DESIGN AND FABRICATION OF STARK WHITEBOARD

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KOK YIN HUI	DIPLOMA IN MECHANICAL ENGINEERING	2011	UMP

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DESIGN AND FABRICATION OF STARK WHITEBOARD

KOK YIN HUI

Report submitted in partial fulfillment of the requirement for the award of

Diploma in Mechanical Engineering

Faculty of Mechanical Engineering

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DECEMBER 2011

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project report and in my opinion this project is satisfactory in terms of scope and quality for the award of Diploma in Mechanical Engineering.

Signature:

Name of Supervisor: Mr. Mohd Azrul Hisham Bin Mohd Adib

Position: Lecturer

Date: 9th JANUARY 2012

STUDENT'S DECLARATION

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

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Name: Kok Yin Hui

ID Number: MB09022

Date: 9th JANUARY 2012

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ABSTRACT

This report presents about the design and fabrication of stark whiteboard which the improvement is focus on the aspect of stability, mobility and manufacturing cost. Whiteboard acts as an important equipment in human life especially used in education, meeting purpose and instant messaging. However, its mobility and stability do not always satisfy by its user due to the difficulty in controlling the movement when transport from a place to another. In this project, concept is generated through research on existing product in order to improve its limitation. The major material used in fabricating the product is mild steel hollow bar. It fabricates using three whiteboards and four castors. Besides, a mini stage is attached to the product to improve its performance. SolidWorks Simulation Xpress software is used for structure analysis in order to identify the maximum load the product can support without deformation. The analysis conducted in three aspects, which are stress analysis, displacement analysis and factor of safety analysis. Methods and processes involved in this project include joining using MIG welding, making hole with drilling method, bending using profile bending machine and bending machine and also cutting using shearing machine. The idea of design and fabrication for this whiteboard is based on student's creativity.

ABSTRAK

Laporan ini membentangkan perekaan dan fabrikasi papan putih yang stabil di mana pengubahsuaian ditumpukan kepada skop kestabilan, mobiliti dan kos pembuatan. Papan putih memainkan peranan penting dalam kehidupan manusia terutamanya luas digunakan dalam perkuliahan, mesyuarat and peyampaian mesej. Walau bagaimanapun, pergerakan dan kestabilan alat tersebut tidak sentiasa memuaskan hati pengguna oleh sebab kesukaran dalam pengawalan pergerakan. Dalam projek ini, konsep dihasilkan berasaskan penyelidikan ke atas produk sedia ada untuk meningkatkan prestasinya. Bahan utama yang digunakan dalam produk fabrikasi adalah bar keluli lembut. Ia dihasilkan dengan menggunakan tiga papan putih dan empat roda. Selain itu, satu pentas mini dipasang pada produk tersebut untuk meningkatkan prestasi. Di samping itu, SolidWork Simulation Xpress digunakan untuk manjalankan analisis bagi mendapatkan had maksimum produk tersebut dapat menampung. Analisis ini dijalankan dalam tiga aspek, iaitu analisis tegasan, analisis anjakan dan analisis keselamatan. Kaedah dan proses yang terlibat dalam projek ini termasuk menggunakan kimpalan MIG, membuat lubang dengan menggunakan penggerudian, lentur menggunakan mesin profil lentur dan mesin lentur dan juga memotong mengunakan mesin ricih. Idea perekaan dan fabrikasi papan putih tersebut adalah dihasilkan berdasarkan kreativiti pelajar.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter explained about the project objective, project background, project scope and problem statement that been conducted.

1.2 BACKGROUND

Whiteboard is a smooth surface which writing using a marker and erased using a duster. It is available in various size and design to suit the user requirement. Whiteboard can be divided into two main categories, which are “Moveable Whiteboard” and “Non-Moveable Whiteboard”. “Moveable Whiteboard” refers to whiteboards that are designed with castors for better mobility. While for “Non-Moveable Whiteboard” refers to whiteboards that attached to wall and used in a completely static condition. Nowadays, whiteboard is widely used for meeting purpose, teaching purpose and instant messaging.

1.3 PROBLEM STATEMENT

One of the common problems faced by the whiteboard in the market is its low mobility. For “wall-attached whiteboard”, obviously it has to be fixed in a completely static condition. For “whiteboard with stand and castors”, there is a difficulty in controlling the movement when it is being pushed by single person. Moreover, whiteboard has low stability which tends

to shack forward and backward during writing. Besides, most of the whiteboard designs do not have a proper storage site for whiteboard writing tools. This causes dust deposited, or may cause falling of writing tools especially when the whiteboard is being moved.

1.4 OBJECTIVE

The objective of the project is to design and fabricate a stark whiteboard with higher mobility and stability at a lower manufacturing cost.

1.5 SCOPE

This project is limited within the following scopes, which are:

i. Fabricate a stable and moveable whiteboard which remain static during writing and is easy to be moved.
ii. Design a storage site for whiteboard writing tools with one duster and three markers only.
iii. The weight of the product less than 70kg.
iv. The height of the product less than 220cm.
v. The product fabricate with less than five castors.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter explains the review of market survey and past research effort related to whiteboard. Reviews of other relevant research studies are also provided. The literature has been studied on types of whiteboard, material usage and fabrication methods.

2.2 TYPES OF WHITEBOARD

2.2.1 Wall-mounted Whiteboard

Wall-mounted whiteboard is attached to the wall and is used in a completely static condition. It is available in aluminium frame and wooden frame with plywood backing for extra strength. All edges of the whiteboard are furnished with safety corner cap. Besides, it consists of a foldable marker tray for whiteboard writing tools. [2]

Table 2.1: Wall-mounted whiteboard overview

Cost	RM672
Size	120cm x 360 cm (H x L)

Figure 2.1: Wall-mounted whiteboard

Source: Banhoh Sdn Bhd

2.2.2 Mobile Stand Whiteboard

Mobile Stand Whiteboard is a combination of a whiteboard with a strong and sturdy stand. The stand is made with scratch resistant epoxy enamel texture. It comes with four lockable castors for better mobility and the using of lockable castor is to avoid sliding during board-writing. This is the most common type of mobile whiteboard used in market. [2]

Table 2.2: Mobile stand whiteboard overview

Cost	RM345
Size	120cm x 360 cm (H x L)

Figure 2.2: Mobile stand whiteboard

Source: Writebest

2.2.3 Mobile Double-sided Stand Whiteboard

Mobile Double-sided Stand Whiteboard is a combination of a double-sided whiteboard with a strong and sturdy stand which made of scratch resistant epoxy texture. The whiteboard is allowed to be turned 360 ° and both sides are available for writing. It is durable, stable, noiseless and lockable castor added for mobility. [2] However, the screws which used in turning the whiteboard will increase in tolerance with the time-passing. This will cause unstable and shaking of board during writing.

Table 2.3: Mobile double-sided stand whiteboard overview

Cost	RM952
Size	120cm x 240 cm (H x L)

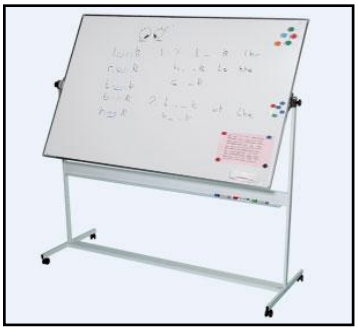


Figure 2.3: Mobile double-sided stand whiteboard

Source: TELFORD Signs

2.2.4 Wing Board

It is a whiteboard with two extended wings board which can be opened for bigger writing surface. The extended wing board comes with magnetic closure for confidentiality. Wing board is manufacture in aluminium frame with plywood core. [2] However, this product has to attach to wall and used in a static condition.

Table 2.4: Wing board overview

Cost	RM1250
Size	120cm x 360 cm (H x L)

Figure 2.4: Wing board

Source: Writebest

2.2.5 Compact Board

Compact Board is a combination of a whiteboard with high quality chromed steel adjustable telescopic leg. The whiteboard is supported by a powder coated steel frame. It consists of a full-length foldable marker-tray and lockable castors. This whiteboard is suitable for children. [2]

Table 2.5: Compact board overview

Cost	RM156
Size	60cm x 60 cm (H x L)

Figure 2.5: Compact board

Source: Writebest

2.2.6 Swing Board

Swing Board is made up by a few whiteboards with a stand which the whiteboards can be turned like a book. It is supported by an aluminium frame with safety corner cap furnished at all the edges. [2] However, by judging of the design, its stability is doubtful. The price for this item is not stated and it is depends on the number of whiteboards required by the customer.

Figure 2.6: Swing board

Source: Writebest

2.3 TYPES OF MATERIAL

2.3.1 Chromed Steel

Chromed steel is a metal which make up by adding 2% carbon and 10% to 12% chromium to molten steel. Steel is popular with its high strength and hardness properties, the addition of Chromium improves its wear and rust resistance. The Chromium will combine with oxygen to form an invisible passive film. If the metal is scratched and disrupted the passive film, oxide will build up quickly to recover the exposed surface, thus protecting it from further oxidation corrosion. Moreover, Chromium which is a bright metal, gives shiny and attractive effect to steel while preventing the building-up of rust. Besides, Chromed steel is magnetic and good heat and electricity conductor.

Because of the high corrosion resistance property, Chromed steel is widely used in making of cutlery, cooking pots, sink, bearing as well as construction field.

Figure 2.7: Whiteboard stand made from chromed steel

Source: Writebest

2.3.2 Wood

Wood is an organic material, natural composite of cellulose fibers. It is produced as secondary xylem in the stems of trees which acts as support mechanism enabling the plants to grow. At the same time, it acts as the medium to transfer water and nutrient to leaves and other growing tissues. Wood may also refer to other plant materials with similar comparable properties, and to material engineered from wood, wood chips or fiber.

