UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS◆

JUDUL: <u>**EVALUATION OF THE DESIGN OF NATIONAL CAR'S SEAT BELT FOR COMFORT OF PREGNANT WOMEN OR BIG SIZE DRIVER**</u>

SESI PENGAJIAN:_____2012/2013_____

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EVALUATION OF THE DESIGN OF NATIONAL CAR'S SEAT BELT FOR
COMFORT OF PREGNANT WOMEN OR BIG SIZE DRIVER

NORAZRIN BINTI SARJU @ HJ MOHD NOR

Thesis submitted in fulfillment of the requirements
for the award of the degree of
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JUNE 2013

EXAMINER APPROVAL DOCUMENT

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I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

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Dedicate to my beloved parents

SARJU @ HJ MOHD NOR BIN HASSAN

MAHNAM BT SAMIRAN

and

My fellow friends

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ABSTRACT

This project presents the factors that are crucial in improving the design of seat belt based on the specific related measurement and others. The problem arises in the usage of seat belt if the driver's body deviates from average anthropometric measurements may cause the driver feel not comfortable during driving task also feel not comfortable and for pregnant woman they feel discomfort, fear of harming the fetus when seat belt on. Anthropometric data is playing a main role in the design development to create an ergonomic product which is seat belt in the car. Appropriate use of anthropometry in design may improve well being, health, comfort, and safety. Understanding the fundamental and get detailed information about seat belt design with part involved in Viva car that produced by PERODUA by a visit to the national car company, PERODUA and safety belt supplier, Autoliv Hirotako. The structured interview was involved with the gynaecologist to obtain information on the correct way to wear a car seat belt for pregnant women and determine the other parameters that important for pregnant woman using a seat belt when driving. A total of 30 respondents were asked or interviewed to determine the level of comfort when wearing a seat belt in certain areas and also to understand how pregnant women wear seat belts and any problems they experienced while driving. The data on 95th percentile female Malaysian citizen will be compared with the data of 95th percentile American Male (AM). The result will generate guidelines and an information resource for designers in the automotive industry of national car seat belt and their supplier in order to improve the quality life of pregnant women or big size driver. In this project, a new design of a device had been designed by using CATIA software.

KEYWORDS: DRIVER SEAT BELT, ANTHROPOMETRY

ABSTRAK

Projek ini membentangkan faktor-faktor yang penting dalam meningkatkan reka bentuk tali pinggang keledar berdasarkan ukuran tertentu yang berkaitan dan lain-lain. Masalah timbul dalam penggunaan tali pinggang keledar jika badan pemandu menyimpang dari ukuran antropometri purata boleh menyebabkan pemandu tidak berasa selesa semasa memandu dan untuk wanita hamil mereka berasa tidak selesa kerana takut mencederakan janin apabila memakai tali pinggang keledar. Data antropometri memainkan peranan utama dalam pembangunan reka bentuk untuk mencipta produk ergonomik bagi tali pinggang keledar dalam kereta iaitu digunakan dalam mereka bentuk bagi meningkatkan kesejahteraan, kesihatan, keselesaan, dan keselamatan. Memahami maklumat yang asas dan mendapatkan terperinci tentang reka bentuk tali pinggang keledar dengan bahagian yang terlibat di dalam kereta Viva yang dihasilkan oleh PERODUA dengan lawatan ke syarikat kereta nasional, PERODUA dan pembekal keselamatan tali pinggang, Autoliv Hirotako. Temuduga berstruktur telah digunakan bersama Ginekologi untuk mendapatkan maklumat mengenai cara yang betul untuk memakai tali pinggang keledar kereta untuk wanita hamil dan menentukan parameter lain yang penting bagi wanita yang hamil menggunakan tali pinggang keledar ketika memandu. Seramai 30 orang responden telah ditanya atau ditemuramah untuk mengetahui tahap keselesaan ketika memakai tali pinggang keledar di kawasan-kawasan tertentu dan juga untuk memahami bagaimana wanita hamil memakai tali pinggang keledar dan apa-apa masalah yang mereka alami semasa memandu. Data pada 95 persentil warganegara Malaysia wanita akan dibandingkan dengan data 95 persentil Amerika Lelaki (AM). Di akhir projek ini akan menghasilkan garis panduan dan sumber maklumat untuk pereka dalam industri automotif tali pinggang keledar kereta nasional dan pembekal mereka untuk memperbaiki kehidupan kualiti wanita hamil atau pemandu yang bersaiz besar. Dalam projek ini, reka bentuk baru peranti telah direka dengan menggunakan perisian CATIA.

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LIST OF ABBREVIATIONS

AM   American Male

MF   Malaysian Female

CHAPTER 1

INTRODUCTION

1.1   BACKGROUND OF STUDY

Ergonomically well designed car seats, comfort, and spaciousness of the environment reduce passenger fatigue which is especially important for the driver. This research will pay considerable attention to the big size driver, the consequences of a car accident because of ergonomically incorrect body posture and non-use of safety belts and airbags. Ergonomic which consist of comfort and safety is also one of the important factors that need to be considered in the design of seat belt system in the car. So that, the seat belt could also suitable to be used by the big size driver especially for the pregnant women. Anthropometric data that consist of measurement of body characteristics will be used to determine the suitability of the seat belt with big sized drivers and specify the location and dimension of the part involved in the seat belt system.

1.2   PROBLEM STATEMENT

Concerning difference in drivers' anthropometric measurements, it is sometimes a problem to adjust the car seats and safety belts. The different size of the human body will cause different problems to occur. This problem arises in the usage of seat belt if the driver's body deviates from average anthropometric measurements may cause the driver feel not comfortable during driving task and the risk of a driver's head slips

outside of the airbag when car crashed occur. However, some people, especially big size driver, feel not comfortable because of the seat belt wearing. An example of the problem during wearing the seat belt are feel belt too tight across chest, and also tight around the hips. This project focus on the problem and factor related among big size driver and pregnant woman when they belt on a seat belt of national car.

1.3   PROJECT OBJECTIVES

The objectives of this study are:

1. To generate guidelines and an information resource for designers in the automotive industry of national car seat belt and their supplier in order to improve the quality life of pregnant women or big size driver among Malaysian,
2. To improve the seat belt design for a national's car based on the anthropometric data of Malaysian citizen,
3. To investigate the additional parameters of pregnant women to be included as one of the elements in designing the seat belt.

1.4   SCOPES OF THE PROJECT

The project used one type of national car which is Perodua Viva as the main case study. The model of Perodua Viva car was selected in this project because it is one of the compact cars that commonly preferred to be used by Malaysian female drivers. Normally, it can be seen on the road, most female Malaysia people use PERODUA Viva car as easy vehicle driven anywhere and because of its small size as well as fuel-efficient. In this study, it will focus on the location and dimension of the parts that are related to seat belt design such as car seat that is going to use by the user. The seat height, width and back angles and other criteria are based on the human anthropometry data for female Malaysian citizen collected from the research and the result will be studied in that anthropometry data. It's important to provide sufficient space for physical and psychological comfort. The projects only focus on female driver to define the big size driver by using the anthropometric data for Malaysian citizens. This study

will be analyzed and used to generate a set of guideline for national automotive companies to use in order to design seat belt more suited to the need of pregnant women or big size driver and also improve safety and comfort for pregnant women during all aspects of car travel.

CHAPTER 2

LITERATURE REVIEW

2.1   INTRODUCTION

The purpose of this chapter is to provide a review of past researches efforts that are related to seat belt comfort and the important element in developing the comfort level seat belt of big size or pregnant women usage. From the related research journals, printed or online conference article, it works as a guideline which is also as a main source to do this project.

2.2   SEAT BELT FOR PREGNANT OR BIG SIZE DRIVER

The seat belt is essential for pregnant women to reduce the risk of their fatalities and the foetuses in car crashes. S. Nakahara et al., (2003) stated that the reasons the pregnant women for not wearing the seat belt including discomfort, fear of harming the fetus, forgetfulness or habitual non-use. Non-seat belt wearers were less likely to have received information on the maternal seat belt use and they tended to misunderstand about the importance of wearing a seat belt and the correct way to wear a seat belt for them. In Japan, there have the legislative exemption to wear seat belts at gestation period of 20 weeks or above. Those who reduced seat belt use during pregnancy reported that discomfort and fear of adverse effects on the fetus deterred them from use.

Wearing seat belts reduce both the mortality and injury severity of vehicle occupants. According to previous reports, seat belt use during pregnancy improves fetal outcome after motor vehicle accidents. Therefore, seat belt use by drivers and front seat passengers is legally required in many countries. However, some countries exempt pregnant women from mandatory seat belt use. Thus, pregnant occupants of vehicles might not be wearing seat belts at the time of vehicle accidents and subsequently suffer adverse fetal outcomes. Duma et al and Moorcroft et al assessed the amount of stress exerted on the abdomen of pregnant women using finite element (FE) model simulation. They analyzed injury mechanisms under the various delta-V (overall accumulative change in velocity) values experienced by pregnant women during collisions and measured strain at the uterus placenta interface (UPI) during impact as a possible predictor of the adverse fetal outcome using the FE uterus model. Their studies used a numeric model, but their assessments included the simplified interior buck model, which does not represent the detailed contour and features of interior components, such as seat shape and stiffness, the steering wheel, instrument panel, or other components that presumably affect the overall kinematics of the occupant. No other studies have comprehensively examined the responses of pregnant drivers during low speed impact, especially when not wearing a seat belt.

From all these researches, none has discussed the effect of the seat belt for the big size driver. The research before just mentioned the general people feel discomfort during wearing a seat belt. They are not stated specified or in detail about the big size driver in their research.

2.3   DESIGN OF SEAT BELT

Design of seat belt not only just draft or create the shape, it should be considered of the human measurement such as body segment length and circumferences, height and widths , among others known as anthropometry. According to Bridger et al. (1995), anthropometry is all about the research area in ergonomics dealing with the certain body characteristic and measurement of human body dimensions. Anthropometric data is playing a main role in the design development to create an ergonomic product which is

seat belt in the car. Ergonomics' factor is one of the important things to be considered in designing new product including the aspect of comfort, safety and health.

Ergonomics describes both the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance (IEA, 2007). Ergonomic seat position and driver's anthropometric measurements are particularly important for driver safety, airbag and safety belt effectiveness and the anthropometric measurements affect driver's body posture in the car and the efficiency of car safety devices. A driver with large anthropometric measurements requires a larger space and appropriate use of safety belts to feel comfortable and safe when driving.

According to Drury and Coury (1982), there are five requirements that a seat must fulfill to be regarded as ergonomic which are safe, adaptable to meet the anthropometric needs of a wide range of users and comfortable. Besides, it also must fit a wide range of bodily curves and shapes; and lastly, it must be practical and solid, so that it is reliable and easy to adjust. As in the case of car seat, a car seat should offer the driver good conditions for moving the steering wheel, foot pedals, and other actuators; and, finally, also contribute to good vision. This means that the seated posture of an occupant in a car seat will be greatly influenced by the driving task and personal preferences of the individual user such as, seat adjustability and as well as geometrical design. So, the car seat adjustment and the other part in the car actually related with the seat belt system of the car that is the important aspect to meet comfortability of pregnant women and also a big size driver woman.

