DETAIL DESIGN OF WASTE PLASTIC BOTTLES RESCUE BOAT

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

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STUDENT'S DECLARATION

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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Date: 18 JUNE 2012

Dedicated to my dearest family

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ABSTRACT

The increasing numbers of waste plastic bottles over the years has create environment issue across the world. By using the waste plastic bottles to arrange at the waterline section of a boat not only to instill the awareness regarding environment issue, but enhance the safety of the boat. Obviously, a fiberglass boat has the tendency to crack during the hit by the heavy wave or accidents. Hence, the wasted plastic bottles filled inside the rescue boat could act as a floating object to support the rescue boat for a while and avoid the boat to sink directly. Despite of the arrangement of bottles in the boat is major objective in the thesis; the design of general arrangement of the boat behaves as a part of objectives. The design of general arrangement is followed the Safety Of Life At Sea (SOLAS) regulations and several analyses on the design have been made to show the compatible of the design. The methodology utilized in this project from the design software to lines plan and general arrangement of rescue boat. From the result, the total displacement of rescue boat is 868.7kg including six people with an average weight of 100kg. The total wasted plastic bottles used are 332 with a total weight of 13.12kg. If the leaking problem occurs, the bottles are able to support 56% of buoyancy from the total weight. The design of the general arrangement is also consider the weigh distribution of a boat. The passenger seat is concentrated at the middle of the boat to maintain the stability of the rescue boat.

ABSTRAK

Jumlah botol plastik sampah yang meningkat setiap tahun telah mewujudkan isu alam sekitar di seluruh dunia. Dengan menggunakan botol plastik terbuang untuk menguruskannya di bawah bahagian air bot bukan sahaja untuk memupuk kesedaran mengenai isu alam sekitar, tetapi meningkatkan keselamatan bot penyelamat. Selain itu, bot yang dibuat daripada gentian serabut kaca mempunyai kecenderungan untuk pecah apabila dipukul ombak atau terlibat dalam kemalangan. Oleh itu, botol plastik terbuang yang diisi dalam bot boleh bertindak sebagai objeck terapung untuk menyokong bot penyelamat untuk meggelakkan bot tenggelam serta merta. Walaupun sususan botol dalam bot antara objektif projek ini, reka bentuk susunan umum bot juga sebahagian daripada objektif. Reka bentuk susunan umum mengikuti peraturan Keselamatan Kehidupan Pada Laut (SOLAS) dan analisis bot telah dibuat untuk menunjukkan serasi reka bentuk. Kaedah yang digunakan di dalam tesis ini dari perisian reka bentuk, pelan garis sehingga susuan umum bot. Daripada keputusan kajian ini, anjakan jumlah bot penyelamat adalah 868.7kg termasuk enam orang yang mempunyai berat sebanyak 100kg. Jumlah botol plastik terbuang yang digunakan adalah 332 buah dan beratnya adalah 13.12kg. Jika berlakunya bot membocor, botol terbuang akan menyokong 56% daripada berat keseluruhan. Reka bentuk susunan umum juga tidak melupakan analisis pengagihan berat bot. Tepat duduk penumpang tertumpu pada bahagian tengah bot untuk mengekalkan kestabilan bot penyelamat.

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LIST OF ABBREVIATIONS

PET	- Polyethylene Terephthalate
BC	- Before Christ
SOLAS	- Safety of Life At Sea
LOA	- Length Over All
LBP	- Length Between Perpendiculars
LWL	- Waterline Length
B	- Beam/Breadth
D	- Draft/ Draught
DWT	- Deadweight Tonnage
LWT	- Lightweight Tonnage
EHP	- Effective Horsepower
BHP	- Major Driving Force
CSA	- Curve Sectional Area
LCB	- Longitudinal Centre of Buoyancy
NSP	- Nederlandsch Scheepbouwkundig Proefstation
HP	- Horsepower
LSA	- Life Saving Appliances

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The waste plastic bottle has a trend of increasing over the year. This can be shown at the graft below. The Figure 1.1 shows the sales wasted and recycled bottle rate in the United State from year 1991 to 2009. Both the sales and wasted bottle have increase from the year 1991 and reached the peak in year 2007. The sales and wasted bottle then experience the shrinkage after the year until 2009. Luckily, the recycle bottled show an increasing rate through out the year. However, the recycled rate is far less behind the wasted rate.

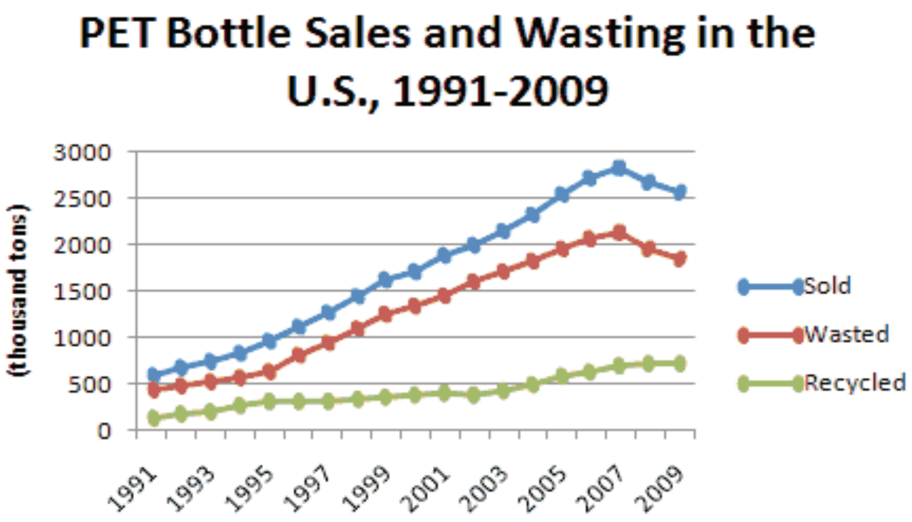


Figure 1.1: The wasted and recycled rate of PET bottle in US from 1991 to 2009

Source: http://www.container-recycling.org/facts/plastic/data/petsaleswasterec.htm

The wasted plastic bottles inspire the idea of making rescue boat using the wasted plastic bottle. This idea is not only to inculcate the environmental awareness among the public, but it can increase the safety of the rescue boat.

The project is continuing from the previous study of design rescue boat by using waste bottle plastic. The plastic bottles will be arrange in the core of the boat to avoid sinking since the fiberglass layer of the boat have the tendency to crack.

Detail design of ship is very important before it is ready to fabricate. Besides, material analysis, technical aspect of the ship operation and facility of ship will consider on the design. The project would determine the amount needed of the wasted plastic bottles in the core of the boat. The line plan and the general arrangement of bottles in the boat will be designed and some theoretical analysis will be done. On the other hand, the facilities of the rescue boat will of the rescue boat will be determined through this project.

1.2 PROBLEM STATEMENT

The boat that made from the fiberglass is noticed to have high possibility to crack at the bottom part of the boat. It may due to the hit by the heavy wave. Besides, the fiberglass will have the tendency to crack during an accident. The consequence is the boat will sink and fail to act as a rescue boat. To overcome this problem, there is an idea to design a fiberglass boat that has arrangement of waste plastic bottles in the frame of rescue boat before it laminated by fiberglass so that even the fiberglass layer crack the boat will still float.

On the other hand, 40 millions of waste plastic bottle are throwing away a day. In contrast, the recycling rate for plastic soft drink bottles is around 30 percent. The community nowadays still lack of conscious about the consequences of producing waste plastic. Furthermore, the concept of reuse the plastic bottle still far away in the peoples' mind. Hence, the use of waste plastic bottle inside the rescue boat would give the plastic bottle a second chance and this action is able to instill the conscious in reduce the use of plastic bottle among the university students.

1.3 OBJECTIVE

The main objective of this study is to design a fiberglass rescue boat that has arrangement of waste plastic bottles in the frame of the rescue boat.

1.4 PROJECT SCOPE

The scopes of this project are:

i. Detail material used and the orientation of the waste plastic bottle in the boat.
ii. Design of the ship facility.
iii. Technical analysis of ship operation.

1.5 EXPECTED OUTCOME

The expected outcome of the project is to produce a line plan design of the rescue boat together with the arrangement of the plastic bottles. The line plan design consists of the waterline and baseline in each ordinate and also the orientation of bottle arrangements and amount of bottles needed.

1.6 SIGNIFICANT OF THE STUDY

The greatest advantage of the plastic bottles rescue boat is to provide extra safety purpose for both the rescue boat itself and passengers. The boat is not facing the sinkage problem if cracking occurred at the bottom part of the fiberglass.

1.7 PROCESS FLOW CHART

Figure 1.2 shows the process flow of how this project is done. This makes useful tools how processes work is done throughout the project.

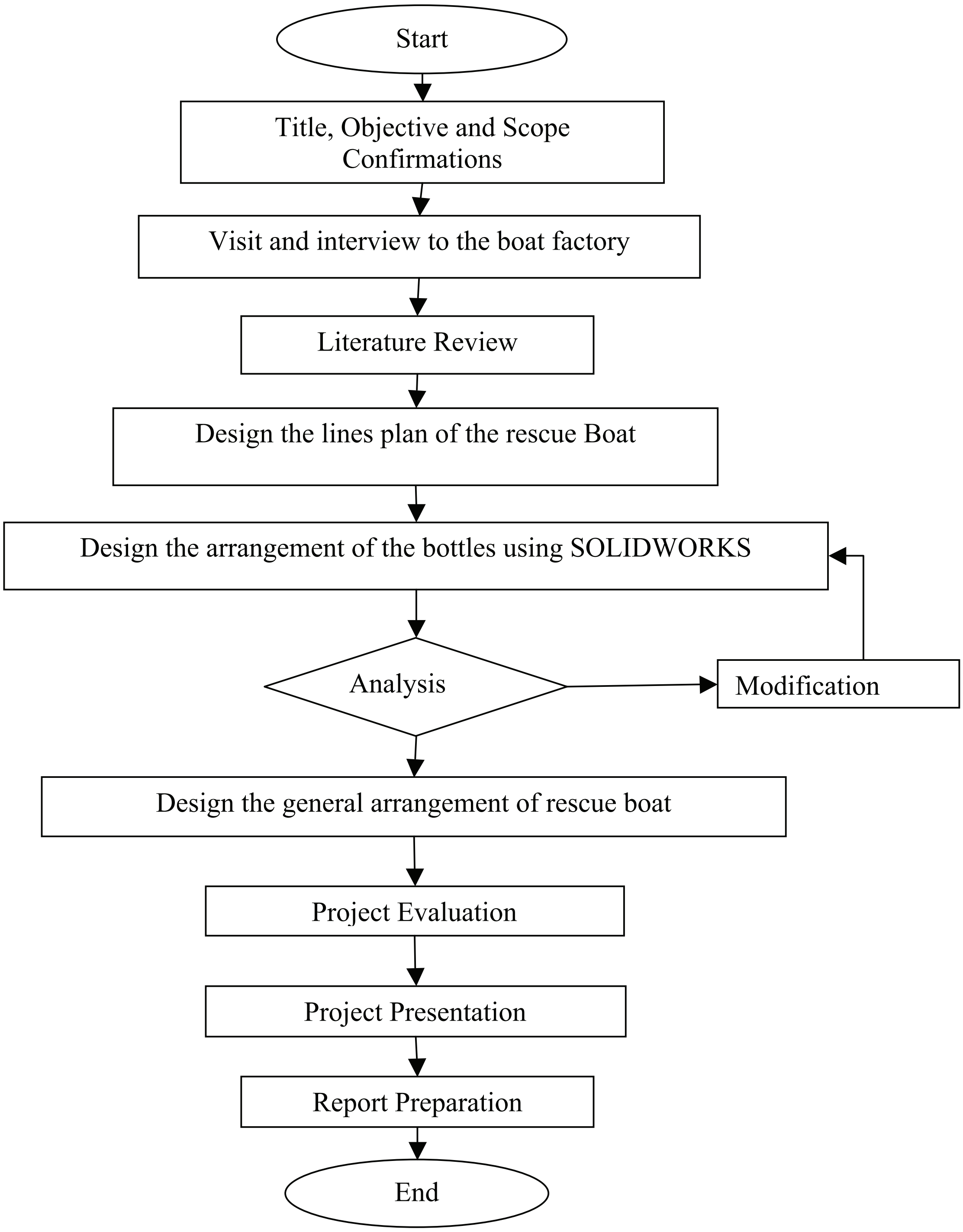


Figure 1.2: Process flow chart

CHAPTER 2

LITERATURE REVIEWS

2.1 ARCHIMEDES'S PRINCIPLE

The Archimedes principle is one of the earliest scientific principles and it is uses in wide range of application. A mathematician, Archimedes of Syracuse, discovered the theory of buoyancy. The idea came from Archimedes who had a flash of inspiration as he felt his own buoyancy in a public bath.

" The buoyant force acting on a body immersed in a fluid is equal to the weight of the fluid displaced by the body, and it acts upwards through the centroid of the displaced volume. "

Archimedes principle stated that buoyant force acting on an immersed object is equal to the weight of the displaced water. The explanation is not limited to the liquid but the gases too. Both density of an object and fluid will determines the buoyant force. An object will float if the object is less dense than the fluid. In contrast, an object will sink if the object is denser than the fluid.

Figure 2.1 : Archemedes of Syracuse (287-212 BC). Greek mathemathician, physicst and engineer. Discovered the formulae for area and volume of cylinders and spheres, and invented rudimentary infinitesimal calculus. Formulated the Law of the Lever, and wriote two volumes on hydrostatic titled On Floating Bodies, containing his Law of Buoyancy

Source : Benny Lautrup, 2008

2.2 SHIP DESIGNED USING WASTED PLASTIC BOTTLE

2.2.1 Plastic Bottle

The bottles for mineral water are utilized by Polyethylene Terephthalate(PET) plastic, an amorphous or transparent material. A PET plastic are also included the semi-crystalline thermoplastic material that own the opaque and white surface. The latter is widely used to store the detergent, lubricant and etcetera. This material is generally good resistance to mineral oils, solvents and acids but not to bases. The semi-crystalline PET has better strength, ductility, stiffness and hardness compare to amorphous type that has better ductility with less stiffness and hardness. On the other hand, the PET will not react with oxygen and carbon dioxide and this well barrier are suitable for the use for mineral water.

2.2.2 Plastiki

Plastiki is a ship that inspired by the Kon-Tiki voyage, which made from approximate 12,500 reclaimed plastic soda bottles (PET). The owner or the expedition leader David de Rothschild conceived the idea after reading a report that indicated the world's oceans were under the threaten of the pollution. The voyage set sail from San Francisco; United State to Sydney Australia across the Pacific Ocean and the duration for the voyage took about 4 months.

Then, his team started to design by fit the bottles together in the right way was the key to producing a solid structure and this inspiration was largely taken from the formation of a pomegranate which pack together many soft seeds to create a hard outer structure. The bottles provide the boat 68% of her buoyancy.

The main material- plastic bottles were filled with dry ice, making them solid and consist in order to provide a smooth exterior as streamline as possible. Despite of recycling the use of plastic bottles, the Plastiki's structure would be made by a new material called Seretex, which is a self re-enforcing PET that is fully recyclable.

Besides, the team has developed special organic glue using cashew nut husks and sugarcane in order to apply at places within the structure. This organic glue is friendly environmental and it is non-toxic material that will not pollute the seawater. Despite all this plastic, the Plastiki weighs in at 12 tons. This ship is 60 feet long and 40 feet high.

