amerika (AM) pada peratusan ke-95 dan data antropometri Lelaki Malaysia (MM) pada peratusan ke-95 akan dibandingkan dan pada masa yang sama tumpuan adalah lebih kepada peratusan ke-5 penduduk Malaysia yang mewakili pemandu bersaiz kecil sebagai satu lagi keperluan dalam reka bentuk tali pinggang keledar.

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LIST OF ABBREVIATIONS

AM	American Male
MM	Malaysian Male
PERODUA	Perusahaan Otomobil Kedua Sendirian Berhad
CATIA	Computer Aided Three-dimensional Interactive Application

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

In this chapter introduction is made of some general information about the national car's seat belt, research study in this project and the essential information of the seat belt design and part involved.

1.2 PROJECT BACKGROUND

Seat belt is a safety harness designed to secure the occupant of a vehicle against harmful movement that may result from a collision or a sudden stop. Seat belt start invented by Benjamin Foulois in 1911 and implemented in aircraft seat for the main purpose is to make pilot hold and firmly in the seat for the better control of aircraft. In automotive, implemented by Nash in 1949 and Ford in 1995 as options for the reason is mainly for safety. In 1970, the world's first seat belt law was put in place at Victoria, Australia making the wearing of seat belts is compulsory for driver and passenger.

There are many types of seat belt such as 2 points seat belt (lap type), a lap belt is strap that goes over the waist and deliver the impact force to pelvis area, usually found in aeroplane. Besides, 3 points seat belt, a Y-shaped arrangement that spread out the energy of the moving body over the chest, pelvis and shoulder. 4,5,6 points seat belt,

the lap portion is connected to a belt between the legs (3 points) and shoulder belts (2 points). Typically found in child safety seat and in racing cars.

Seat belt is designed to hold person in place in the prevent of a motor vehicle accident, that is why choosing the best seat belt design is important to stay safe on the road, especially for user that may have special needs such as small size driver that need more specific or special design to make sure the comfort and safety of the driver.

Besides that, seat design also plays an important role in the perception of a vehicle's overall quality. More effective ways have been seeking from car makers to improve car seats to make sure the comfort of driver. Flexible is one of the most important factors that must be considered to design a car seat. So that, it can be adjusted to fit the driver's body size to make sure the driver feel comfortable when driving.

Ergonomic is one of the important factors that need to be considered in the design process. Ergonomics is a scientific discipline, which is concerned with improving the productivity, health, safety and comfort of people, as well as promoting effective interaction between people, technology they are using and the environment in which both must operate. A product may be ergonomically designed for a specific application. The product selected must be matched the characteristics of the required operations and the characteristics of the people who use the products. Some products are designed to specifically reduce risk factor. The importance of ergonomic and safety had grown significantly.

Thus, anthropometry data plays a main role in the design development. Anthropometry refers to the measurement of humans. Anthropometry has been considered as the very basic core of ergonomics in an attempt to resolve the dilemma of "fitting people to machine ". Bridger and Chou & Hsiao S.W. 2005. *International Journal of Industrial*, believed anthropometry is a research area ergonomics dealing with the measurement of human body dimensions and certain physical characteristics. Anthropometry can be used in ergonomics to specify the physical dimensions of workspaces, workstations and equipment as well as applied to product design.

1.3 PROBLEM STATEMENT

From the previous project background, there are many consideration should be taken in designing and producing a national car's seat belt that have ergonomics and more safety characteristic. Today, seat belt failure due to malfunction is not common. However, there are some very real problems with seatbelt design, and seat belt problems that could put driver and passengers at risk

Seat belt injuries can occur when a defective seat belt fails to adequately protect a vehicle passenger in the collision phase of an automobile accident. Seat belt injuries also occur when there is a seat belt design, production, or installation can be suspected under the defect. Most of the seatbelt design today is the three-point design, which has a conjoined sash and lap belt. However, some people, especially small driver, like to pull the sash part behind their backs or wearing a loose fitting seat belt because they feel not comfortable. Not wearing the seat belt properly is extremely dangerous with the sash going from the center of the shoulder and across the chest to the waist, because the seatbelt is too big to be worn that way. That is why, this project will focused on evaluation of the design of a national car's seat belt for comfort of small size driver

Many people, especially those who are short, know how annoying it can be to have a seatbelt rubbing against their neck. Car manufacturers and safety organizations recommend adjusting the seatbelt to "rest across the middle of the shoulder" for safety, but for many shorter people, there has been no way to safely do this.

The thing about seatbelts is that they weren't designed to fit all people. Even in many cars where the belt attachment at the door pillar is adjustable, the seat belt can't be adjusted enough to move it away from the neck of a shorter driver or passenger.

As we all know seatbelts can save lives, and today most states have laws requiring occupants to wear one. But the discomfort of having a seatbelt rub against the neck has led many people to wear the seatbelt improperly - either placing the shoulder portion behind their arm, behind the back, or not wearing it at all.

The seatbelt is designed to spread the force of a collision across two of the body's strongest areas: the pelvis and the upper chest, without jeopardizing the neck. Even the collarbone and shoulder can be damaged from the extreme forces encountered during an accident. But the neck is more delicate. If the seatbelt is positioned in a way that transfers its restraining force to the neck, more serious damage can result.

1.4 PROJECT OBJECTIVES

i. To evaluate the design of a national car's seat belt for comfort of small size (5^{th} percentile) driver among Malaysian citizen.

ii. To suggest improvement on the design of the seat belts system for national car by including the aspect of small size driver.

1.5 PROJECT SCOPES

For this project, evaluation of the national car's seat belt design for the comfort small size driver, PERODUA Viva were used as a model car because Viva is a compact car that commonly preferred by female driver since this project only focuses on female and small size driver.

Then, to evaluate the seat belt design for comfort small size female driver, the study on female anthropometric data for Malaysia citizen were needed to improve wellbeing, health, comfort, and safety.

Besides that, for this project also need to understand more about fundamental of seat belt and the details of seat belt's design with part involved such as measurement of seatbelt size, dimension, location, elasticity and also material used.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter is focusing on the literature review for seat belt design and its factor. Seat belt's comfort level and part involved and also seat dimension are described in details based on the finding during completion of this project.

2.2 SEAT BELT

The seat belt is widely regarded to be the most important piece of safety equipment in a vehicle. When used, seat belts are approximately 45% effective at preventing fatal injuries and 67% effective at preventing serious injuries .Seat belt use has been demonstrated to decrease serious injury in crashes (Tison et al.,2008). The legacy of research on increasing seat belt use has focused on enactment of primary laws, public education, high-visibility police enforcement, and seat belt reminder systems.

Compulsory seat belt wearing has become part of highway codes worldwide, probably because seat belts are among the most effective measures for the maintenance and enhancement of (personal) safety in traffic (Elvik and Vaa, 2004; Evans, 1996, 2004; Routley et al., 2008). Curtis et al., (2007) for instance, see safety belts as the single most effective means to reduce fatal and non-fatal injuries. Nonetheless, overwhelming proof for the seat belt's effectiveness as a safety promoting device is

in sheer contrast with the amount of motorized vehicle occupants who still refrain to make (continuous) use of safety restraints while driving. The World Report on Road Traffic Injury Prevention (Peden et al., 2004) asserts that the extent of non-users remains significant.

According to Campbell BJ. (1987), persons wearing seat belts are significantly less likely to die in motor vehicle accidents than persons that not wearing seat belts. Although the belt prevents more life threatening injuries to the head and thorax, the force of the restrained occupant against the belt may cause some injuries. The principal mode of protection afforded by the three-point seat belt is the minimization of bodily, contact of the occupant with the interior surfaces of the vehicle. Therefore, the three-point seat belt can contribute to or actually cause injuries in deceleration type motor vehicle crashes, e.g. tearing of the mesentery, rupture of the small bowel or colon, disruption of retroperitoneal organs and ligamentous elements, initial tearing or dissection with thrombosis of the iliac artery or abdominal aortas (King AI.,1995) .

In the roll-over vehicle accident, although there was a report of the victim wearing the diagonal belt without the lap belt, to our knowledge, this is the first report of strangulation by a properly used three-point belt. As the seat belt in this case was of the modern ‘‘inertia-reel’ type, which allows slow movements but locks when tugged sharply (Arnold, 1996.), we believe that the seat belt unreeled to some extent as the car decelerated slowly during its roll. The loosened belt allowed the driver’s body to move, but then locked and applied external pressure to the neck at some point. Although wearing a seat belt can prevent ejection and internal injuries, in this case, the driver died of strangulation by the seat belt. This case illustrates that a properly used three-point belt can cause strangulation in roll-over vehicle accidents.

The effectiveness of wearing seat belts is widely known to reduce injury severity to vehicle occupants in accidents, and the effectiveness of seat belt use for rear seat passengers has also been revealed in many studies (Evans, 1988; Krafft et al., 1990; Padmanaban and Ray, 1992; Huelke and Compton, 1995). Although these measures

have proven to be effective, they have not increased U.S. seat belt use to 100% (Pickrell & Ye, 2009). Behavioral programs have produced large sustained increases in seat belt use, and several of these techniques have been employed on a national, State, and community wide basis to increase belt use. For example, highly publicized enforcement techniques such as *Click It or Ticket* influence behavior via a direct punishment contingency. The message is clear, "If I don't wear my seat belt, I may get stopped by the police, get a ticket, and get points." The national seat belt use rate reached 83% across the United States in 2008 (NHTSA, 2009). Innovative technologies may have the potential to elevate this rate further, possibly to 100%.

2.3 SEAT BELT DESIGN

Research carried out n many countries testifies to the effectiveness of seat belts, as shown by the reduction in injury and fatality which accompanies, seat belt wearing in accidents (Hobbs, 1978;Milne,1979; Hakkert et al,1981). However, the effectiveness of sear belts depends in part upon the individual deciding to wear the belt and being physically able to do so. In countries where no legislation exists for compulsory use , or where data collected before legislation was enacted, voluntary wearing rates tend to be extremely low (Simpson and Warren,1981; MacKay,1981).The most commonly reported reasons for non-use are ' discomfort' and 'inconvenience' (Pierce et al.1974;Galer,1977;Toms et al.1979). Despite these low wearing rates, research has shown that many non-wearers do appreciate the effectiveness and benefits of seat belts (Pierce et al,1974;Knapper et al,1976). One might therefore assume that the design and positioning of the belts appear to inhabiting their use. Chliaoutakis et al. (2000) for instance, found seat belt usage to be related to both positive beliefs (i.e., seat belt is an effective measure for self-protection, generates confidence while driving, is easy to use) and negative beliefs (i.e., seat belt implies discomfort, loss of time, infringement of movements, fear to get trapped, loss of prestige) .

International research has identified several reasons for belt non-use including: discomfort associated with wearing, forgetting to secure the belt, perceived uselessness

of the restraint, carelessness, perceived danger associated with belt use, interference with movement in the vehicle, and lack of established habit (Barss et al.,2008). In addition, from the research done by (Ahmet Demirer et al.,2011) most of the drivers report that they would use their seat belt if the discomfort problem is solved.

Besides, courses on ergonomics (disconformities between driver seat and seat belt, discomfort of seat belt, adjustable seat belt), precaution signal (unbelted seat belt alarm), automatic seat belt, seat belts having air bag function and easily unbelted seat belts should be given in primary and high schools. (S_ims_ekog˘lu, 2009), declared that discomfort, lack of habit of seat belts and short distance drives were among the frequently reported reasons for not using a seat belt when driving.