According to (Annett, 2002), besides ensuring realistic conditions, in terms of seat, posture, task, and environment, which are necessary (especially in a lab-based study) for their contextual effect on the human response, a safety belt should also be incorporated for the same reason. During the past 5 years (2000–2004), safety belt usage rates in the US have risen from 72% to 81% (BTS, 2006). Thus, to better represent driving conditions, a safety belt should be worn during an experiment.

Further, without a proper restraining system, participants are more likely to slip forward and to be in (more) slouched postures, which can result in pressure changes.

According to Dinh-Zarr et al. (2001), using seat belts is one of the most effective strategies available to the driving public for avoiding death and injury in a crash . He also mentioned that properly used seat belts are one of the most effective measures for reducing death and injury on the highway. Today, however, nearly 35 years after the federal government required that all passenger cars be equipped with seat belts, approximately one-quarter of U.S. drivers and front-seat passengers are still observed not to be buckled up (Glassbrenner, 2002). Nonusers tend to be involved in more crashes than belt users (Reinfurt et al. 1996), and belt use is lower about 40 percent for drivers in severe crashes (O'Neill, 2001). Moreover, at observed national belt use rates of 75 percent, the United States continues to lag far behind the 90 to 95 percent belt use rates achieved in Canada, Australia, and several northern European countries. Buckling up can reduce the risk of fatal injury for drivers and front-seat occupants of passenger cars involved in crashes by about 45 percent. The fatality reduction for front-seat belt wearers in light trucks is 60 percent (Kahane, 2000).

2.4   ANTHROPOMETRY DATA FOR SEAT BELT DESIGN

There are several studies done by past researchers in constructing anthropometric database. One of it is Barroso et al. (2005) had conducted a study development of a procedure for data acquisition of an anthropometric database for Portuguese adult workers. Anthropometry consists of the measurement of body characteristics such as reach body segment length and circumferences, widths, and heights, among others. This information can be used to inform the design of tools, equipment, workstations and clothes. Appropriate use of anthropometry in design may improve well-being, health, comfort, and safety. Figure 2.1 is the drawing figure of anthropometric body measurement from Panero and Zelnik (1979). Anthropometric data measurement collection is done while in sitting or standing position according to the measurement variables required.

As the subject matters of the study are Malaysian, there are is research on Malaysian anthropometry data as well done by Darliana et al. (2010). The researchers presents a summarized data of a Malaysian population anthropometric study which it can be useful in the designing process of part of vehicle or else in the future.
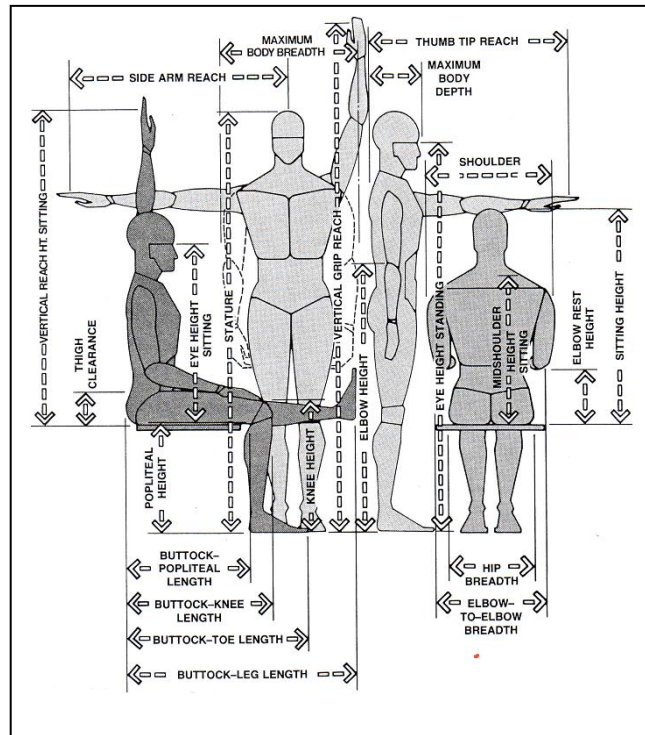
Figure 2.1: Anthropometric body measurement

Source: Panero and Zelnik (1979)

CHAPTER 3

METHODOLOGY

3.1   INTRODUCTION

Flow work of the project is generally a guideline for solving a problem occurred. The framework of flow work must clearly clarify in order to make sure the project run smoothly and the objective of the project are able to achieve successfully. The methods of conducting the project are briefly discussed which involved the specific techniques and tasks to make sure the progress of the project will follow the flow from the beginning until the end of the project.

The methodologies used in conducting this research are through:
1. Site visit to Perodua and Autoliv Hirotako.
2. Interview with Gynecologist.
3. Survey approach for the comfort level of the driver.
4. Data analysis
5. Propose new design

All these methodologies are illustrated in Figure 3.1

Figure 3.1: Methodology Flow Chart

3.2   UNDERSTANDING FUNDAMENTAL OF SEAT BELT AND STUDY OF SEAT BELT DESIGN AND PART INVOLVED

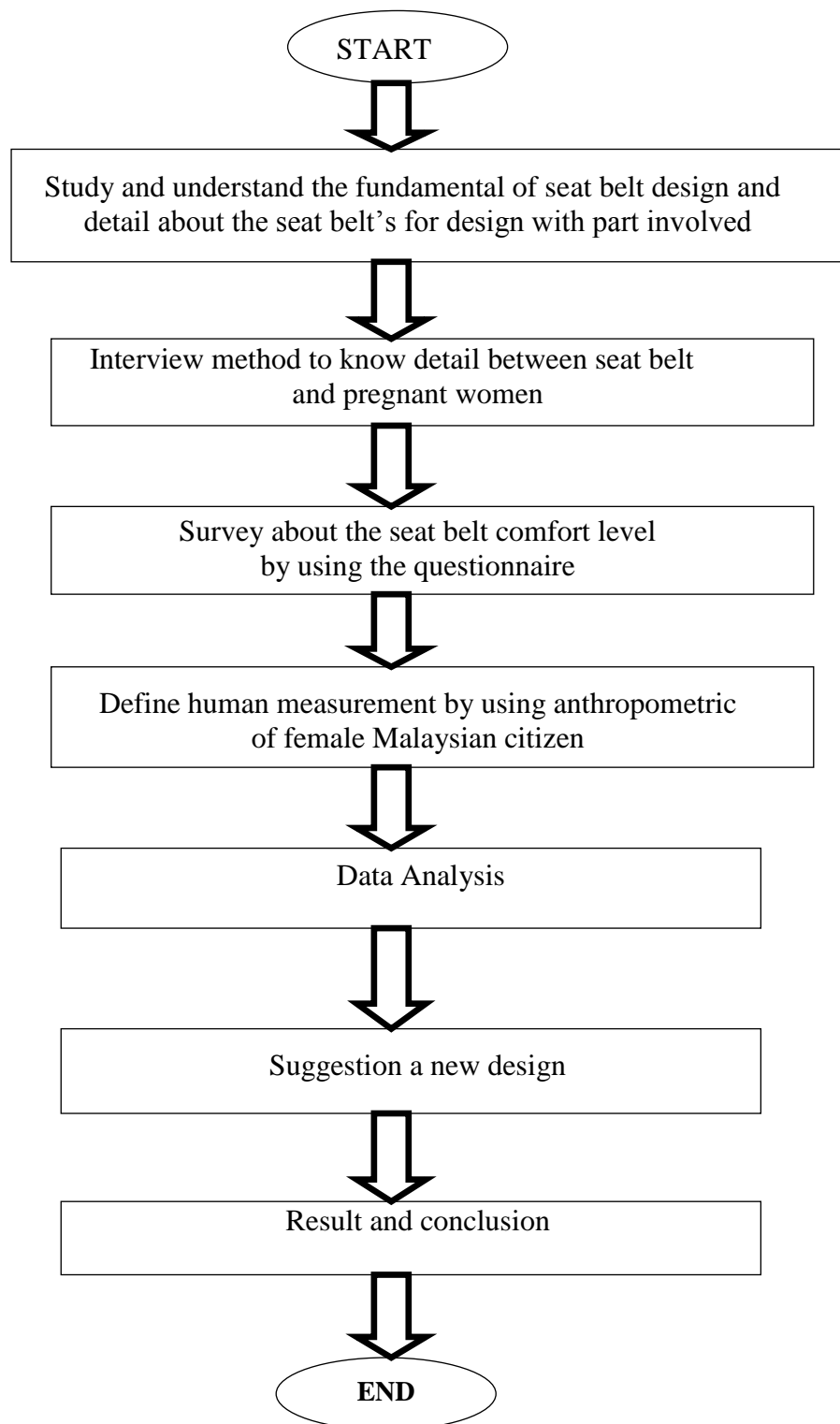The start of the flow work is to understand the fundamental of the seat belt. Fundamental objectives are the essential reasons we care about a decision, whereas means objectives are things we care about because they help us achieve the fundamental objectives. In the automotive safety example, maximizing seat-belt use is a mean objective because it helps to achieve the fundamental objectives of minimizing lives lost and injuries.

Type of seat belt for Viva car is 3 point seat belt. It's usually can found at any car in Malaysia in the driver seat. 3 points seat belt has a Y-shaped arrangement (Figure 3.2). It will spread out the energy of the moving body over the chest, pelvis and shoulders. Buckling up is not the end of it, but going about it the right way is what matters. The seat belt usually contains two parts, the lower part and the upper one. The hip area is normally supposed to be held near the seat using the lower part; hence the belt needs to pass through the hip and not the stomach. The upper part is supposed to pass across the chest for effectiveness.

Site visit at PERODUA is very important to deeply understand the fundamental and get detailed information about seat belt design with part involved in Viva car that produced by PERODUA. Another company visit is Autoliv to get an info car seat belt of Viva car that they produced and supplied to PERODUA.There are several important components in the seat belt system such as webbing, retractor, tongue plate, and slip anchor. The system in seat belt consists of outer and inner component. Each of the items in the seat belt has their own functions to allow the belt system worked well. For Viva car which has 3 point seat belt, there are consist of inner component such as buckle assy, buckle plate and seat belt warning wire. The effective belt anchorages are a point used to determine the angle of each part of the seat belt in relation to the wearer. The point to which strap should need to be attached to provide same lie as the intended lie of the seat belt when worn. The anchorage point should be within the zone area and should fulfil the requirement related to regulations of United Nation.