On the other hand, the vessel consist a cabin that provide a living space for the crews. The cabin consist a sleeping quarter, main cabin with two sleeping berth, galley, slelf-contained head and navigation room. The cabin is inspired from the eggshell and it is capable to withstand outside pressure though it is thin. The roof of cabin covered by solar panel to generate electricity and has a rainwater capture system to collect the fresh water. Other than solar panel, the electricity bike and wind turbine act as a mini power station to generate adequate electricity for navigation and communication system.

The six-crew members meet and share at least one meal per day and the meal was prepared using the galley. Since there is no fridge on board and the team have to be innovative in their preservation methods such as sourcing local, sustainable produce to be canned, dried and stored pre-departure. However, the vessel contained vertical hydroponic gardens to provide the crew with nutritious greens throughout the voyage.

Figure 2.2: The voyage of Plastiki in sea

Source: http://www.theplastiki.com/photos/

2.2.3 Isara Bottle Boat

An Isara charity project based in Nong Khai, and the boat founder Kirk Gillock design the catamaran. He plan to travel down the Mekong River by boat to remind the people about the household waste that pollute the river. The main design is strongly refer to the Plastiki. The two hulls are made from timber, steel frame join the hulls and support the cabin structure. The buoyancy obtained solely from 5000 recycled plastic bottles. The boat powered by electric motors with a combination of wind and solar power generation.

Before fabrication, the sample pontoon of about 100 bottles is ready to undergo an experiment. These bottles are arranged in different layouts to see which would be the most efficient and practical. These three layouts include cylindrical, trapezoid, and rectangle shape. The cylindrical was the easiest to make but connecting the rest of the boat to it would have been very difficult. A trapezoid shape was tested and the result in less drag. A rectangle arrangement will hold more buoyancy and create more buoyancy, but it has more drag.

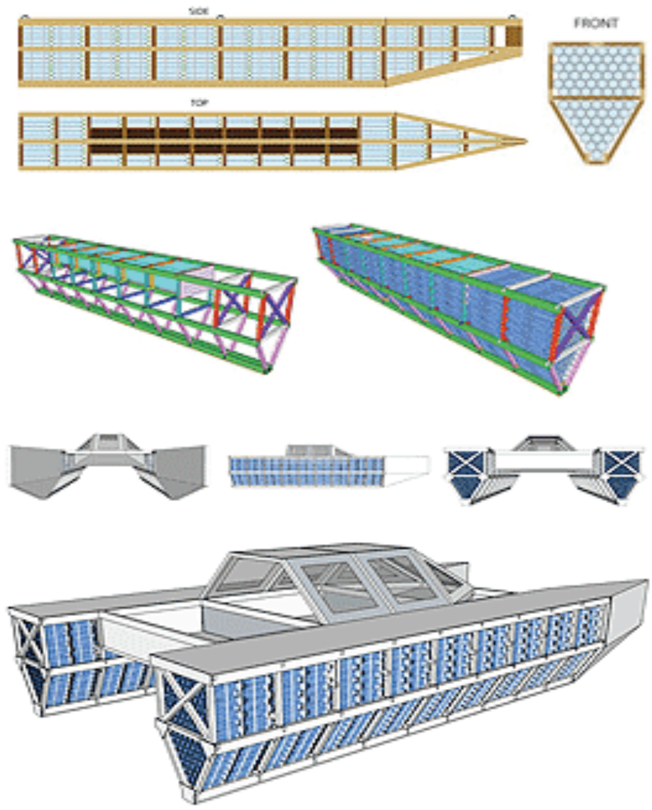


Figure 2.3: Drawing of the Isara Bottle boat

Source: http://www.isara.org/community/pages/plastic-bottle-boat

2.2.4 Bottle Up

The owner's Tom Davies, who claimed that "Bottles Up" is the first plastic bottle in Fiji. 600 empty beverage bottles were used to construct the Fiji's first recycled bottle boat with the length of 4.5 meters and wide of 1.4 meter. All the plastic bottles are 600 ml plastic bottles and the small boat was said to have the ability to cater three big Fiji man. These bottles glue together with a layer of foam underneath to aid in floatation and some plastic sheeting for the seats and floor deck. Davies said that this is a better way to recycle the bottles as it was tested it can float pretty well. Hence, “Bottles Up” will be used as a form of activity for tourist to paddle around an 110ft-deep lake near his chalet.

Figure 2.4: The Fiji’s bottle boat named Bottles Up

Source: The Fiji Time Online, 2010

2.3 GENERAL FEATURES OF RESCUE BOAT

A rescue boat is a vessel that provide special feature for rescuing or saving the lives of people at the sea. Rescue boat may be either of rigid or inflatable construction or a combination of both and it shall not less than 3.8m and not more than 8.5m in length. Besides, the rescue boat shall be capable of carrying at least five seated persons and a person lying on a stretcher. A rescue boats shall have sufficient mobility in a seaway to enable persons to be retrieved from water. On the other hand, a rescue boat shall be fitted with an inboard or outboard engine. If it is fitted with an outboard engine, a rudder and tiller may form part of the engine. The rescue boat is also need the capable to tow life rafts. Figure 2.5 shows the interior design of a rescue boat. The enclosed cabin area is designed to accommodate a stretcher and a rescue team of three. The storage of rescue materials is located under the patient stretcher area and consist a navigation area. The absorbing seats are designed to absorb any vibration to increase the comfort of the passenger. All the design of rescue boat must follow the SOLAS regulation. Please refer Appendix A.

Figure 2.5: The Interior Design of a Rescue-B

Source: http://www.rescueboat.eu/the-boat/

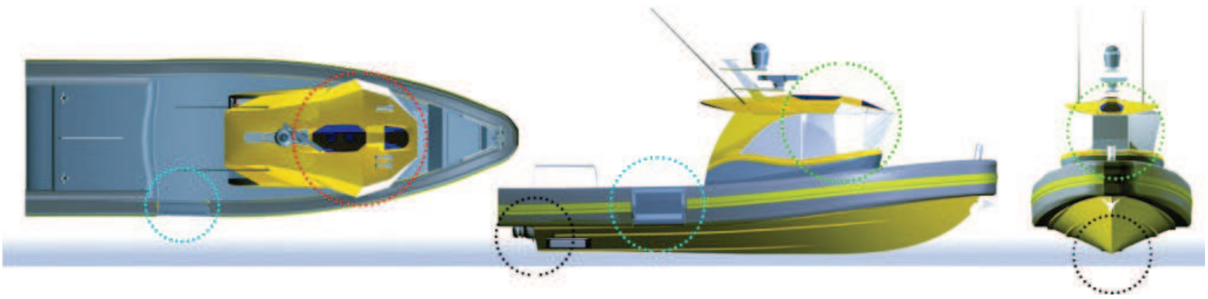


Figure 2.6: Top, side and front view of a typical rescue boat

Source: http://www.rescueboat.eu/the-boat/

2.4 BOUYANCY AND STABILITY OF SHIP

2.4.1 Ship Buoyancy

Ship buoyancy may define as the float ability of a vessel. If the weight of the vessel is less than the weight of an equal volume of water, the vessel will rise or float. The rises of the vessel is due to the force that buoys it up is greater than the weight of the vessel. It will continue to rise until it is partly above the surface of the water. Furthermore, the volume of the submerged part of a floating ship provides the buoyancy to keep the ship float. When the ship is in rest mode, the buoyancy must be equal to the weight of the ship. Hence, the weight of the ship called as displacement, meaning the weight of the volume of water displaced by the hull.

Draft is the depth of a ship below the waterline. As the displacement increase, the draft increases. Figure 2.7 shows the successive draft lines on the midship section of a ship. The volume of an underwater body for a given draft line can be measured in the drafting room by using graphic or mathematical means. The values obtained are plotted on a grid on which y-axis represent the draft in feet and x-axis represent the displacement in thousand tons. Figure 2.8 show a smooth line is faired through the points plotted and providing a displacement curve.

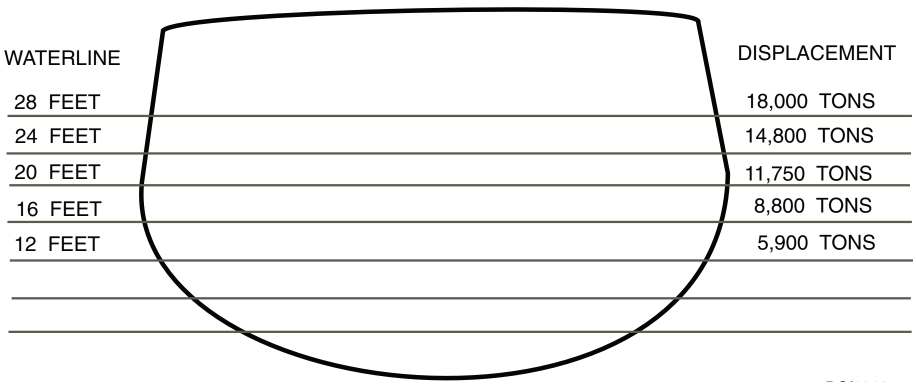


Figure 2.7 : Example of displacement data

Source: Introduction to Naval Engineering, David A. Blank, 2005

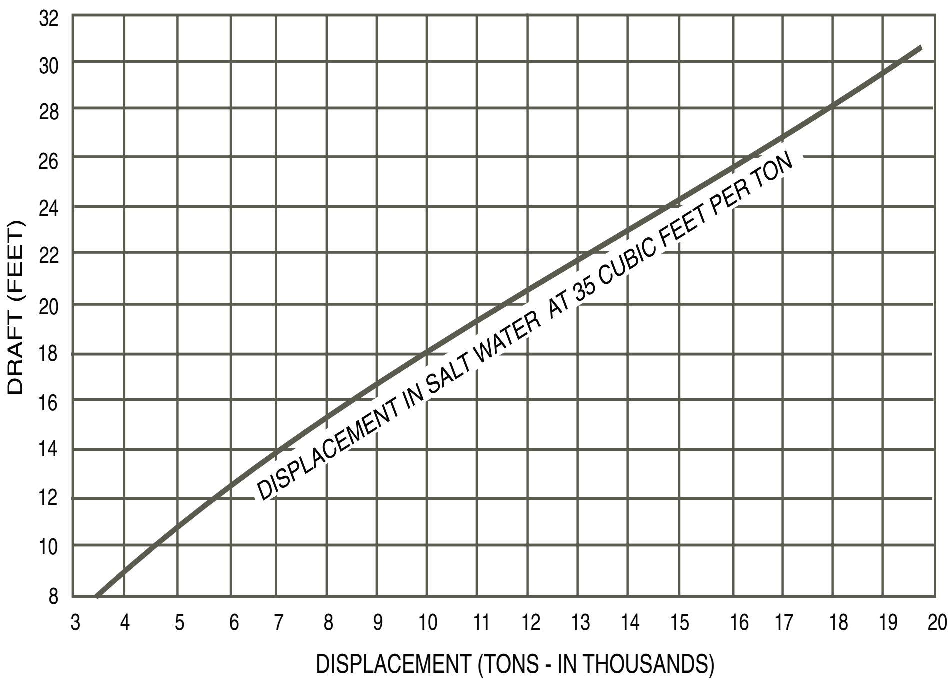


Figure 2.8 : Displacement curve for cruiser

Source: Introduction to Naval Engineering ,David A. Blank, 2005

2.4.2 Ship stability

Stability is a great important factor in manufacturing the ships and submarine. There are two general stabilities, which are vertical stability and rotational stability. A floating body is said to have vertical stability if the immersed neutrally buoyant body is neutrally stable since it does return to its original position after a disturbance. However, rotational stability of an immersed body depends on the relative locations of the center of gravity (G) of the body and the center of buoyancy (B).

The shape of the underwater ship body will experience a change when a disturbing force exerts an inclining moment on a ship. The underwater volume is relocated and this will cause the centre of buoyancy (B) away from centerline and shift in the direction of the heel. Hence, the separate line of centre of buoyancy and gravity exert a moment on ship that tends to restore the ship to original position.

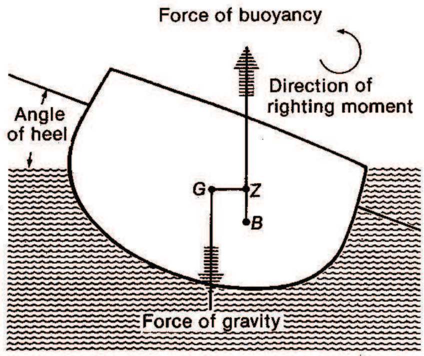


Figure 2.9: Development of righting moment when a stable ship inclines

Source: John Pike, Global Security.

Figure 2.9 above shows a righting or restoring moment of a ship that caused by two equal and opposite forces. The displacement separated by a distance GZ, which called as righting arm. The ship is stable because the center of buoyancy (B) has shifted far enough where it tends to restore the ship to a vertical position. If two equal and opposite forces are separated by a distance, the moment will become a couple. The righting moment of a ship is the product of fore of buoyancy and distance GZ. It can be expressed as the force of gravity times GZ. The force of gravity is known as the weight of the ship or it called displacement. Righting moment equal to W times GZ, where W is displacement in tons and GZ is righting arm in feet.

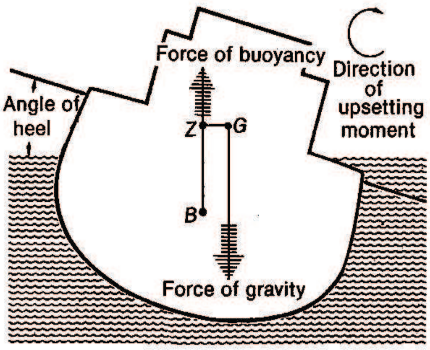


Figure 2.10 : Development of an upsetting moment when an unstable ship inclines

Source: John Pike, Global Security.

However, there is a possible condition where the center of buoyancy (B) does not move far enough and it will cause a upsetting moment to the ship. Figure 2.10 above show an unstable ship where the relative positions of B and G produce an upsetting moment. It is obvious that the cause of the upsetting moment is the position of center of gravity (G) is much more higher than the center of buoyancy.

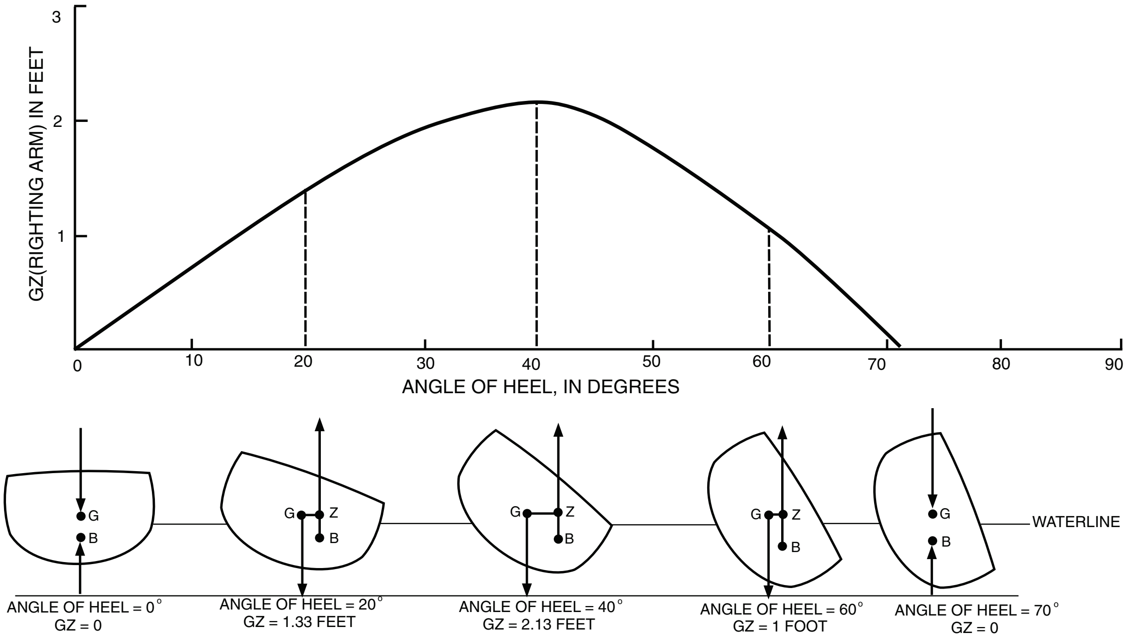


Figure 2.11: Curve of static stability

Source: John Pike, Global Security.