Wood has been used for hundreds of years for both fuel and as construction material. It is widely used in making houses, tools, weapon, furniture, artworks and paper. [3]

Figure 2.8: Whiteboard stand made from wood

Source: Dreamstime.com

2.4 TYPES OF CASTOR

2.4.1 Lockable Castor With Bearing

This castor designs with a bearing and lockable device. The bearing allows this castor to be moved 360 ° movement easily. This institutional castor is ideal for any light duty application where the castor must be totally immobile when the castor brake is applied. It has a unique brake which locks both the wheel and the swivel bearing at the same time. “Total-Lock” brake

insures that the swivel castor will not turn when the wheel is locked. This combination of wheel brake and swivel lock is essential for safety in some applications. It can support the load capacity up to 300 pounds per castor. [4]

Table 2.6: Lockable castor with bearing overview

Cost	RM8.50
Size	50mm - Radius

Figure 2.9: Lockable castor with bearing

Source: Castercity.com

2.4.2 Non-lockable Castor With Bearing

This castor designs with a bearing to improve its mobility in 360° movement direction. The castor bracket is makes of stamped stainless steel, thus is high corrosion resistance. The swivels bearing is standard with a seal and grease fitting. Besides, this castor is ideal for use under wet or corrosive environment. It can support the load capacity up to 300 pounds per castor. However, it does not have a lockable device, so it is limited to be fixed in a static condition. [4]

Table 2.7: Non-lockable castor with bearing overview

Cost	RM6.00
Size	50mm - Radius

Figure 2.10: Non-lockable castor with bearing

Source: Castercity.com

2.4.3 Non-lockable Castor Without Bearing

This castor also known as rigid plate mount castor. It does not have both bearing and lockable device. Thus, it is unable to be locked in a completely static condition. Besides, due to the absent of bearing, it is limited to forward and backward movement only, instead of 360 ° direction turning. In another word, it is comparative lower mobility.

Table 2.8: Non-lockable castor without bearing overview

Cost	RM7.00
Size	50mm - Radius

Figure 2.11: Non-lockable castor without bearing

Source: Rockler

2.5 STABILITY

The term "*Stability*" refers to the resistant of an object to change of position or condition, which is not easily moved or disturbed. [6] In another word, *stability* refers to the resistance to disturbance of equilibrium. When discuss about stability of an object, it always concern about its *center of gravity*. *Center of gravity* is a point at which all body's mass is equally balanced of equally distributed in all direction. The figure 2.12 shows the center gravity of an object. The factors in increasing the stability of an object included:

i. Center of gravity falls within the base of support; Decrease in stability when center of gravity becomes near to edge of base.
ii. Larger base.
iii. Greater weight.
iv. Lower of center gravity
v. When anticipating an oncoming force,
    - Place center of gravity near the side of base of support expected to receive force
    - Extending base of support in direction of expected force
vi. Increase the friction between the contact surface of object and ground.

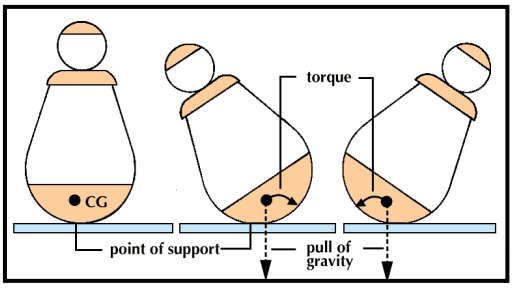


Figure 2.12: Center of gravity

Source: Britannica.com

2.6 MOBILITY

The term *Mobility* is also known as *Degree of freedom* (DOF) of an object. In mechanics, DOF is the number of parameter that defines the configuration of a mechanical system. The degree of freedom of a body is the number of independent parameter that define the displacement and deformation of the body. This is the fundamental concept relating to systems of moving bodies in mechanical engineering, aeronautical engineering, robotics, and structural engineering.

Taking examples to explain about the degree of freedom, the position of a single car moving along a track has one degree of freedom, because the position of the car is defined by the distance along the track. Skidding or drifting is a good example of an automobile's three independent degrees of freedom. The position of rigid body in space is defined by three components of translation and three components of rotation, which means that is has six degrees of freedom. [7]

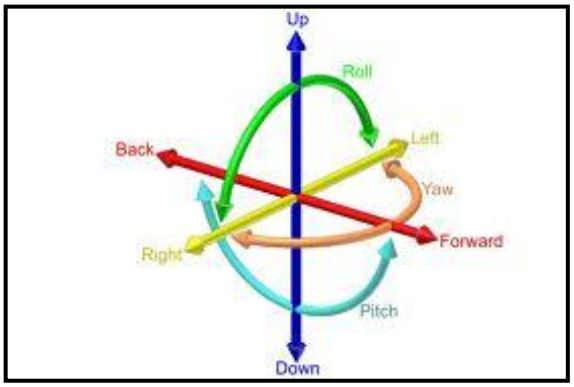


Figure 2.13: Six degree of freedom

Source: johnclarkeonline.com

2.7 TARGET USERS

Nowadays, whiteboard is widely used in human daily life especially for education and meeting purpose. Many offices, meeting rooms, schools, universities and tuition centers are using whiteboard in sharing of information. In all of these whiteboard usages, the users are mostly adult with the average age above 20 years old.

From the studied, it found that the average height of a Malaysian male adult is 1.647m and Malaysian female adult is 1.533m. This result was obtained through measurement which conducted in the year of 1996. [5] The graph explaining the relationship between the average height with body weight is shown in Figure 2.14 with the explanation of BMI value.

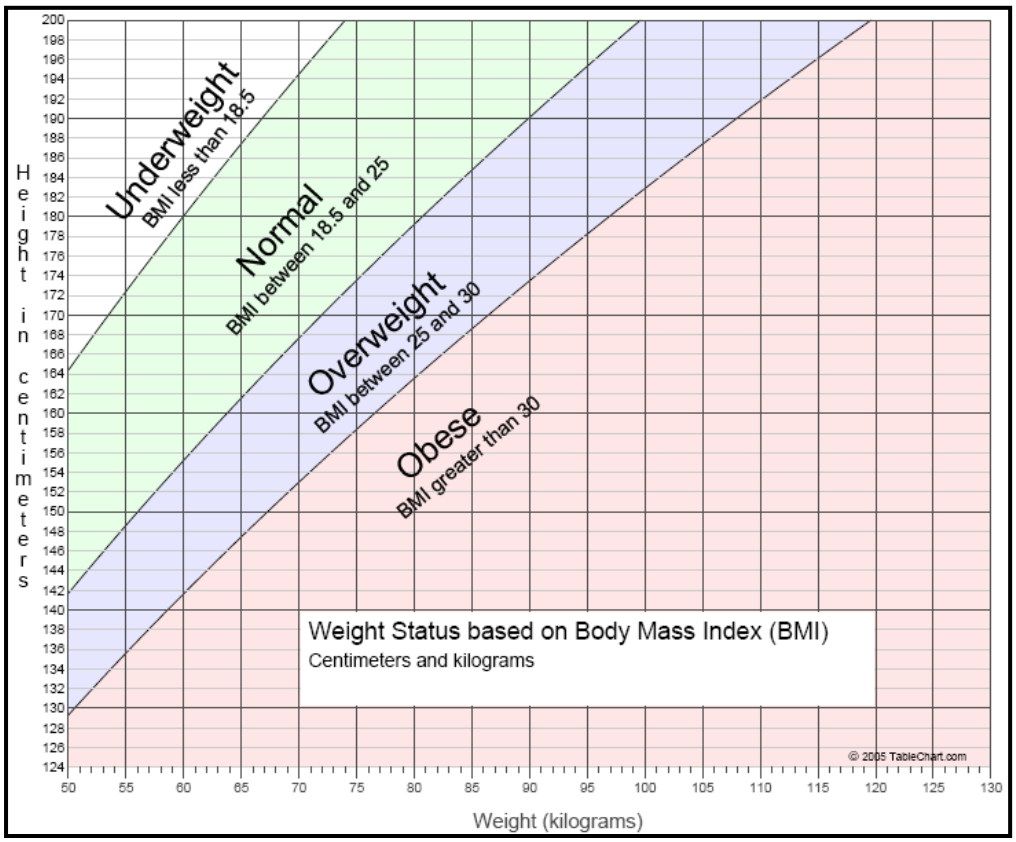


Figure 2.14: Graph of height to weight

Source: chartsgraphsdiagrams.com

2.8 TYPES OF MANUFACTURING PROCESS

2.8.1 Welding

Welding is a fabrication process that joins materials, usually metals or thermoplastics by causing coalescence with pressure and heat. The concept is to melt the metal and adding a filler material to form a small pool of molten material, which cools and become a strong joint.

Many energy sources can be used for welding, which includes gas flame, electric arc, laser, electron beam, friction and ultrasound. Besides, welding can be performed in various environments, like open air, underwater, or even outer space. However, welding is considered as a hazardous activity which may lead to burns, vision damage and inhalation of poisonous gases and fumes. Hence safety precaution like wearing face mask in carrying out welding is important. [8]

2.8.1.1 Arc Welding

Arc welding uses power supply to create an electric arc between an electrode and base material to melt the metal at welding point. The welding region is protected by shielding gas, vapor and / or slag, in order to protect the weld area from atmospheric contamination. This welding uses either DC or AC current, and consumable or non-consumable electrode.

For consumable electrode, the electrode rod is made of a material that is compatible with base material that being welded and is covered with a flux. The electrode core itself acts as filler material, making separate filler unnecessary. Non-consumable electrode is made of tungsten, an inert gas mixture and a separate filler material. It is significant with its stable arc and high quality weld, hence very useful for welding thin material. Arc welding is very versatile, requiring little operating training and inexpensive. [9]

Figure 2.15: Arc welding

Source: Wikipedia.org

2.8.1.2 MIG Welding

Metal Inert Gas (MIG) welding is also known as Gas metal arc welding (GMAW) and Metal active gas (MAG) welding. It is a semi-automatic arc welding process in which a continuous and consumable wire electrode and shielding gas are fed through a welding gun. The basic equipments are welding gun, wire feed unit, power supply, electrode wire and shielding gas supply. There are four major methods of metal transfer in GMAW, which are globular, short-circuiting, spray and pulsed-spray, every of the method has distinct properties, advantages and limitation. Nowadays, MIG welding is the most common industrial welding process, preferred for its versatility, speed and relative ease of adapting the process. [10]

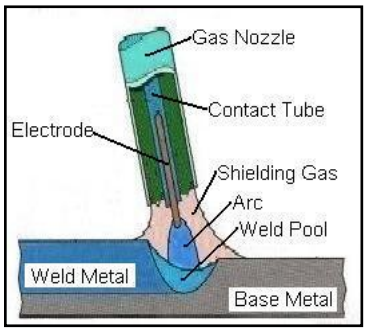


Figure 2.16: MIG welding

Source: weldingengineer.com

2.8.2 Shearing

Shearing is a metal cutting process which used to cut straight lines on flat metal stock. Shearing usually starts with formation of cracks on top and bottom edges of workpiece, caused by the movement of upper blade and lower blade in which the shear stress in the material exceed the ultimate shear strength. The cracks meet each other and separation occurs.