Previous research into health actions has shown the influence of different psycho-social variables on preventative behavior, which are similar for most forms of self-protective behavior (Bandura, 1986; Baye´s, 1995;Kirscht, 1983). Furthermore, the engagement in preventative behaviors seems to be related to their consequences (Baye´s, 1995). For example, the result of risky behavior is often immediate pleasure, whilst the possible negative consequences of engaging in risky behavior are normally perceived only as a slight possibility and a long way into the future. On the other hand, the consequences of engaging in preventive behavior are immediate negative sensations (e.g. the discomfort of using a seat belt), while the appearance of positive consequences is often only a long term outcome (e.g. reducing the chances of being killed or injured if an accident occurs). Therefore, according to this research the negative and immediate consequences of behavior, such as discomfort and hindered movement, are important variables for predicting the likelihood of subjects not using their seat belts (Chliaoutakis et al.,2000).

That is why there are many consideration should be cautioned to design and produce a national car’s seat belt that have ergonomics and more safety characteristic. Ergonomic is one of the important factors that need to be considered in the design process, the importance of safety and ergonomic had grown significantly (Mattila, M.

1996) . The branch of ergonomics that deals with human variability in size, shape and strength is called anthropometry.

From all these researches, none have discussed about the effect of the seat belt for the small size driver.

2.4 ANTHROPOMETRIC DATA FOR SEAT BELT DESIGN

Anthropometry refers to the measurement of humans. Adolphe Quetelet has used the word Anthropometric in his book entitled "Anthropometrie". The word Anthropometric is also derived from the Greek word *"anthropos", which means human, and "metros", which means measure* (Pheasant, S., Haslegrave, C.M. 2006.) Anthropometry has been considered as the very basic core of ergonomics in an attempt to resolve the dilemma of 'fitting people to machine' (Wang, E.M.Y., Wang, M.J., Yeh, W.Y., Shih, Y.C. & Lin, Y.C. 1999). Bridger, R.S. 1995. and Chou, J.R. & Hsiao, S.W. 2005 believed anthropometry is a research area in ergonomics dealing with the measurement of human body dimensions and certain physical characteristics. Anthropometric data can be used in ergonomics to specify the physical dimensions of workspaces, workstations, and equipment as well as applied to product design. Appropriate use of anthropometry in design may improve wellbeing, health, comfort, and safety (Pheasant, S. 1998.)

There are several studies done by past researchers in constructing anthropometric database. According to Barroso et al. the data collected will serve as a basis for the design of industrial tools, equipment and clothing. In addition, the data constitutes an essential element for the ergonomic design of workplaces (Barroso, M.P., Arezes, P.M., da Costa, L.G. & Miguel A.S. 2005.)

2.5 SEAT DESIGN

Seats are an essential part of a car because the feeling or comfort of seat can determine the value of the car. That s why comfortable seat plays an important role for safety and comfort of drivers, especially for the driver that have special size such as very small driver or very big driver.

Sitting comfort has become an important issues that demands adequate ergonomic interventions (Dunk and Callaghan, 2005). In addition, Vink (2005) said that "…discomfort is more related to physical characteristics, while comfort is more related to experience, emotion, unexpected features, and luxury". Physical seat characteristics are the optimal backrest width and seat cushion width based on anthropometrics as specified by Reed et al. (1994 in their literature review.

Based on the requirements for Federal Motor Vehicle Safety Standard 208 (FMVSS 208) testing (NHTSA, 2000) and research on occupant positioning (Manary et al., 1998, Reed et al., 2000 and Reed et al., 2002, the baseline occupant position for 5th percentile and smaller females is considered to be the full forward seat position. Conversely, the baseline position for the 95th percentile occupant is considered to be the full rearward seat position. These two positions are used as a basis for comparing actual seating positions for both groups of occupants.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In order to achieve the aim and objectives of this thesis, there are several method used, which are:

i. Site visit to understand the fundamental of seat belt design.
ii. Questionnaire/ surveys to get the level of comfort seat belt use from respective respondents.
iii. Design evaluation.

After the survey is finished, then from the data collected the data can be analysis to get the result. See Figure 3.1 to clear detail about this project thesis.

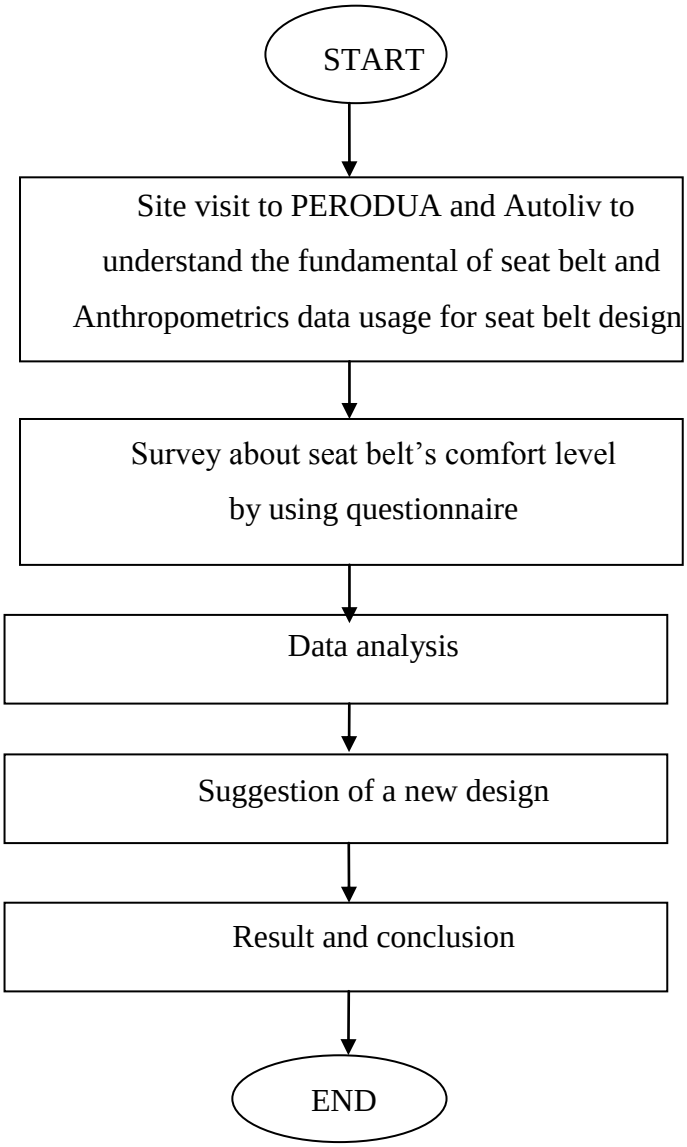

Figure 3.1: Project methodology flow chart

3.2 SITE VISIT TO UNDERSTAND FUNDAMENTAL OF SEAT BELT AND ANTHROPOMETRIC DATA USAGE FOR SEAT BELT DESIGN

Before know detail about seat belt restraint system, the first thing to understand is about the fundamental of seat belt. All the information collected from the visit to PERODUA. Two important aspects of the seat belt's fundamentals are design of the seat belt systems and the anthropometric data usage for the seat belt's design. From the visit to PERODUA and AUTOLIV, the two important aspects are obtained.

PERODUA (Perusahaan Otomobil Kedua Sendirian Berhad), is Malaysia's second largest automobile manufacturer after Proton. It was established in 1992 and launched their first car, the Perodua Kancil in August 1994. The shareholders of Perodua are UMW Corporation Sdn Bhd with 38% stake, Daihatsu Motor Co. Ltd. (20%), MBM Resources Bhd (20%), PNB Equity Resources Corporation Sdn Bhd (10%), Mitsui & Co. Ltd (7%) and Daihatsu (Malaysia) Sdn Bhd (5%). Perodua mainly produces minicars and superminis and does not have models in the same market segments as Proton. They do not design or engineer their main components such as engine and transmission in house. Perodua cars have historically used Daihatsu component designs. Daihatsu held a 20% stake in Perodua at the company's launch, increasing this to 25% in 2001 and then to 35%.

While, AUTOLIV is a Swedish-American company with headquarters in Stockho , Sweden, that in 1997 sprung from the merger of the Swedish company Autoliv AB and Morton Automotive Safety Products, Inc., a division of the American firm Morton International. Autoliv develops and manufactures automotive safety systems for all major automotive manufacturers in the world. Together with its joint ventures Autoliv has over 80 facilities with 48,000 employees in 29 countries. In addition, the company has 17 development and engineering centers in nine countries around the world, including 20 test tracks, more than any other

automotive safety supplier. The company's shares are listed on the New York Stock Exchange and its Swedish Depository Receipts on the OMX Stockholm Stock Exchange.

From the site visit, Mr. Mazwan, and his colleagues from PERODUA and Mr. Nasir from Autoliv were interviewed about fundamental of seat belt design and anthropometric data usage of seat belt's design. It has come to the information that PERODUA has been using Anthropometric data of American Male (AM) 95th percentile as the measurement in designing the car seat belt for all models. They are using guidelines from Regulation that stated by United Nation. Table 3.1 shows anthropometric data for the 95th percentile American Male (AM) that use for dummy specification as stated in Regulation No.14.

Table 3.1: Anthropometric data for the 95th percentile American Male (AM)

No.	**Anthropometric dimension**	**95th percentile**
1	Mass	97.5± 5 kg
2	Erect sitting height	965 mm
3	Hip breadth (sitting)	415 mm
4	Hip circumference (sitting)	1200 mm
5	Waist circumference (sitting)	1080 mm
6	Chest depth	265 mm
7	Chest Circumference	1130 mm
8	Shoulder height	680 mm
9	Sitting Height	667.12 mm

Tolerance on all length dimension ± 5 per cent.

Remark: a sketch explaining the dimensions is given in the figure below.

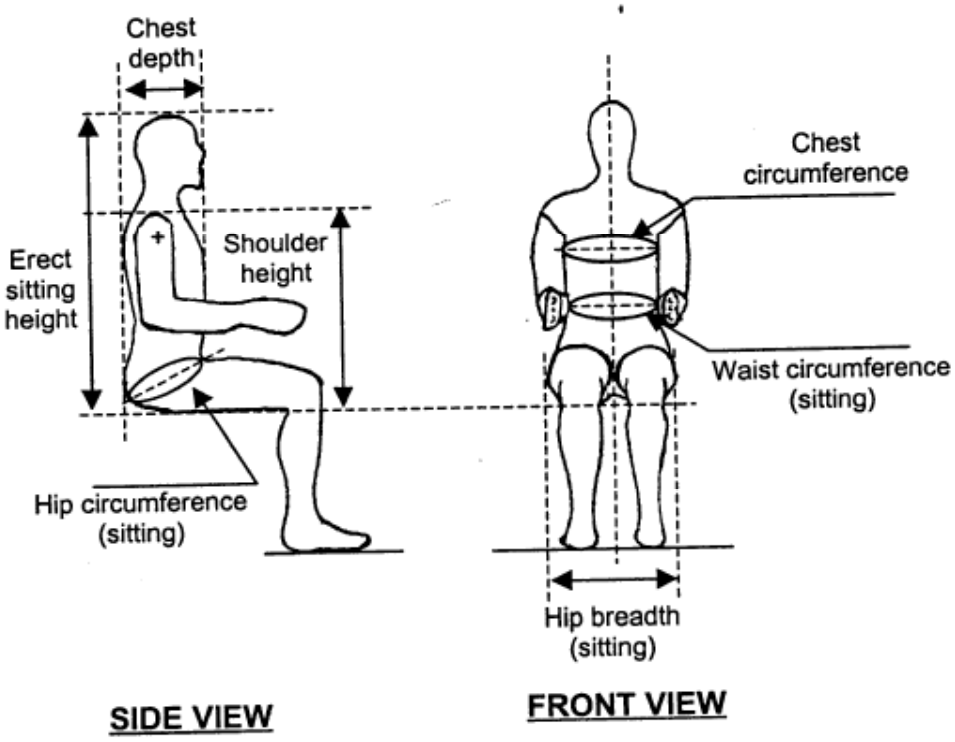

Figure 3.1: Dummy Specification (Regulation No.14)

3.3 SURVEY OF SEAT BELT'S COMFORT LEVEL BY USING QUESTIONNAIRE

In this project, survey technique were used to get the data. Survey research is one of the most important areas of measurement in applied social research. Survey is a technique for gathering information from a large number of users (Brehob, 2001). Surveys are an important technique because they provided information regarding users' preferences and ideas about the design in many stages of the interface development. Users' reactions can have strong impact on the design and development of an interface.