Figure 2.11 shows the graph of stability curve of a ship at different inclined angle. A series of value s for GZ is obtained at a different heel angle. However, noted that the stability curve is calculated graphically by design engineers for values indicated by angles of inclined above 7 degree. There are 3 necessary facts that needed to be considering in order understanding the curve.

"Firstly, the ships's center of gravity does not change position, as the angle of heel is changes. Secondly, the ship's center of buoyancy is always at the geometric center of the ship's underwater hull. Thirdly, the shape of the ship's underwater hull changes as the angle of heel changes. "   -John Pike, Global Security

The position of G remains constant and the position of B change after the ship inclined through various angles. When B is change, it is not in the same vertical line with G and a righting arm (GZ) is exist. The length of righting arm is depending on the heel angle. From the Figure 2.11**,** GZ increases to a maximum as the heel angle increase until 40 degree. Then, the GZ decrease again as the heel angles increase after 40 degree. The GZ value reach zero finally at a large angle of heel.

Metacenter (M)

The ship's metacenter is the intersection point of two successive lines of buoyant through the body before and after rotation. The metacenter is considered as a fix point or reference point when the ship is upright or vertical and most stable. A ship is considered stable if point M is above point G, thus a positive value of metacentric height will be produced. Whereas, a ship is unstable if point M is below point G because it will produce a negative value of metacentric height. For the latter case, the weight and the buoyant force acting on the titled body generate an overturning moment instead of restoring moment and causing the ship to capsize.

Metacentric height is denoted as GM, is the distance from center of gravity (G) to metacenter (M) and measure in feet. Z is a point where parallel with waterline and intersects the vertical though B. GZ is the righting arm of the ship and it may be expressed by the equation GZ= GM sin θ.

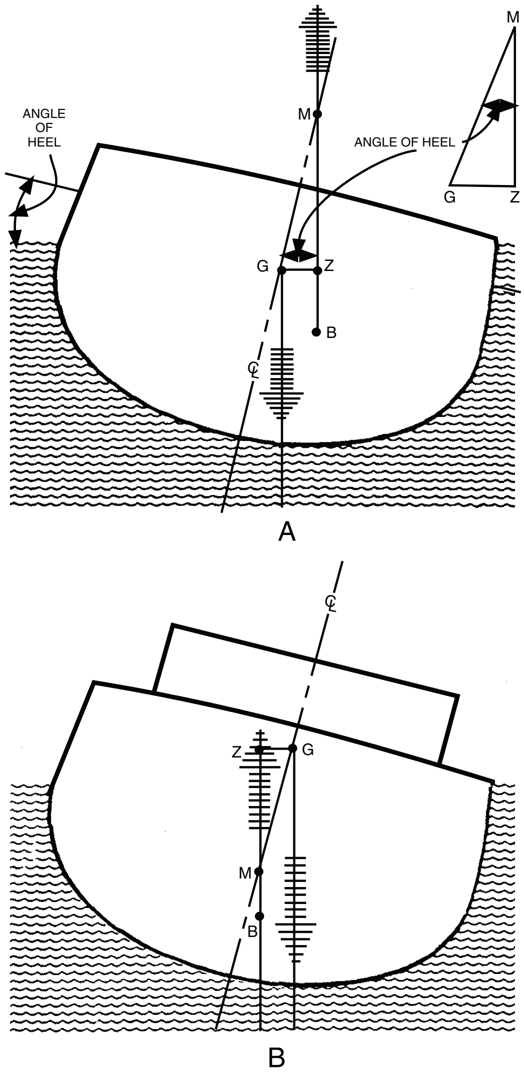


Figure 2.12: A.Stable condition, G is below M; B.Unstable condition, G is above M

Source: John Pike, Global Security.

Figure 2.12 show a ship is inclined through a small angle, establishing a metacenter at M. In the triangle GZM, GZ is the righting arm and the angle of heel is at M. GM is the metacentric height and ZM is perpendicular to the waterline when ship is inclined. Since GZ= GM sin θ, there is a relationship between GM and GZ. The ship's metacenrtric height (GM) is not only to measure the righting arm (GZ) but it can indicate a ship's stability. Picture A shows the ship is in stable condition since the M is above G, which develop a righting moment or restoring moment. The ship B shows the M is below G, moments that develop are overturning or upsetting moments.

2.5 PRINCIPAL DIMENSION OF HULL

Before design a boat or a ship, we must understand the principle dimension of a vessel. The dimensions have their own standard abbreviation that describes each specific part on the vessel. The preliminary specification dimension included length (LOA), beam (B) Draft (D) and weight. Other dimension consist LBP, LWL, and etcetera.

2.5.1 Length Over All (LOA)

Length overall normally abbreviated as LOA, o/a, o.a, or oa. But LOA is widely used nowadays to express the size of the boat. From the Figure 2.13**,** LOA is a maximum measurement from the extreme end of a vessel.

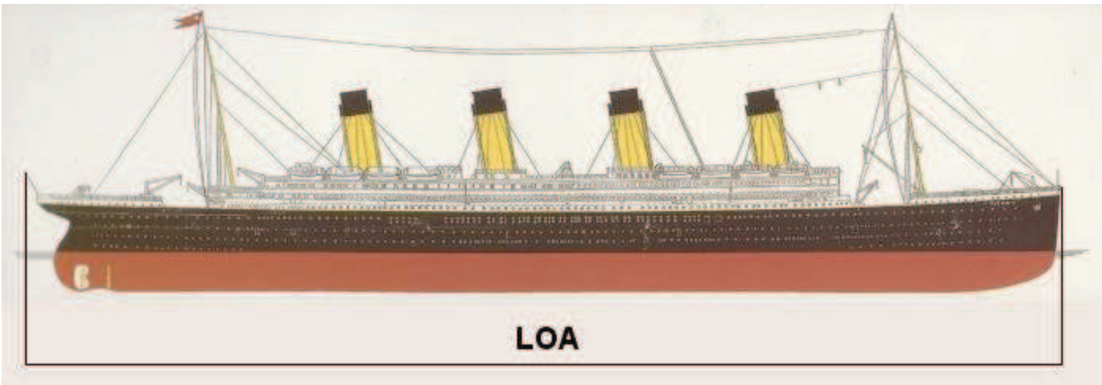


Figure 2.13: The Length Overall of Titanic

Source: http://www.mytitanic.co.uk/specs/dimensions.php

2.5.2 Length Between Perpendiculars (LBP)

Length between perpendiculars abbreviated as LBP, or LPP. LPP is the measurement of a ship between the point where the stem cut the designed waterline and the after edge of the rudderpost. This was believed to give a reasonable idea of the ship's carrying capacity, as it excluded the smell, often unusable volume contained in her overhanging ends.

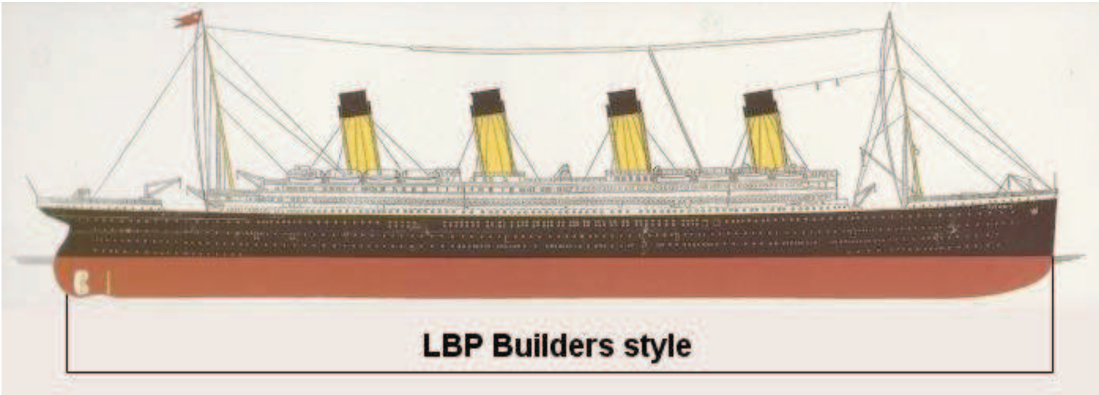


Figure 2.14: The Length Between Perpendiculars (LBP/LPP) of Titanic

Source: http://www.mytitanic.co.uk/specs/dimensions.php

2.5.3 Waterline Length (LWL)

Waterline length normally abbreviated as LWL, w/l, w.l. or wl. It denotes the length of the vessel at the point where it adopts in the water when carrying designed load. Figure 2.15 below shows the length overall and waterline length of a kayak. Design waterline that takes into consideration of the expected weight to hold. If the kayak is under loaded, it will sit higher in the water and sit lower in water if overloaded. It can be said that it is the intersection of a boat's hull and the water's surface.

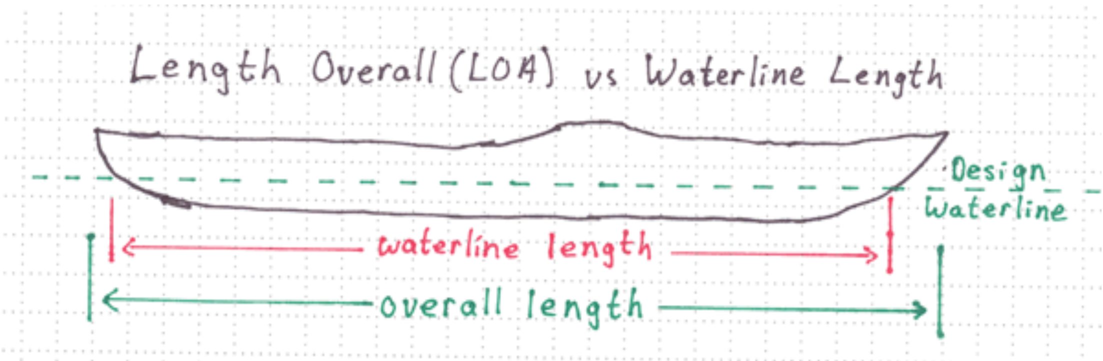


Figure 2.15: LOA and LWL of a kayak

Source: http://www.buildingakayak.com/2009/02/28/kayak-hull-shapes-length-width/

2.5.4 Beam (B)

Beam or breath is always abbreviated as B, BOA or BWL. It is measured between the outer surfaces of the ship's plating. One of the ways to calculate the value of beam is using the formula.

$$\text{Beam} = \text{LOA}^{2/3} + 1$$

Where LOA is Length Overall, and all units are in feet.

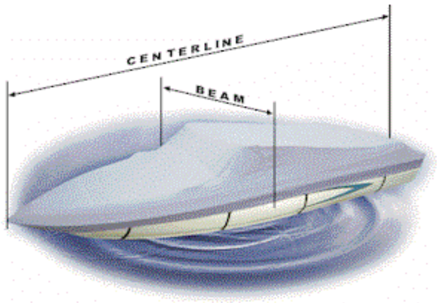


Figure 2.16: The centerline and the beam of a boat

Source: http://www.boatersoutlet.com/v-hullcenterconsoleshallowdraftfishingboatswithaftpolingplatforms-1.aspx

2.5.5 Draft (D)

Draft is usually abbreviated, as D. Draft is the vertical distance from the waterline to the lowest part of a vessel. It can be denote as the minimum depth of water in which a vessel will float.

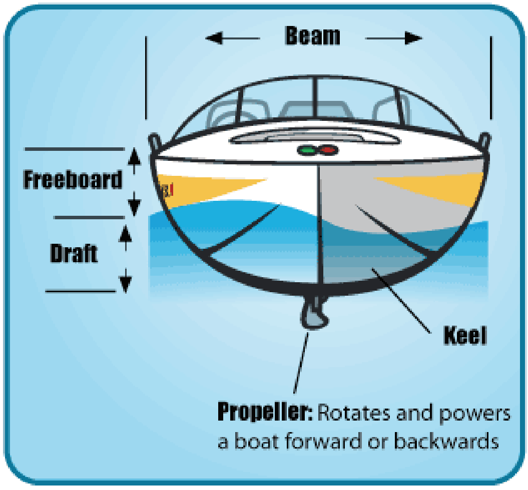


Figure 2.17: Beam, freeboard, draft, keel and a propeller of a vessel

Source: http://www.boaterexam.com/usa/florida/education/?chapter=1&page=2

2.6 COEFFICIENT USED IN HULL CONSTRUCTION

2.6.1 Block Coefficient

According to Principles of Naval Architecture, block coefficient as "the ratio of the volume of displacement of the moulded form up to any waterline to the volume of a rectangular prism with length, breadth and depth equal to the length, breadth and mean draft of the ship at that waterline."

$$\text{Block coefficient } (C_b) = \frac{\nabla}{BTL_{pp}}$$

However, the definition of length, beam and draft are depending on the authorities. For example, the length may be LPP or LWL or some effective length. It may be infer as the “streamline” of a vessel. A vessel with small block coefficient experience less resistance and consequently achieving higher speeds. For example, oil tanker would have a larger value of block coefficient than a container ship.

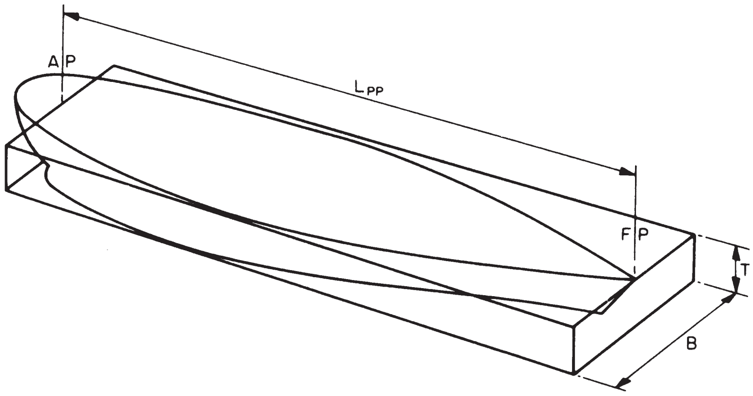


Figure 2.18: Block coefficient

Source: Basic Ship Theory, Rawson, Tupper, 2001

2.6.2 Prismatic Coefficient

Prismatic coefficient or it is called, as longitudinal prismatic coefficient is the ratio of the volume of displacement to the volume of a prism having the length equal to the length between perpendiculars and a cross-sectional area equal to the midship sectional area.

$$C_p = \frac{\nabla}{A_M L_{PP}}$$

Prismatic coefficient provides an indication of the distribution of ship displacement. It indicates the fineness of the ends relative to the midsection of the hull. A low primatic means fine ends and large mid-body such as cruising boats to maintain smother ride in most condintion. A high prismatic means there is more displacement distributed towards the end such as a racing boats so that it would easy to plane.