A small clearance is present between the edges of the upper and lower tools, which facilitates the fracture of the material. The size of clearance is typically 2-10% of the material thickness and depends upon the type of material with response to its strength and hardness. This process can be performed on sheet, strip, bar, plate and even angle stock.

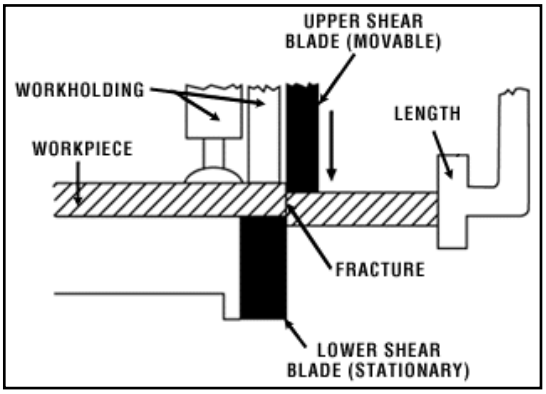


Figure 2.17: Metal shearing

Source: advantagefabricatedmetals.com

2.8.3 Bending

Bending refer to the behavior of subjecting an external load perpendicular to the longitudinal axis of a slender structural element. Bending can occur locally in all objects. To make the term of Bending more precise, engineers refer to the *bending of rods*, *bending of beams*, *bending of plates*, *bending of shells* and so on based on the shape of the structural element.

In a horizontal beam loaded at middle and supported at the ends, the material at the over-side of the beam is compressed while the material at the underside is stretched. There are two types of internal stresses developed by lateral loads, which are *shear stress* (parallel to lateral loading plus complementary shear stress on planes perpendicular to the load direction), *compressive stress* (develop at upper region of beam) and *tensile stress* (develop at lower region of beam). [11]

Figure 2.18: Bending machine

Source: endmillwebsite.com

2.8.4 Drilling

Drilling is a cutting process that uses a drill bit to cut or enlarge a hole in solid material. It cuts by applying pressure and rotation onto the workpiece through using a drill bit, which will form chips at the cutting edge. Chips may be long spirals or small flakes, depending on the material and process parameters. [12]

There are variety of drill bits and every different drill bits result different hole making. For example like a center drill, it is used to provide a starting hole for a larger sized drill bit; for step drill, it is used to produces holes of two or more different diameters; for core drill, it is used to enlarge an

existing hole. Hence, selection of drill bits for drilling is one of the factors an operator should always concern. There are two types of holes can be produced by drilling, which are through-holes (drill exits the opposite side of work) and blind-holes (drill does not exit work on opposite side).

Figure 2.19: Drilling machine

Source: endmillwebsite.com

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter discusses about the concept designs that have been develop during concept generation. The designs had undergoes concept selection and lastly the finalization stage before proceed to fabrication of product. It also explained about the tools and fabrication planning for the project.

3.2 CONCEPT GENERATION

3.2.1 Concept 1

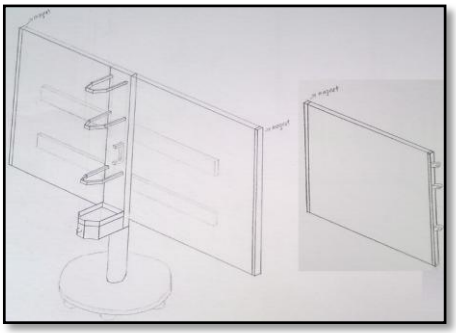


Figure 3.1: Concept 1

The concept of this whiteboard is similar to the concept of attaching a piece of paper to an office file. There are a few rings designed at the middle of the whiteboard, which allow add-in of whiteboards based on user's

requirement. The disadvantage of this design is that, the whiteboard will tense to shake during writing.

3.2.2 Concept 2

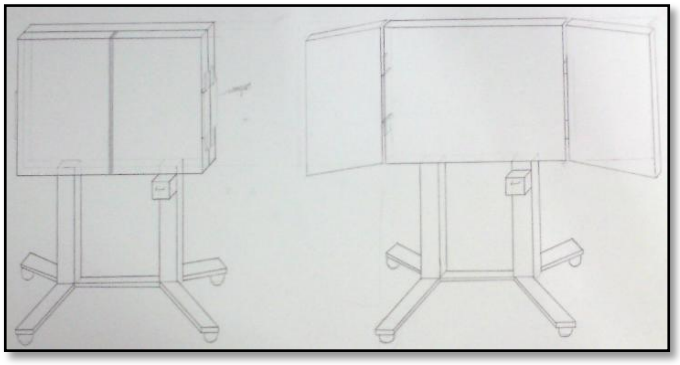


Figure 3.2: Concept 2

This design consists of a big whiteboard attached with two smaller whiteboards. The special of this is the small whiteboard has double-sided writing surface, allowing the expanding of writing surface area by opening the two small whiteboards. Besides, there is a storage box designed to keep whiteboard writing tools.

3.2.3 Concept 3

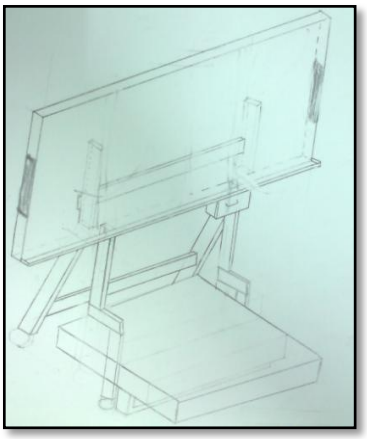


Figure 3.3: Concept 3

The special of concept 3 is the combination of a stage and a whiteboard. The idea in developing this idea was motivated by the sense of important of a stage for a public speaker. A board presenter can performed better with a stage and grab the attention of audience. The stage can be kept while not in use and lowered when it is needed.

3.2.4 Concept 4

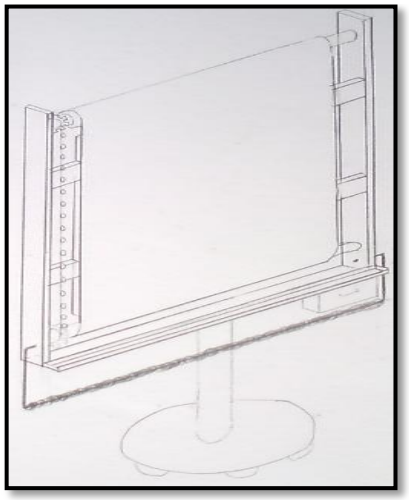


Figure 3.4: Concept 4

This is a comparative complex design of whiteboard in which whiteboard sheet is used instead of whiteboard plywood. It has a roller attached on top to allow turning of whiteboard sheet. The turning mechanism is similar to the turning mechanism of an office curtain which made of plastic. However, this turning mechanism is not applicable for frequent operation due to the low strength of plastic.

3.3 CONCEPT SCREENING

The objective in carried out concept scoring is to make comparison among concept designs in order to improve the concept. Comparison is made in the aspects of *board stability*, *mobility*, *writing tools storage site*, *consideration of user height* and *estimated manufacturing cost*. In this

concept scoring, I had chosen *mobile double-sided stand whiteboard* as the reference. The result is shown in Table 3.1.

Table 3.1: Concept screening

SELECTION CRITERIA	1	2	3	4	REF.
Board stability (during writing)	0	+	+	-	0
Mobility	+	+	+	0	0
Writing tools storage site	+	+	+	+	0
Total writing surface	0	+	-	+	0
Consideration of user height	0	0	+	+	0
Estimated manufacturing cost	+	+	+	+	0
PLUSES	3	5	5	4	
SAMES	3	1	0	1	
MINUSES	0	0	1	1	
NET	3	5	4	3	
RANK	3	1	2	4	

Notes:

+ = Better than reference

- = Worse than reference

0 = Same as reference

3.4 CONCEPT SELECTION

Referring to the result of concept scoring, ranking number 1 goes for concept 2, ranking number 2 goes for concept 3, followed by concept 1 and 4. Hence in deciding my final concept, I would like to fabricate the best whiteboard with the combination of advantages between concepts ranking 1 and 2. For the aspect of *total writing surface*, concept 2 shows a better result but for the aspect of *consideration of user height*, concept 3 can perform better. Thus, by combining the advantages, a new final design concept is obtained and is shown in figure 3.5.

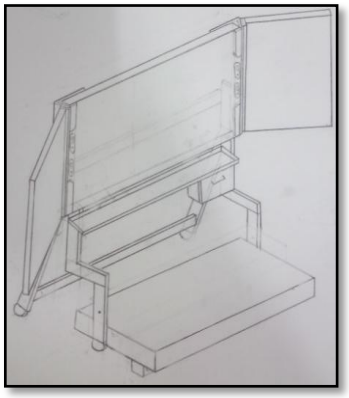


Figure 3.5: Final design concept

3.5 CONCEPT FINALIZATION

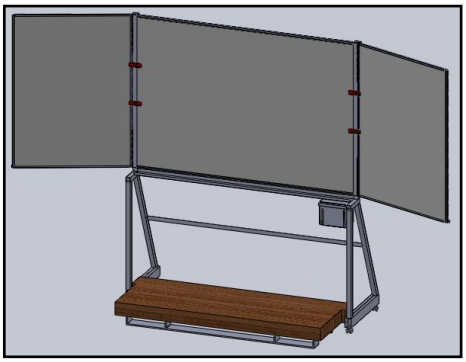


Figure 3.6: Final design

The final design consists of total three whiteboards (a 120cm x 180cm whiteboard, and two 120cm x 90cm whiteboards), a whiteboard writing tools storage box, pan, stage and two supporting legs. This design believes will result in good mobility and stability. However, due to cost and time limitation, I decided to fabricate my product in 1:2 ratio prototype.