Survey by using questionnaire was use for this project. Questionnaire " a form that people fill out, used to obtain demographic information and views and interests of those questioned (Brehob,2001). In addition, a questionnaire in a more structural way as a method for the elicitation and recording and collecting information, (Kirakowski, 1998) .

3.3.1 Respondent

Participants were 30 undergraduate engineering students studying at the University Malaysia Pahang. The participant only female and 5^{th} percentile of Malaysian that represent the small size driver.

3.3.2 Materials and procedure

The students were asked to participate in a evaluation on the comfort of seat belts. Highly structure questionnaire that direct occupants to assign feelings of comfort/discomfort about seatbelt. Participation was voluntary and all responses were anonymous. All of the students that were in the classroom the date of the survey agreed to participate by completing a questionnaire that measured by following variables.

i. Personal information

Participants were asked their age, weight, height. They were also asked did they ever drive PERODUA Viva, how long they had held a driving license, how often they drove

ii. Frequency of seat belt use

Using a five point scale (1= never to 5= always) subjects were asked whether they usually wore a seat belt on urban roads and also whether they wore a seat belt while travelling on the highway.

iii. Comfort

Participants were asked to rate the level of discomfort/comfort they felt from wearing the seat belt while driving on urban roads and on highways. The scale ranged from 1 (very uncomfortable) to 5 (very comfortable).

iv. Seat belt fit

Participants were asked to rate the seat belt fit level when they wearing the seat belt while driving on urban roads and on highways. The scale range 1 (not fitted) to 5 (fitted)

v. Risk perception and safety perception

The subjects were asked the degree of risk (crash-injury risk) they perceived from not wearing a seat belt on urban roads and on highways. They were also asked to rate the degree of safety they felt from using the seat belt. The scales ranged from 1 (no risk/safe) to 5 (very risky/unsafe)

vi. Belief about the seat belt's effectiveness

Subjects were asked whether they thought using a seat belt was an effective preventive measure if they were driving. The scale ranged from 1 (not effective) to 5 (very effective).

vii. Degree of worry about having a crash or being fined for not using a seat belt

Subjects were asked whether they were worried about having a traffic accident and also whether they were worried about being fined for not wearing a seat belt. The scale went from 1 (not worried) to 5 (extremely worried)

Results and analysis of the surveys are discussed in Chapter 4.

3.4 DESIGN SUGGESTION FOR SEAT BELT'S DESIGN FOCUSING ON HEIGHT ADJUSTER

3.4.1 Using CATIA Software to Draw Seat Belt Design

CATIA (Computer Aided Three-dimensional Interactive Application) is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Dassault Systemes (Wikipedia). CATIA system engineering can integrates complex product behavior into the product definition, enabling a lifelike experience which predicts the actual performance of products in the real world. Besides, CATIA has significantly improved ability to complete the design to manufacture processes of very advanced structures. In this project, CATIA were used to draw part of seat belt design. This drawing can show the improved design.

CHAPTER 4

RESULTS AND ANALYSIS

4.1 INTRODUCTION

This chapter discussed about the Seat belt restraint system, survey of seat belt comfort level of small size driver, seat belt design using CATIA and also car seat design.

4.2 SEAT BELT RESTRAINT SYSTEM

PERODUA Viva used 3 points seat belt. A 3-point belt is a Y-shaped arrangement, similar to the separate lap and sash belts, but unitized. Like the separate lap-and-sash belt, in a collision the 3-point belt spreads out the energy of the moving body over the chest, pelvis, and shoulders. Volvo introduced the first production three-point belt in 1959. The three point belt was developed by Nils Bohlin who had earlier also worked on ejection seats at Saab. Volvo then made the new seat belt design patent open in the interest of safety and made it available to other car manufacturers for free.

There are four main functions of seat belt. Seat belt cause the occupant to decelerate at the same time the vehicle is crushing. Seat belt also spread the force of the impact over the strongest parts of the occupant's body and prevent occupant crash/colliding with interior parts. Other than that, seat belt also functions for better handling and control during driving.

Seat belts are the most effective restraint systems, for mitigating the fatalities/injury caused in frontal collisions. The most widely used seat belts are the three point seat belts. The three point seat belt were design to protect the occupant as regards contact with the passenger compartment and to avoid being thrown out of the vehicle.

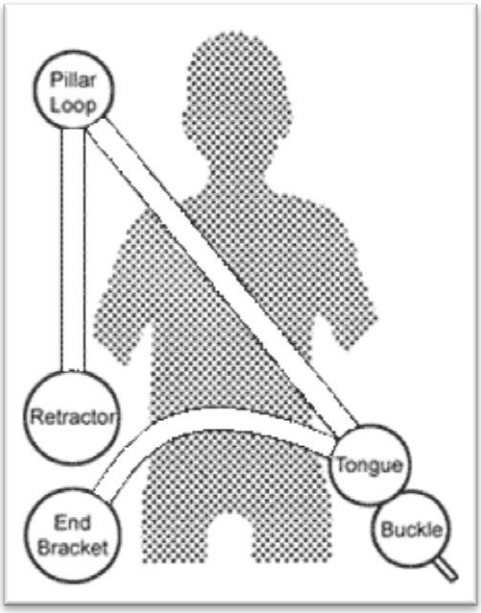

Figure 4.1: Three point seat belt

4.2.1 Components of a Seat Belt System

The various components that make up a complete seat belt restraint system are retractor, webbing, buckle, tongue plate, belt anchor plate and mini anchor plate.

i. Retractor:

Retractors are that component of the seat belt restraint system which allows the belt material to be paid out. The retractors serve the purpose of mitigating the thoracic loads during the initial stages of the frontal collisions.

Figure 4.2: Retractor

ii. Webbing:

Webbing is generally black and woven from thousands of strands of polyester or nylon. Made to a high specification and designed to elongate by 10% to 15% in an accident to absorb energy. Webbing must be in good condition such as fluffing, fraying or broken strands weaken webbing, just like any piece of cloth. Webbing is generally about 50mm wide, wider webbing (i.e. 75mm) is used on some 'special' applications and Race/Rally Harnesses.

Figure 4.3: Webbing

iii. Belt anchor plate:

Belt anchor plates were used to construct seat belt systems for vehicles to restrain forward movement of a vehicle occupant in the event of a sudden vehicle deceleration. It is also known to construct a belt anchor assembly for the seat belt system to anchor a length of belt webbing to vehicle structure.

Figure 4.4: Belt anchor plate

iv. Tongue (male) connector:

The part is pushed into the buckle when connecting the seat belt and is ejected when the quick release is used.

Figure 4.5: Tongue

v. Buckle (female connector):

The part into which the tongue is pushed when connecting the seat belt. Generally located just on or below the hip on seat belts or on the lap of harnesses. The buckle is connected to the vehicles by means of:-

- A stalk/cable with an anchorage hole
- A metal strap with an anchorage hole
- Webbing with an end bracket

Figure 4.6: Buckle

4.3 SURVEY ANALYSIS

A total of 30 completed questionnaires were returned for analyses. Participants were 30 undergraduate engineering students studying at the University Malaysia Pahang. The participants only female and 5th percentile of Malaysian that represents the small size driver. All participants have experience drive PERODUA VIVA and have driver license.

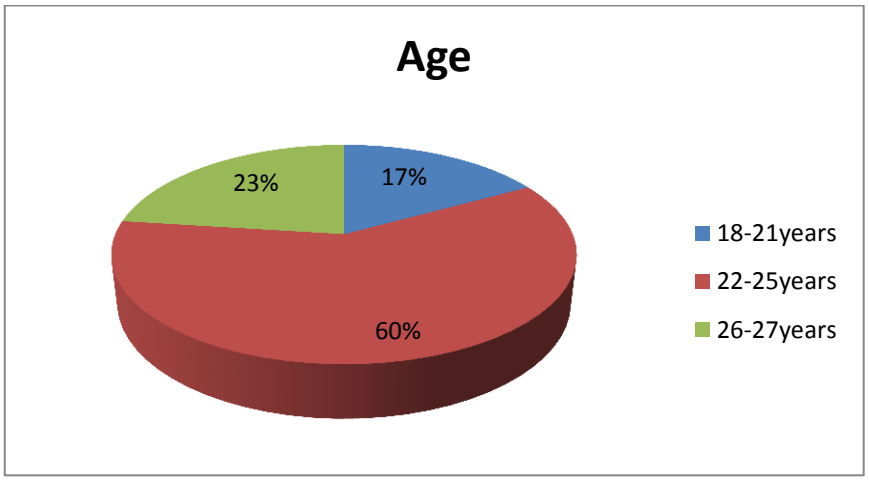

Figure 4.7: Respondent's age

Majority participant's age ranges are between 22 to 25 years old, 60 percent. Then, 23 percent of participants are 26 to 27 years old and 17 percent participants are 18 to 21 years old.

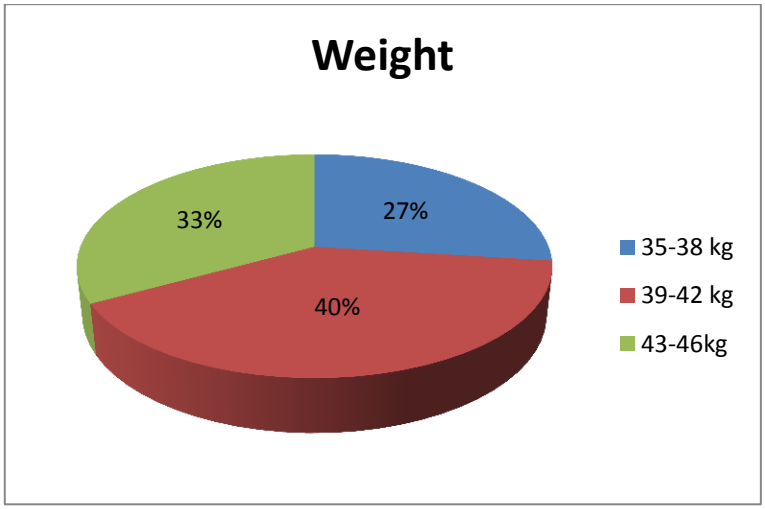

Figure 4.8: Respondent's weight

Since the range of all respondent's weight are less than 46.3kg,that means all the respondent are 5th percentile.40 percent of respondent's weight are range between 39

to 42 kg. followed by 33 percent range between 43 to 46 kg and 27 percent are 35 to 38 kg.