One of the parts involved in the seat belt system is a car seat. Inch of adjustment of seat car give the different comfort level for the driver and it will affect to the comfortable of wearing belt. Car seat dimensions data should also be taken into account in determining the level of big size driver or pregnant comfort.
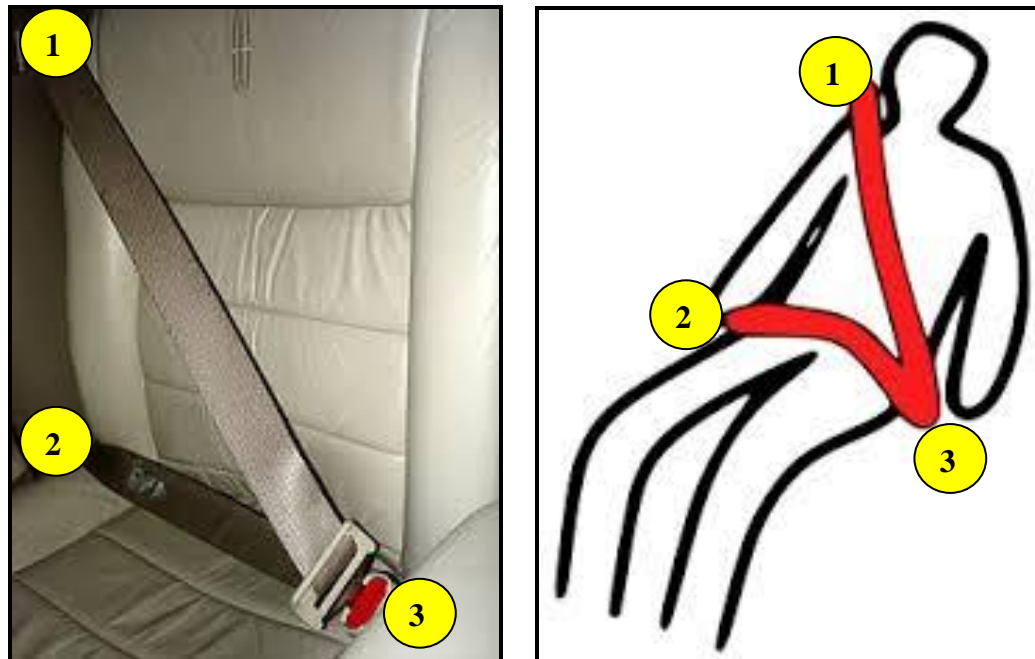
Figure 3.2 : View of Y-Shaped arrangement (3-points belt)

3.3   INTERVIEW METHOD WITH GYNAECOLOGIST

In order to collect safety belt usage and perception data from Viva car driver, these projects used a structured survey interview approach. The structured interview was conducted at Hospital Pakar Sultanah Fatimah, Muar Johor involved with the Gynecologist to obtain information on the correct way to wear a car seat belt for pregnant women. In fact, the use of 3 point restraint seat belt is different for non-pregnant women with pregnant women. Besides, the interview session ask on what other parameters that important for a pregnant woman using a seat belt when driving.

3.4   SURVEY OF THE CURRENT STATE OF CAR SEAT BELT COMFORT DEVELOPMENT

Due to the perceived lack of proven analytical metrics, these project methods have opted to rely on subjective evaluations as the main indicator of seat belt comfort. The subjective evaluation usually involves highly structured questionnaires that direct occupants to assign feelings of discomfort to specific regions of the seat belt and also to understand how feel the pregnant women wear seat belt and any problems that they experiencing during driving. The questionnaire method is to strongly support the problem related to the seat belt and want to know which part or region that usually user feel discomfort when wear the Perodua Viva seat belt.

3.4.1   Data collection method

3.4.1.1 Scope of study

The questionnaire are distributed to the respondents around Kuala Pahang, including areas in the UMP to know the level of comfort during wear a seat belt for car Viva.

3.4.1.2 Number of sample/respondents.

The number of respondents who are involved in this project is a total of 30 people, consisting of staff and students UMP as well as residents in the vicinity of Kuala Pahang . All respondents are only big size and pregnant woman driver. A probabilistic sample is going to used in which every member of a target population has a known, non-zero probability of being included in the sample. The aim of a probabilistic sample is to eliminate subjectivity and obtain a sample that is both unbiased and representative of the target population. It is important to remember that this project cannot make any statistical inferences from our data unless have a probabilistic sample. Systematic sampling involves selecting every member from a population list. If the list is random, then selecting every nth member is another method of obtaining a simple random sample. However, if the list is not random, this procedure can introduce bias.

3.4.2 Types of question

There are several parts of question that require the respondent to answer which are Part 1 until Part 3. The big size driver requires filling up or answering from Part 1 till Part 2. For pregnant women, they have to answer all the Part (Part 1 -3) because Part 3 have questions about pregnancy and seat belt use. The shape of question have close and also open question.

3.4.2.1 Driver information

The respondents were asked about their age, weight, height. They were also asked how often and how long they drove.

3.4.2.2 Vehicle information

Participants were asked whether they are having experience driving using a PERODUA VIVA car.

3.4.2.3 Question about Using Seat

The question consists of a few questions that asked to rate the seat belt fit level when they wearing the seat belt while driving. The questionnaires, which typically contain numeric scale. (e.g. 1= uncomfortable to 5 = very comfortable), then through the scale, it will translate into performance requirement and specification when wear the seat belt. The question also asked about risk perception and safety perception that have ranged from 1 (no risk/safe) to 5 (very risky/unsafe).

3.4.2.4 Question About Pregnancy and Seat Belt

The respondents were asked on the average weight before pregnant and current weight. Besides, the question asked the level comfort and safety of driver during driving on the road.

3.5   ANTHROPOMETRY OF FEMALE MALAYSIAN CITIZEN

From the visit to Perodua, it is known that the seat belt design for the model Viva car has been using American Male (AM) 95th percentile anthropometric as guideline before being released on the road. All the requirement to design a seat belt for any car should to follow the Regulation related to seat belt issued by United Nation as long as no less or more than the allowable standard.

Ergonomics criteria related to anthropometry have been considered a key aspect of comfortable seat belt use. From this perspective, designers must ensure that a range of people from small to big size driver fit in the seat belt. In general, automobile seat belt designs are specified by noting, for a target population, the constraining values of appropriate anthropometric dimensions (usually 5th percentile female and 95th percentile male).

The project uses the anthropometric Malaysian Female to define human measurement of big size driver. There is a research or work in anthropometric Malaysian citizen data done by researcher before. From that, this project will study data of anthropometric should be used to measure big size women, and also data involved with designing of seat belt for Viva car such as shoulder height, chest breadth and others .In addition, referring on Regulation of United Nation as a guideline is an important method before to do any design a seat belt system.

Table 3.1 shows several data should be used to define the human measurement for big size Malaysian citizens.

Table 3.1: Anthropometric data for 95th percentile Data for Female Malaysian Citizen

Anthropometric data	Measurement(mm)
Stature	1663.1
Chest Breadth	401.6392303
Hip Breadth	495.452831
Chest circumference	1062.24289
Waist circumference	962.4657619
Thigh clearance	278.833819
Weight	60.4kg

3.6 COMPARISON 95TH PERCENTILE AMERICAN MALE WITH 95TH PERCENTILE MALAYSIAN FEMALE

After the human measurement of big size women were determined, the data on 95th percentile female Malaysian citizen will be compared with the data of 95th percentile American Male (AM). From that, the differences of both data will be obtained. Any improvement will do for designing seat belt based on the specific related measurement and others.

CHAPTER 4

RESULT AND DISCUSSION

4.1   INTRODUCTION

From the data that will be used to define the measurement of big size driver Malaysian citizen, this project would like to propose to PERODUA to use the anthropometric data of Malaysian citizens to design a car belt for the other model's car from PERODUA. Results will generate guidelines and an information resource for designers in the automotive industry of national car seat belt and their supplier in order to improve the quality life of pregnant women or big size driver .

In addition, by using the questionnaires that will distribute to certain respondents which is big size women, the survey will show the level of comfort of wear belts for car Viva. From that, improvement in term design or component related to the seat belt will do to increase the comfort level for them.

4.2   UNDERSTANDING FUNDAMENTAL OF SEAT BELT AND STUDY OF SEAT BELT DESIGN AND PART INVOLVED

The design of seat belt for PERODUA Viva must refer to vehicle regulation of the United Nations Economic Commission for Europe (UNECE or ECE). The regulations involved in designing car seat and seat belt are ECE R14, ECE 16 and ECE R21. Each of regulation have their own rule, dimension that need to be followed when designing a new design of part or whole the seat belt system as long as within their specification.

The component that involved in seat belt system are buckle, webbing, retractor, and seat belt adjuster (on B-pillar). Every single of component have their own function and dimension to complete in one system. The parameters that will be used to designing of seat refer to dummy specifications stated in Regulation 14 (ECE R14).

4.2.1   Components of Seat Belt System

4.2.1.1 Buckle

The buckle is designed to hold the tongue firmly and allows the seat belt to be fastened and unfastened with very little force. In an emergency situation, it is designed so another person can easily remove the tongue from the buckle and free the passenger. Type of buckle that designed by Perodua for Viva car is steel wire which it can move to front and back as appropriate driver. The path into which the tongue is pushed when connecting the seat belt. Generally located on or just below the hip on seat belts or on the lap of harnesses. The buckle and tongue assembly should securely latch together with no free play.

Figure 4.1: View of buckle

4.2.1.2 Tongue

The part is important to connect with the buckle where it will be pushed into the buckle ejected when the quick release is used. The tongue will prevent the movement of webbing from shoulder belt and lap belt. The tongue should eject actively when released. There should be no visible cracks on the buckle and the buckle cover must be intact. The tongue should have no metal deformation, webbing marks, or visible cracks on metal or plastic sections.

Figure 4.2: View of seat belt tongue

4.2.1.3 Webbing

Webbing is the part of the seat belt in contact with the passenger that receives and softens the shock of an impact. It's made of polyester and woven from about 300 warp strands and one weft strand. According to Perodua Manufacturing Sdn Bhd, the width of the webbing is about 4.8cm and 300cm in length. It has a tensile strength sufficient to support approximately three metric tons. The webbing is designed to stretch without breaking in order to absorb deceleration forces in a crash. Once the webbing has been subjected to the forces resulting from a crash it is usually stretched permanently and loses its vital elasticity. If used in a subsequent crash, the webbing may not stretch as originally designed and thereby can cause serious injury by increasing the risk of chest, neck and back injuries to the driver or passenger.

Figure 4.3 : View of seat belt webbing

4.2.1.4 Retractor

The retractor is a winding mechanism that allows the seat belt webbing to be withdrawn and brought back into its housing. It's located in the B-pillar section of the car. When the retractor pulls the belt out as far as it will go, and then release it, the belt should return all the way into the retractor without sticking, gripping or stalling. The retractor should lock when the webbing is pulled out suddenly. At Viva car, there are two sensors. One of its acts to locks the seat belt webbing when the car decelerates

quickly or accelerates faster than a certain speed. The second sensor will locks the extraction of webbing when it is pulled out at a faster rate than normal movement.

Figure 4.4: View of seat belt retractor

4.2.1.5 Seat belt height adjuster (on B-pillar)

A seat belt height adjuster which located on B-pillar acts to adjust the height of shoulder lap by pull the button and move the upper seat belt anchor to position it as necessary or high as possible so that the shoulder section of the belt is across the seat occupant's collarbone and not across the throat. The height of the shoulder section of the seat belt must be correctly adjusted to make sure the driver feel comfortable and not distract during driving.

Figure 4.5: View of seat belt height adjuster

Table 4.2: Dummy Specifications

Parameter	Dimension
Mass	97.5kg
Erect sitting height	965mm
Hip breadth (sitting)	415mm
Hip circumference(sitting)	1200mm
Waist circumference (sitting)	1080mm
Chest depth	265mm
Chest circumference	1130mm
Shoulder height	680mm

4.3   INTERVIEW METHOD WITH GYNAECOLOGIST

The gynaecologist recommends all the pregnant woman wearing of seat belts. Pregnant women sometimes feel uncomfortable when wearing a seat belt or worry about seat belt may harm the unborn baby. However, when the seat belt worn properly, it puts a little pressure on the stomach. A seat belt will reduce a risk both baby and mother in the event of a crash. The right way to wear the seat belt for pregnant woman where the shoulder belt should across the chest (between your breasts) and away from

the neck. It is because the pressure of the belt is equally transferred to the right regions which not give bad impact to the neck and breast as well. The lap belt (lower part of seat belt) should go over the upper thighs, across pelvic region and below the belly. If the belt positioned across the stomach, pressure from it could hurt the baby if the driver in an accident.

