DESIGN OF FIBERGLASS RESCUE BOAT BY USING WASTE PLASTIC BOTTLES

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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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Name of Supervisor: DR AGUNG SUDRAJAD
Position: LECTURER
Date:

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.

Signature

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Date:

Dedicated to my beloved parents

Mr Zakaria bin Md Zin
and
Mdm Maria binti Mohamed

for their everlasting love, guidance and support in the whole journey of life

ACKNOWLEDGEMENTS

First I would like to express my grateful to Allah S.W.T as for the blessing given that I can finish my project.

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I acknowledge my sincere indebtedness and gratitude to my parents for their love, dream and sacrifice throughout my life. I cannot find the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to attain my goals.

Thank you all.

ABSTRACT

This thesis describes the design of fiberglass rescue boat by using waste plastic bottles. Fiberglass layer of rescue boat has tendency to crack when hit by a heavy wave or involves in accident. As an alternative of this problem, waste plastic disposal has been reuse to fill the displaced volume of the designed rescue boat. The main objective of this thesis is to design a fiberglass rescue boat that has arrangement of bottles under the waterline section of the designed rescue boat. Lines plan of the rescue boat and general arrangement has been designed to visualize the design. Several analyses on the design have been made to show the compatible of the design. This thesis described methodology utilized, design software and final lines plan and general arrangement of the designed rescue boat. From the results, it is observed that the rescue boat use 303 waste plastic bottles to fit the displaced volume of the fiberglass rescue boat. The displaced volume of the rescue boat is 1156kg. The design rescue compatible for 6 persons on an average weight of 100 kg, 12.0261kg for the total weight of waste plastic bottles arrangement, boat's engine and storage tanker of the rescue boat on the rescue boat at one time.

ABSTRAK

Tesis ini berkaitan dengan rekabentuk bot penyelamat gentian serabut kaca yang diperbuat daripada botol plastik terbuang. Lapisan gentian serabut kaca bot penyelamat mempunyai kecenderungan untuk pecah apabila dipukul ombak atau terlibat dengan kemalangan. Sebagai alternatif kepada masalah ini, botol plastik buangan digunakan semula untuk mengisi sesaran isipadu bot penyelamat rekaan di atas air. Objektif utama tesis ini ialah mereka bentuk bot penyelamat gentian serabut kaca yang mempunyai sususan botol plastik buangan di bawah bahagian air untuk bot penyelamat tersebut. Pelan garis dan susun atur umum direbentuk untuk menggambarkan rekaan bot penyelamat tersebut. Beberapa analisis rekaan bot penyelamat tersebut dibuat untuk menunujukkan kebolehan guna rekaan tersebut. Tesis ini menerangkan cara kerja yang digunakan, program computer dan rekabentuk akhir pelan garis dan susun atur umum untuk bot penyelamat yang direka. Daripada hasilnya, dapat dilihat bot penyelamat ini menggunakan 303 buah botol plastic buangan untuk dipadankan di dalam isipadu sesar bot penyelamat gentian kaca ini. Jumlah sesaran bot penyelamat ini adalah 1156 kg. Rekabentuk bot rekaan ini sesuai untuk 6 orang yang mempunayai purata berat anatara 100 kg, 12.0261kg jumlah berat susunan botol plastic buangan , enjin bot, tangki simpanan untuk satu masa di atas bot penyelamat ini.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Production of solid waste in Malaysia is 1Kg per day for one person. In average, approximately 26 million peoples in the country produce 26 million kilos of solid waste every single day. Plastic waste is the most common solid waste that generate in the country accounting for 7-12 percent by weight and 18-30 percent by volume of the total residential waste generated (Agarwal, 2007). Solid waste such as plastic if not disposed off properly can not only pose significant health threats but also add to visual, air and water pollution, clogging drains, water ways, breeding air borne diseases and nuisances (Curlee, 1986).

The need of recycling plastic waste has made an idea to reuse waste plastic bottles as one way to reduce the waste at the source because it delays or avoids its entry in the waste collection and disposal system.

This project is about to design a fiberglass rescue boat that has arrangement of waste plastic bottles at the core of under waterline volume of the boat. The arrangement of waste plastic will avoid the rescue boat from sinking when fiberglass layer of the boat crack.

The idea of Archimedes principle states "any body partially or completely submerged in a fluid is buoyed up by a force equal to the weight of the fluid displaced by the body" (Meredith, 2009). The weight of arrangement waste bottles acts downward, and the buoyant force provided by the displaced fluid acts upward. If these two forces are equal, the rescue boat will float even the fiberglass layer crack.