3.6 MATERIAL SELECTION

Table 3.2 shows the material selection of the project with dimension of the prototype product design. The prototype will be fabricated in the dimension ratio of 2:1.

Table 3.2: Bill of material

No.	Component	Material	Dimension	Quantity
1.	Whiteboard	Melamine board with aluminium frame	600mm x 900mm 600mm x 450mm	1 2
2.	Pan	Mild steel	800mm x 80mm	1
3.	Leg	Mild steel square hollow bar	35mm x 35mm x3500mm 75mm x 25mm x 1500mm	1 1
4.	Stage	Wood	1000mm x 1500mm	1
5.	Castor	Rubber	Diameter – 50mm	4
6.	Stage holder	Galvanized iron	870mm x 30mm	1
7.	Storage box	Mild steel	500mm x 600mm	1
8.	Angle stopper	Mild steel	65mm x 28mm	4
9.	Angle player	Galvanized iron	190mm x 600mm	2

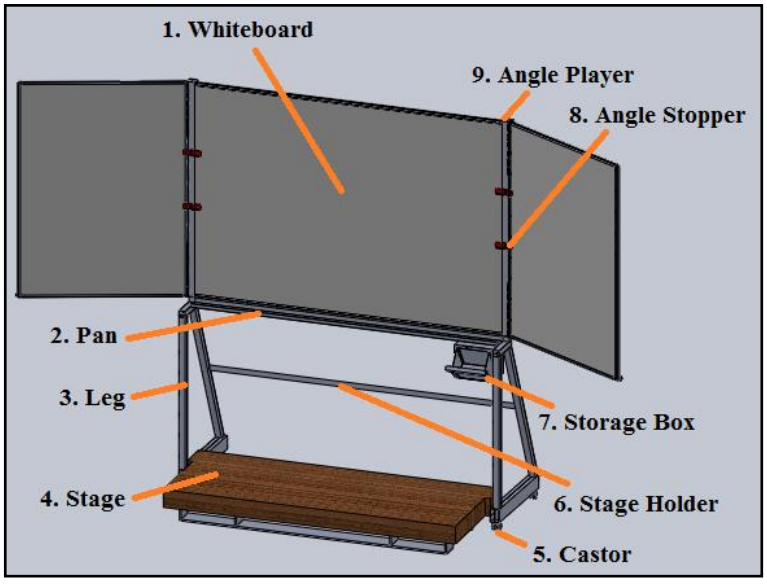


Figure 3.7: Components of final design

3.7 STRUCTURE ANALYSIS

I have used Simulation Xpress Analysis of Solid Work 2010 to analyze the strength of my product. The analysis conducted in three aspects, which are *stress analysis*, *displacement analysis* and *factor of safety analysis*. The analysis is important as it can know which part of the product with the highest stress value and easier to crack. By knowing this, we can understand the structure and limitation of the product better and able to prevent the crack by improving the parts which has higher stress concentration. Figure 3.8 show the structure analysis flow:

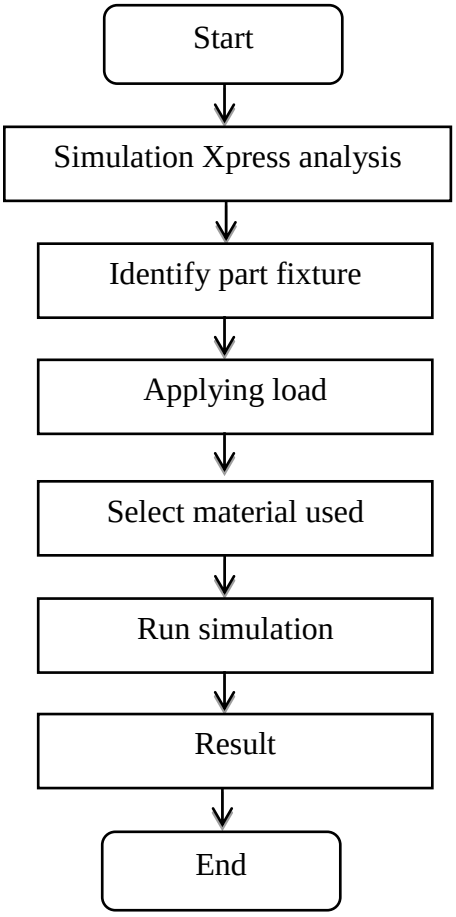


Figure 3.8: Structure analysis flow

3.8 FABRICATION

The phase after project designing is the fabrication process. This process will focus on the use of raw material referring to material selection and make the product based on the design and dimension stated. It is a value added process that involves the construction of machines and structures from various raw materials.

Fabrication consists of three major stages, which are cutting, shape forming and assembly. First, we have to cut the material into the dimension required using shearing or sawing. Next, form the material into specified shape by applying angle or degree through bending, hammering or others. Finally, assembly all the parts through welding, riveting, screwing, threaded fastener or other joining methods to form the final product. For better appearance, finishing process like grinding and painting are always carried out.

3.8.1 Fabrication Flow

Figure 3.9 shows the fabrication flow chart of the project. It consists of six phases, which are:

i. Phase 1 – Dimension measuring
ii. Phase 2 – Material cutting
iii. Phase 3 – Shape forming
iv. Phase 4 – Drilling
v. Phase 5 – Material joining
vi. Phase 6 – Finishing

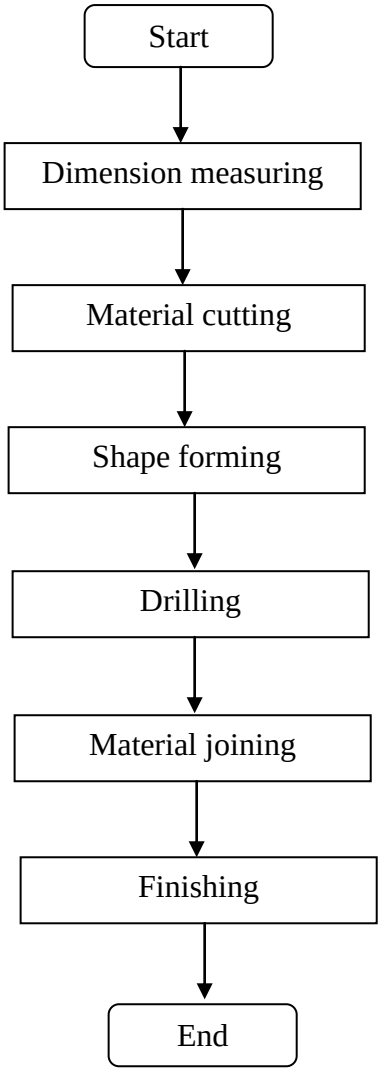


Figure 3.9: Fabrication flow chart

3.8.2 Fabrication Process

3.8.2.1 Dimension Measuring

The materials were measured according to the decided measurements using a measuring tape. Unit of measurement has to be concerned. Marking was applied using a marker pen or a center punch (drilling) to identify the cutting length.

Figure 3.10: Measuring process

3.8.2.2 Material Cutting

The used of suitable cutting machine or equipment in cutting process was depends on the type and shape of the materials. For hollow bar, it was cut using a disc cutter; for sheet material with not more than 5mm thickness, it was cut using shearing machine; wood was cut using vertical band saw machine.

Figure 3.11: Cutting process

3.8.2.3 Shape Forming

Sheet metal was formed into desired shape by using bending machine. Data like critical angle, type and thickness of metal were inserted to the machine to control its shearing force. However, the bending machine is limited to bend the length with less or equal to 10mm. Thus, for bending the length which less or equal to 10mm, manual hammering for bending was applied.

3.8.2.4 Drilling

The marked holes were drilled for placing of screw, bolts and nuts and also for riveting. The drill bit used has to suit to the diameter of screw, bolt or rivet. Hand drill and drill press machine were used for my drilling process.

3.8.2.5 Material Joining

Riveting, welding, gluing, screwing and nailing were used in material joining process. Some of the material contact surfaces were joined using two joining methods in order to improve its strength of joining.

Figure 3.12: Material joining (Nailing)

3.8.2.6 Finishing

Any rough surfaces of the product were finished using a grinder, file or sand paper to give smooth surfaces. Meanwhile, this will also improved the safety level of the product by eliminated sharp edges. Lastly, spray and shellac painting is applied to give better appearance to the product.

Figure 3.13: Finishing

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter discusses about the result of fabrication and has a view with the final product. Product fabrication process was done in within 7 weeks. The product will be explained in detail with respect to its function, usage, cost and structure analysis.

4.2 RESULT

Figure 4.1 and 4.2 shows final product in several views.

Figure 4.1:
Final product in closed condition

Figure 4.2:
Final product in opened condition

4.3 PRODUCT ADVANTAGE OR FUNCTION

4.3.1 Whiteboard

It consists of three whiteboards (a 60cmx90cm whiteboard, two 60cmx45cm whiteboards) which the two smaller whiteboards have double-sided writing surfaces. It can be closed or opened depends on the user's writing surface area requirement.

Figure 4.3: Whiteboards

4.3.2 Angle Player

Angle Player acts as a connecting mechanism between the center whiteboard and the two small whiteboards. Besides, it gives an angle of 165 ° during the opening of two small whiteboards for better board reading.

Figure 4.4: Angle player

4.3.3 Angle Stopper

There are total four angle stoppers used in this product. It acts as an obstacle to prevent the small whiteboard from swinging backward when it is opened. This improves the stability of board writing. In Figure 4.5, the top angle stopper is in rest condition, the bottom angle stopper is in used condition.

Figure 4.5: Angle stopper

4.3.4 Whiteboard Legs

Whiteboard legs are the main support mechanism for the product. One of the advantages of this product is that it has a comparative larger width of whiteboard legs than the one selling in current market. The average width of whiteboard legs in market is 57cm, but for this product in actual dimension has whiteboard legs of 59cm width. In another word, it has a larger bottom surface area and better stability. Besides, the ratio of *whiteboard length* to *distance between whiteboard legs* is comparative larger compared to the whiteboard in market. Shorter distance between the two legs allow better controlling of movement, thus improve the mobility of whiteboard.