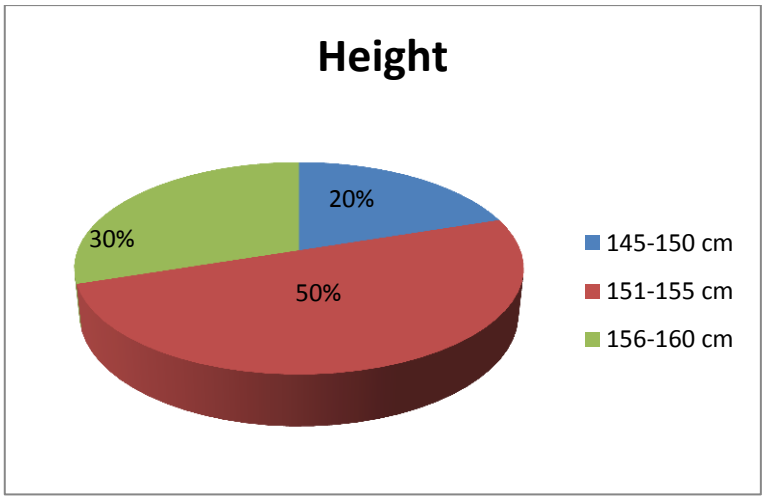

Figure 4.9: Respondent's height

Respondent's height range between 151 to 160 cm shows the highest percentage, 50 percent. Then followed by height range between 156 to 160 cm and 145 to 150 cm with the percentage of 30 percent and 20 percent.

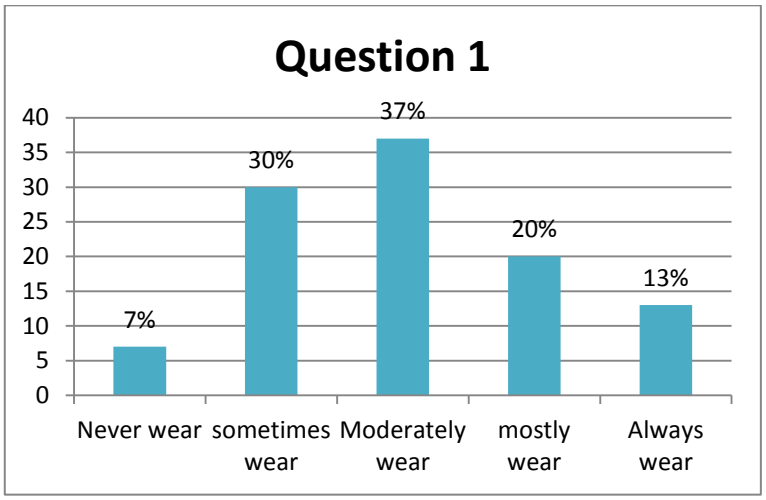

Figure 4.10: Do you always wear your seat belt when driving?

From survey, majority participants show that they moderately use a seat belt when driving (37%). More participants reported that percentage of sometimes wear (30%) than mostly wear (20%).Next, always wear (13%) and never wear (7%).

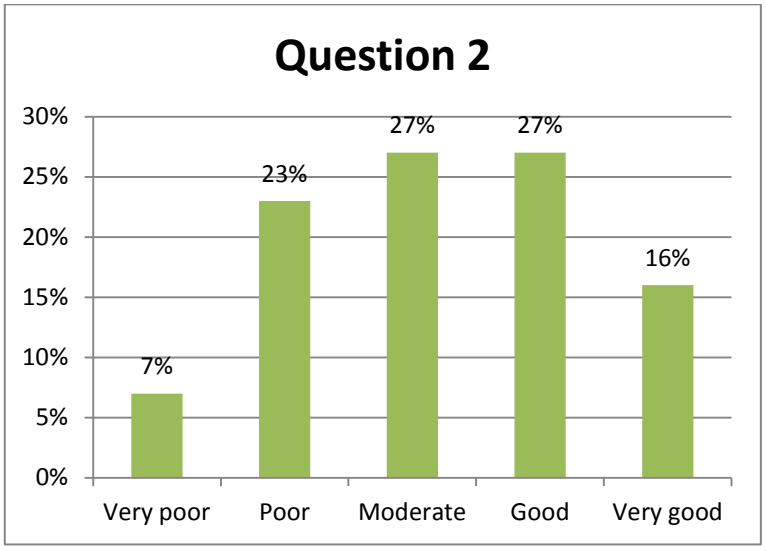

Figure 4.11: Do you believe in the effectiveness of seat belt?

The participants were asked did they believe in the effectiveness of seat belt. From the chart, only 16% of participant really do believe (very good) and mostly participant said that they do believe or good (27%) and moderately (27%) believe in the effectiveness of seat belt. 23% of participant not believe (poor) and 7% of participant not believe at all (very poor) in the effectiveness of seat belt.

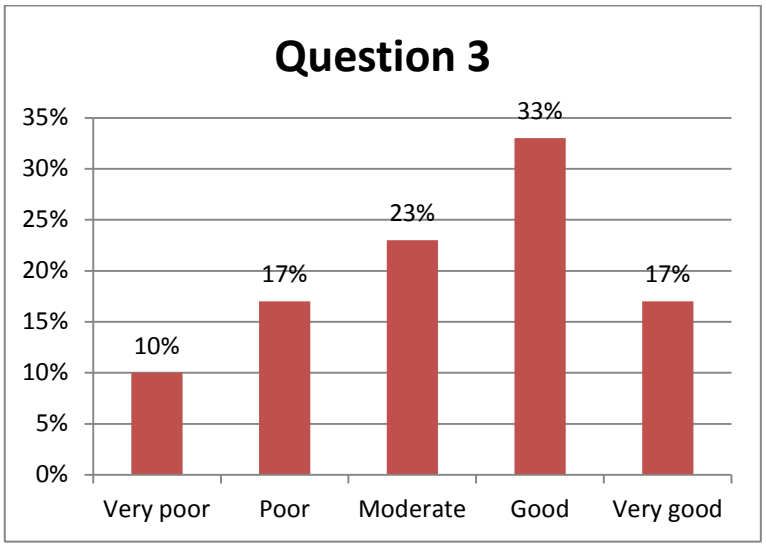

Figure 4.12: Please rate the degree of safety that you feel from using the seat belt

In the survey, participants also were asked to rate the degree of safety that they feel from using the seat belt. After the data were analyzed it shows that the highest percentage of participant (33%) said that the degree of safety is good. Followed by moderate (23%), very good and poor reported the same percentage, 17% and the lowest percentage is very poor (10%).

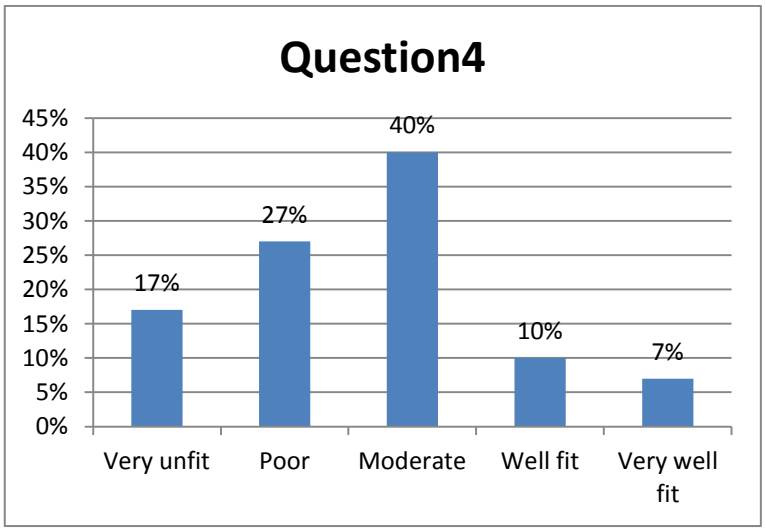

Figure 4.13: Do you feel the seat belt fit your body size very well?

The overall belt fit is measured with a five-point scale in which one indicates "very uncomfortable" and five indicates "very comfortable". Almost half percent of participants reported that they moderately (40%) feel the seat belt fit the body size well. More participant feel that the seat belt poorly fit (27%) and very unfit (17%) compared with feel the seat belt well fit (10%) and very well fit (7%)

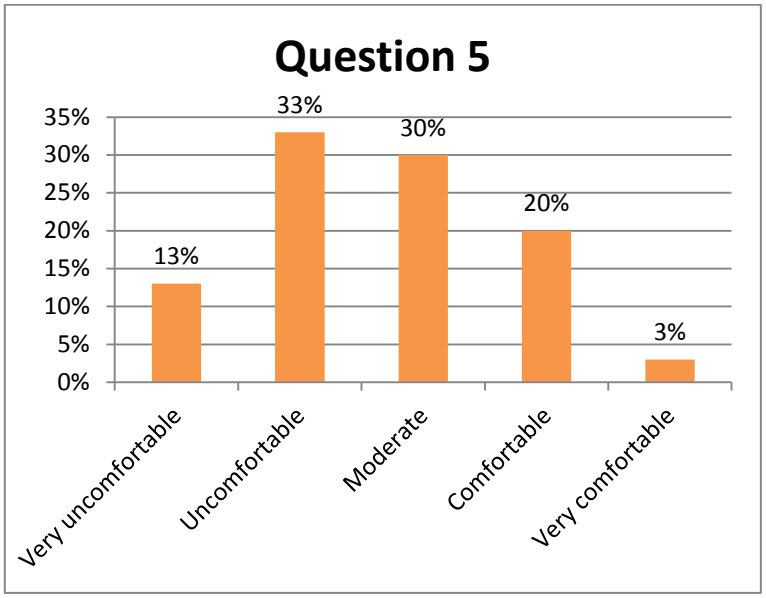

Figure 4.14: State the level of comfort when you wear a seat belt while driving

This chart shows that the highest percentage of participant reported they feel uncomfortable (33%) when they wear a seat belt while driving, whereas, the lowest percentage is 3% of participant feel very comfortable wear a seat belt while driving. Next, 30% of participant choose moderate the level of comfort,20% of participant feel comfortable and the other 13% feel very uncomfortable wear a seat belt while driving.

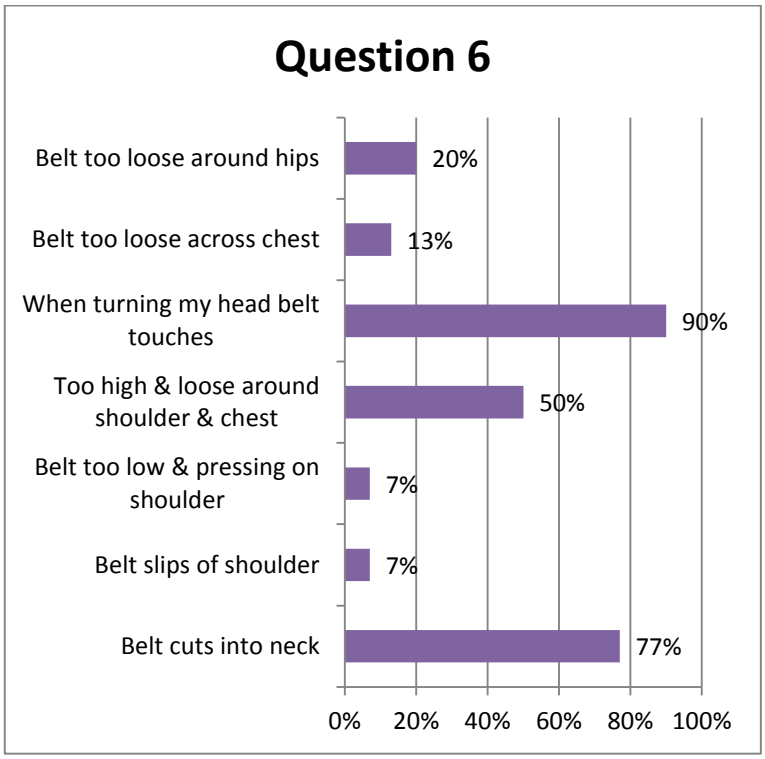

Figure 4.15: Do you experience any of the situations when having belt on

From the aspects involve in belt usage, most participant were complaining about belt touches when turning head with the highest percentage (90%).Then, belt cuts into neck (77%) also have higher percent of complaint from participants. Half percent of participants have problem with the seat belt that too high and too loose around shoulder and chest. Beside that, belt too loose around hips (20%), belt too loose across chest (13%) and the lowest percent of respondents complaints about belt slips of shoulder (7%) and belt too low and pressing on shoulder (7%).