The design rescue boat will count on quantity and mass of waste plastic bottles to be used in the core of the boat. The lines plan and general arrangement of the boat will be designed and some theoretical analysis will be made.

The design work uses AutoCAD 2009 software to draw the Lines Plan and General Arrangement of the boat.

1.2 PROBLEM STATEMENT

Fiberglass boat has tendency to crack when hit by heavy wave or involves in accident. Cracking on the fiberglass layer will result the boat sinks and it will fail the purpose of rescue boat to rescue peoples. To overcome this, 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.

1.3 OBJECTIVE

The main objective of this study is to design a fiberglass rescue boat that has arrangement of waste plastic bottles at under waterline volume of the rescue boat.

1.4 PROJECT SCOPE

The scopes of this project are:

i. Design the Lines Plan of Rescue Boat.
ii. Design the General Arrangement of Rescue Boat.
iii. Theoretical analysis on the design of Rescue Boat.

1.5 PROCESS FLOW CHART

Figure 1.1 shows the process flow of how this project is done. This makes useful tools how processes work is done throughout the project.

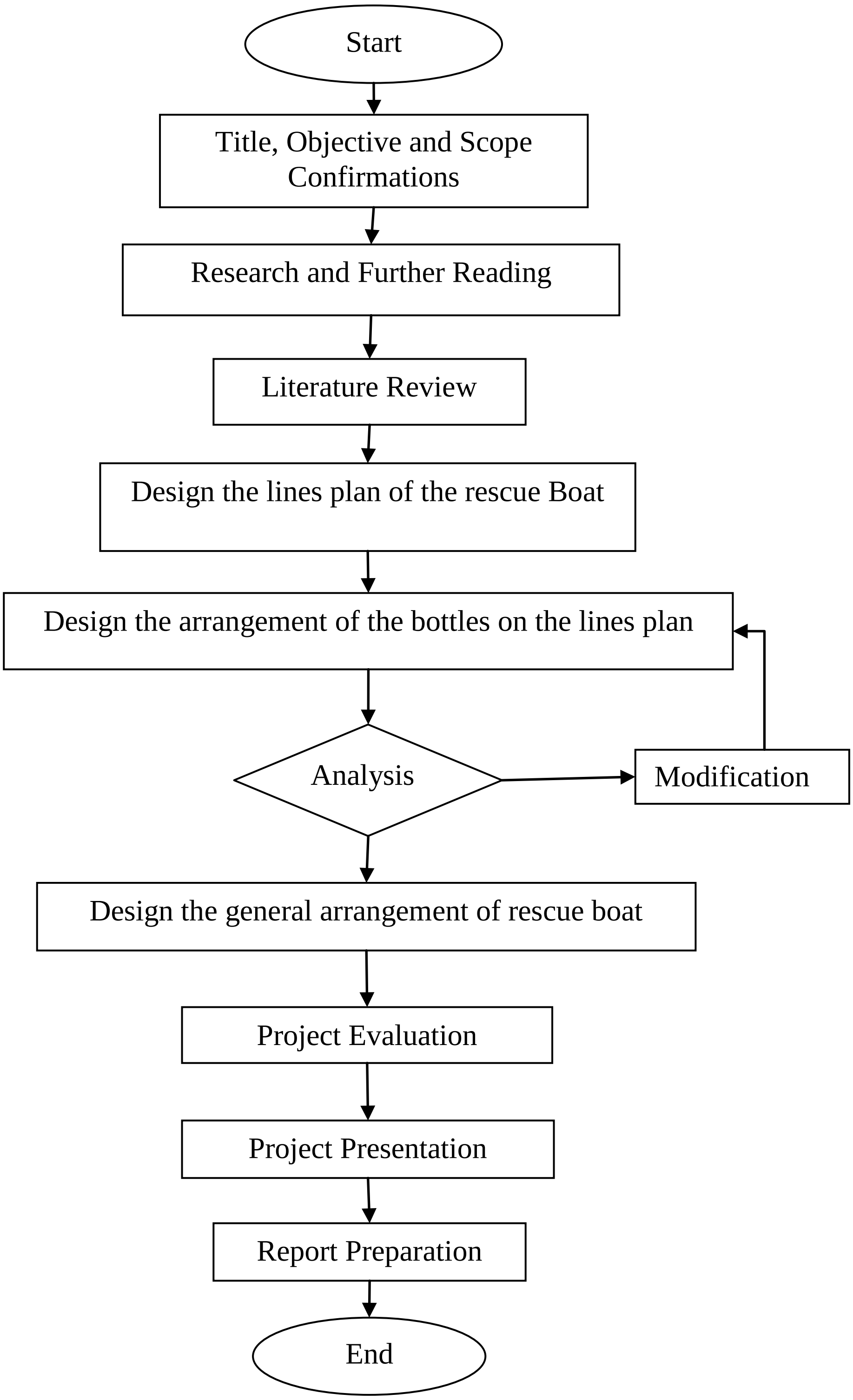

Figure 1.1: Process flow chart

CHAPTER 2

LITERATURE REVIEWS

2.1 ARCHIMEDES PRINCIPLE

Archimedes' principle is the law of buoyancy. It states that "any body partially or completely submerged in a fluid is buoyed up by a force equal to the weight of the fluid displaced by the body." The weight of an object acts downward, and the buoyant force provided by the displaced fluid acts upward. If these two forces are equal, the object floats. Density is defined as weight per volume. If the density of an object exceeds the density of water, the object will sink (Meredith, 2009).