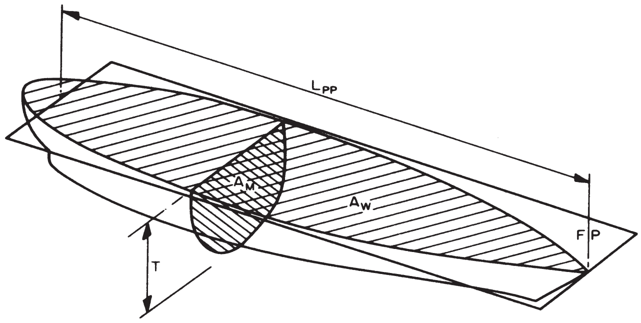


Figure 2.19: Longitudinal prismatic coefficient

Source: Basic Ship Theory, Rawson, Tupper , 2001

2.6.3 Midship Coefficient, Cm

Midship coefficient is the ratio of the midship section area to the area of a rectangular whose sides are equal to the draught and the breadth extreme amidships.

$$C_m = \frac{A_M}{BT}$$

Midship Coefficient is refers to the shape of the vessel that water would bypass. The larger the value of Cm, the shape of vessel would become more rectangular. In other words, large Cm will produce more drag.

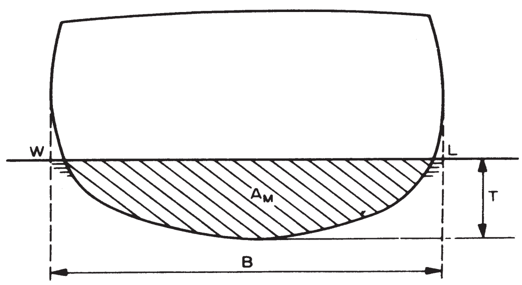


Figure 2.20: Midship coefficient

Source: Basic Ship Theory, Rawson, Tupper, 2001

2.6.4 Waterplane Coefficient

The water plane coefficient is the ratio of the area of the waterplane to the area of its circumscribing rectangle. The waterplane coefficient expresses the fullness of waterplane.

$$C_W = \frac{A_w}{L_{WL}B}$$

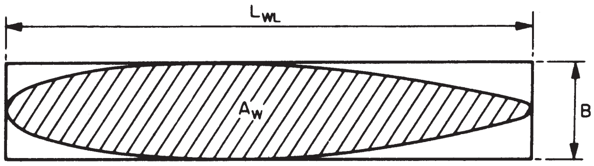


Figure 2.21: Waterplane coefficient

Source: Basic Ship Theory, Rawson, Tupper , 2001

2.7 LINES PLAN

Lines plan is also called as lines drawing, or a drawing of a vessel. A lines plan consists of three views; there are body plan, half-breadth plan and sheer plan. The point of intersection of these planes with the hull results in a series of lines that are projected onto a single plane located on the front, top, or sides of the vessel. Body plan is the sectional lines projected onto a single plane in front of the vessel. Half-Breadth plan is the waterlines that are projected onto a single plane of the vessel. Each waterline shows the true shape of the hull from the top view. Sheer plan is the butt lines that are projected onto a single plan in the side of the vessel. In Figure 2.22, the top lines plan represent the body plan, the middle is sheer plan where the bottom lines plan represent the half-breadth plan.

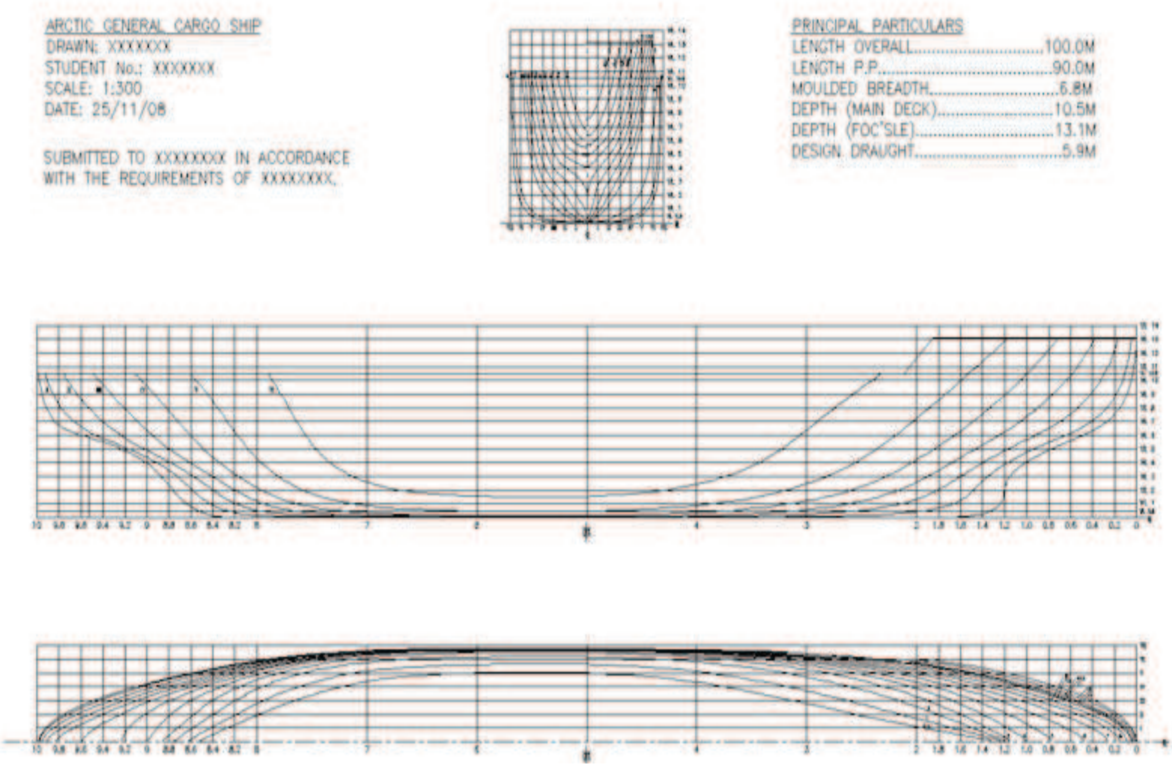


Figure 2.22: The example of lines plan for a cargo ship

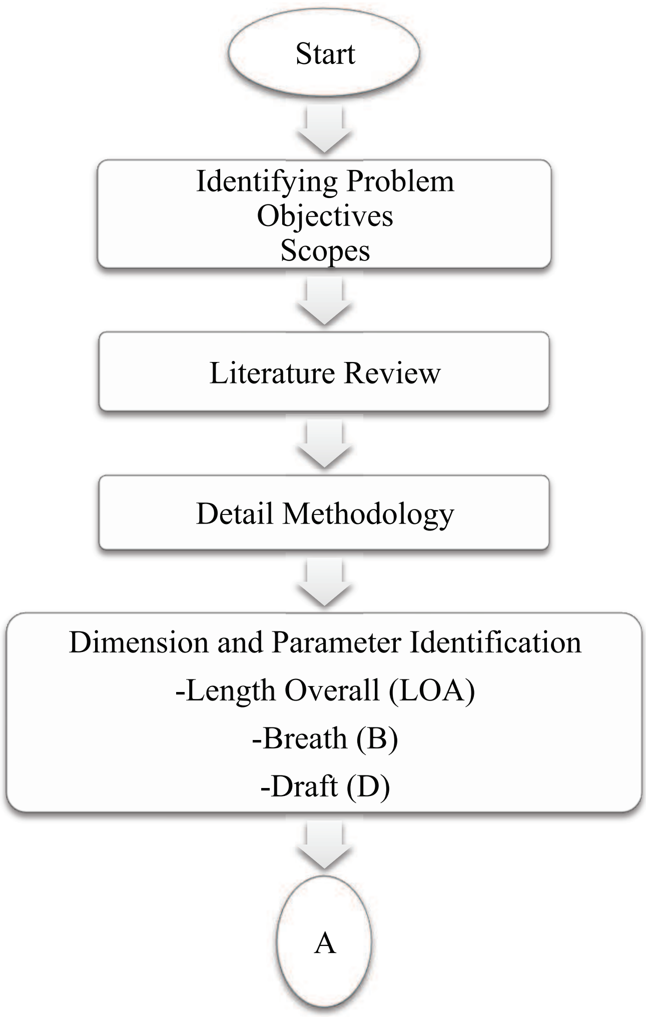
Source: http://www.neely-chaulk.com/narciki/File:Initiallines.png

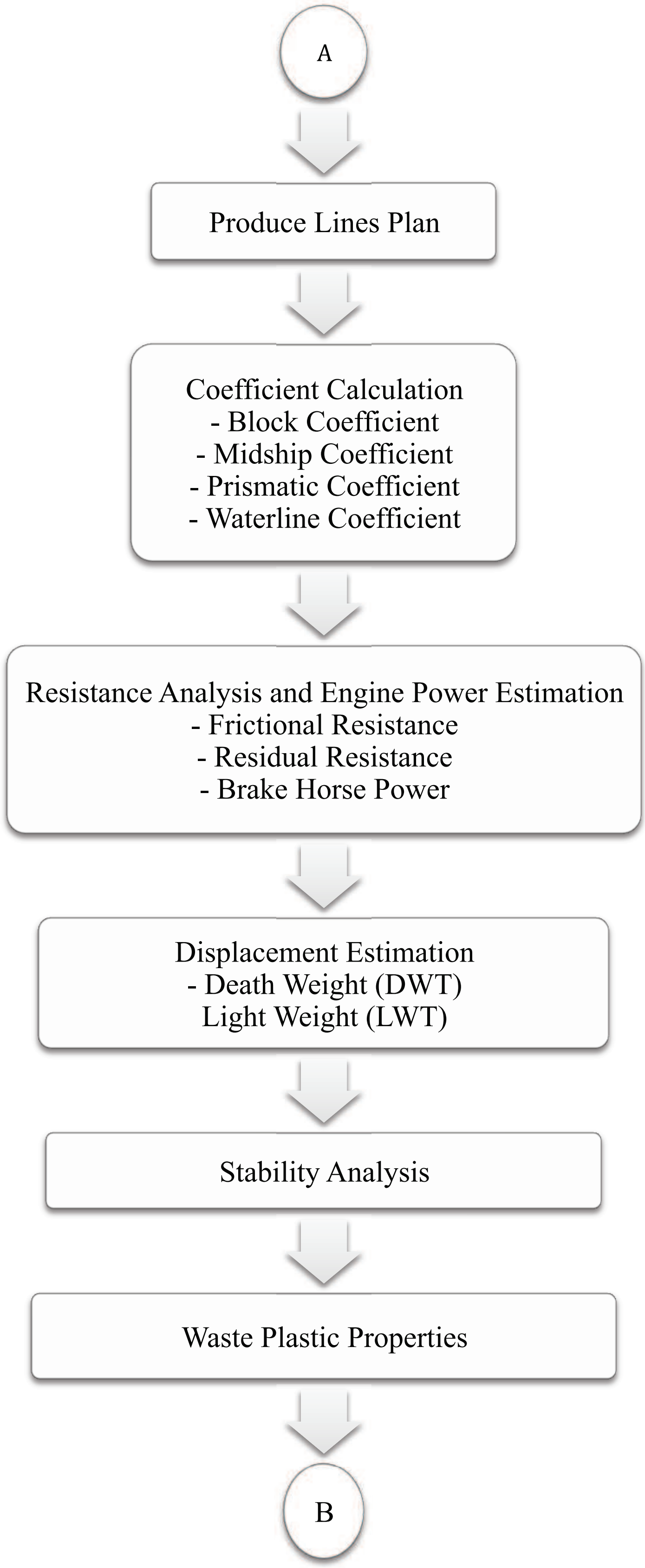
CHAPTER 3

METHODOLOGY

3.1 PROJECT PROCESS FLOW

The flow chart below will display the process of the project starting from the research until the details analysis.




A
Produce Lines Plan
Coefficient Calculation
- Block Coefficient
- Midship Coefficient
- Prismatic Coefficient
- Waterline Coefficient
Resistance Analysis and Engine Power Estimation
- Frictional Resistance
- Residual Resistance
- Brake Horse Power
Displacement Estimation
- Death Weight (DWT)
Light Weight (LWT)
Stability Analysis
Waste Plastic Properties
B

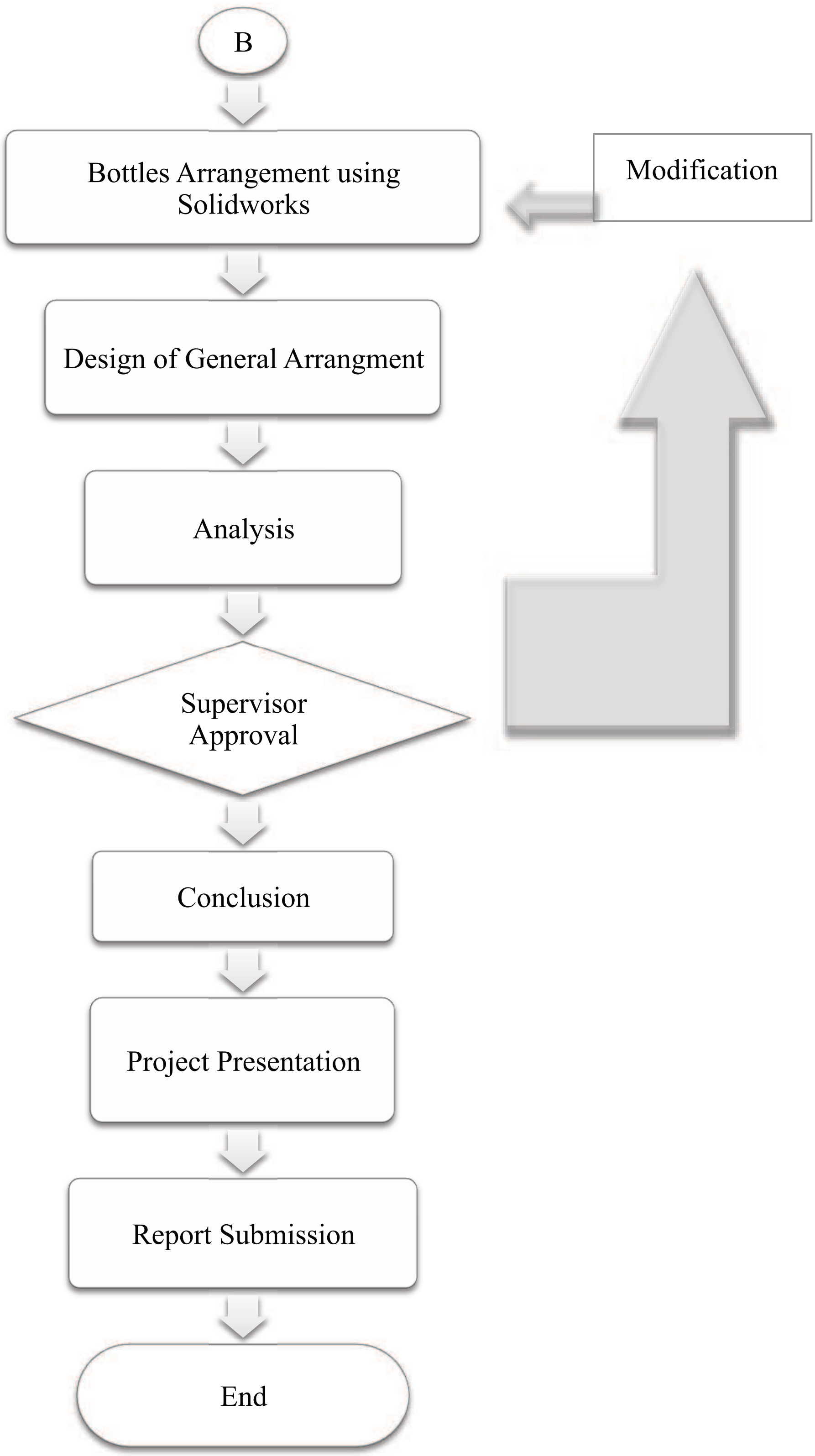


Figure 3.1: Project Process Flow Chart

3.2 PARAMETER IDENTIFICATION

Firstly, start the design by deciding the desirable dimension and speed of the rescue boat.