Figure 4.6: Whiteboard leg

4.3.5 Storage Box

The purpose of the storage box is to keep whiteboard writing tools in a proper condition. However, the measurement for the fabrication of this storage box is a little bit critical, hence minor mistake is made in giving over measurement of tolerance. It seems a little bit loosen but can actually functioned well in storing writing tools.

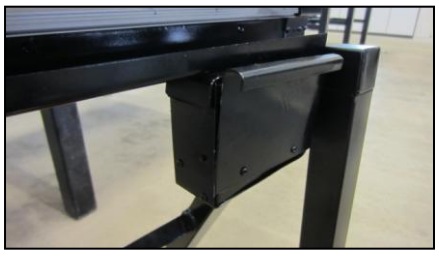


Figure 4.7:
Storage box in closed condition

Figure 4.8:
Storage box in opened condition

4.3.6 Pan

Pan is a U-shaped sheet metal which allows user to temporary place the whiteboard writing tools.

Figure 4.9: Pan

4.3.7 Stage

One of the advantages of this product is that it designed with a foldable stage. Every board-presenter like people who is giving lecture or meeting required a stage for better communication with audiences. The stage is connected to the whiteboard legs. It can be lowered down when needed by the user. This design reduces the manufacturing cost by attaching a stage on whiteboard instead of building a stage and place a whiteboard on it. Besides, the attachment of stage has lowered the centre gravity of the product, this has improve its stability as well.

Figure 4.10: Stage

4.3.8 Castors

With the consideration of product's load, rubber castors are used because of its better strength and durability. Lockable castors are used as the front castor while non-lockable castors are used as the back castor. Using of lockable castors is to allow user to set the whiteboard in a completely static condition by locking it. The locking device locks both the castor and bearing,

preventing moving and also turning of castor. However, two lockable castors are used instead of four for cost reducing purpose. Using of non-lockable castor is cheaper and locking two castors giving the same result as locking of four castors.

Figure 4.11: Front castor

Figure 4.12: Back castor

4.4 STRUCTURE ANALYSIS

Stress Analysis, Displacement Analysis and Factor of Safety Analysis had been conducted to the whiteboard leg and stage using SolidWork Structure Simulation.

4.4.1 Whiteboard Leg Analysis

The vertical load of 300N is the estimated load of it carries. The maximum load that has been applied is 3000N in uniform distribution. Results of the analysis show the stability of whiteboard during moving.

4.4.1.1 Whiteboard Leg Stress Analysis

The result of stress analysis is shown in Table 4.1 and Figure 4.13. The maximum stress is 1918.286N/mm ². The part with higher stress value will usually deform first when load is continue adding on the product. By noticed the average stress value on every parts, it can focus on parts with higher stress value, add support mechanism to improve the product's strength.

Table 4.1: Stress analysis of whiteboard leg

NAME	TYPE	MIN	MAX
Whiteboard Leg	Stress Analysis	0.542N/mm ²	1918.286N/mm ²

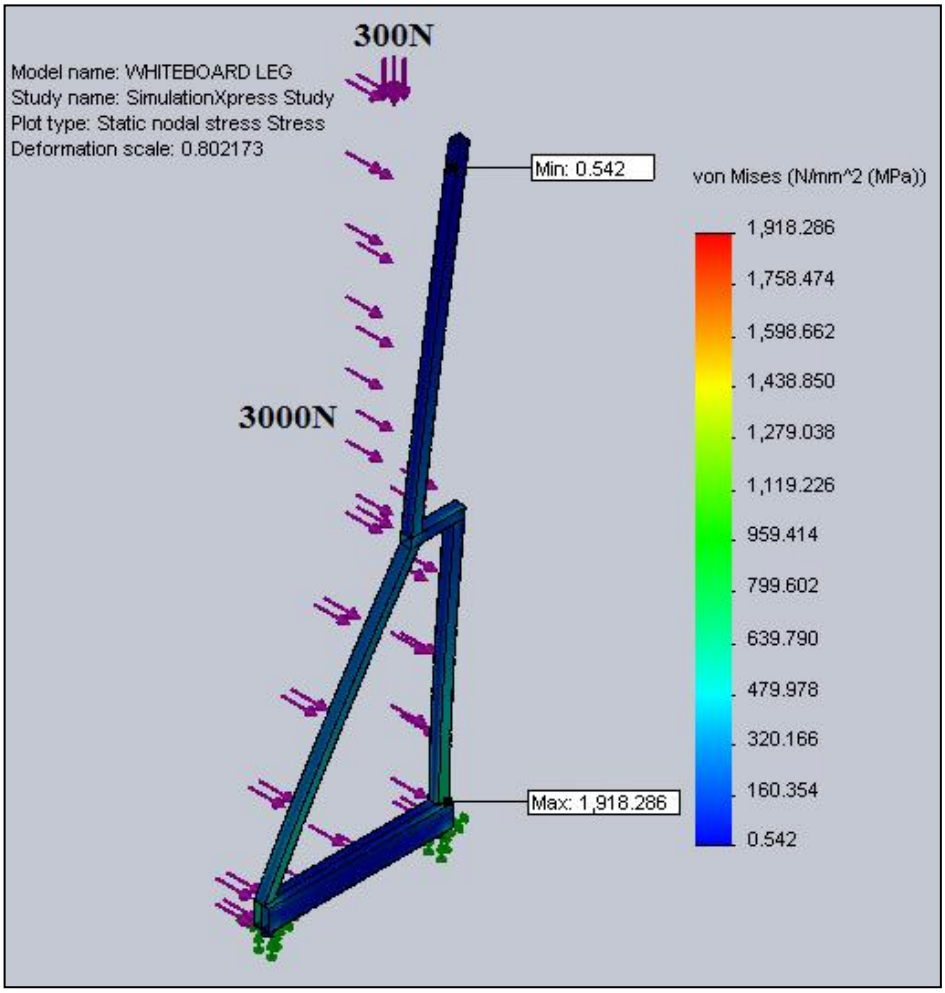


Figure 4.13: Stress analysis of whiteboard leg

4.4.1.2 Whiteboard Leg Displacement Analysis

The result of displacement analysis is shown in Table 4.2 and Figure 4.14. The maximum displacement is 274.897 mm. Referring to the scale in Figure 4.14, part colored in red shows higher deformation in term of displacement when load is adding. This part will deform up to 274.897mm before it crack. By knowing this, user can prevent cracking by avoiding the deformation of red colored part up to its maximum deformation limit.

Table 4.2: Displacement analysis of whiteboard leg

NAME	TYPE	MIN	MAX
Whiteboard Leg	Displacement Analysis	0 mm	274.897 mm

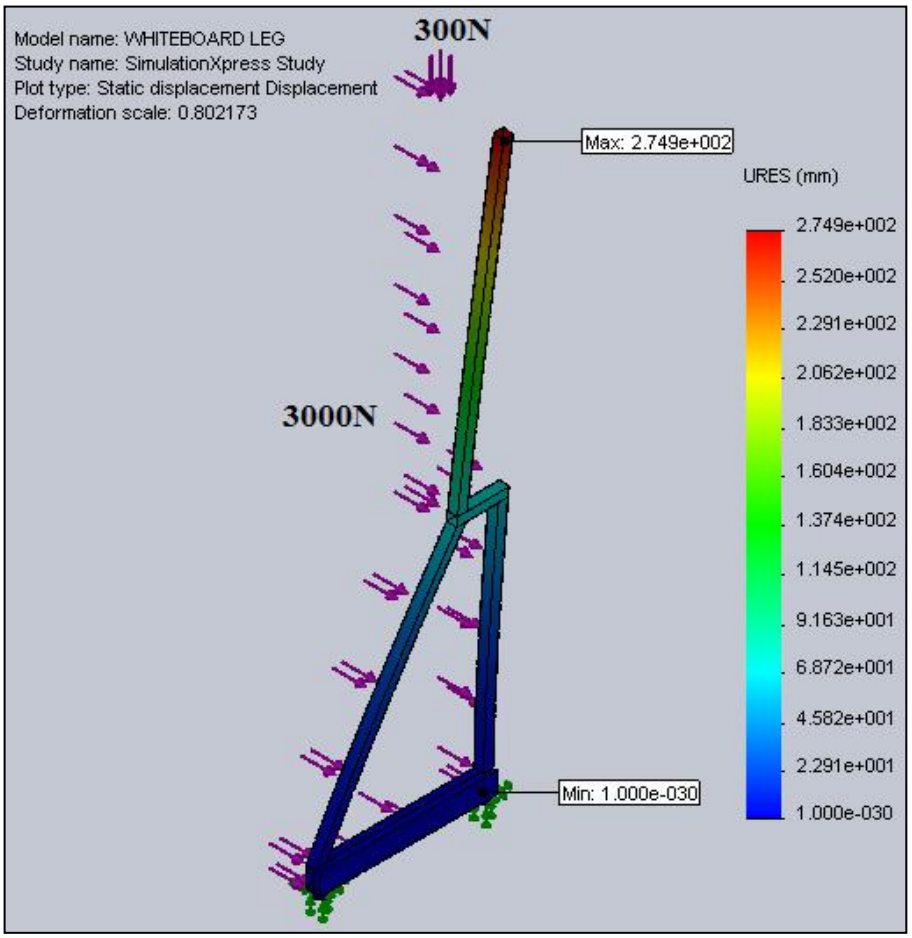


Figure 4.14: Displacement analysis of whiteboard leg

4.4.1.3 Whiteboard Leg Factor of Safety Analysis

Result of factor of safety is shown in figure 4.15. The red zones show the part of whiteboard which its factor of safety is less than 1, in another word, deformation will occur on these zones when over load is applied. The blue zones show the part of whiteboard which its factor of safety is more than 1, in another word it means these zones have lower possibility to deform when over load is applied. Analyze the result, the whiteboard leg can support up to 3000N before it crack.