4.4 CATIA REPRESENTATION

From the data analysis of surveys of seat belt comfort level for female small size driver, some part from seat belt were improved to make sure the comfort and safety for small size driver. As a suggestion of improvement, seat belt height adjuster and seat belt loop to be designed.

4.4.1 SEAT BELT HEIGHT ADJUSTER

Seat belt height adjusters were function to raise or lower the height to fits well and comfortable for the drivers when buckle up for safety, the locking button on the adjuster were pressed and moved as necessary. The slider were lifted slightly while pressing the locking button makes it easier to release the locking mechanism and it relieves seat belt tension to allows to use seat belt in comfort without compromising safety. Besides, the seat belt height adjuster can be adjusted for any individual and keeps within National Highway Traffic Safety Administration slack guidelines for seat belts. In existing design, there are four major components at seat belt height adjuster of the seat belt design which are:

i. Height adjuster
ii. Belt anchor plate
iii. Buckle (female connector)
iv. Tongue (male connector)

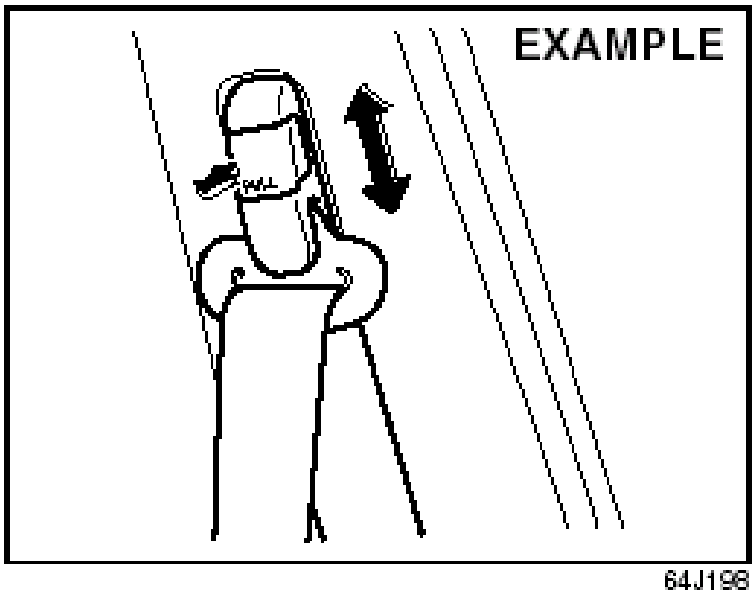

Figure 4.16: Seat belt height adjuster

i. Height adjuster

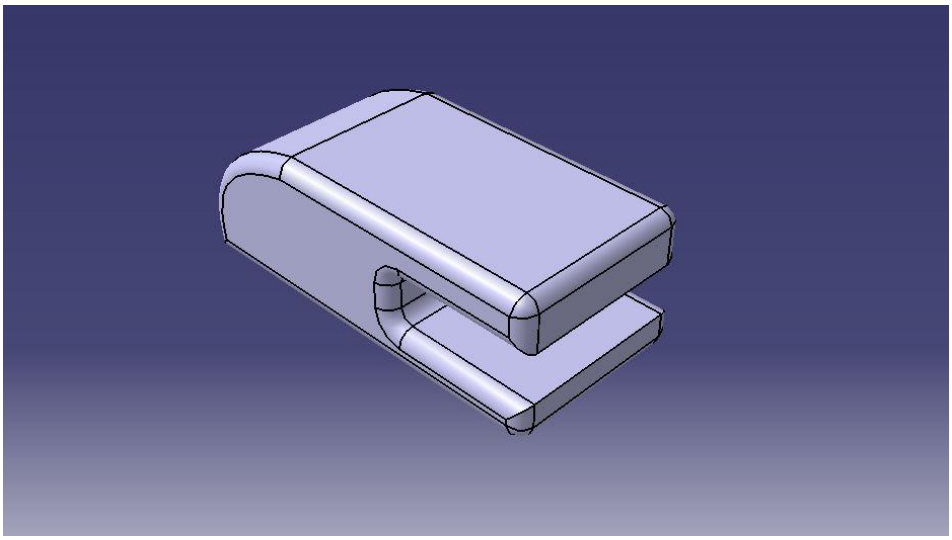

Figure 4.17: Isometric view of seat belt height adjuster

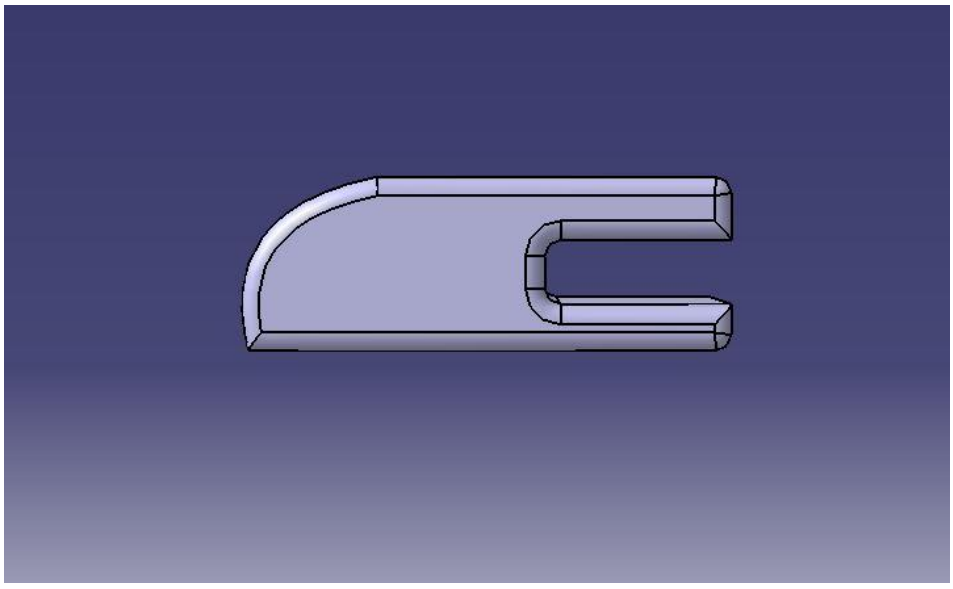

Figure 4.18: Side view of seat belt height adjuster

ii. Belt Anchor Plate

Belt anchor plates were used to construct seat belt systems for vehicles to restrain forward movement of a vehicle occupant in the event of a sudden vehicle deceleration. It is also known to construct a belt anchor assembly for the seat belt system to anchor a length of belt webbing to vehicle structure. Typically, the belt anchor assembly includes an anchor plate having the belt webbing attached thereto. The anchor plate is secured to the vehicle structure by a fastener. While this approach securely anchors one end of the seat belt system to the vehicle structure. The anchors are classified into a fixing anchor and a slip anchor. The fixing anchor is used for fixing the end of the webbing of a lap belt at a position near the floor of the vehicle. The slip anchor is mounted on the upper position of the pillar of the vehicle by a fixing bolt or the like so as to pivot on the fixing bolt in a predetermined direction.

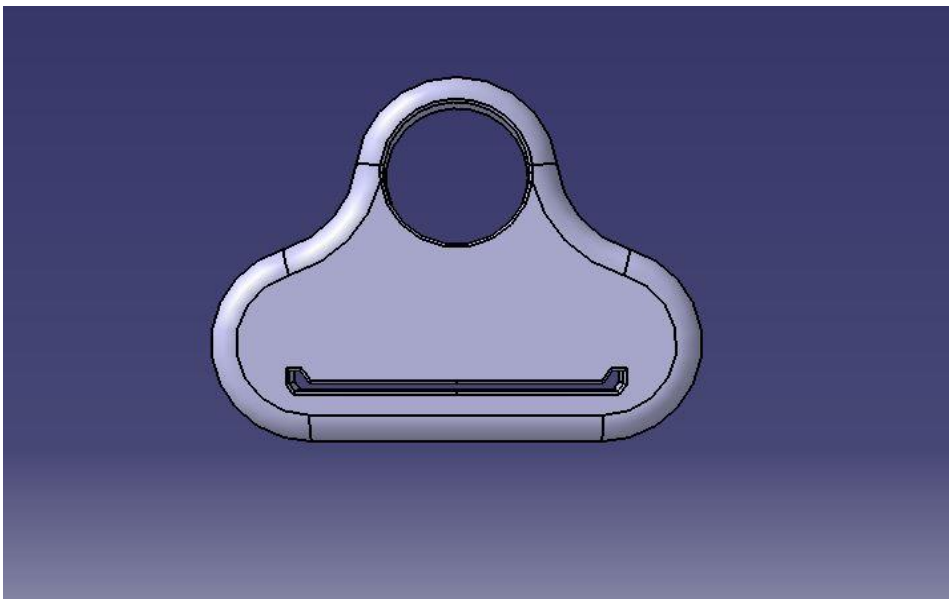

Figure 4.19: Front view of belt anchor plate

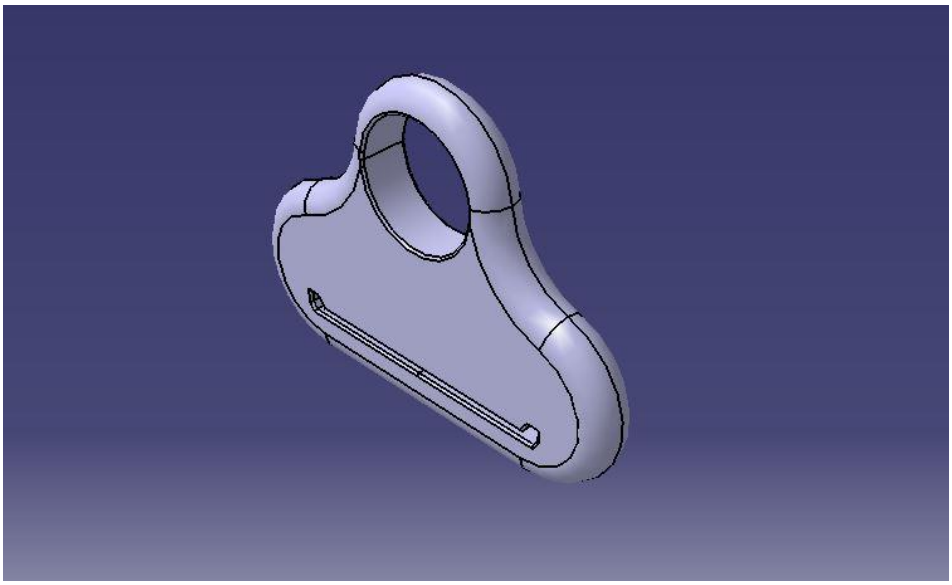

Figure 4.20: Isometric view of belt anchor plate

iii. Buckle (female connector):

The present invention is a buckle for a vehicle seat belt system. The buckle comprises a latch mechanism for connection with a tongue assembly of the seat belt system. The latch mechanism has a latched condition and a released condition. The buckle also comprises a manually engageable pushbutton connected with the latch mechanism. The pushbutton is movable between a first position in which the latch mechanism is in the latched condition and a second position in which the latch mechanism is in the released condition. The pushbutton contains an illumination mechanism comprising an electroluminescent panel movable with the pushbutton when the pushbutton moves between the first and second positions.