Length Overall, LOA	: _______	meters
Breadth, B	: _______	meters
Draft, D	: _______	meters
Speed, Vs	: _______	knots

3.3 DESIGN THE SHAPE OF BOAT USING DELFTSHIP

The first step to design the boat is using the marine soft named DELFT SHIP. This software able to produced the lines plan of the boat with desire dimensions of a boat. The software is not friendly with Solidworks software, where Solidworks unable to read the file type from DELFT SHIP. Hence, the lines plan produced from DELFT SHIP will be imported as picture in Solidworks and the boat will be redraw in Solidworks.

3.4 COEFFICIENT CALCULATION

After identify all the parameters for the boat dimension, all coefficients must be calculated. Before we could proceed to the next step, all coefficients must be calculated and these coefficients would decide the size and shape of the boat. There are four coefficients, which are block coefficient, midship coefficient, prismatic coefficient, and waterline coefficient.

3.4.1 Block coefficient, C_b

$$C_b = \frac{V}{L \bullet B \bullet D} \tag{3.1}$$

Where : V = Displaced Volume

L = Length Overall

B = Breath

D = Draft

3.4.2 Midship Coefficient, C_m

$$C_m = \frac{A_m}{B \bullet D} \tag{3.2}$$

Where : A_m = Midship section area

B = Breath

D = Draft

3.4.3 Prismatic Coefficient, C_p

$$C_p = \frac{C_b}{C_m} \tag{3.3}$$

Where : C_b = Block Coefficient

C_m = Midship Coefficient

3.4.4 Waterplane Coefficient, C_w

$$C_w = \frac{A_w}{L \bullet B} \tag{3.4}$$

Where : A_w = Waterplane area

L = Length Overall

B = Breath

3.5 DETERMINATION OF RESCUE BOAT RESISTANCES AND ENGINE ESTIMATION

The engine use for the boat is strongly related to the total resistance of a designed boat. Hence, the resistances must be determined before we choose the suitable engine. There are two main resistances to be calculated at different speed- frictional resistances, R_f and residual resistance, R_r. After obtained the value of total resistance, major driving force able to calculate and select the suitable outboard engine.

3.5.1 Frictional Resistance. R_f

$$R_f = \frac{1}{2} f \times s \times v^{1.825} \tag{3.5}$$

Where : $f = 0.00871 + \dfrac{0.053}{LPP + 8.8}$

$s = 15.5 \times \sqrt{\Delta \times LPP}$

$v = knot$

3.5.2 Residual Resistance. R_r

$$R_r = 12.5 \times C_b \times \Delta \times \frac{v^4}{LPP^2} \tag{3.6}$$

3.5.3 Total Resistance, R_T

$$R_T = R_f + R_r$$

3.5.4 Effective Horse Power, EHP

$$EHP = \frac{R_T \times v \times 0.5144}{75} \tag{3.7}$$

3.5.5 Major Driving Force, BHP

$$BHP = \frac{EHP}{P_c} \tag{3.8}$$

Where P_c= 0.53

$$BHP_{sm} = BHP + (BHP \times 15\%)$$

3.6 DETERMINATION OF THE DISPLACEMENT OF BOAT

Displacement of boat is also described as the weight of the boat. There are two major displacement need to be calculated, which are the deadweight tonnage (DWT) and lightweight tonnage (LWT). The standard unit to measure the displacement is tonnage.

3.6.1 Deadweight tonnage, DWT

Deadweight tonnage often describe as the weight of the carried by a vessel. It is a measurement for vessel to carry the correct weight in order to maintain the safety of boat. In the project, the deadweight tonnage included the weight of bottles, weight of fresh water and food, weight of passengers, and other weight. Other weight included the first-aid kit, tools and accessories need in the boat.

3.6.1.1 Weight of bottles, W_b

$$W_b = N \text{ x } W \tag{3.9}$$

Where: N= Number of bottle

W= Weigh for each bottle

3.6.1.2 Weight of fresh water, W_{fw}

$$W_{fw} = DW \times Z \tag{3.10}$$

Where: DW = Drinking Water for each person, 1 kg/person/day

Z = Total passenger

3.6.1.3 Weight of food, Wp

$$Wp = Cp \times Z \tag{3.11}$$

Where: Cp = 1.5kg/person/day

Z = Total passenger

3.6.1.4 Weight of passenger, Wcp

$$Wcp = Z \times P \tag{3.12}$$

Where: Z= Total passenger

P= Average weight of passenger, 100kg/person

3.6.1.5 Other Weight, Wr

Wr include the weight of safety jacket, first aid kit and others safety accessories inside a boat.

$$W_r = 1.5\% \times \Delta \tag{3.13}$$

3.6.1.6 Total Deadweight Tonnage ,DWT

$$DWT = W_{fo} + W_{afo} + W_{lo} + W_{fw} + W_p + W_{cp} + W_r \tag{3.14}$$

3.6.2 Lightweight Tonnage, LWT

Lightweight tonnage refers to the actual weight of the vessel such as the weight of the hull, engine, and propeller. The weight of fuel, passengers, water and others do not calculated into lightweight tonnage.

3.6.2.1 Weight of hull , W_{hull}

Weight of fiberglass,

$$W_{fiberglass}\,(oz) = \frac{SurfaceArea(ft^2)}{9(ft^2)} \times 10(oz/yard^2) \tag{3.15}$$

Weight of polyester resin,

$$W_{resin} = \text{Weight of fiber glass}$$

$$W_{hull} = W_{fiberglass} + W_{resin}$$

3.6.2.2 Weight of general Arrangement, W_o

For this section, the general arrangement such as the seat of passengers, floor and panel were made by fiberglass. Hence, By searching the area for these three components and using the method in section 3.6.2.1 to determine the weight for each component, then find the total of the general arrangement.

$$W_O = W_{floor} + W_{seats} + W_{panel} \tag{3.16}$$

3.6.2.3 Weight of installation machine, W_{ep}

By using methods JB Polko and Oroenewey

$$W_{ep} = \frac{BHP \times (895 - 0.025 \times BHP)}{10^4} \quad (3.17)$$

3.6.2.4 Other weight, W_{ow}

$$W_{ow} = (30 - 50) kg / BHP \quad (3.18)$$

3.6.2.5 Total LWT

$$LWT = W_{hull} + W_o + W_{ep} + W_{ow} \quad (3.19)$$

3.7 PRELIMINARY ASSESSMENT OF THE STABILITY OF THE BOAT

3.7.1 Calculation of Height of The Center of Buoyancy From Keel, $\overline{KB}$

According to Schneekluth in Harald Poehls,1979

$$\overline{KB}_1 = d \times (0.828 - 0.343 \frac{C_b}{C_w}) \quad (3.20)$$

According to Posdunine in Harald Poehls, 1979

$$\overline{KB_2} = \frac{C_w d}{C_w + C_b} \quad (3.21)$$

According to Jaeger Morish I in Harald Peohls, 1797

$$\overline{KB_3} = \frac{(5C_w - 2C_b)d}{6C_w} \quad (3.22)$$

According to Jaeger Morish II in Harald Poehls, 1979

$$\overline{KB}_4 = \frac{d}{1.015 + \frac{C_b}{C_w}} \tag{3.23}$$

Average $\overline{KB_{avg}}$

$$\overline{KB}_{avg} = \frac{\overline{KB_1} + \overline{KB_2} + \overline{KB_3} + \overline{KB_4}}{4} \tag{3.24}$$

3.7.2 Calculation for Metacentric Radius, $\overline{BM}$

$$\overline{BM} = \frac{(2C_w + 1)^3}{323} \times \frac{B^2}{d \cdot C_b} \tag{3.25}$$

3.7.3 Calculation for Vertical Distance From Keel to the Metacenter , $\overline{KM}$

$$\overline{KM} = \overline{KB} + \overline{BM} \tag{3.26}$$

3.7.4 Calculation for Vertical Distance From Keel To The Center of Gravity, $\overline{KG}$

$$\overline{KG} = 0.6 \times H \tag{3.27}$$

3.7.5 Calculation for Height of Metacenter, $\overline{GM}$

$$\overline{GM} = \overline{KM} - \overline{KG} \tag{3.28}$$

Where: $\overline{GM}$= Height of metacenter

$\overline{KM}$= vertical distance fromKto the metacenter whenthe ships upright

$\overline{KG}$= Center of Gravity

$\overline{KB}$= Height of the center of buoyancy from keel

3.8 CURVE SECTIONAL AREA (CSA) DIAGRAM

CSA is a curve that describes the area of the vessel at each ordinate and it is largely determines the shape of the designed boat. Before constructing Curve Sectional Area (CSA), following parameters must be calculated:

a) Midship Area (Am)

b) Longitudinal Centre of Buoyancy (LCB)

c) Prismatic Curve Percentage

3.8.1 Midship Area , A_m

Based on the book, Principles of Navel Archtecture,

$$A_m = Cm \text{ X } B \text{ X } T \tag{3.29}$$

3.8.2 Longitudinal Centre of Buoyancy, LCB

The Longitudinal Centre of Buoyancy (LCB) expresses the longitudinal distance from mid point to the center of buoyancy position of the centre of buoyancy and the mid-point between the ship's foremost and aft most perpendiculars. With LCB diagram, we can get the value for Longitudinal Centre of Buoyancy (LCB) by determining the value Vs/ √ Lpp and lcb from the graphic from the book of Ikeda Masaharu.

3.8.3 Prismatic Curve Percentage

3.8.3.1 Foremost Prismatic Coefficient, C_{pf}

After the value of LCB was obtained, the value of $C_{pf} – C_{pa}$ should be determined using the equation below. From the page 53, graphic number 39 in Ikeda Masaharu, the value for $Cp_{pf}– C_{pa} = 0.05$.

$$C_{pf} = C_p + \frac{(C_{pf} - C_{pa})}{2} \qquad (3.30)$$

3.8.3.2 Aftermost Prismatic Coefficient, Cpa

From the page 53, graphic number 39 in Ikeda Masaharu, the value for $Cp_{pf}- C_{pa} = 0.05$.

$$C_{pa} = C_p - \frac{(C_{pf} - C_{pa})}{2} \qquad (3.31)$$

3.8.4 Determination on Area of Each Section of the Boat (NSP Method)

Nederlandsch Scheepbouwkundig Proefstation (NSP) is one of the methods that can be used to determine the Curve Sectional Area (CSA) diagram. According to this method, ordinate of the boat must be divided into 10 sections.

Curve Section Area (CSA) diagram is obtained by multiply area percentage of each section from NSP diagram with Midship Area, Am. In order to get area percentage in the NSP diagram,Vs/ Lpp is calculated and the value is moved parallel rightward and each intersect with 1 to 20 section curve is read vertically upward from. The value 0 to 100 percent is the area percentage corresponded to each section.

From the information, Curve Sectional Area (CSA) can be constructed by setting station no. at x-axis and sectional area at y-axis.

3.9 WASTE PLASTIC BOTTLES PROPERTIES

Figure 3.2: Waste plastic bottles

Waste plastic bottles selection is one decision that needs to be made. The bottles may have different type of shape, mass and volume. Hence, take some samples of waste plastic bottles and measure the properties.

After the selection of waste plastic bottles, take three samples bottle to get a naverage mass and volume of the bottles.

Next, measure the dimension of the plastic bottles and drawn it into SolidWorks 2011.

3.10 DESIGN OF THE BOAT IN SOLIDWORKS

Step to design the boat using SOLIDWORKS 2011

1. Based on the lines plan produced from the DELFT SHIP software, the lines plan export to solidworks 2011.

2. The body of boat was produce based on the lines plan in Solidworks.

3. After the body of boat was done, assembly the plastic bottle drawing into the body of boat.

4. Arrange the plastic bottle into desired orientation.

5. Fill the waste plastic bottles into the body of boat until reached the desired waterline.

6. Design the general arrangement such as the seat of the 6 victims, driving panel, engine mounting space, and storage on the surface of the boat based on the SOLAS regulation.

3.11 ANALYSIS

Quantity of the waste plastic bottles used been analyze. The mass of the arrangement and the buoyancy support by the wasted plastic bottles will be calculated. Besides, the weight distribution of the boat will be discussed.

CHAPTER 4

RESULTS AND ANALYSIS

This chapter will present the design of the boat including the lines plan and the general arrangement. All analysis and of the design been shown in this chapter.

4.1 DESIGN OF THE RESCUE BOAT BODY

The design of the rescue boat body was drawn in the DELFTSHIP marine software. It is to visualize the design dimension before designing the lines plan of the rescue boat.

4.1.1 Design Dimension of the Rescue Boat

Table 4.1: Dimension of Hull For Rescue Boat

Parameter	**Value**
Length Overall, LOA	6.000 m
Breadth, B	1.400 m
Draft, D	0.250 m
Maximum Speed, V	20knots

4.1.2 Lines Plan Design of Rescue Boat

Figure 4.1 showed the lines plan design of the rescue boat before it is further design using waste plastic bottles. The lines plan included the side view, front view, back view and top view of the rescue boat. Figure 4.5 showed the orthographic view of the rescue boat.