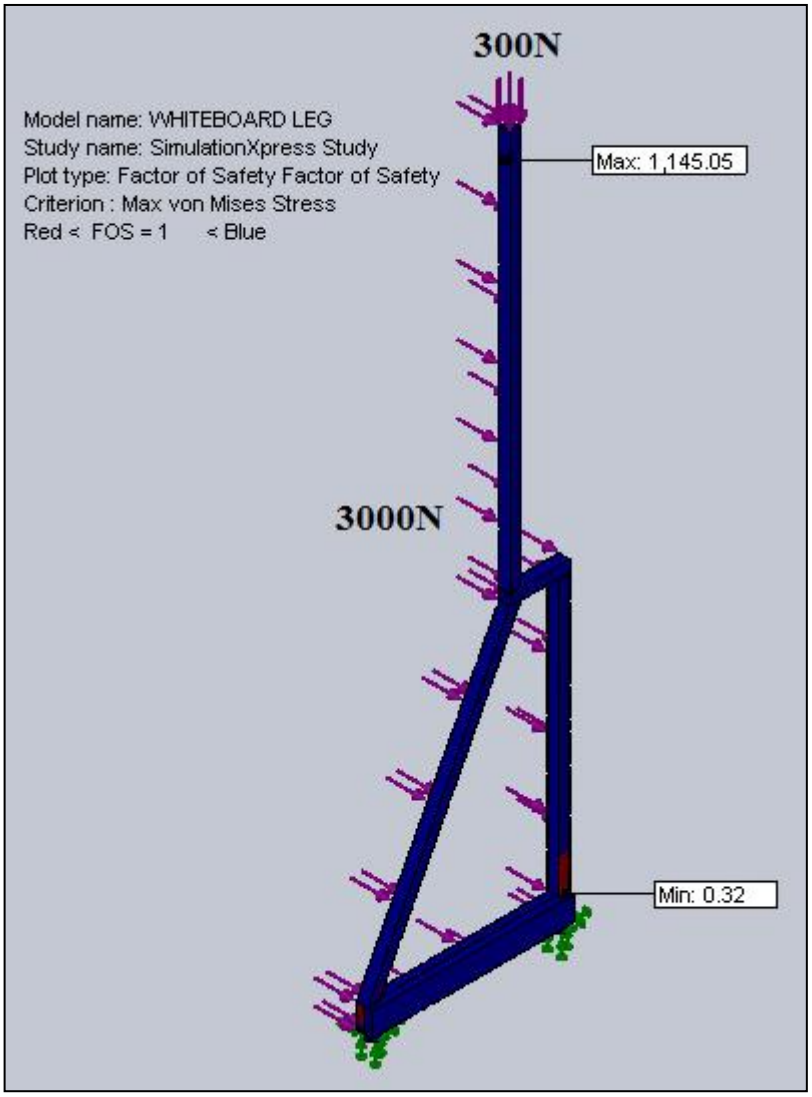


Figure 4.15: Factor of safety analysis of whiteboard leg

4.4.2 Stage Analysis

The stage analysis was carried out on the inner support mechanism of the stage. The maximum load that has been applied is 7000N in uniform distribution. In another word, analysis was made based on ten 70kg people standing on the stage. The results show the strength of stage respond to load.

4.4.2.1 Stage Stress Analysis

The result of stress analysis is shown in Table 4.3 and Figure 4.16. The maximum stress is 35.364N/mm². The edges of the stage support mechanism have higher stress value. These parts will usually deform first when people standing on the stage. Hence, the joining mechanism at the edges has to be stronger to support the higher stress value.

Table 4.3: Stress analysis of stage

NAME	TYPE	MIN	MAX
Stage	Stress Analysis	0.027N/mm²	35.364N/mm²

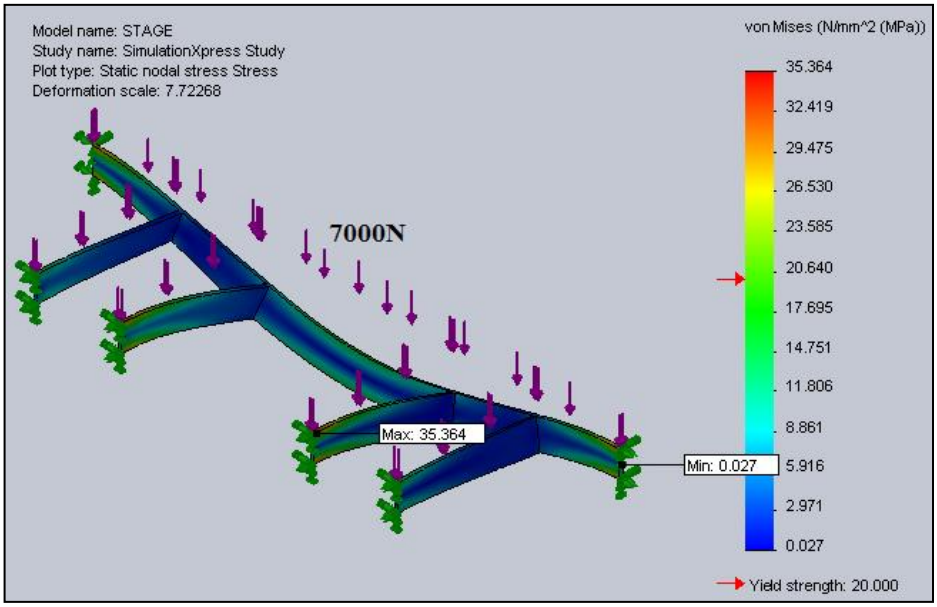


Figure 4.16: Stress analysis of stage

4.4.2.2 Stage Displacement Analysis

The analysis result is shown in Table 4.4 and Figure 4.17. The minimum displacement is 0mm and the maximum displacement is 21.04mm. When over load is applied on the stage, the red colored zone will deformed the most and ending up with crack when the deformation displacement reached 21.04mm. Through this analysis, we can improve our product by adding support mechanism on the red colored zone to prevent the deformation up to its maximum limit, so that crack of the product can be partially avoided.

Table 4.4: Displacement analysis of stage

NAME	TYPE	MIN	MAX
Stage	Displacement Analysis	0 mm	21.04 mm

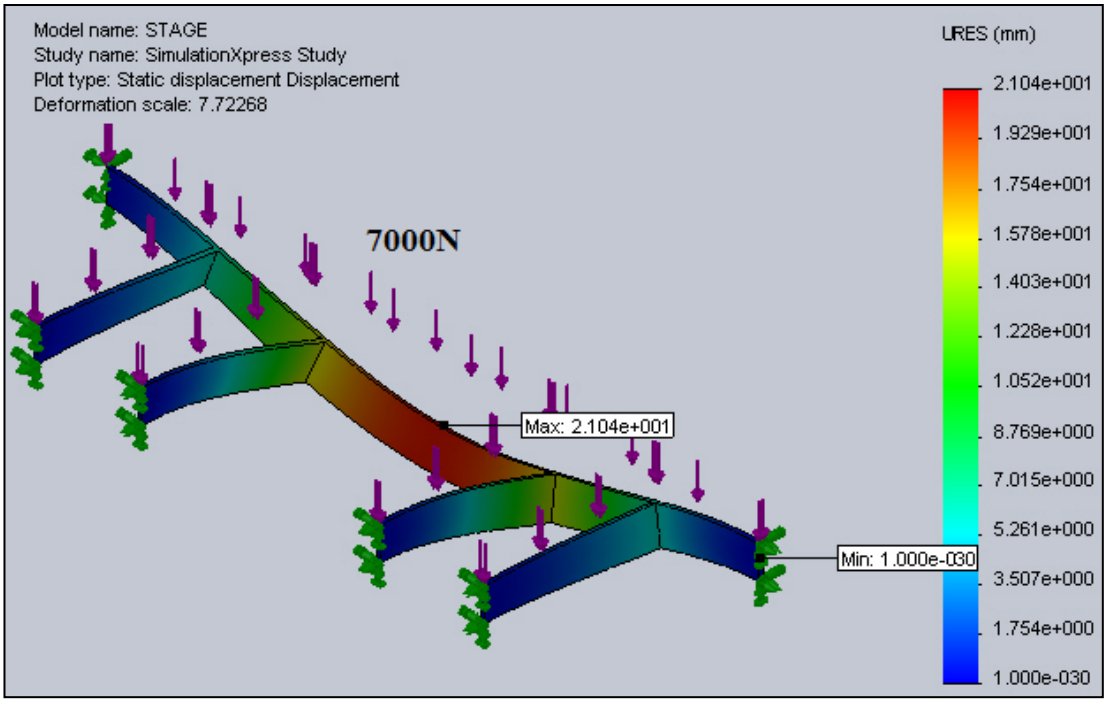


Figure 4.17: Displacement analysis of stage

4.4.2.3 Stage Factor of Safety Analysis

Result of factor of safety is shown in figure 4.18. The red zones show the part which its factor of safety is less than 1, in another word, deformation will occur on these zones when over load is applied. The blue zones show the parts of stage which its factor of safety is more than 1, in another word it means these zones have lower possibility to deform when over load is applied.