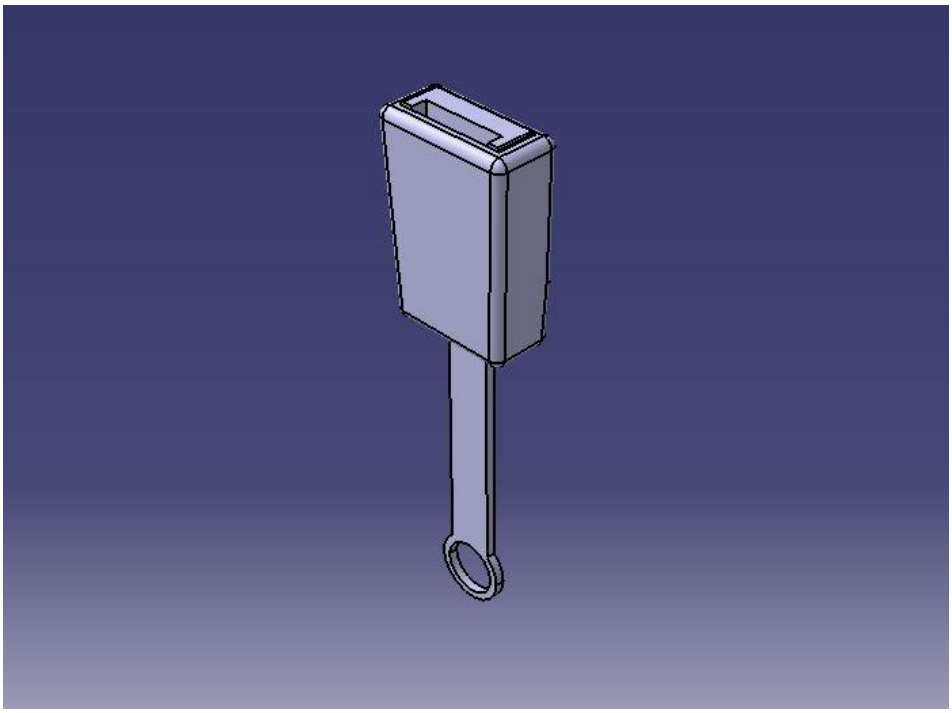

Figure 4.21: Isometric view of seat belt buckle

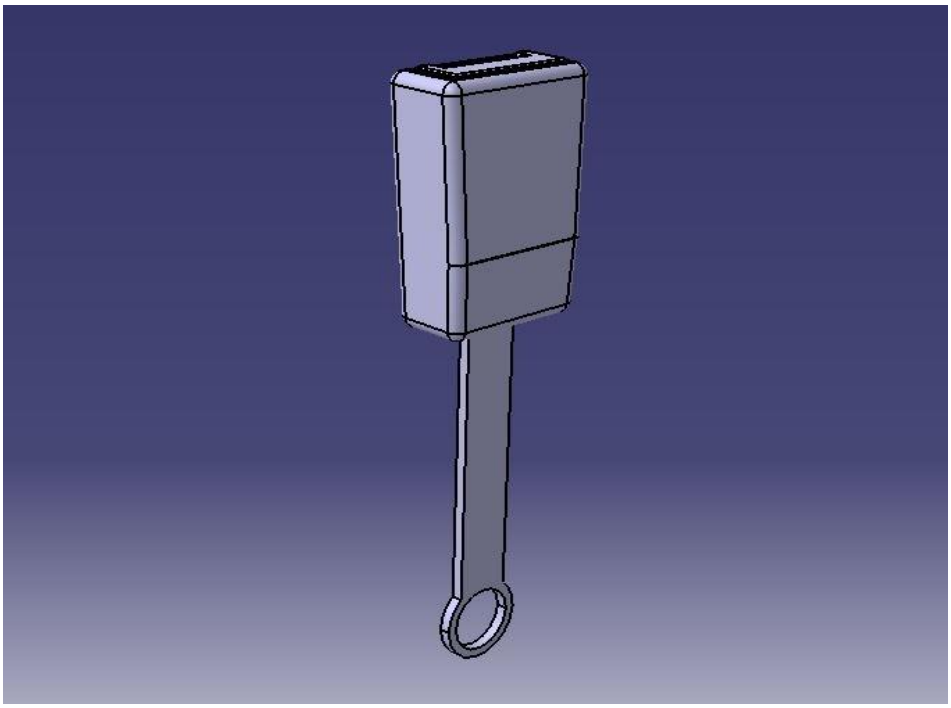

Figure 4.22: Isometric view of seat belt buckle

iv. Tongue (male) connector:

A tongue for a seat belt device can prevent or suppress movement of webbing from a shoulder side to a lap side, and further, at which localized load is not applied to the webbing in this state in which movement is prevented or suppressed. A tongue for a seat belt device main body that is provided at an intermediate portion of a webbing in a longitudinal direction of the webbing, and at which the webbing is folded over in a state in which the tongue main body is inserted in a buckle; a train-around portion that is provided at the tongue main body, and at which the webbing is bent due to the webbing being trained therearound and a bending angle increasing section that includes a movable portion provided so as to be apart from the train-around portion by more than a thickness dimension of the webbing, and that, in a case in which tension of the webbing is a predetermined magnitude or greater, moves the movable portion in a predetermined direction to cause the movable portion to push the webbing, and trains the webbing around the train-around portion and increases a bending angle of the webbing in a state in which the movable portion is apart from the train-around portion by more than the thickness dimension of the webbing.

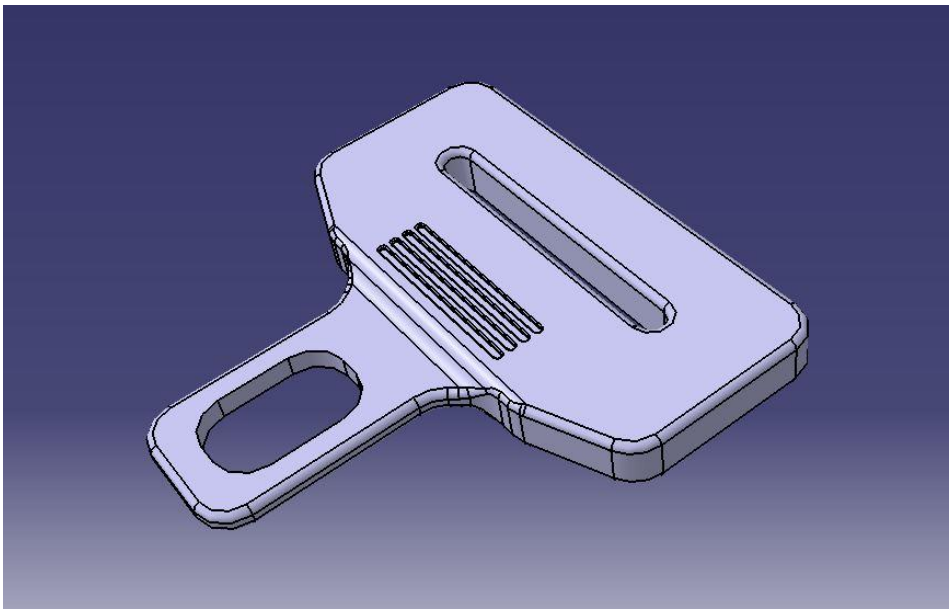

Figure 4.23: Isometric view of seat belt tongue

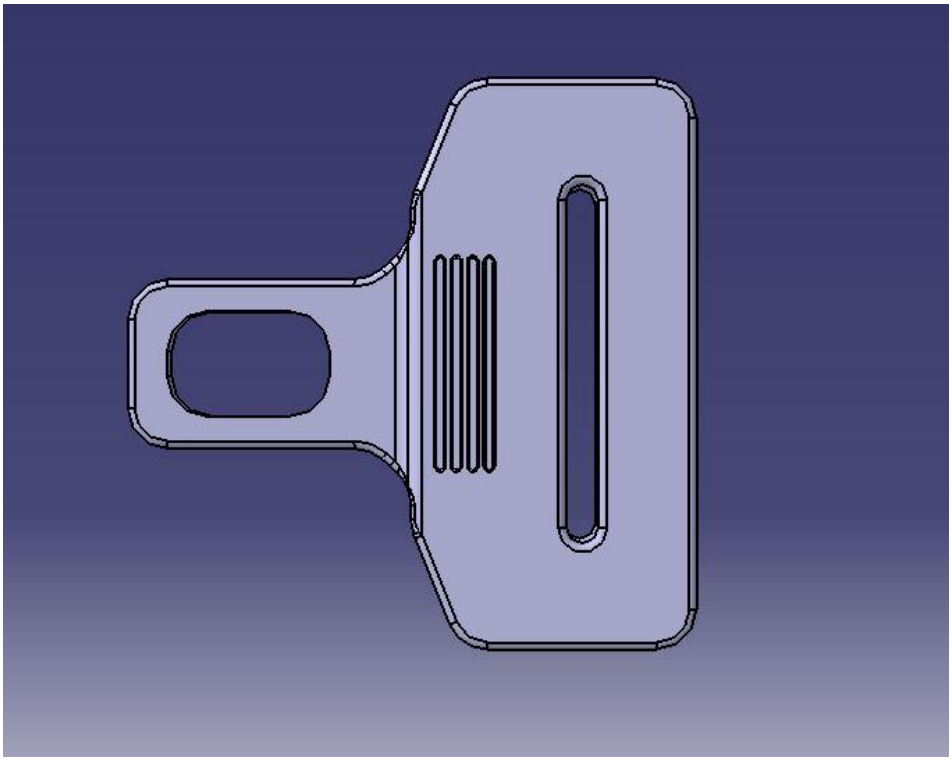

Figure 4.24: Front view of seat belt tongue

4.4.2 SEAT BELT LOOP

The existing accsessory has already installed in SUBARU cars, so now by recommending to apply this existing seat belt loop to PERODUA cars. These snapping seat belt loops are meant to help get the belts out of the way, thus aiding ingress/egress to and from back seat. This loop can prevent belt cuts into neck and belt touches head when turning. So, the drivers feel more comfortable when buckle up for safety.

Figure 4.25: Seat belt loop

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

In the end of this project, the small size female driver's comfort levels of seat belt's usage for PERODUA VIVA car were determined by using surveys and seat belt's design by CATIA. For this project, surveys technique were used to get the data, this techniques can provided information regarding users' preferences and idea about the design in many stages of the interface development since the users' reactions can have strong impact on the design and development of an interface. Then, using catia to draw the improved design from this software show the drawing in 3D.

5.2 CONCLUSION

The result of this study further indicates that the benefit that can be realized by using anthropometric data of Malaysian citizen. It is more appropriate and precise measurement since this research focus is on the Malaysian citizen. Safety belt comfort and convenience refers to the design and/or installation of safety belts to ease fit and accessibility for all vehicle occupants. Seatbelt design continues to be improved. Energy absorbing fibers, height adjusters and seat belt tensioner are example of improvement making seat belts both safer and more comfortable. In general, the assessment was that the majority of safety belts were practical and functional and that proposed design seat belts had features that made them even more user-friendly. However, current belts were not as comfortable or effective with large or small statured individuals.Besides that,

the proposed design seat belt also included additional ergonomics and human factors considerations such as ride quality, comfort, and the interaction.

From the survey conducted, only 13% of respondent that stated always wear seat belt when driving, while the others respondent majority stated that moderately wear and sometimes wear. The reasons drivers not use seat belt because the seat belt does not fit body size well, uncomfortable for other reasons and restricts movement in vehicle.