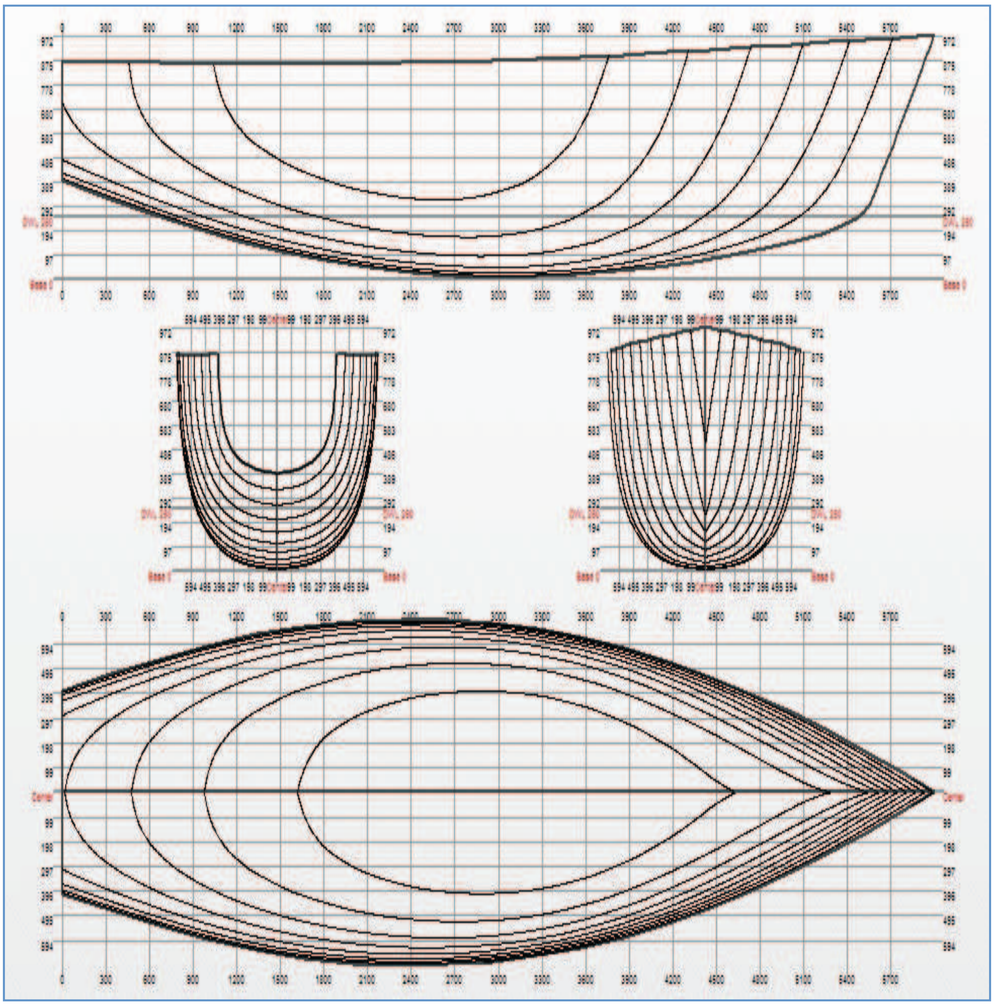


Figure 4.1: Lines plan of rescue boat

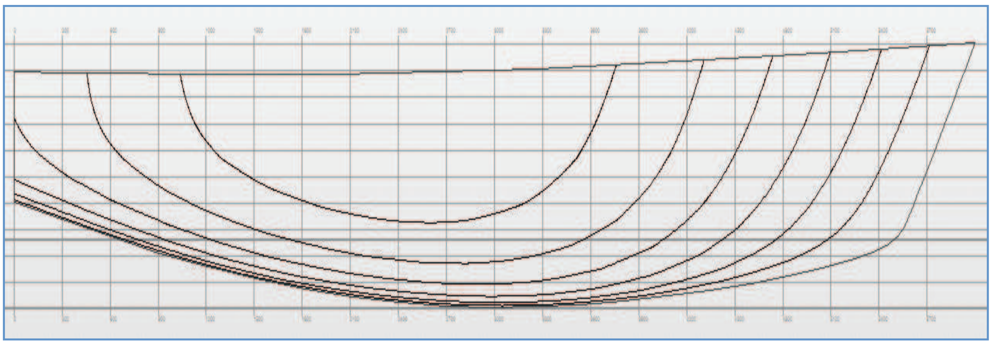


Figure 4.2: Sheer plan view of rescue boat

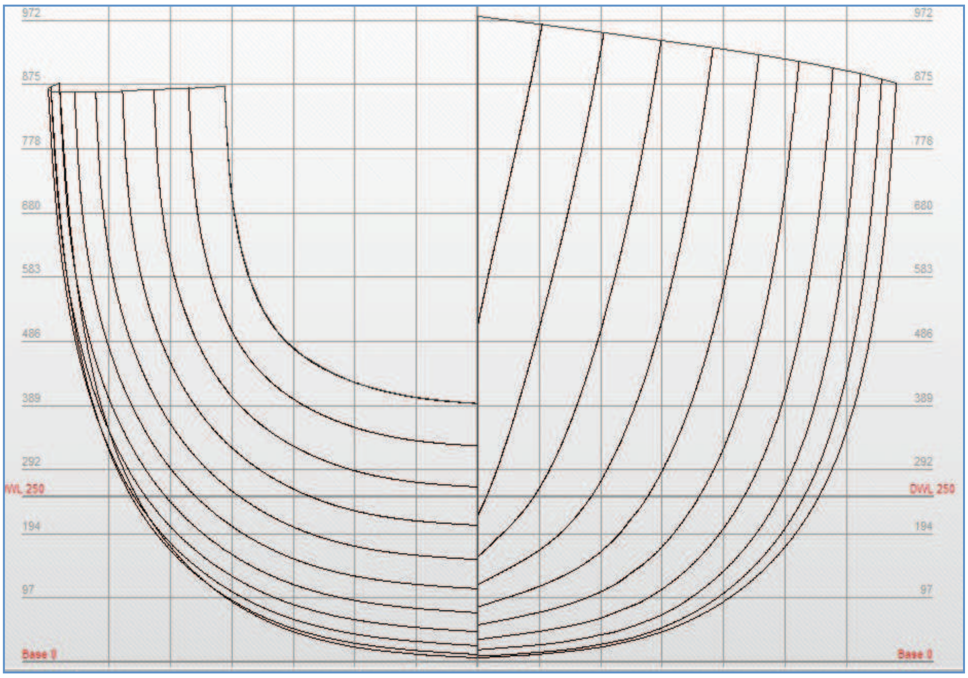


Figure 4.3: Body plan view of rescue boat

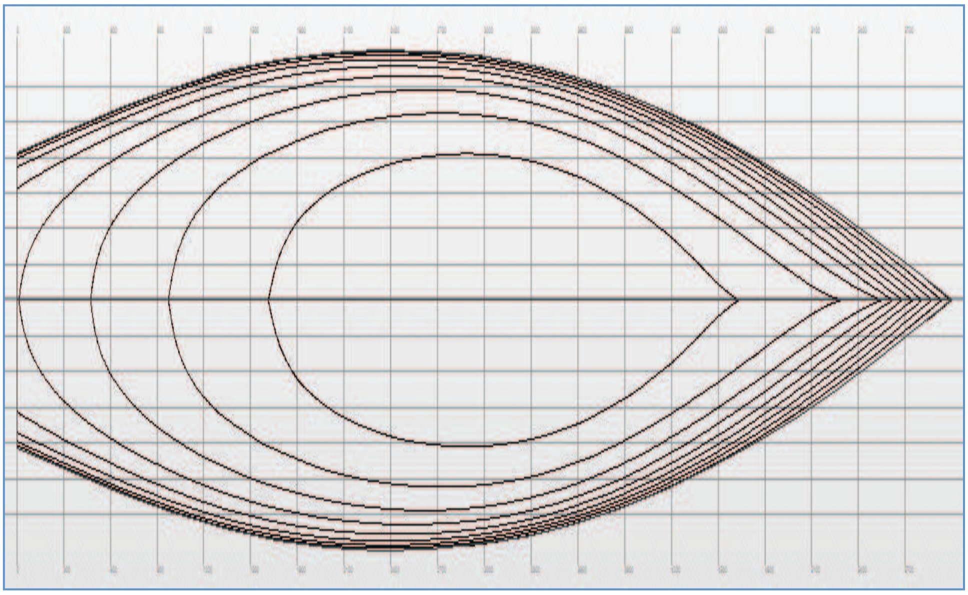


Figure 4.4: Breadth plan view of rescue boat

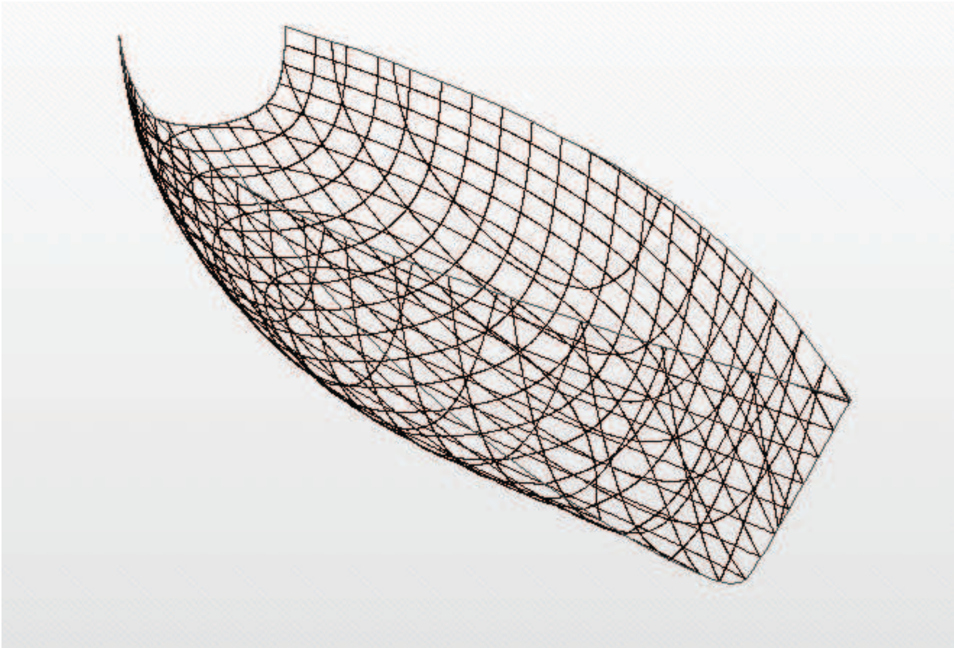


Figure 4.5: Othorgraphic view of rescue boat

4.2 HYDROSTATIC ANALYSIS

Hydrostatic analysis is the most basic qualification for a boat. The hydrostatic analysis of the design was analyzed by DELFTSHIP marine software based on the design dimension of the rescue boat.

4.2.1 Volume Properties

Table 4.2: Volume Properties of Rescue Boat

Volume Properties	Value
Moulded Volume	$0.512m^3$
Total Displaced Volume	$0.512m^3$
Displacement	0.525tonnes
Wetted Surface Area	$4.232m^2$
Midship Area	$0.359m^2$
Longitudinal Center of Buoyancy	2.901m
Vertical Center of Buoyancy	0.163m

Based on Table 4.2, the volume properties were provided in the DELFTSHIP software. The properties also included the displacement of the rescue. The displacement for the boat is 0.525 tonnes or 476.27 kg for draft 0.25. This simply means that a boat will reach a draft of 0.25m from keel when the weight of the boat at 467.27kg. In this research, the displacement above is design for the lightweight (LWT) of boat and does not include the death weight (DWT). In other words, the lightweight such as the weight of hull, weight of seats and engine should not exceed 467.27kg. Since the displacement, midship area and waterplane area will manipulate the value of block coefficient, midship coefficient and waterplane coefficient, hence the shape of the boat will be decided by these parameters.

4.2.2 Sectional Area Properties

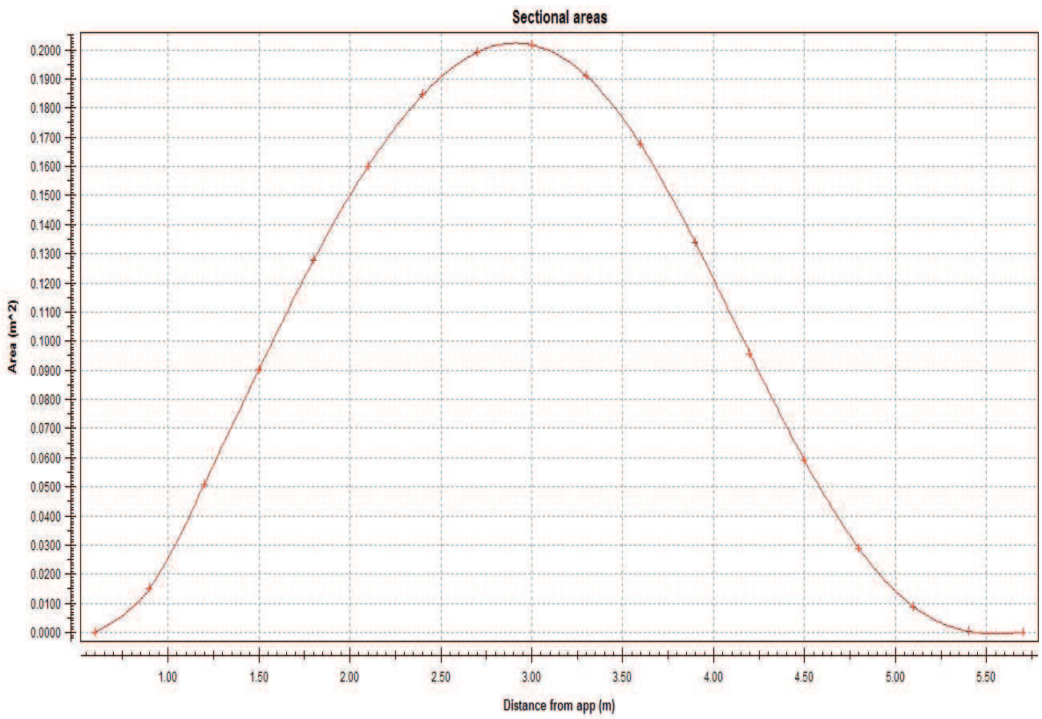


Figure 4.6: Sectional area curve

Figure 4.6 shows the sectional area curve obtained. From the graph above, we know that the midship area is 0.359m^2 where the midship location is at 3.0m.

4.2.3 Waterplane Properties

Table 4.3: Waterplane Properties of Rescue Boat

Waterplane Properties	Value
Length on Waterline	4.890 m
Beam on Waterline	1.238 m^3
Entrance Angle	7.929 degree
Waterplane Area	4.233 m^2
Waterplane Center of floatation	2.770 m

The design of waste plastic bottles arrangement in the lines plan will be under waterline surface. Table 4.3 listed all the waterplane properties of the designed rescue boat.

4.2.4 Coefficient Calculation

Table 4.4: List of Coefficient of Rescue Boat

Coefficient	Value
Block Coefficient, C_b	0.2438
Midship Coefficient, C_m	0.5771
Prismatic Coefficient, C_p	0.4224
Waterplane Coefficient, C_w	0.4406

By using the formula provided in section 3.3 in Chapter 3, we are able to obtain the value of basic ship coefficient. The coefficient above would decide the shape of the designed boat. Table 4.4 shows the value of all the coefficient of designed boat.

4.2.5 Resistance Analysis and Engine Power Estimation

The equation in section 3.4 from Chapter 3 shows that the speed of boat will affect the total resistances.

Table 4.5: Total Resistance at different Speed of Boat

V (knot)	V (m/s)	R_f (kN)	R_r (kN)	R_T (kN)
0	0.0000	0.0000	0.0000	0.0000
4	2.0576	0.0661	0.0048	0.0709
8	4.1152	0.2342	0.0768	0.3110
12	6.1728	0.4909	0.3889	0.8798
16	8.2304	0.8299	1.2291	2.0590
20	10.288	1.2470	3.0007	4.2478

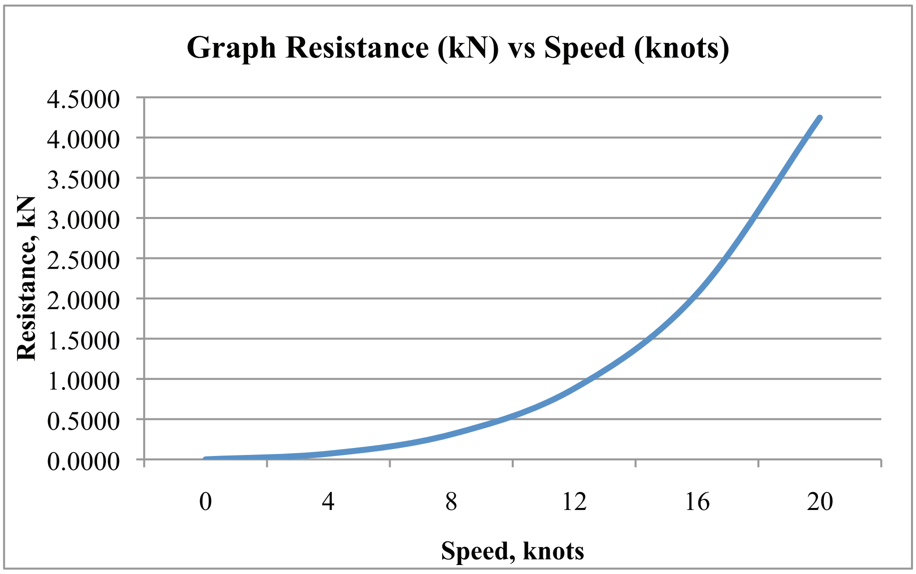


Figure 4.7: Graph total resistance versus speed of boat

Table 4.5 shows the value of each resistance at different speed. From Figure 4.7, the parabolic curve obtained from Table 4.5 and it show that the resistance increases when the speed of the boat increases. At the maximum speed of 20knot, the total resistance is up to 4.2478kN. Hence, it is very important to determined the engine horse power needed to overcome such a resistance so that the boat designed are able to achieve the speed of 20knot on the sea.