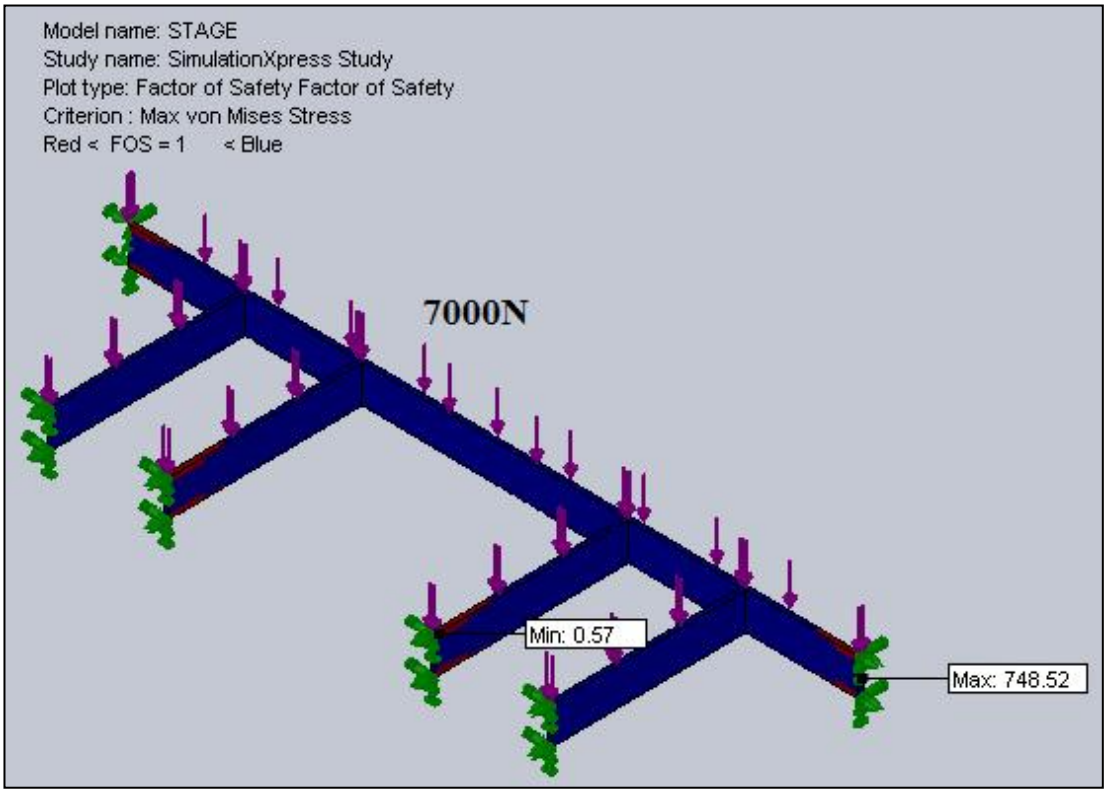


Figure 4.18: Factor of Safety Analysis of Stage

4.5 COST ANALYSIS

Materials needed in fabricate this product which are unable to obtain in FKM Mechanical Laboratory have to be self-purchased. Table 4.5 shows the list of purchased material for the project:

Table 4.5: Cost analysis

PART	PRICE	QUANTITY	TOTAL
Whiteboard (60cmx90cm)	RM 50.00	1	RM 50.00
Whiteboard (60cmx45cm)	RM 25.00	2	RM 50.00
Plywood	RM14	1	RM14.00
Lockable castor	RM 8.50	2	RM 17.00
Non-lockable castor	RM 7.00	2	RM 14.00
Spray	RM 6.50	2	RM 13.00
Shellac	RM7.50	1	RM7.50
Handle	RM1.45	2	RM2.90

4.6 DISCUSSION

In the fabrication process, due to the broken down of some machines and equipments, addition with the limitation of personal mechanical skill, the progress of project was slightly delayed. However, it was glad to be able finished it on time.

In this project, the design of storage box is critical towards its measurement. Some angles and tolerance has to be considered to allow a smooth opening and closing of the storage box. However, mistake was made by giving over tolerance in bending the material and caused the storage box a little bit loosens. Anyway, it can still function normally and continuously with the limitation of no over force exerted during opening and closing.

The product consists of four castors and it is fabricated by using lockable castor as the front castors; non-lockable castor as the back castors for cost reducing purpose. However, after I finish fixed all the castors using bolts and nuts, I realized that I had used the wrong non-lockable castor. The castor do not has bearing and allowed only straight movement. Thus, I

repaired my mistake by replaced the castor it with another two non-lockable castors but with bearing attached. After replacing the castors, the product can be moved easily and available in all direction.

Figure 4.19: Non-lockable castor without bearing

Figure 4.20: Non-lockable castor with bearing

CHAPTER 5

CONCLUSION

5.1 INTRODUCTION

This chapter concludes the entire project by referring to the objective and recommendation is given for further improvement of product.

5.2 CONCLUSION

The objective of the project is to design and fabrication of stark whiteboard with higher stability and mobility at lower manufacturing cost.

For the aspect of stability, it has been improved by increasing the width of whiteboard legs for larger bottom surface area and attachment of stage to lower its centre of gravity. Improvement in stability gives positive effect in the aspect of mobility. Besides, product mobility is further improved by minimizing the length between whiteboard legs for better controlling of movement. At the same time, manufacturing cost is always be concerned throughout the fabrication process, for example like fixing two lockable castors instead of four, since lockable castor is more expensive than non-lockable castor.

In conclusion, the outcome of stark whiteboard is achieved the objective of the product. All the components can basically function well and is ready to be used.

5.3 RECOMMENDATION

The whiteboard legs which are made of mild steel have facing corrosion problem when exposed to air and water. Mild steel is perfect in term or strengthness, but it is poor in corrosion resistance. Thus, chromed steel is suggested to be used replacing mild steel. It has high strength and good corrosion resistance.

The stage of the product is slightly heavy and the plywood used is unsuitable for nailing and is low quality. Thus, for better performance, a lighter wood with higher quality and strength is preferred.

Besides, the whiteboard used in this project are non-magnetic whiteboard. It does not have magnetic effect, any attachment of note or paper onto the whiteboard using magnet is unavailable. Hence, for better performance, magnetic whiteboard can consider to be used in fabricate the product.

Graph is one of the most important elements in mathematics, thus the combination of graph with whiteboard can surely improve the value of product. The whiteboard has total 5 writing surfaces, grid line can apply on any one of the small whiteboard surface to improve teaching efficiency. Through this, the whiteboard can used to teach the drawing of graph clearly and effectively.

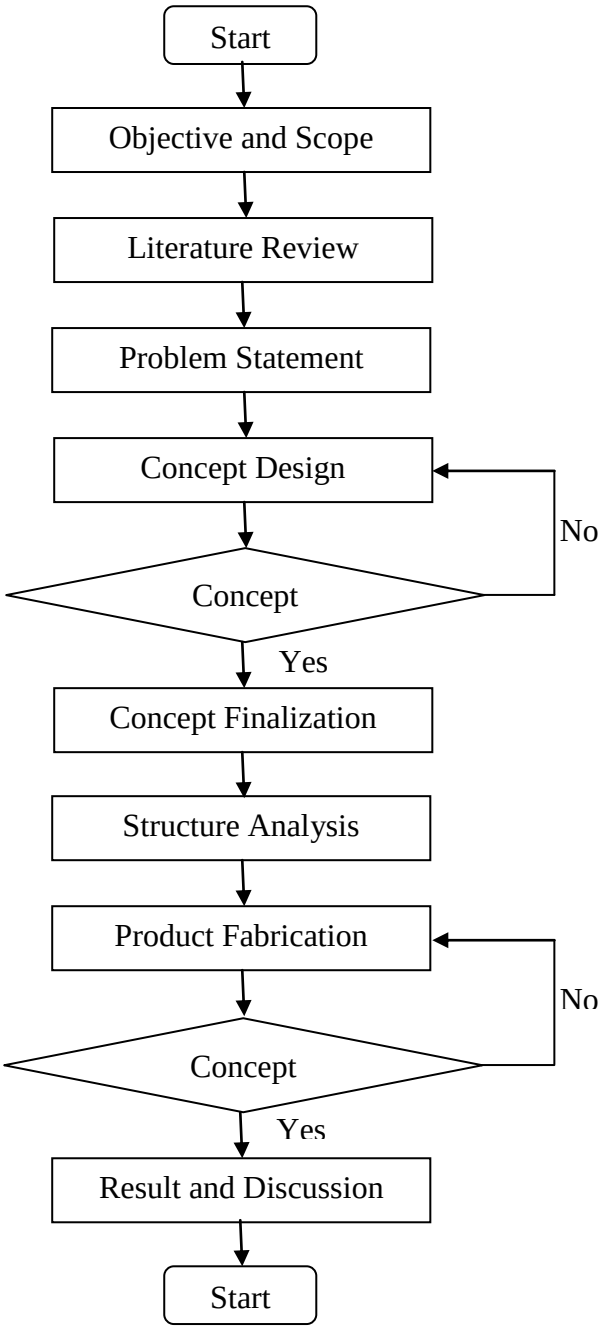
REFERENCES

1. http://banhoh.com/index.php?main_page=index&cPath=24, dated on 2009
2. http://writebest.com/products/whiteboards/, dated on 2011
3. http://en.wikipedia.org/wiki/Wood, dated on August 7th, 2009
4. http://www.castercity.com, dated on 2012
5. http://ms.wikipedia.org/wiki/Tinggi_manusia, dated on October 18th, 2011
6. http://www.thefreedictionary.com/stable
7. http://en.wikipedia.org/wiki/Degrees_of_freedom_(mechanics), dated on January 3rd, 2012
8. http://en.wikipedia.org/wiki/Welding, dated on October 9th, 2009
9. http://en.wikipedia.org/wiki/Arc_welding, dated on October 9th, 2009
10. http://en.wikipedia.org/wiki/Gas_metal_arc_welding, dated on October 9th, 2009
11. http://en.wikipedia.org/wiki/Bending, dated on April 2009
12. http://en.wikipedia.org/wiki/Drilling, dated on June 2008
13. *2012 IKEA*,IKANO Pte Ltd, dated on 2012