The major complaints about safety belt comfort were safety belt touches when turning head, safety belt rubbing or vibrating against neck/shoulder, locking of safety belts, safety belt being uncomfortable, safety belt being too tight, and safety belt having a limited range of motion. The major suggestions that drivers gave to make the safety belt easy to use were that it should not be too tight, not interfere with driving, be easy to put on and take off, and be easy to position.

From the data analysis of surveys of seat belt comfort level for female small size driver, some part from seat belt were improved to make sure the comfort and safety for small size driver. In order to optimize the geometry of safety belts to fit a wide variety of occupant sizes, some passenger and commercial vehicles are equipped with seat belt height adjuster (Figure 10). The height of the top anchorage point can be adjusted so that the take-off point (point where the safety belt last contacts the occupant on the shoulder) can be optimized for comfort. If the seat belt height adjuster is placed too high, the safety belt cutting across necks/head of small stature occupants.

The tongue plate has a relatively hard plastic coating over molded on the tongue plate where the tongue plate slot receives the webbing. The tongue plate also has a relatively soft plastic surround over molded on at least a portion of the relatively hard plastic coating in cooperation therewith and sufficiently thick that any noise made by the tongue plate imparted by movement of the seatback and/or vehicle vibrations is reduced. The invention is also a method of making a potentially noise-proof tongue plate for a vehicle seat belt system.

In addition, seat also plays an important role for comfort of small size driver since the seat also relate to seat belt usage. The principle that the seat should fit the sitter is the most universally employed concept in seating ergonomics. However, in the passenger car market, where a single seat must accommodate a large percentage of the population, knowledge of population anthropometry is required. The constraints on fit parameter design values are usually imposed by the desire to accommodate a sufficient range of the population on one anthropometric measure. A widely used design criterion is that the seat should accommodate the members of the population who lie between the 5^{th} percentile-female and 95th-percentile-male values on some anthropometric measure of interest to design the comfort seat. Height of seat also must be able to adjust to fit with the occupant's comfort.

5.3 FUTURE RECOMMENDATION

In the future, the Seat-integrated safety restraints (Figure 5.1) can be use for national car. The seat-integrated safety restraints operate much like traditional safety belt systems. However, the upper belt plate anchor and lower anchorage points are attached to the seat structure itself.

The benefit of these systems would be to reduce the relative motion that occurs between suspended seats found in many cars' fixed anchorages traditionally mounted on the vehicle B-pillar and floor. With an integrated restraint, the safety belt system would travel vertically with the seat structure as it moves up and down and fore and aft during travel. These systems could reduce contact forces and rubbing while driving. These devices are currently offered in many passenger vehicles and commercial vehicles in order to improve safety belt fit and comfort for drivers.

Figure 5.1: Seat-integrated safety restraints

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APPENDIX A

A Survey of Comfort Level Car Seat Belt System Usage

I.D number : _____

(1) Age : ☐ 18 – 21 years ☐ 22 – 25 years ☐ 26 – 27 years

(2) Weight: ☐ 35 – 40 Kg ☐ 41 – 44 Kg ☐ 45 – 48 Kg

(3) Height: ☐ 45 – 150 Cm ☐ 151 – 155 Cm ☐ 156 – 160 Cm

(4) Have you ever drive PERODUA VIVA? ☐ YES ☐ NO

(5) Do you have a driver license? ☐ YES ☐ NO

(Please tick (√) one choice answer only scale from 1 – 5)

1 = very poor 2 = poor 3 = moderate 4 = good 5 = very good

No	Question	1	2	3	4	5
1	Do you always wear your seat belt when driving?					
2	Do you believe in the effectiveness of seat belt?					
3	Please rate the degree of safety that you feel from using the seat belt					
4	Do you feel seat belt fit your size very well?					
5	State the level of comfort when you wear seat belt while driving					

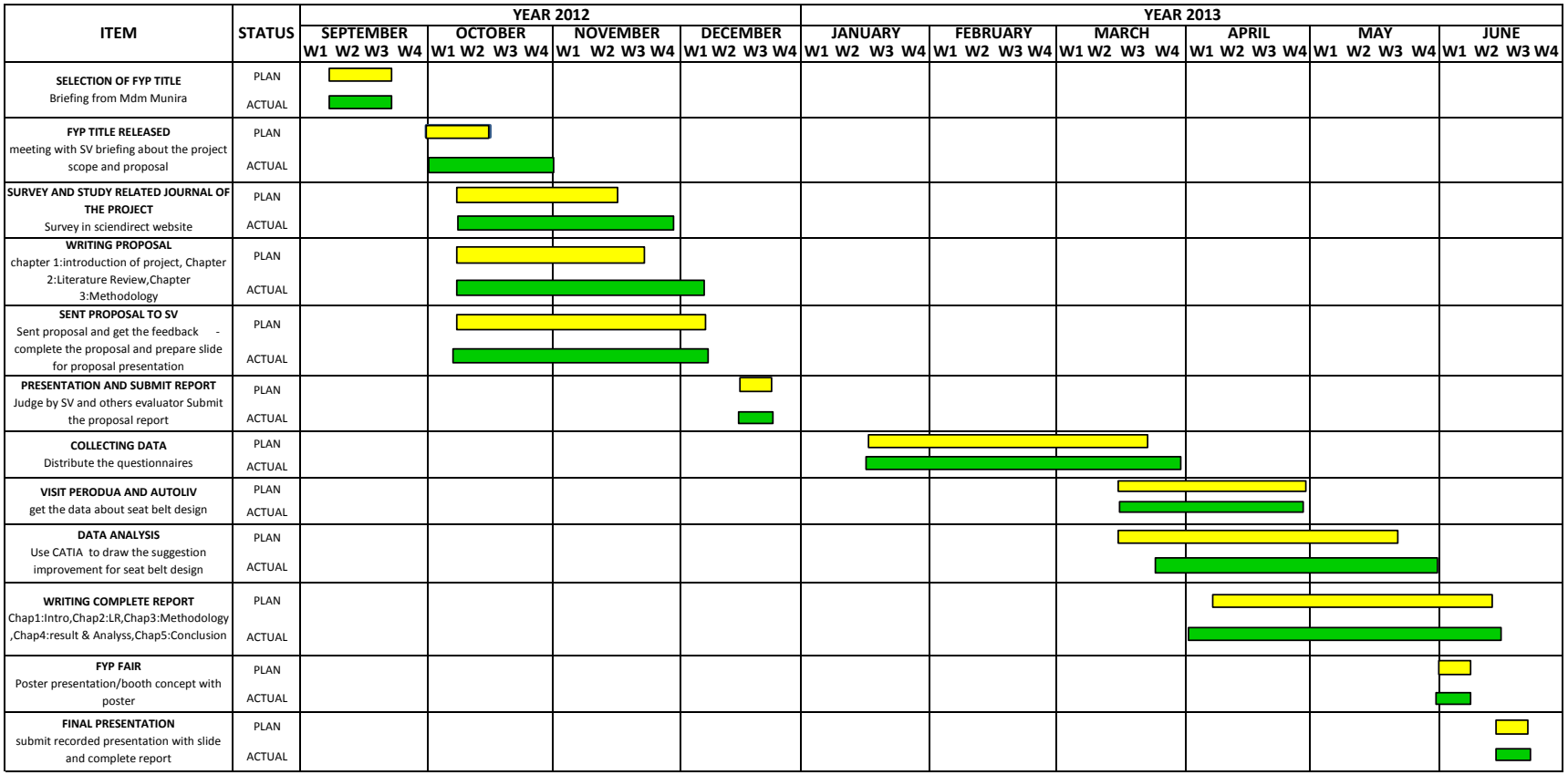
Tick your answer (not limited to only selection)

6) Do you experience any of the situations when having belt on

- ◯ Belt cuts into neck
- ◯ Belt slips off shoulder
- ◯ Belt too low and pressing on shoulder
- ◯ Too high and loose around shoulder
- ◯ When turning my head belt touches
- ◯ Belt too loose across chest
- ◯ Belt too loose around hips