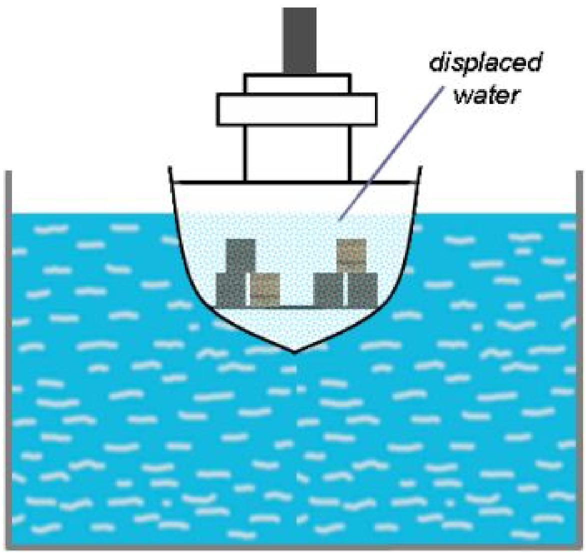

Figure 2.1: The picture of Archimedes Principle for ship

Source: http://www.diracdelta.co.uk/science/source/a/r/archimedes%20principle

2.2 GENERAL FEATURES OF RESCUE BOAT

A rescue boat is a boat rescue craft which is used to attend a vessel in distress, or its survivors, to rescue crewmen and passengers. It can be hand pulled, sail powered or powered by an engine. Rescue boats may be rigid, inflatable or rigid-inflatable combination hulled vessels. In many cases, composite boat are built by sandwiching thin fiber-reinforced skins over a lightweight but reasonably rigid core of foam, balsa wood, impregnated paper honeycomb or other material. The shape of the hull is entirely dependent upon the needs of the design. Many variables must take into accounts when selecting rescue boat. Some of the features of rescue boat are the seats are removable and can be used as floatation devices. There are also 10 handles around the outboard perimeter for carrying even in the most difficult places. The bow can be opened to allow divers to enter and exit the water safely and easily. Seating arrangements can accommodate up to 12 personnel. Swim aids, first aid kits, spot light, basic life support supplies and food storage tanker are basic features of rescue boat (Robert Rhea et al., 2010).