Parameters that important for a pregnant woman using a seat belt when driving is the sym-physio fundel height. This parameter is determined to measure the size of a pregnant woman's body from 1st trimester until the 3rd trimester.The parameter is important because of it is the critical region of the pregnant woman that involved herself and the baby also. Part of the risk gets injured for pregnant women is on belly area where need to be focused on it.
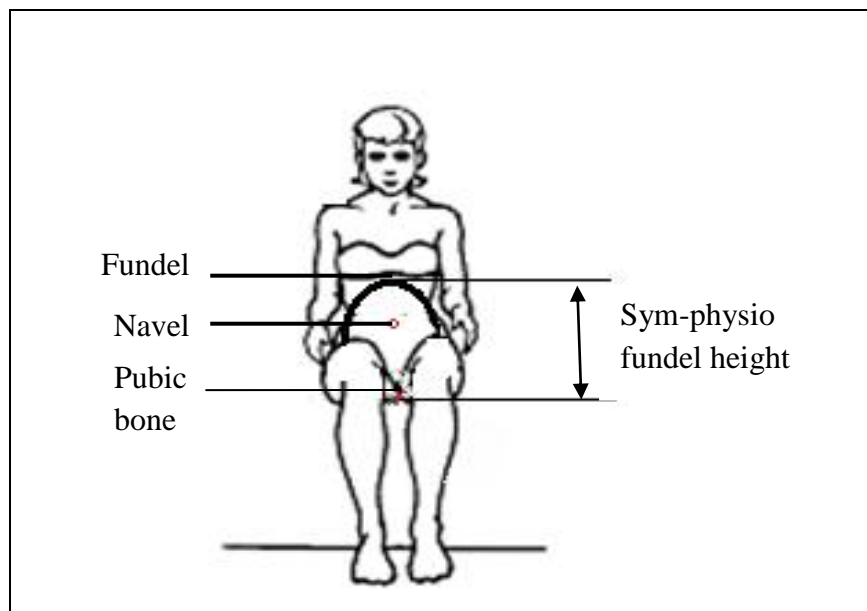

Figure 4.6 : View of Sym-physio fundel height

4.4   ANALYSIS OF SURVEY DATA

The data collected were first analyzed and tabulated into a table and then further analyzed using the computer software – Microsoft Excel. In this section, the findings will be shown and briefly described. From surveyed, all the respondent has experience driving PERODUA Viva.
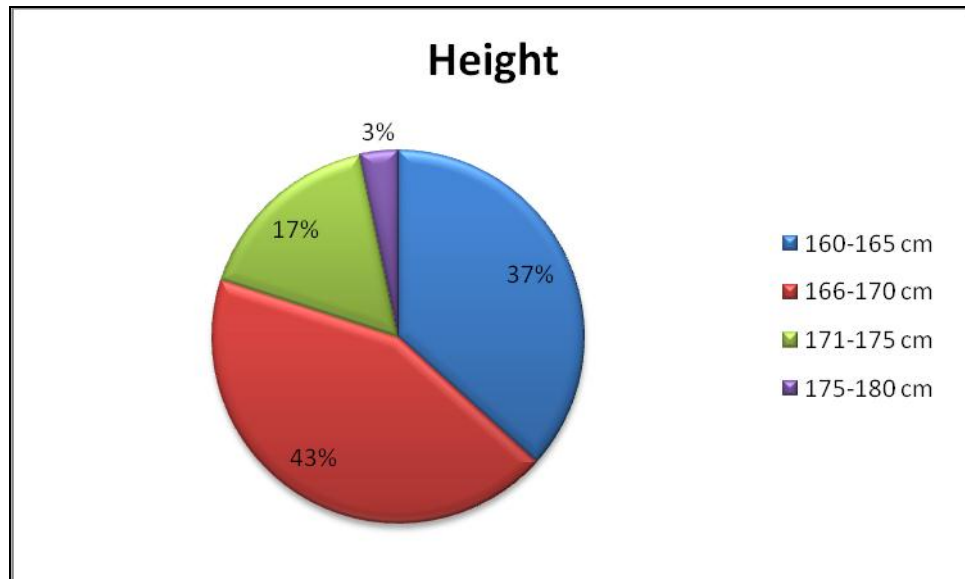
Figure 4.7: Distribution of respondent's height range

Figure 4.2 shows the respondent's height range where all the range around the 95th percentile (above 166 cm). 43 percent of respondent's height are range between 166-170cm. Next, 37 percent range between 160-165cm followed by and 17 percent are 171-175cm. The least percentage is about 3 percent were respondent's height between 175-180cm. Since the range of majority respondent's heights is higher than 166cm show that the respondent is 95th percentile.
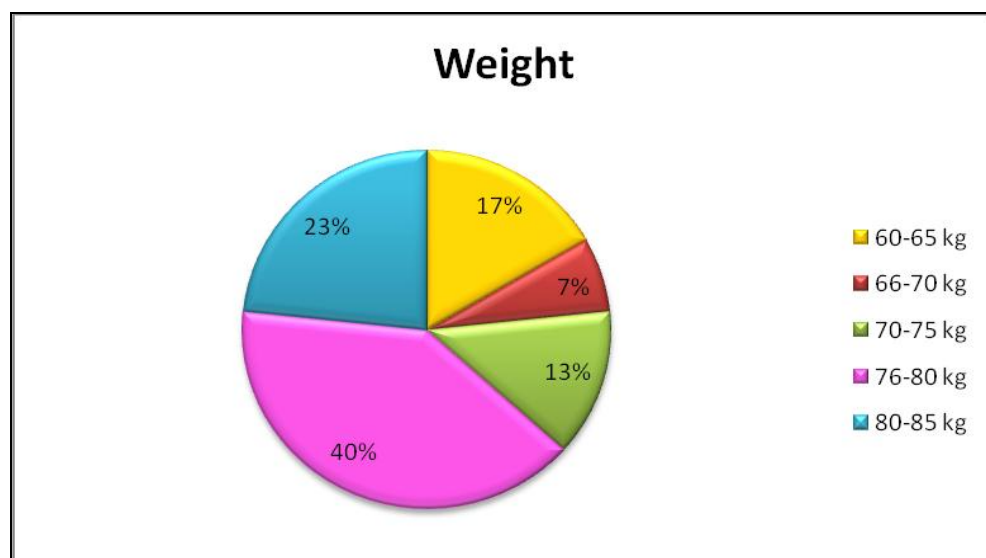

Figure 4.8: Distribution of respondent's weight range

Figure 4.3 shows the respondent's weight range where all the range around the 95th percentile (above 60.3 kg). All the respondents are 95th per

centile Malaysian female because range of all respondent's weights is more than 60.4kg. The highest percentage is 40 percent of respondent's weight are range between 76 to 80 kg. Next, 23 percent range between 80-85kg.Next, 17 percent range between 60-65kg followed by 13 percent respondent's weight at range 70-75kg. The least percentage is 7 percent where the range between 66-70kg.
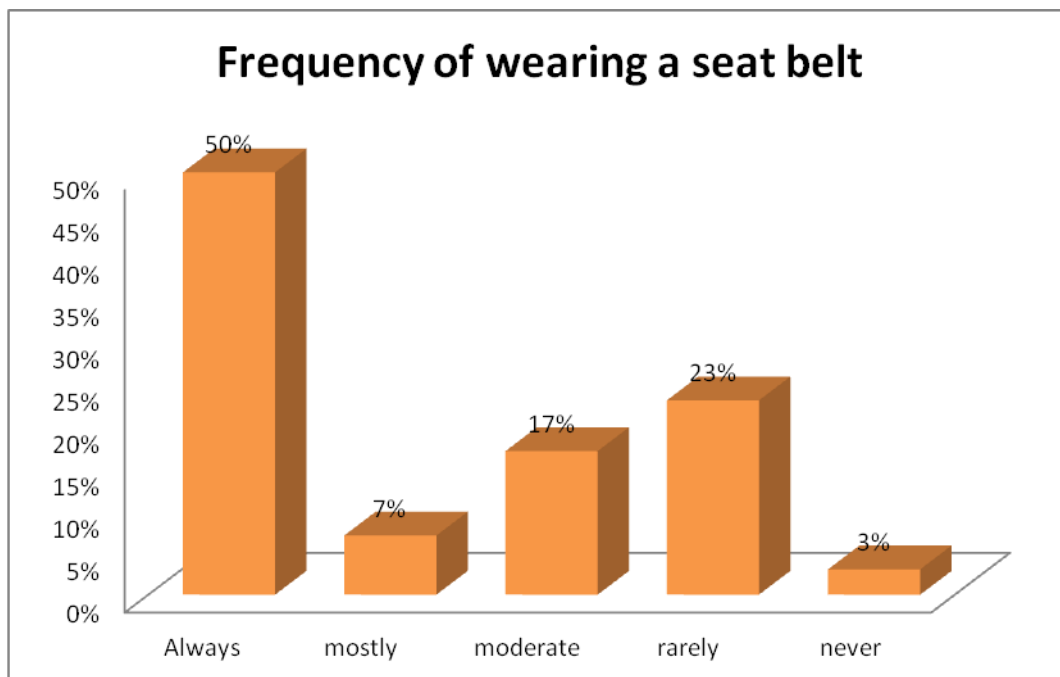

Figure 4.9:Frequency of wearing a seat belt

The graphs show that majority participants show that they always use a seat belt when driving (50%). More participants reported that percentage of rarely wear (23%) than moderately wear (17%). Next, mostly wear (7%) and never wear (3%).
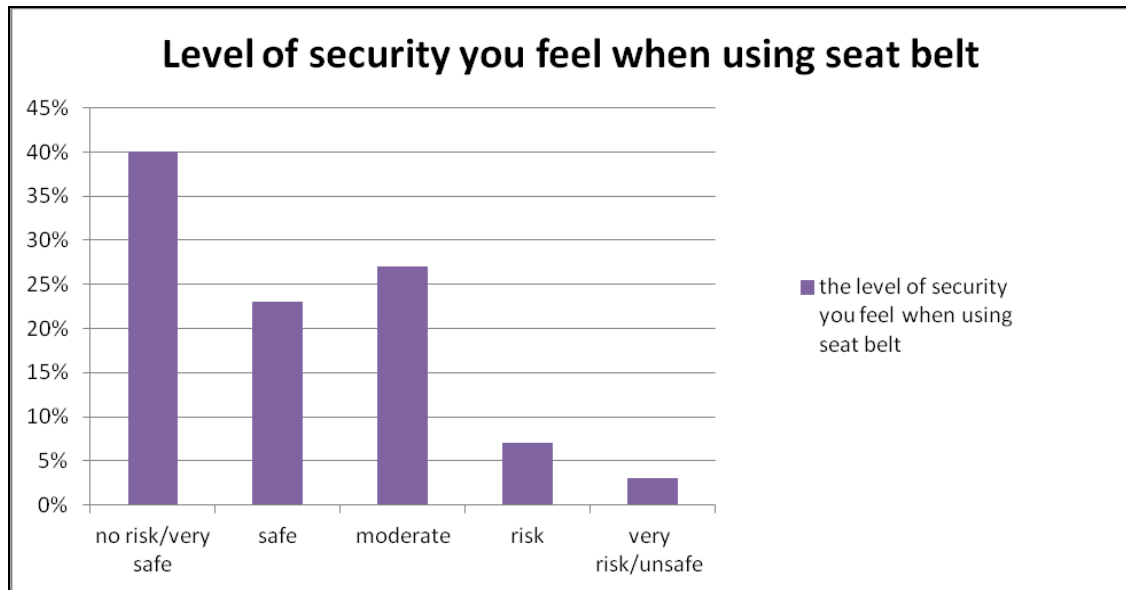
Level of security you feel when using seat belt