APPENDIX

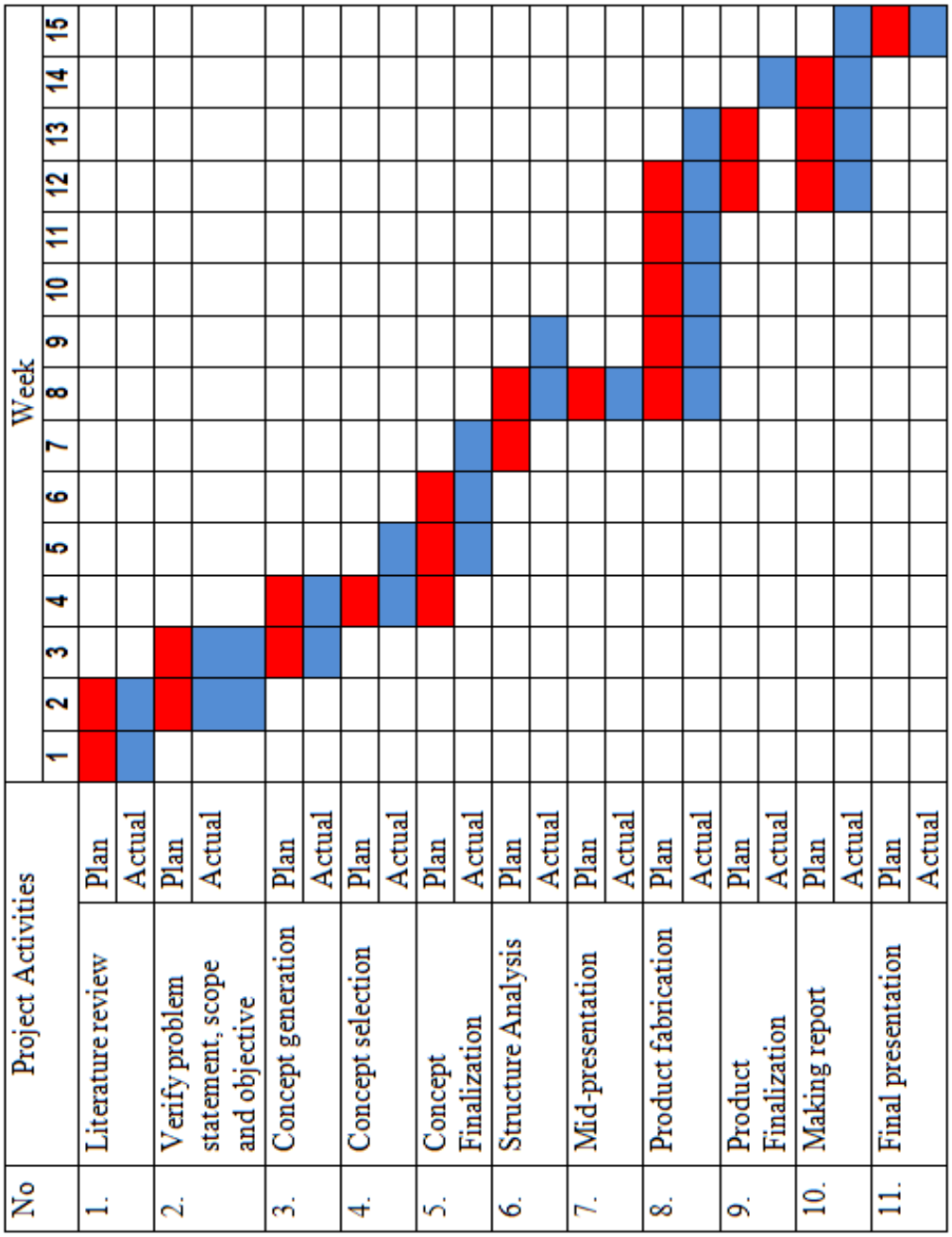
APPENDIX A

PROJECT FLOW CHART



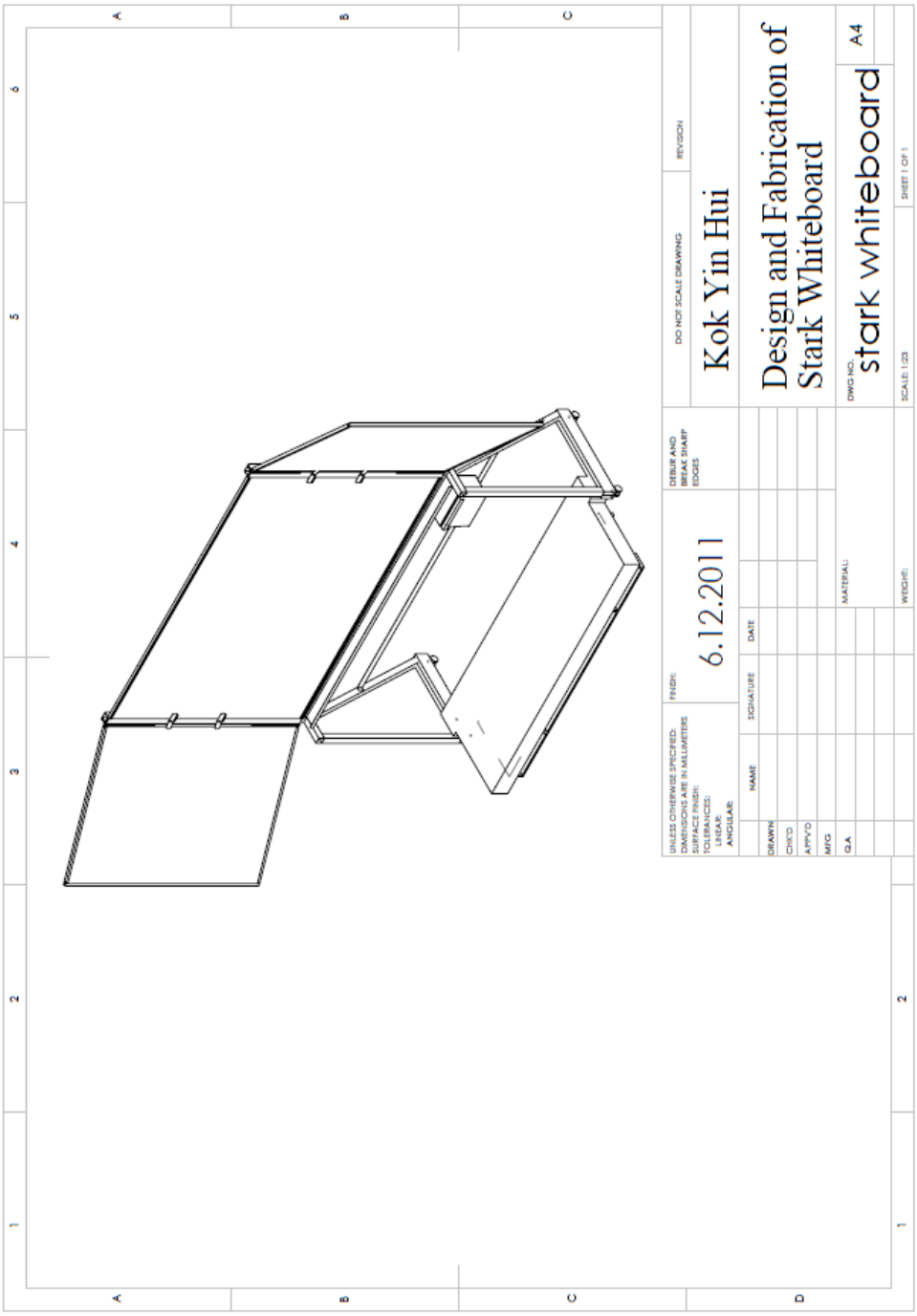
APPENDIX B

PROJECT GANTT CHART



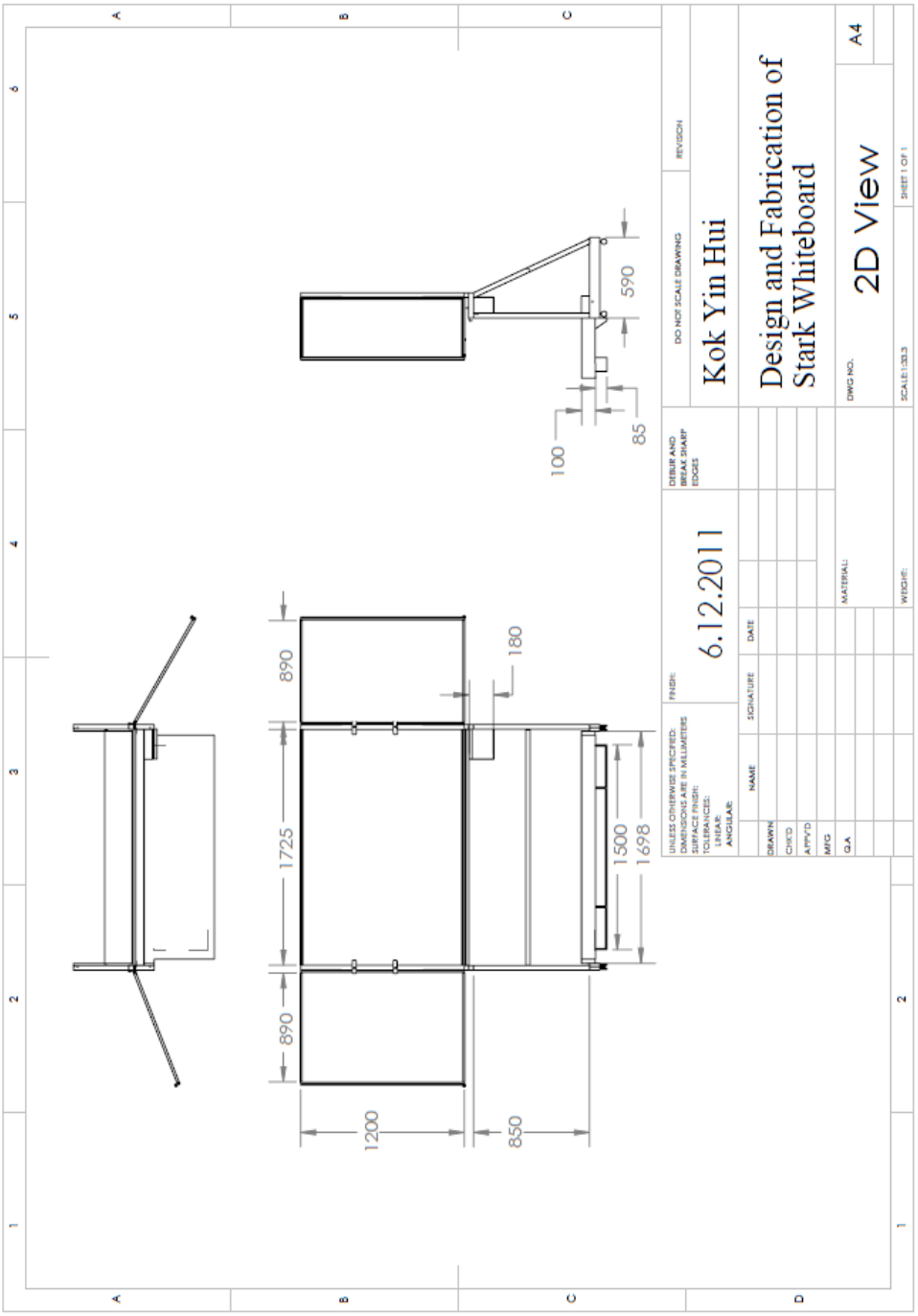
APPENDIX C

PRODUCT ISOMETRIC VIEW



APPENDIX D

PRODUCT 2D VIEW



APPENDIX E

STAGE 2D VIEW