Table 4.6: Engine Power Estimation At Speed of 20knot

Resistance	Value
Frictional Resistance, R_f	1.2470kN
Residual Resistance, R_r	3.0007kN
Total Resistance, R_t	4.2478kN
Effective Horse Power, EHP	58.2682HP
Major Driving Force, BHP	134.0168HP

Table 4.6 shows the major driving force needed for an outboard motor and the estimation of engine horsepower needed is around 134HP. However, there is no engine that could produce the exact horsepower of 134HP.

Table 4.7: List of Outboard Motor In The Market

Engine HP	Manufacturer	Price
70HP	Yamaha	$7,699.00
75HP	Mercury	$5,499.00
90HP	Mercury	$6,699.00
115HP	Yamaha	$8,899.00
150HP	Yamaha	$12,999.00
250HP	Yamaha	$19,699.00
300HP	Yamaha	$21,899.00

Source: http://www.boatmotors.com/rebuilt_outboard_motors/ , (2012)

Yamaha outboard engine with 150HP is the most suitable engine for the project. Hence, the engine specification selected will take into to remaining analysis. Please refer Appendix B for the specification of the Engine.

4.2.6 Displacement Estimation

Displacement refers to the actual weight of the vessel. There are two types of weight take into the calculation, which are death weigh (DWT) and light weigh (LWT) and The latter is the measurement for the actual weight of the ship with no fuel, passengers, cargo, and water. However, death weight s the displacement at any loaded condition includes the crew, passengers, fuel, water, and stores.

Table 4.8: Deadweigh (DWT) of A Rescue Boat

Deadweigh (DWT)	**Value**
Weight of bottles, W_b Weight of passenger, W_{cp} Other weight, W_r	13.12kg 600.00kg 7.14kg
Total DWT	620.26kgor 0.6837tons

Table 4.9: Lightweight (LWT) of A Rescue Boat

Lightweight (LWT)	**Value**
Weight of hull, W_{hull} Weight of general arrangement, W_o Weight of machine, Wep	21.98kg 8.46kg 218.00kg
Total LWT	248.44kg or 0.2739tons

Total Weight = DWT + LWT **= 868.7kg or 0.9576tons**

Based on the Life Saving Appliances (LSA) Code, the average of weigh for each passenger is 100kg.The designed arrangement of waste plastic bottles will be in the moulded volume. In the calculation, we assume the weight of food and fresh water is negligible since the design rescue boat is not suitable to long operate for longer than 1 day. The deadweight is 0.6837ons or 620.26kg and the lightweight is 0.2739tons or 248.44kg. The total estimated weight is about 0.9576tons or 858.7kg.

4.2.7 Stability Analysis of Rescue Boat

Table 4.10: Metacenter Height At Different Draft

D (m)	$\overline{KB}$ **(m)**	$\overline{BM}$ **(m)**	$\overline{BM}$ **(m)**	$\overline{KG}$**(m)**	$\overline{GM}$ (m)
0.05	0.0321	3.3140	3.3461	0.5250	2.8211
0.15	0.0963	1.1047	1.2010	0.5250	0.6760
0.25	0.1605	0.6628	0.8233	0.5250	0.2983
0.35	0.2247	0.4734	0.6982	0.5250	0.1732
0.45	0.2890	0.3682	0.6572	0.5250	0.1322
0.55	0.3532	0.3013	0.6544	0.5250	0.1294

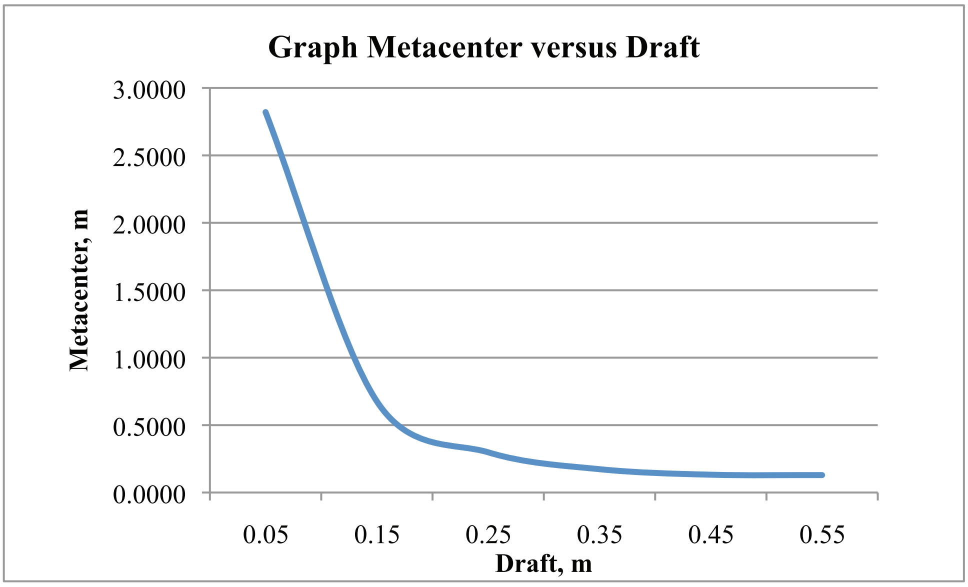


Figure 4.8: Graph metacenter versus draft

Table 4.10 is the calculation of metacenter for different draft from 0.05m to 0.55m. The data was plotting into Figure 4.8 and it show the curve decreases as the draft increases from 0.05m to 0.55m. The values of metacenter show a positive value and this indicates that the boat is stable. However, if the value of metacenter is negative, the boat is considered unstable and it may capsize.

4.3 ARRANGEMENT OF BOTTLES IN RESCUE BOAT

The lines plan design of the rescue boat was drawn in SOLIDWORKS 2011 software based on the design created in the DELFTSHIP marine software previously. The lines plan of the rescue boat will include the arrangement of waste plastic bottles in displaced volume of rescue boat on water in top view, side view and front view.

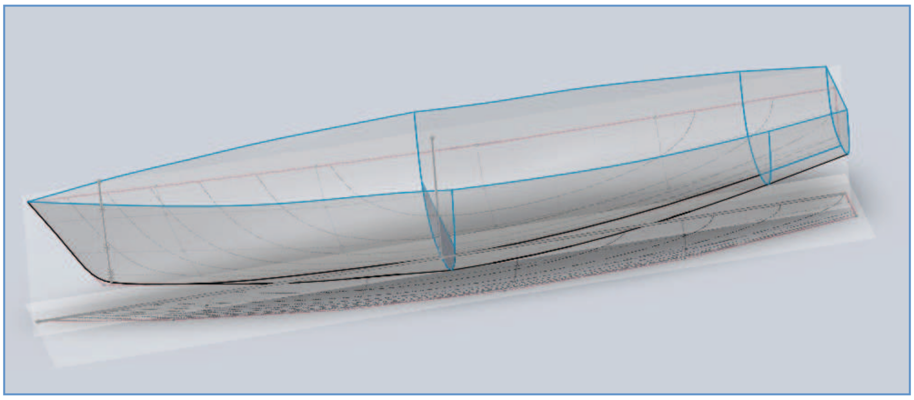


Figure 4.9: The 3D view from Solidworks 2011

4.3.1 Waste Plastic Bottles Properties

The drawing for selected waste plastic bottles was showed in Figure 4.10. Three sample bottles was weight and the average mass for a bottle at dry condition is 39.53grams with the volume of $0.0005m^3$.

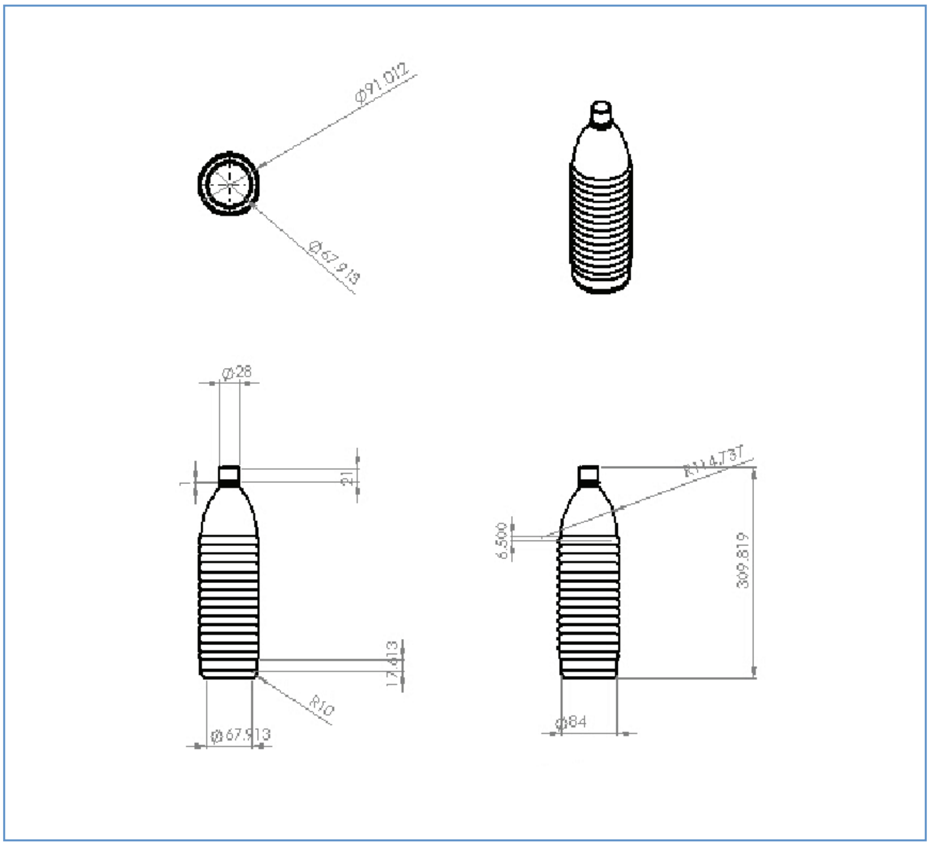


Figure 4.10: Dimensions of waste plastic bottle

Table 4.11: Mass and volume for selected bottle

Mass (g)	39.53
Volume (m^3)	0.0015

4.3.2 Designed Rescue Boat with The Arrangement of Bottles

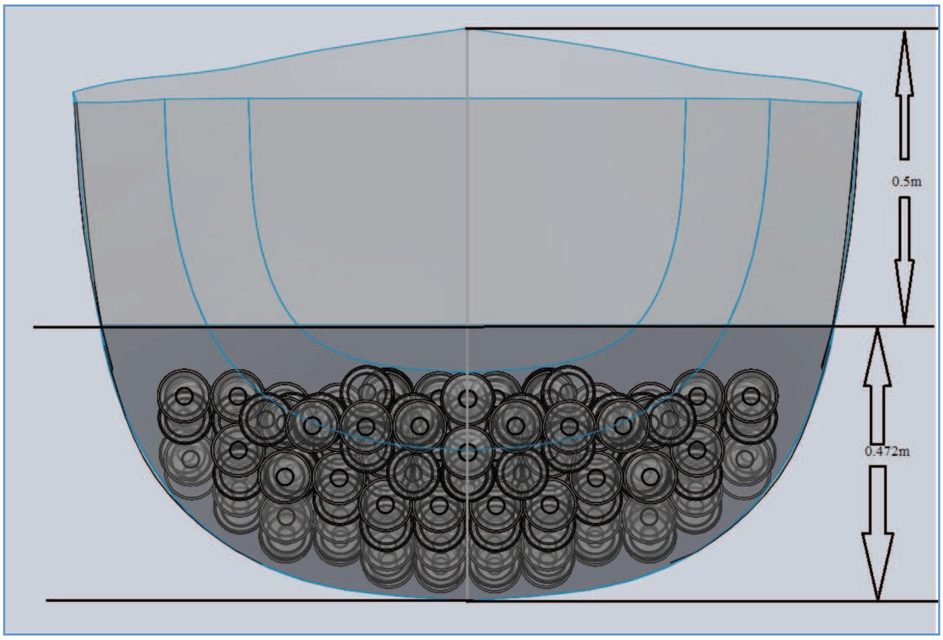


Figure 4.11: Body plan of rescue boat with waste plastic bottles arrangement

The waste plastic bottles were arranged at a height that not exceeds 0.472m from the keel. The waste plastic bottles were filled based on each station until the bottles exceed 0.35m from keel. From the design, there are eight stations occupied with waste plastic bottle. Figure 4.11 shows the body plan of rescue boat with waste plastic bottles arrangement.

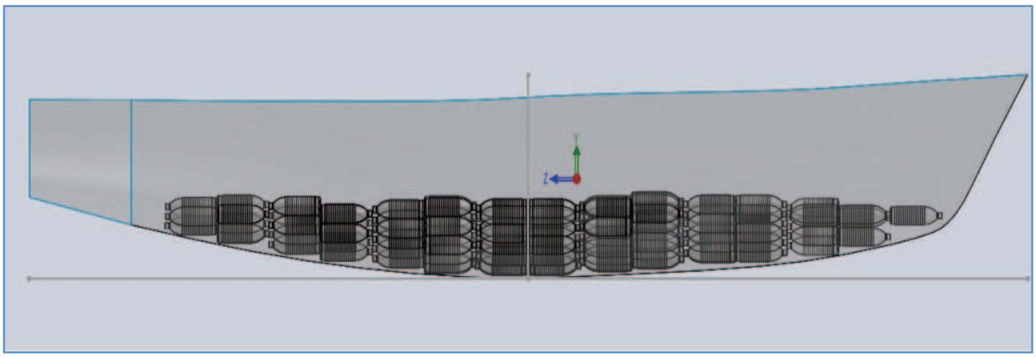


Figure 4.12: Sheer plan of rescue boat

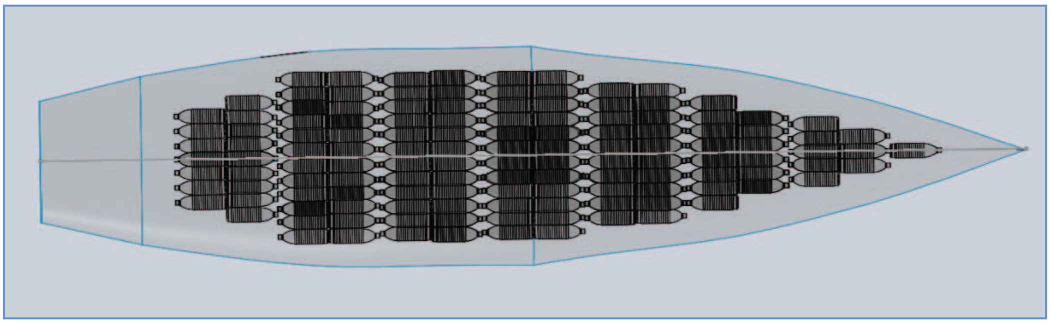


Figure 4.13: Breadth plan of rescue boat

Figure 4.12 shows the sheer plan of rescue boat and Figure 4.13 shows the breatdth plan. Sheer plan visualized the side view of the rescue boat and breadth plan represent the top view. From both sheer plan and breadth plan, the waste plastic bottles were arranged horizontally. There are 15 columns of bottles arranged in the boat and each columns if bottles were tie by using the fish net.