Figure 4.10: Level of security when using a seat belt

From the graph, 40% of participant feel there is no risk (very safe) when wearing a seat belt and mostly participant said that they said moderately (27%) and safe or good (23%) when wearing a of the seat belt. 7% of participant said there is a risk (poor) and 3% of participant felt very risk (unsafe) when wear of seat belt. From that, the respondents have awareness about their own safety during driving. They know the seat belt will protect themselves if anything happen like in the event of a crash.
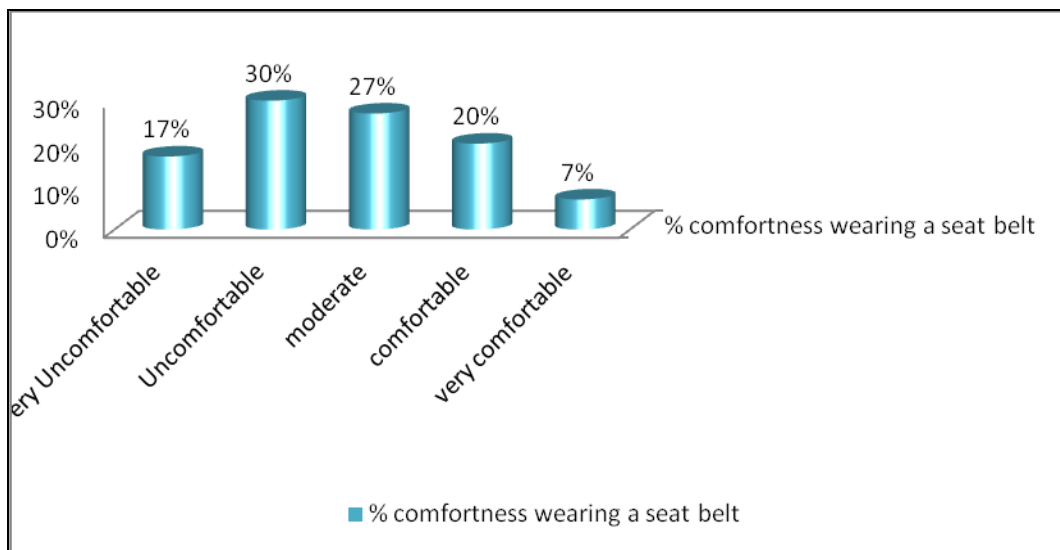

Figure 4.11: Degree of comfort that the driver feel from using the seat belt

The chart shows the percentage of level of comfort when wearing a seat belt during driving. The highest percentage of participants reported they feel uncomfortable (30%) when they wear a seat belt while driving, Next, 27% of participant choose moderate the level of comfort, 20% of participant feel comfortable and the other 17% feel very uncomfortable wear a seat belt while driving. The least percentage is7% of participant feel very comfortable wearing a seat belt.
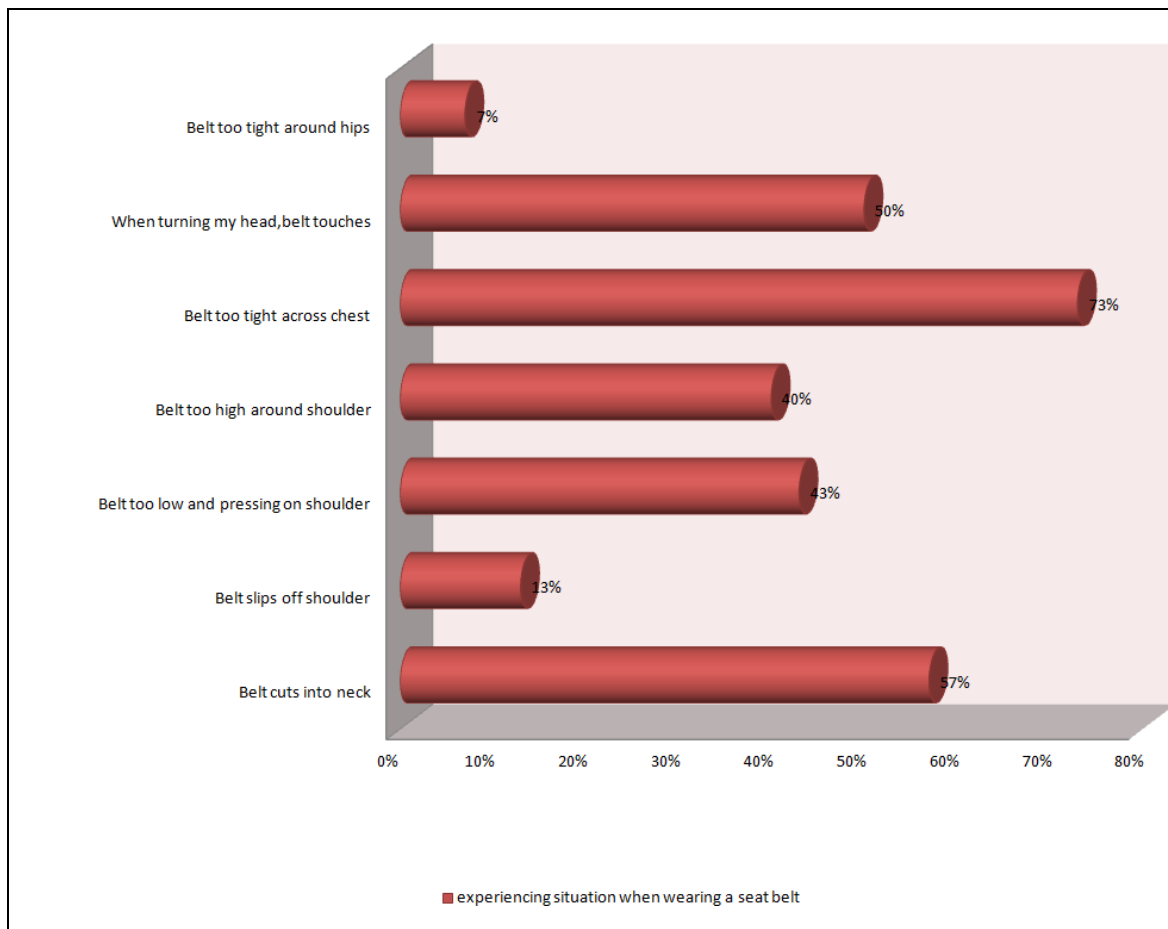

Figure 4.12:Percentage of experience situation when wearing a seat belt

The graph shows that the highest percentage of complaints about seat belt is belt too tight across chest (73%). Next, is belt cut into the neck when wearing seat belts (57%), followed by the belt touches their face when turning their head(50%). The results also show belt too low and pressing on shoulder (43%) and belt too high around shoulder (40%). Besides, belt slip off shoulder (13%) and the lowest percentage of complaint about seat belt from big size driver is belt too tight around hip (7%).
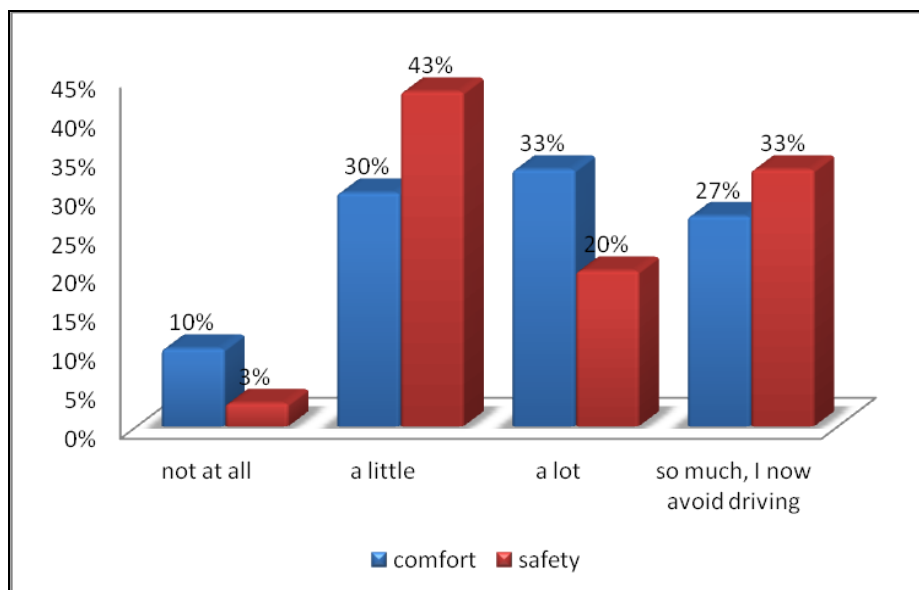
Figure 4.13 : Percentage of driving being adversely affected by pregnancy

The graph shows the percentage of respondents of pregnant women were experiencing driving and use safety belt. For the comfort aspect, 33 percent of them felt a a lot of disturbance to them when wearing seat belts during driving. It is the highest percentage compared to the others. Besides, at the safety aspect, 43 percent of pregnant woman felt a little of disturbance from seat belt to their pregnant because they believe when wearing a safety belt, it will prevent mother and the unborn child from any serious injuries when car crashes happen.
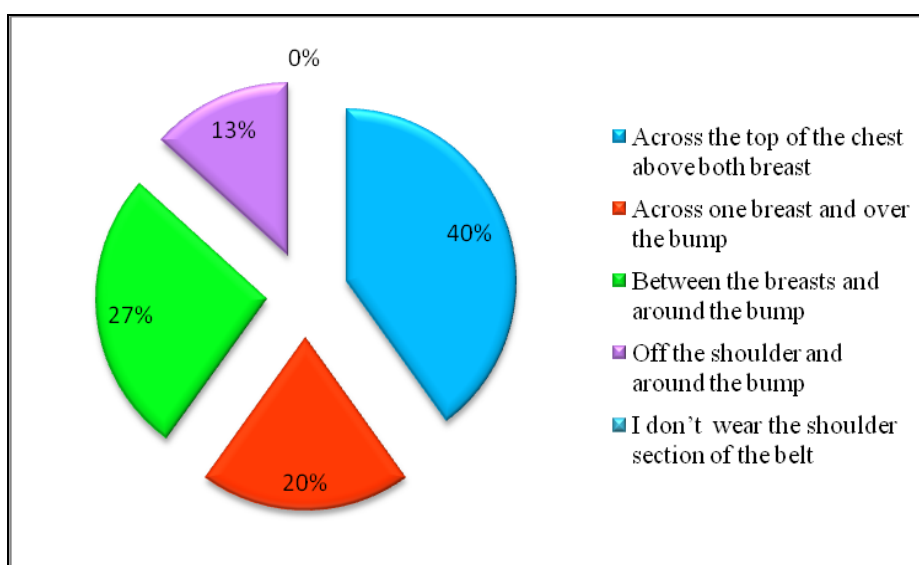