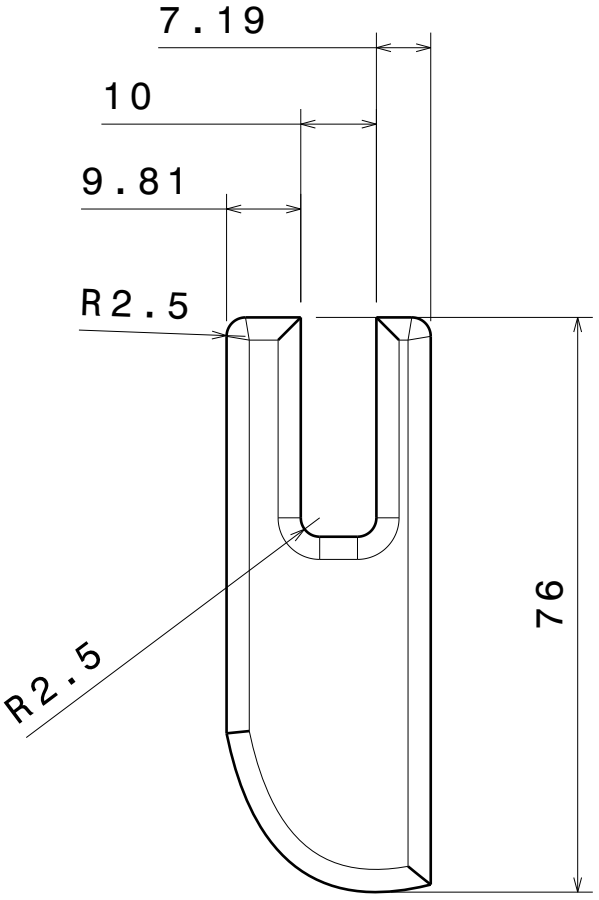
APPENDIX C

GANTT CHART FOR FINAL YEAR PROJECT

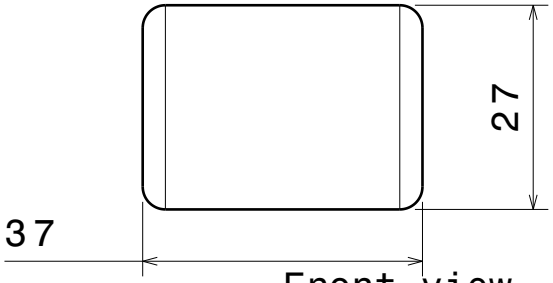


APPENDIX B4

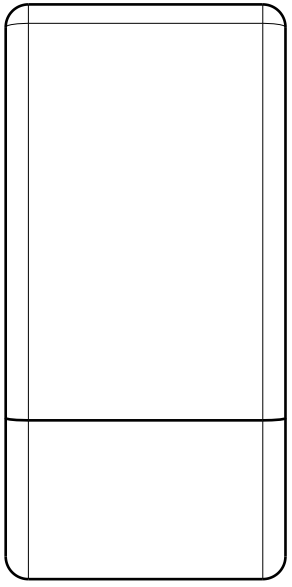
BELT ADJUSTER 1



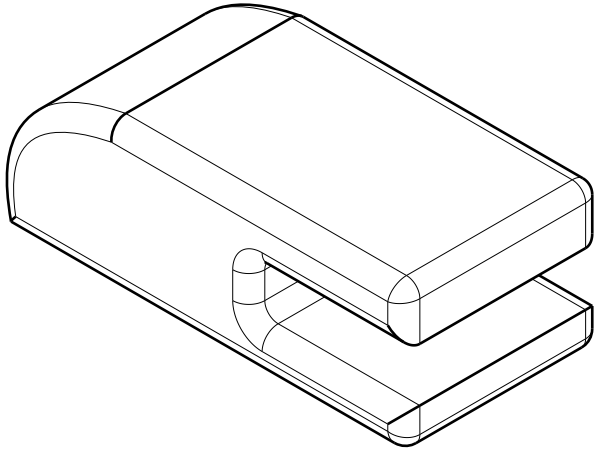
Side view
Scale: 1:1



Front view
Scale: 1:1



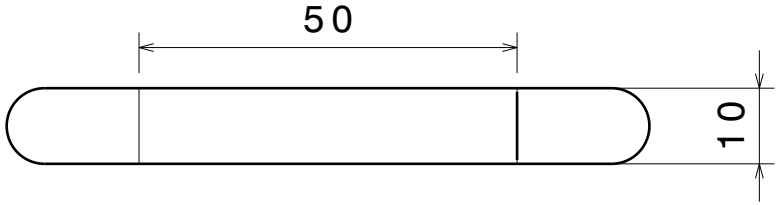
Top view
Scale: 1:1



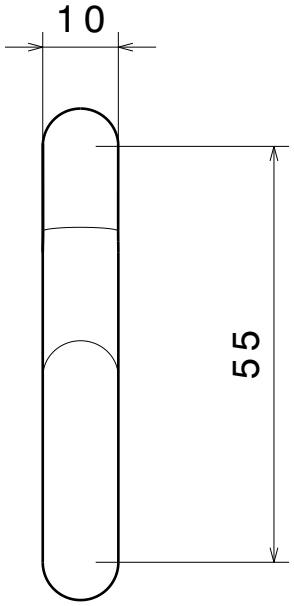
Isometric view
Scale: 1:1

APPENDIX B5

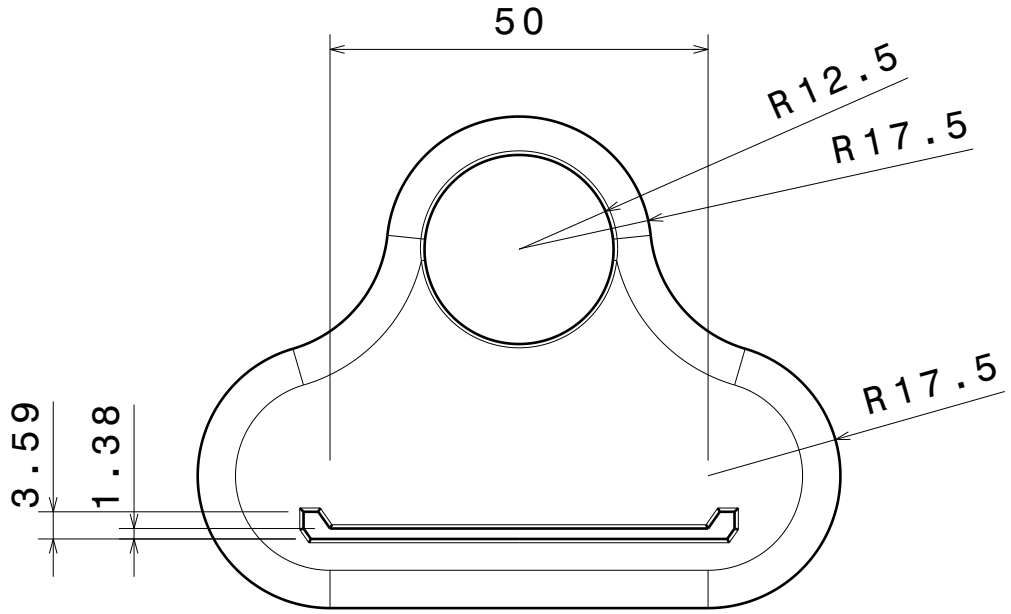
BELT ADJUSTER 2



Bottom view
Scale: 1:1



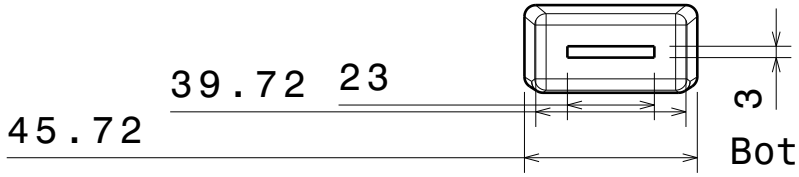
Side view
Scale: 1:1



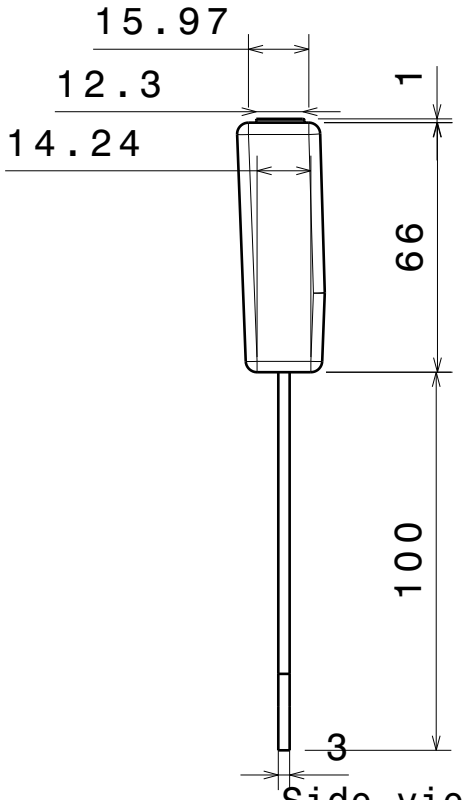
Top view
Scale: 1:1

APPENDIX B3

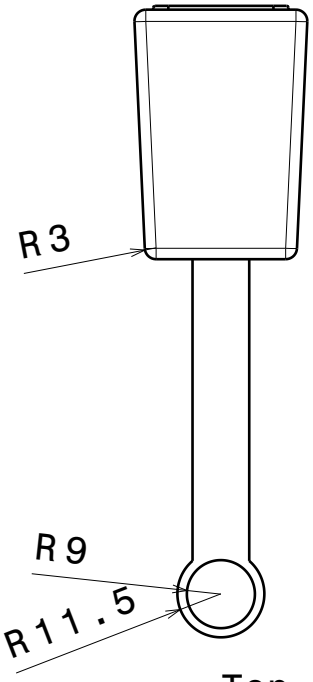
BUCKLE



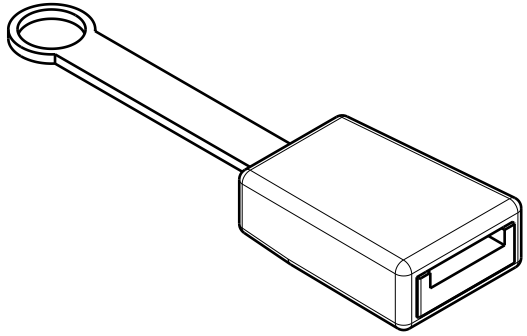
Bottom view
Scale: 1:2



Side view
Scale: 1:2



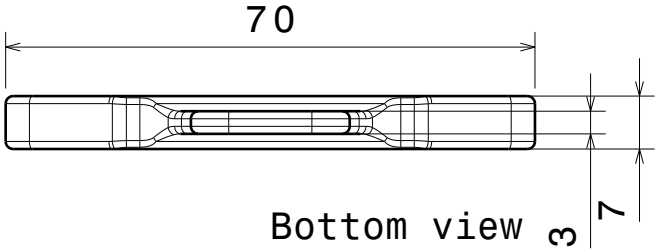
Top view
Scale: 1:2



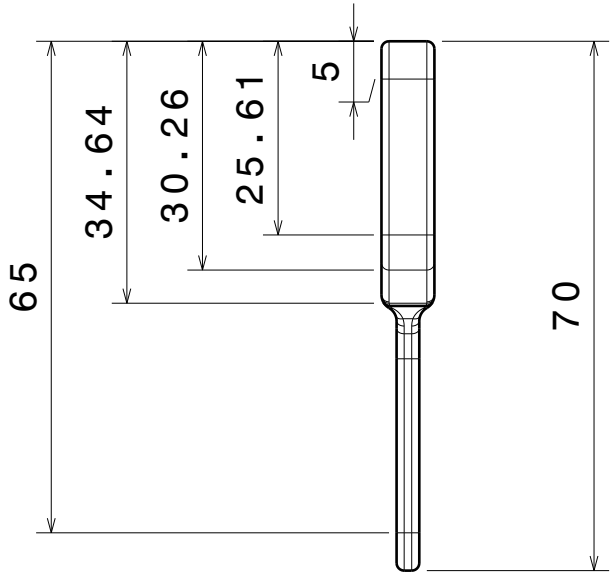
Isometric view
Scale: 1:2

APPENDIX B2

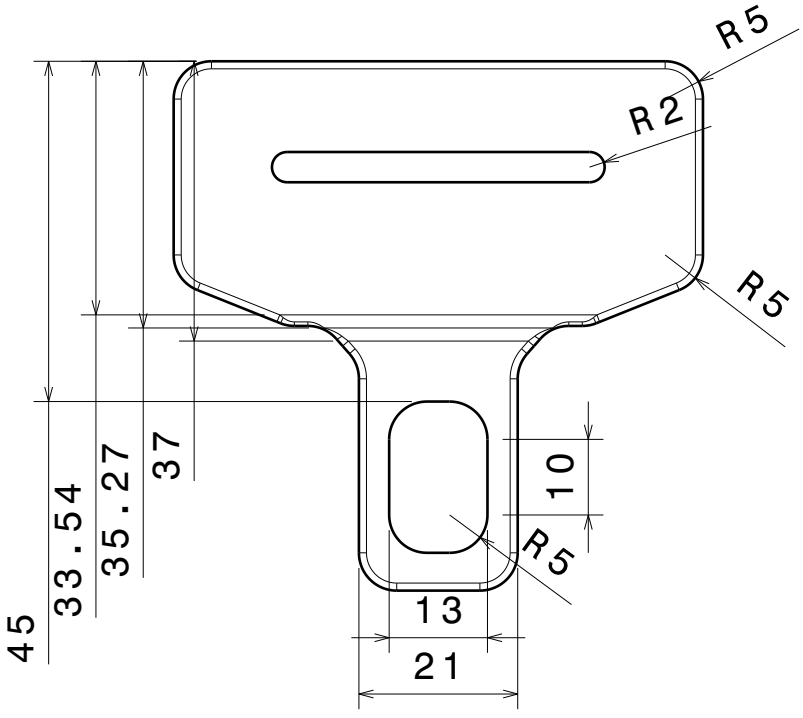
TONGUE



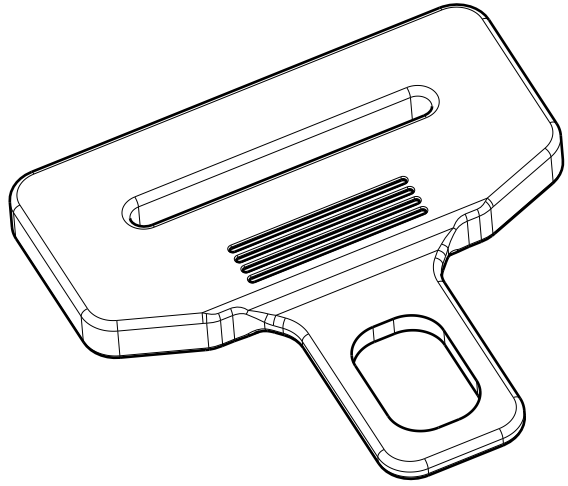
Bottom view
Scale: 1:1



Side view
Scale: 1:1



Front view
Scale: 1:1



Isometric view
Scale: 1:1