4.3.3 Analysis of Design

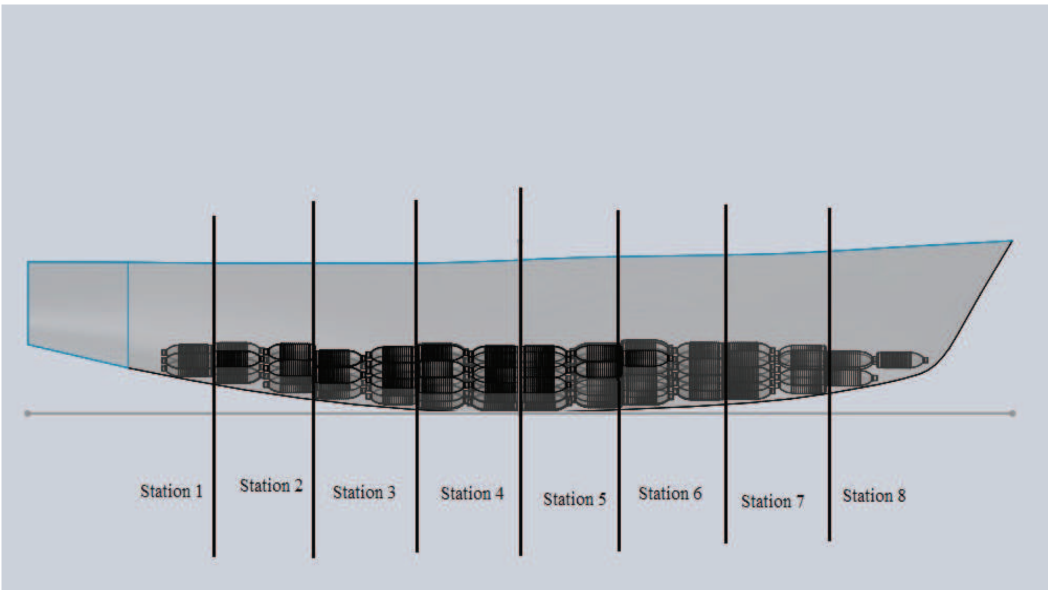


Figure 4.14: Plastic bottles arrange in each station of the boat

One of the analysis was to calculate the total mass of waste plastic bottles been used in the design. Based on Figure 4.14 above, the plastic bottles were arranged horizontally in each station and the length for each station is about 60cm long. Besides, the bottles were arranged at the height range from 0.3m to 0.4m in each station. All the bottles are unable to arrange in the same height due to the irregular size of the boat. The arrangement of waste plastic bottles has 8 stations and mass of the bottles was calculated in each station. Started from station 1 to station 8, it represents the rear part of boat for the former and the front part of boat for the latter.

Table 4.12: Mass Analysis of Waste Plastic Bottles

Station	**Mass of Bottle (kg)**	**Total Bottles**	**Total Mass per Station (kg)**	**Buoyancy Force. F_b(N)**
Station 1	0.03953	8	0.31624	117.36
Station 2	0.03953	40	1.5812	586.80
Station 3	0.03953	58	2.29274	850.86
Station 4	0.03953	76	3.00428	1114.92
Station 5	0.03953	68	2.68804	997.56
Station 6	0.03953	52	2.05556	762.84
Station 7	0.03953	25	0.98825	366.75
Station 8	0.03953	5	0.19765	73.35
Total		**332**	**13.124**	**4870.44**

Based on Table 4.12, total quantity of waste plastic bottles need to be used for the design is 332 bottles and the total mass is 13.124kg. From the Law of Archimedes, the buoyancy force a plastic bottle is able to calculate using the equation of $F_b = \rho_f gV$. The buoyancy force is the weight of the liquid whose volume is equal to the volume of the plate. Table 4.12 show the total buoyancy force supported by the plastic bottles is 4870.44N if leaking problem occurs at the keel. If the leaking problem occurs, the bottles are able to support 56% of buoyancy from the total weight of 868.7kg or 0.9576tons.

As mentioned earlier, the total number of people on the rescue boat is six and each has an average mass of 100kg. From Section 4.2.5, the estimated displacement of the boat is 0.9576tons. From Appendix C, it shows that the estimated weight has a draught of about 0.35m. Referring to Figure 4.7, the graph metacenter versus draft, the value of metacenter is 0.1732m and this positive value shows that the boat is still in the stable condition.

4.4 GENERAL ARRANGEMENT

4.4.1 Detail Design of The General Arrangement

General Arrangement refers to how the seat, toolbox, first-aid box and other accessories arrange on the boat.

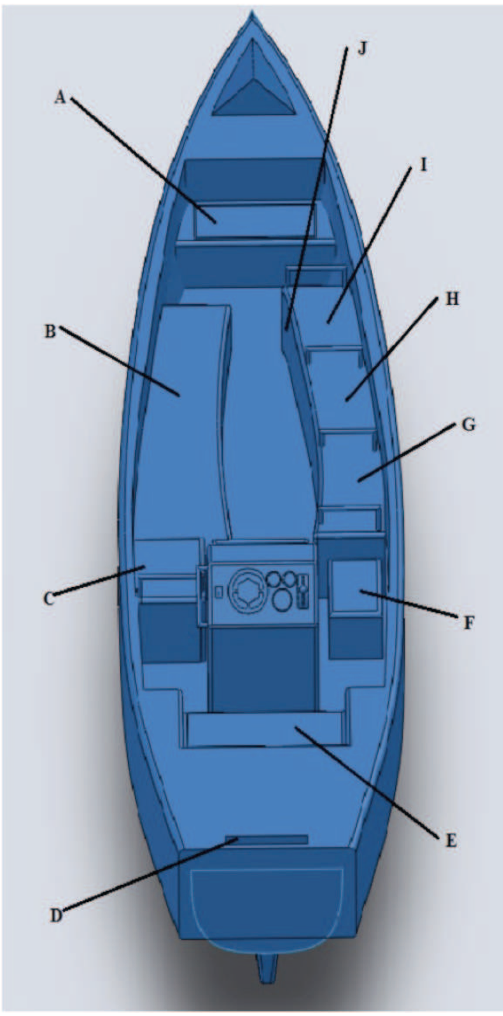


Figure 4.15: General arrangement of rescue boat

Figure 4.15 shows the detail design of the general arrangement for a rescue boat. All labels is showed as below:

A: Food and drink storage
B: Space for victim to lay down
C: Seat 1
D: Mounting Point for Outboard Engine
E: Driver Seat
F: First Aid Storage
G: Seat 2
H: Seat 3
I: Seat 4
J: Life jacket storage and tool storage

The boat able to accommodate six men including a platform for a victim to lay down. The boat is equipped with a panel for the driver including compass and navigation system. Besides, first aid box and toolbox are located near to the driver seat and the food storage is located in the front of the boat. On the other hand, the lifejackets are suggested to place under the victim seat for easy excess. Figure 4.16 shows the side view of the designed rescue boat together with the arrangement of wasted plastic bottles at the bottom part of the boat.

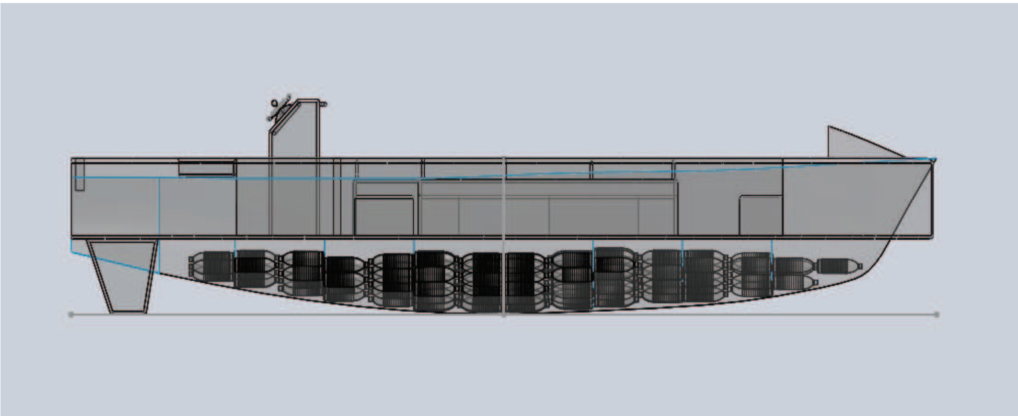


Figure 4.16: Side view of the designed rescue boat

4.4.2 Analysis of General Arrangement

The weight distribution for a boat is important issue before fabrication. Higher Load at the front and rear of back will affect the stability of boat during the movement of a boat. In order to make sure the boat is in balance condition, the idea weight should focus on the middle of boat. From the design, the seat of passenger gathered in the middle of boat.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

By inserting the waste plastic bottles into the rescue boat will produce a different result of rescue boat when the fiberglass boat crack at keel. The boat may not sink directly after a collision. The orientation of the waste plastic bottle is placed horizontally since the bottles could fill easily and stay in stable condition.

On the other hand, the recycle of waste plastic bottles is one way to create an awareness among the public especially the young generation. However, the design only uses the 1.5L of mineral bottles in the arrangement. Other size of waste plastic bottles can be use for any other smaller boat such as fishing boat.

The general design of the rescue boat the basic requirement where the boat is able to accommodate for six people and enough space for at least one passenger to lay down. The passengers are concentrated at the middle part of the boat to improve the weight distribution of the boat. The skipper or driver is responsible to arrange the seat for the passengers to distribute weight evenly in the rescue boat for example not to load a boat with all passengers on one side.

5.2 RECOMMENDATION

To get a better design of waste plastic bottles rescue boat, the shape of the bottle use should not be in the shape of cylinder. Waste plastic bottles with square base are a better choice to arrange inside the boat. In this case, the bottles are able to tie together tightly and able to reduce the unfilled volume compare to plastic bottles that own a round base. However, the square base plastic bottle is only widely used in Japan and Korea. The used of square base plastic bottles still lack of the popularity and hence the thesis only consider the used of round base plastic bottles. The way to tighten the bottles should be improve since using the fish net would become a burden to the boat.

The boat should be trim well to make sure the stability of the boat. An outboard engine trimmed too far out when running into sea has a tendency to lift the boat right out of the water as it crest or peak even waves. Hence, the outboard engine should be idea trim for calm water. So, research for the trim should be does in detail.

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Appendix A

SOLAS Standard of A Rescue Boat Fitting And Inventory

	Item	**Required no. (S92)**
1	Automatic draining valve with cap or plug attached with lanyard	1
2	Rudder and tiller	1
3	Buoyant lifeline around the rescue boat	1
4	Handholds underside the hull	2
5	Release mechanism for hook	1
6	Release device for forward painter	1
7	Watertight lockers for storage of small items	1
8	Arrangement for towing liferafts	sufficient
9	Buoyant oars or paddles to make headway in calm seas	sufficient
10	Thole pin and crutches attached with lanyard or equivalent arrangements	for each oar
11	Buoyant bailer	1
12	Efficient compass in binnacle provided with means of illumination	1
13	Sea-anchor and tripping line with hawser of adequate strength (10m length)	1
14	Painter of sufficient length and strength attached to the release device	1
15	Buoyant line for towing liferafts (50m length)	1
16	Waterproof Morse electric torch with spare batteries and bulb	1
17	Whistle	1
18	First-aid outfit in waterproof case	1
19	Buoyant rescue quoits with 30m buoyant line	2
20	Searchlight	1
21	Efficient radar reflector	1
22	Thermal protective aids	10% person/ 2 (the greater)
23	Boat-hook (rigid rescue boats)	1
24	Bucket (rigid rescue boats)	1
25	Knife or hatchet (rigid rescue boats)	1
26	Buoyant safety knife (inflated rescue boats)	1
27	Sponges (inflated rescue boat)	2
28	Efficient manually operated bellows or pump (inflated rescue boats)	1
29	Puncture repair kit in suitable container (inflated rescue boats)	1
30	Safety boat-hook (inflated rescue boats)	1

Source: Form MAINTPSC02-04/01, Annex 5- Rescue boat fitting and inventory, pp45,

http://www.pomorci.com/Propisi/80-100/SOLAS%20-%20LSA%20requirment%20table

Appendix B

Engine Specification

Manufacturer	Yamaha
Model Number	F150TLR
Engine Type	In-Line Four Cylinder
Displacement	162.8ci (2670cc)
Bore x Stroke	94.0 x 96.2mm (3.70 x 3.79in)
Prop Shaft Horsepower	150HP S5500rpm
Compression Ratio	9.0:1
Fuel/Induction System	EFI (DOHC)
Exhaust	Through Propeller
Intake	Four Individual Throttle Valves
Ignition System	TCI Micro Computer
Spark Plug	LFR5A-aa-00-000
Alternator Output	35AMP
Starting System	Electric
Lubrication	Wet Sump
Engine Oil Capacity	4.5L/4.3L w/without filter
Full Throttle RPM Range	5000-6000
Cooling	Water/Thermostatic Control
Recommended Engine Oil	Yamalube 4M
Recommended Fuel	Regular Unleaded (Min Pump Octane 87)
Recommended Fuel Filtration	Yamaha 10 Micron Fuel
Ethanol Blend Limit	10% Maximum
Gear Ratio	(28:14) 2.00:1
Gear Shift	Forward, Neutral, Reverse
Shaft Length	20’
Degree of Tilt	70^{o}
Degree of Trim	-4 through 16^{o}
C.A.R.B Rating	3-Star
Dry Weight	218kg (480lba)

Source: http://www.yamahaoutboards.com/outboards/Inline-4/specifications#section-nav

APPENDIX C

Hydrostatics Report

Designer					
Created by					
Comment					
Filename			New model.fbm		
Design length	6.000	*(m)*	**Midship location**	3.000	*(m)*
Length over all	6.000	*(m)*	**Relative water density**	1.025	
Design beam	1.400	*(m)*	**Mean shell thickness**	0.0000	*(m)*
Maximum beam	1.387	*(m)*	**Appendage coefficient**	1.0000	
Design draught	0.250	*(m)*			

Trim: 0.000 *(m)*

Draught *(m)*	**Lwl** *(m)*	**Bwl** *(m)*	**Vol. mould** *(m^3)*	**Volume** *(m^3)*	**Displ.** *(tonnes)*	**Displ.** *(tonnes)*	**LCB** *(m)*
0.050	2.065	0.620	0.020	0.020	0.020	0.020	3.043
0.150	3.805	0.952	0.198	0.198	0.202	0.202	2.979
0.250	4.802	1.116	0.512	0.512	0.525	0.525	2.901
0.350	5.397	1.217	0.928	0.928	0.951	0.951	2.815
0.400	4.560	1.247	1.105	1.105	1.105	1.105	2.798
0.450	5.660	1.281	0.000	0.000	0.000	0.000	0.000

NOTE 1: Draught (and all other vertical heights) is measured above base Z=0.00!
NOTE 2: All calculated coefficients based on project length, draught and beam.

Nomenclature

Lwl	*Length on waterline*
Bwl	*Beam on waterline*
Vol. mould	*Moulded volume*
Volume	*Total displaced volume*
Displ.	*Displacement*
Displ.	*Displacement*
LCB	*Longitudinal center of buoyancy, measured from the aft perpendicular at X=0.0*