Figure 4.14: Percentage position the shoulder section of seat belt of pregnant woman

The chart shows that the highest percentage of pregnant women place the sash (the upper part of the seat belt) is where they across the top of the chest above both breasts (40%). Next, they place the lap at   between the breast and over the bump (27%), followed by across one breasts and around the bump (20%). The least percentage is they off the shoulder and around the bump. No one of respondent mentioned they do not wear the shoulder section of the belt during driving.
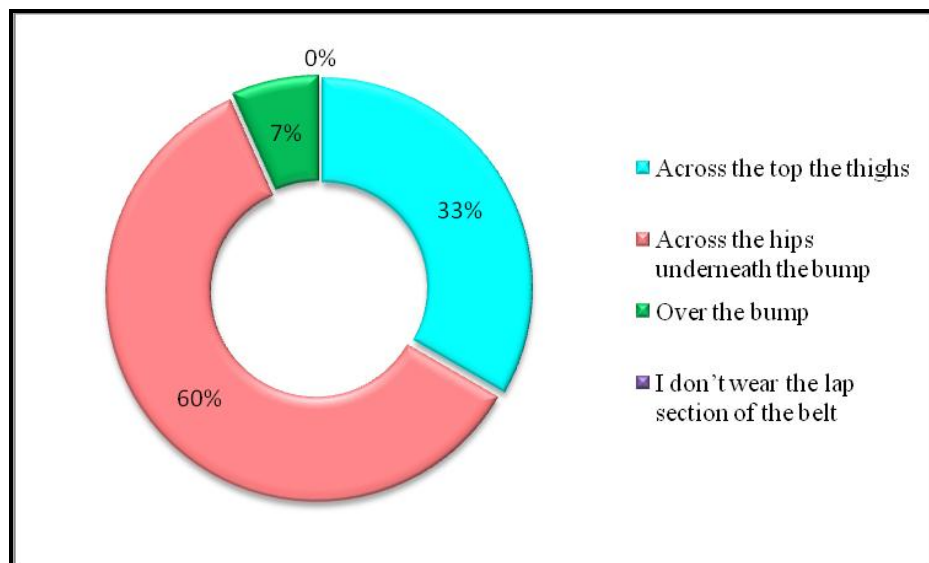
Figure 4.15: Percentage position the lap belt over the abdomen of pregnant woman

The highest percentage of pregnant women place the lap (the lower part of the seat belt) is 60% where the respondents put the lap across the hips underneath the bump. Next, they place the lap belt across the top the thighs (33%) and followed by placing the lap over the bump.

4.5   SUGGESTIONS FOR IMPROVEMENT OF THE SEAT BELT DESIGN

Discussion of the improvements is categorized into two areas which are adjustable seat belt anchorage points on the B-pillar for the big size driver, and accessory of the driver seat cushion for pregnant woman.

4.5.1   Adjustable Seat Belt Anchorage Points On The B-Pillars

According the results of surveyed conducted among female big size driver, the level of feeling comfort wearing a PERODUA Viva's seat belt were determined even there is no research or complaint about the problem of seat belt among big size driver. One of the disturbance that respondents felt is when belt cuts into neck during driving.

Some Viva car that PERODUA produced does not have adjustable seat belt anchorage points on the B-pillars. According to the regulation number 16 of the United Nations Economic Commission for Europe (UNECE or ECE) or ECE R16, at point 2.14.6 mentioned that a belt adjustment device for height enable the position in height of the upper loop a belt to be adjusted according to the requirement of driver wearer. Its such a device may be considered as a part of the belt or a part of the anchorage of the belt.

The design that can improve is at adjustable seat belt anchorage points on the B-pillars by additional of the length host where the device placed it. The current measurement of the host is 15.3cm. The suggestion is to add length of host 2.35cm at the top and bottom from the actual place (Figure 4.16), so that the total of the host has now been 20cm and ensure the adjustable B-pillar shoulder belt anchors can be adjusted up and down more. Dimension of car seat which is height of the seat should be considered in determining the suggested length of the host. If add the length at top and bottom side, it still possible because the point of anchorage is not lower than the height car seat and not cause belt slip off the shoulder (Figure 4.17). The results will reduce the uncomfortable feel for the big size driver which is the webbing at shoulder section cut into the neck.
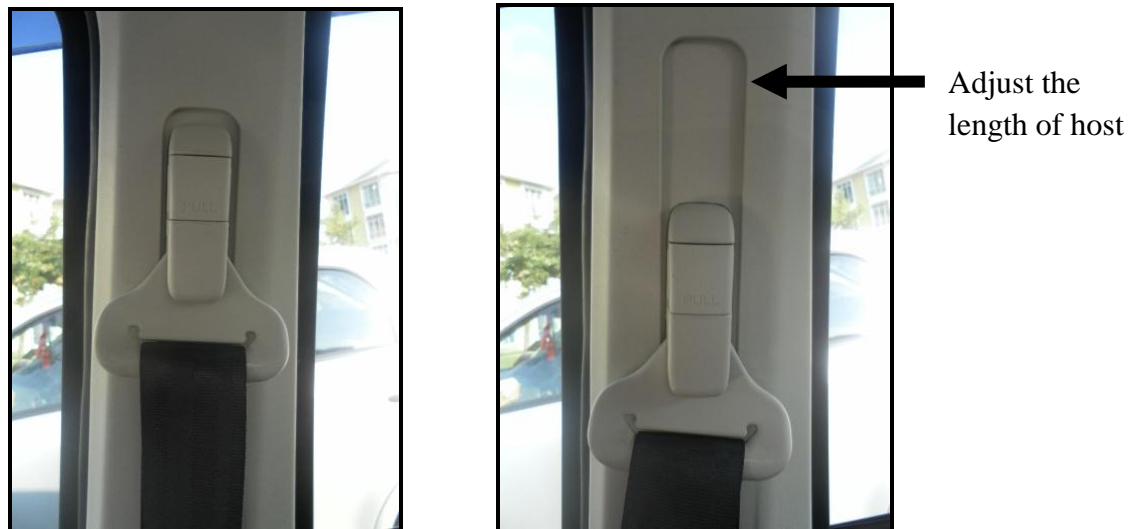
Adjust the length of host

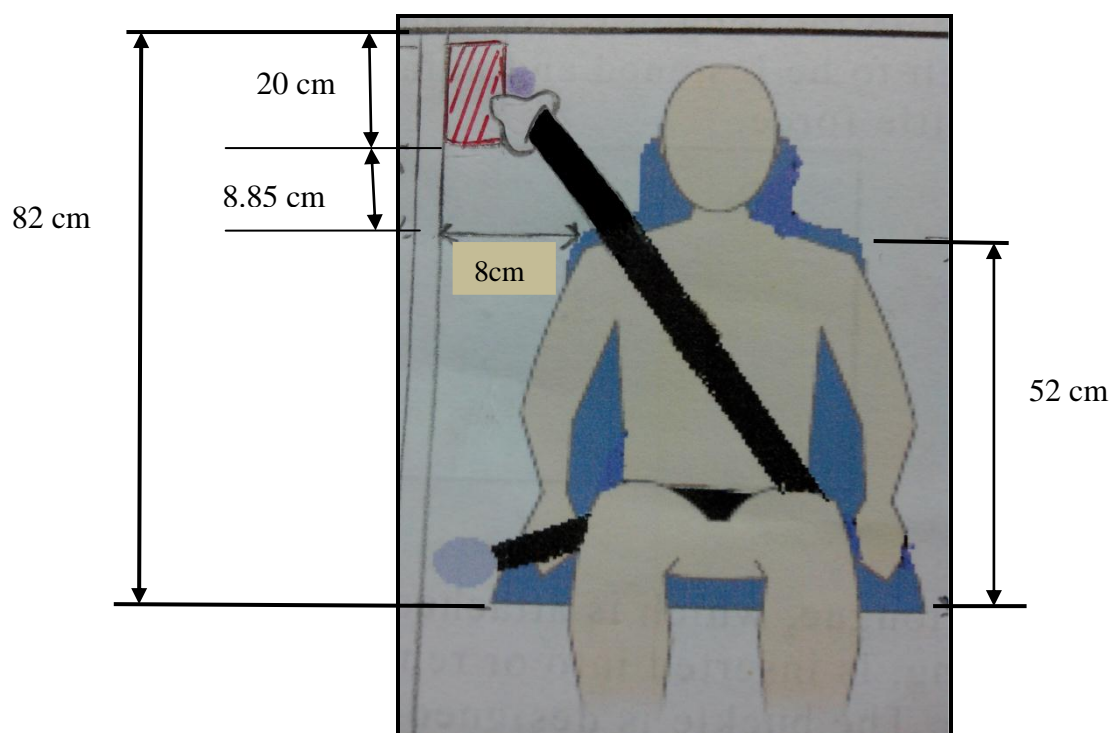**Figure 4.16:** View of maximum and minimum adjustable B-pillar shoulder belt anchors

Figure 4.17 : View of position of adjustable seat belt anchorage points with the measurement improvement
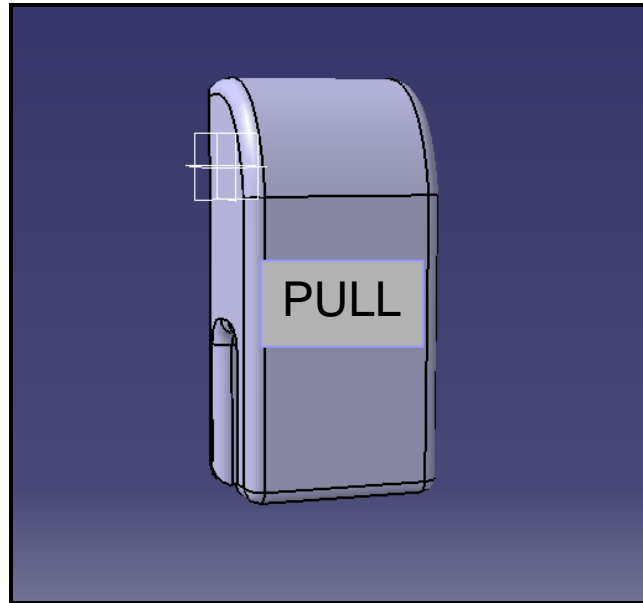
Figure 4.18: View of adjustable seat belt anchorage points on the B-pillars

4.5.2   Special Designed Cushion For Seat Of Pregnant Woman Driver

Based on the survey conducted for pregnant woman, the results show that the pregnant woman driver felt uncomfortable and feel harm wearing a seat belt even it is the car's safety part for secure the driver if anything happen.

Mostly the respondent felt uncomfortable at the belly area because not only think about herself but the unborn baby safety. A device like a cushion should be placed at the bottom of the hip, above the seat (Figure 4.19). Then, buckle the strap at the back of the car seat (Figure 4.20). The strap can be adjusted either too short or long depend on the circumference of the back car seat. Then, wear a seat belt as the driver normally would until fasten at the buckle. After that, pull the webbing away at hip area to fasten it to the provided hook. It actually will divert the seat belt pressure from the tummy area to thigh and pelvis area (Figure 4.21). So that, these devices will reduce the risk of injury to the unborn baby and mother which reduce severe damage to the placenta. The cushion may become a simple solution to such as huge problem where the pregnant woman unrefuse to wear a seat belt or feel worried about the unborn child.

These device is suggested to those wear pants during driving because the lap belt (the lower part of seat belt) need to fasten it to provided hook at between of the thigh.
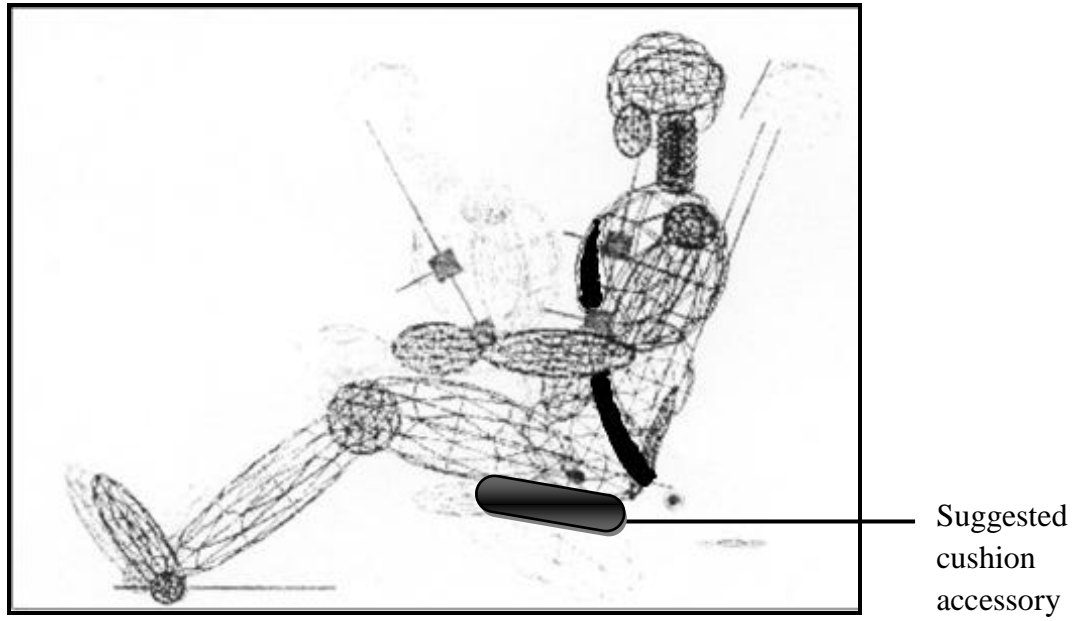
Figure 4.19: View of dummy using cushion
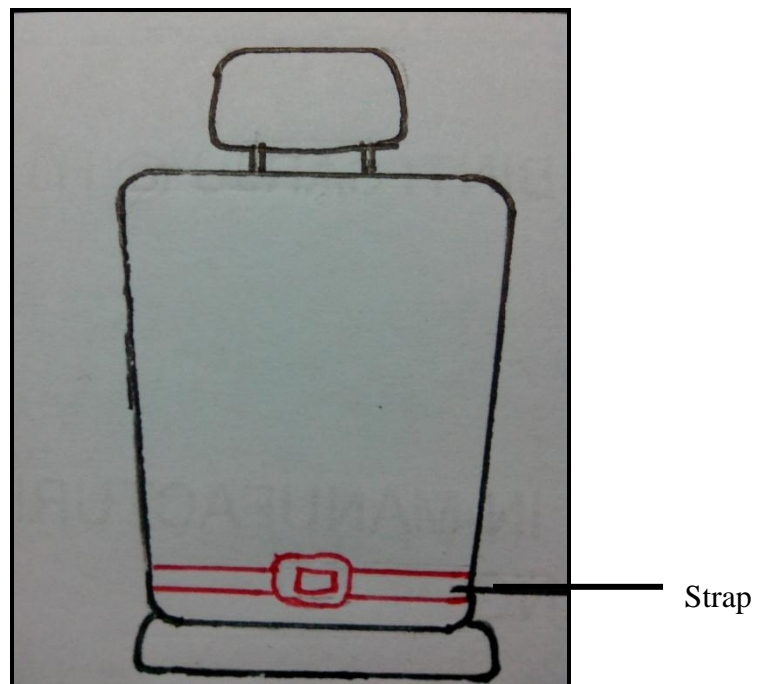
Figure 4.20: View of strap position tighten at car seat (back view)

Suggested cushion accessory
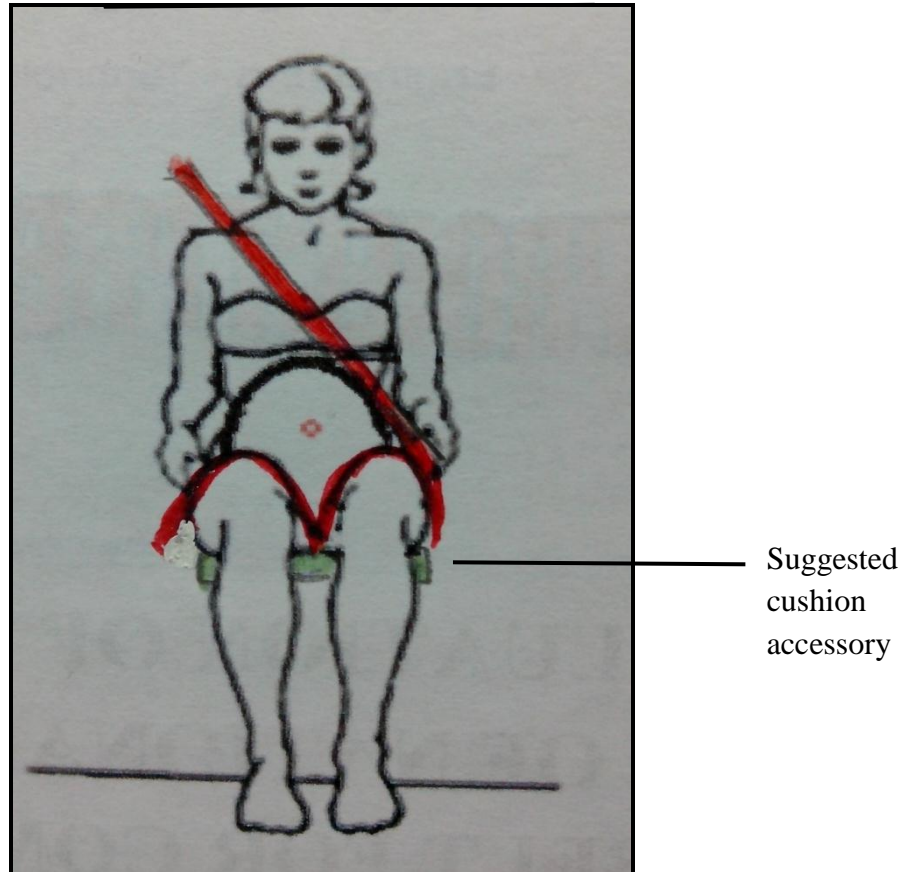
Figure 4.21 : View of seat belt position with a device (front view)

4.5.3   Dimension And Material Used

The dimension of the cushion is suggested to be 33 cm in length and 37 cm in width. This measurement is based on the antropometric dimensional data for Malaysian female. The measurement that must be referred to make a design are the measurement of the hip breath (sitting) , (Figure 4.22) and the measurement of buttock-poptieal length (Figure 4.23). The dimension of the car seat also was taken to make sure fit with the device. The important thing is the dimension of hip breath to make a design of the device. In addition, the devices also have an additional or extension cushion to attach at the back side of the device for need of big size driver or further along in pregnancy. It designed to make sure all the pregnant driver either in 5th percentile or 95th percentile can use it.

The material used to design the cushion is a normal fabric cushion that good at absorbing heat and cooling effect to make sure the driver will seat comfortable with it. Strap attached with the cushion that will tighten to the seat car is made of polyester.The length of it is 130 cm, means can fit with or without extension cushion because the circumference of seat is about 115 cm and the length can be adjusted.
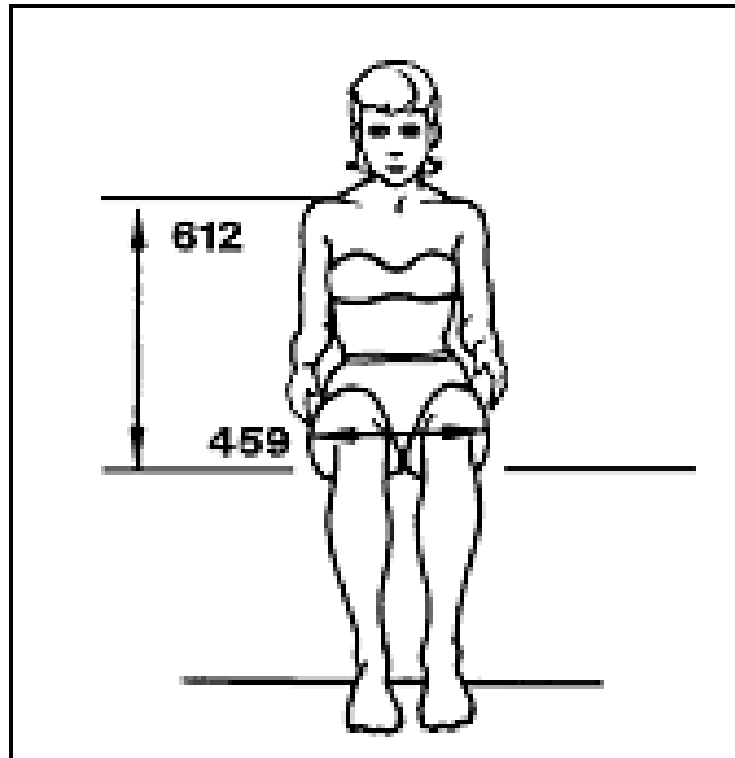
Figure 4.22: View hip breath (sitting), (see at 459)
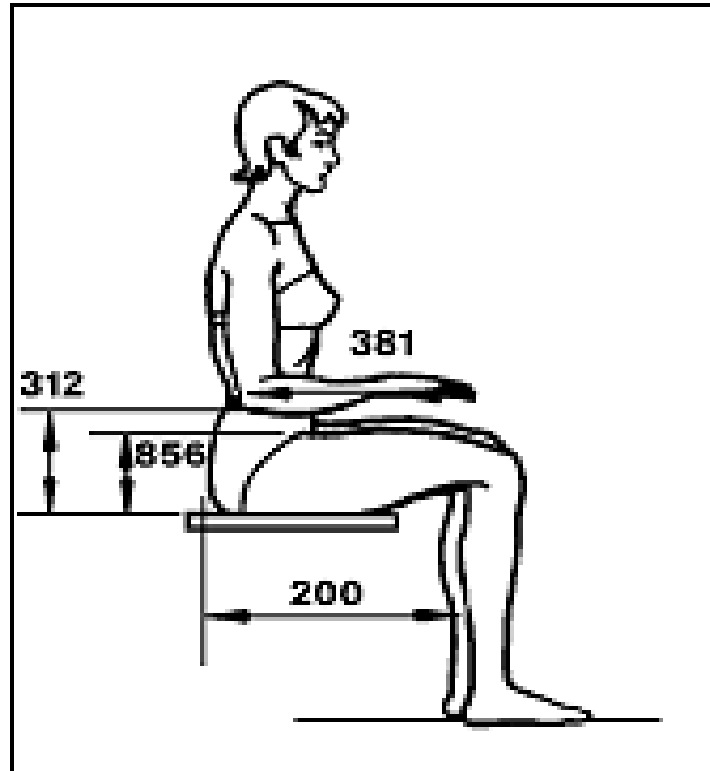
Figure 4.23: View of buttock-popliteal length (see at 200)

The design of the cushion is represented by CATIA V5 software as in Figure 4.24. Since there are have small size and big size pregnant woman driver, this project suggest the cushion for an extension that will attach at the back side of the device (Figure 4.25). It's designed to make sure all the pregnant woman driver either 5th percentile or 95th percentile can use it.
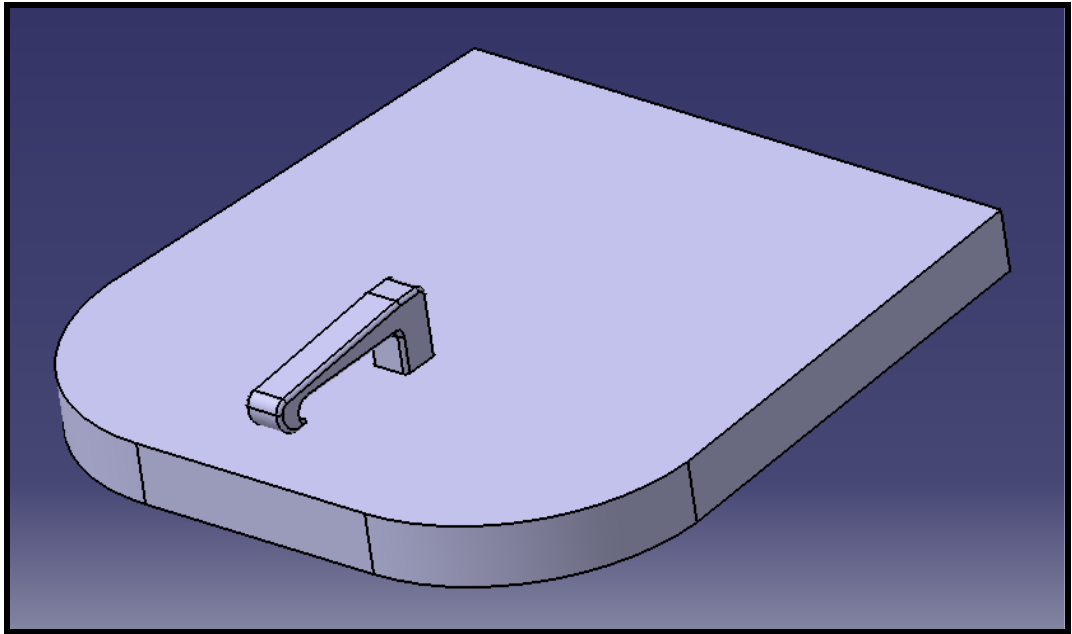
Figure 4.24: View of cushion
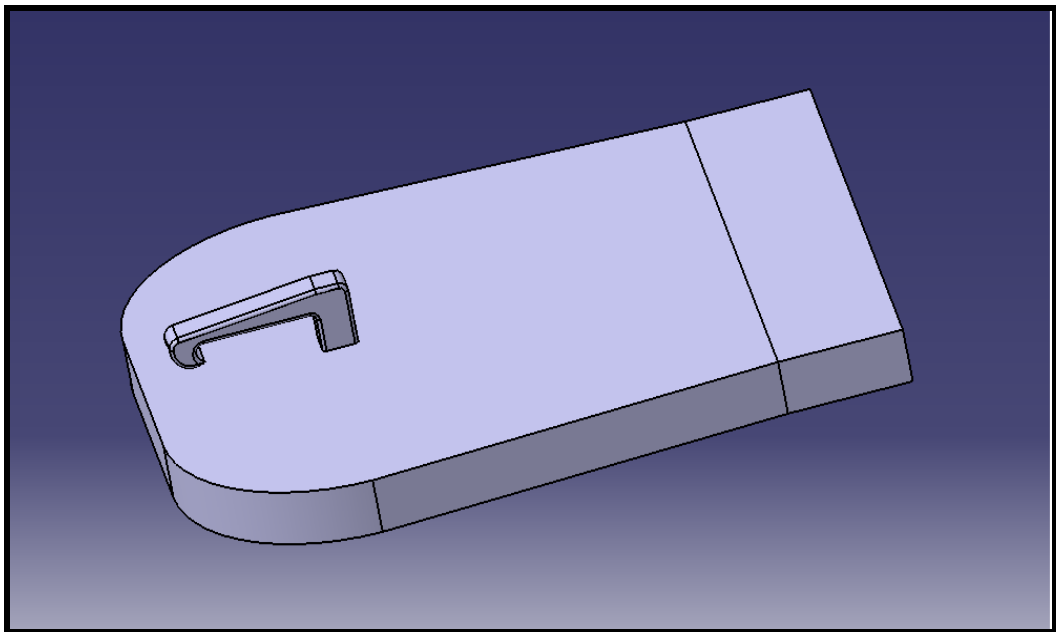
Figure 4.25: View of cushion attached with extension cushion

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

This chapter will conclude all the work that has been done during this project. Starting with the chapter one until chapter four, the conclusion will be included with all the progress and the working area of the project. The process involved is follow the methodology such as survey conducted for big size driver and pregnant woman. From the survey, the new design was improved in ergonomically aspect.

5.2 THE CONCLUSION

Anthropometry data of 95th percentile are very useful to determine big size driver. From the survey conducted, the comfort level of big size driver and pregnant woman during wearing a seat belt are obtained.

This thesis is discussed about the design of PERODUA VIVA car's seat belt and development of it.To develop the new design a seatbelt, there are important criteria must be considered which are human measurement anthropometry data for 95th percentile and regulation related seat belt in United Nation Economic Commission for Europe (UNECE) that should refer for design a new part of vehicle. In this project, protectPREG had been designed by using CATIA software. Dimension of the car seat

was taken to fix it with the seat and make sure the big size driver or pregnant woman feel comfortable and safety.

5.3   THE RECOMMENDATION

The recommendation of this project for the future research is as the project is not produced; in future, a more detailed study of the cushion can be carried out and can be realized, thus can be used by pregnant women. So, it will become meaningful or useful for pregnant woman from 5th percentile until 95th percentile or big size driver.

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APPENDIX A

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A SURVEY ON COMFORT LEVEL OF CAR SEAT BELT SYSTEM USAGE

These project research are currently reviewing issues related to seat belt system usage, especially its comfort and usability. You are invited to complete this questionnaire by going through the actions prompted. Please read each question carefully and make your best effort to answer it. Your participation in this survey is much appreciated and the results will contribute to better designs of seat belt systems.

PART 1:
QUESTIONS ABOUT YOU

Age: ○ < 20 years ○ 21-30 years
○ 31-40 years ○ 41-55 years
○ 55-70 years

Height: ○ 160-165cm ○ 166-170cm
○ 171-175cm ○ 175-180cm
○ 180-185cm

Weight: ○ 60-65 kg ○ 66-70kg
○ 70-75 kg ○ 76-80 kg
○ 80-85kg

1. Do you drive?
○ Yes   ○ No

2. Have you experience driving using PERODUA Viva car?
○ Yes   ○ No

3. How often do you drive/travel in a vehicle?
○ Daily   ○ 3-4 times a week
○ once a week

4. How long is your typical trip?
○ < 10min ○ 10-30min
○ 30-60min ○ > 60min.

5. When getting in a car, what is the usual order of actions?
○ adjust seat and then put on seat belt
○ put on seat belt and then adjust seat

PART 2: QUESTION ABOUT USING SEAT

Questions	Answer not limited to only selection and ratings(check all that apply):
1. How often do you wear seat belt?	○ Always ○ mostly ○ rarely ○ never
2. Do you experience any of the situations when fastening belt?	○ Difficult to locate buckle ○ Buckle or stalk inaccessible/in awkward location ○ Needs both hands to fasten ○ Tongue not securely latched ○ Not sure if it's latched
3. The degree of risk (crash-injury risk) they perceived from not wearing a seat belt on urban roads and on highways?	1- no risk/every safe 2- safe 3 - moderate 4 - risk 5 - very risk/unsafe
4. Overall when the belt is on, how comfortable is the fit?	1- Very Uncomfortable 2 -Uncomfortable 3 -Moderate 4 -Comfortable 5 -Very Comfortable

5. 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 ○ Belt too high around shoulder ○ Belt too tight across chest ○ When turning my head, belt touches ○ Belt too tight around hips
6. When adjusting belt, how do you feel?	○ Chest belt too tight and difficult to adjust ○ Belt locks when being pulled out ○ Belt does not roll (retract) back ○ Belt easily twisted ○ Ok. No problem
7. Describe how the belt affects your driving task:	○ Uncomfortable and always distract you ○ Cannot move freely for steering ○ Blocks your side view through windows ○ None

PART 3:
QUESTION ABOUT PREGNANCY & SEAT BELT USE

1. What was your average weight before pregnant?
   ....
2. How much do you weigh now?
   ....
3. How much is your driving being adversely affected by pregnancy

	not at all	a little	a lot	So much, I now avoid driving
Comfort	○	○	○	○
Safety	○	○	○	○

4- How easy is it for you to reach and operate the seat belt?
- ○ Very use
- ○ Easy
- ○ Difficult
- ○ Very difficult

5. How do you position the shoulder section of your seat belt over your chest? (Please choose the picture that best describes how you wear your belt across your chest)

6. How do you position the lap belt over your abdomen? (Please choose the picture that best describes how you wear your belt over your abdomen)

7. Have you received any advice about how to wear your seat belt during pregnancy?
   ○ Yes   ○ No

8. If yes, where did you receive this advice?
- ○ Television   ○ Internet
- ○ Radio   ○ Magazine

APPENDIX B

TECHNICAL DRAWING AND DIMENSION OF CUSHION

APPENDIX C

Bil.	Project activities	September			October				November				December			February		March				April					June
		W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12
1	**APPOINMENT WITH SUPERVISOR**																										
	Identifying Research Title	■	■																								
	Discussion on assigned research title		■	■																							
	Verify Project Title, Project Objectives and Project		■	■																							
2	**THE PROJECT**																										
	anthropometric data				■	■	■																				
	comfort using seat belt					■	■	■																			
3	**WRITING PROPOSAL**																										
	Writing on Chapter 1, Chapter 2, Chapter 3								■	■	■	■	■														
4	**PRESENTATION AND SUBMIT REPORT**																										
	Presentation (PSM I)													■	■												
	Judge by supervisor and other evaluater													■	■												
	Submission of Proposal (PSM I)													■	■												
5	**METHODOLOGY**																										
	Set an appointment with Gynecologist to know detail between seat belt and pregnant women															■	■	■	■								
	Study on Anthropomety data and Regulation related with seat belt																		■	■							
	Visit to Autolive Hirotako to get an info about seat belt																			■	■						
	Distribute survey																				■	■					
6	**RESULTS AND ANALYSIS**																										
	Analysis survey question & info from visit																					■	■				
	Come out with new guideline and information about seat belt																						■	■			
	Design the new seat belt based on data analysis using CATIA																							■	■		
7	**PRESENTATION AND SUBMIT REPORT**																										
	Final Presentation FYP 2(Poster, Video,Report)																								■	■	■