Figure 2.2: The picture of fast rescue boat

Source : http://adeeplife.blogspot.com/2009/08/fast-rescue-boats.html

2.2 PRINCIPAL DIMENSION OF HULL

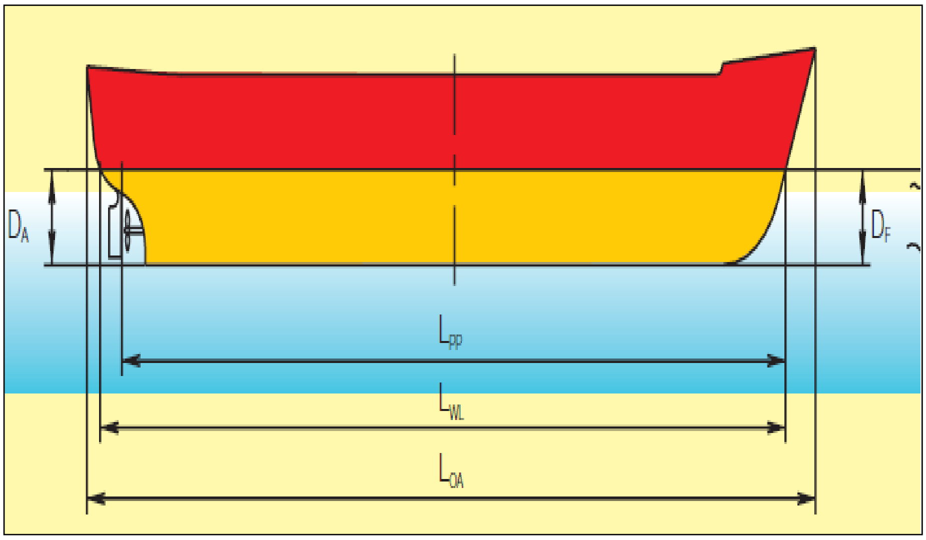

Figure 2.3: Hull dimension

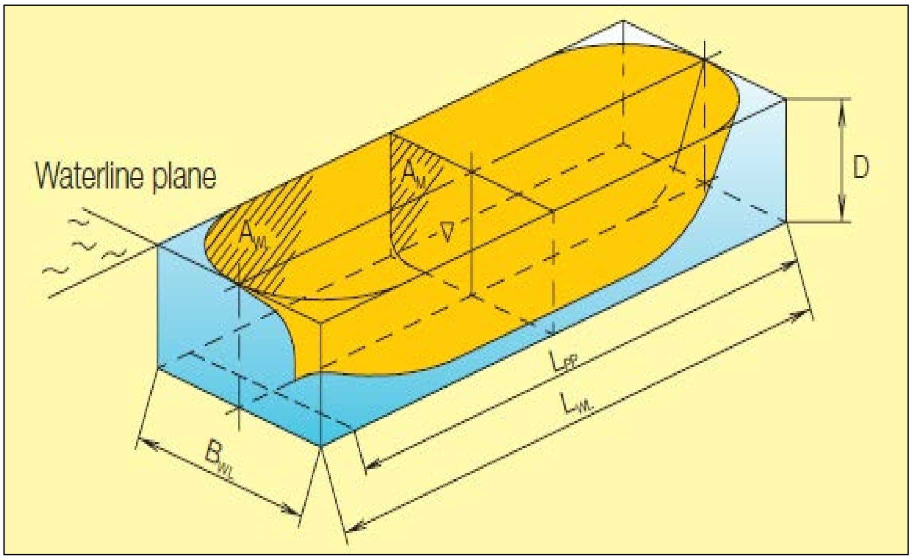

Figure 2.4: Hull dimension under waterline

Source: Sv. Aa. Harvald, 1983

Based on Figure 2.3 and 2.4, principal of hull dimensions are :

- **Length overall (LOA)** is the extreme length from one end to the other end.
- **Length at waterline (Lwl)** is the length from the forwardmost point of the.
- waterline measured in profile to the stern-most point of the waterline.
- **Length between perpendicular (Lpp)** is the length of the summer load waterline from the stern post to the point where it crosses the stem.
- **Beam or breadth (Bwl)** is the width of the hull on waterline.
- **Draught (D)** is the vertical distance measured from the bottom of the hull to the waterline.

The overall length of the ship, $\boldsymbol{LOA}$ is normally of no consequence when calculating the hull's water resistance. The factors used are the length of the waterline $\boldsymbol{Lwl}$ and the so-called length between perpendiculars $\boldsymbol{Lpp}$. The dimensions referred to are shown in Figure 2.3 and 2.4.

The length between perpendiculars is the length between the foremost perpendicular, usually a vertical line through the stem's intersection with the waterline, and aft most perpendicular which, normally, coincides with the rudder axis (Sv. Aa. Harvald, 1983). Generally, this length is slightly less than the waterline length, and is often expressed as:

$$Lpp = 0.97 \times Lwl \qquad (2.1)$$

2.3 COEFFICIENT USED IN HULL CONSTRUCTION

Various coefficients are used to express the shape of the hull. Its includes block coefficient, water plane area coefficient, midship section coefficient, longitudinal prismatic coefficient and longitudinal center of buoyancy.

2.3.1 Block coefficient, Cb

Various form coefficients are used to express the shape of the hull. The most important of these coefficient Cb, which is defined as the ratio between the displacement volume V and the volume of a box with dimensions Lwl x Bwl x D, see Figure 2.4 (Sv. Aa. Harvald, 1983).

$$Cb = \frac{V}{Lwl \times Bwl \times D} \tag{2.2}$$

In the case cited above, the block coefficient refers to the length on waterline Lwl. However, shipbuilders often used block coefficient Cb,pp based on the length between perpendiculars, Lpp, in which case the block coefficient will, as a rule, be slightly larger because, as previously mentioned, Lpp is normally slightly less than Lwl.

$$Cb,pp = \frac{V}{Lpp \times Bwl \times D} \tag{2.3}$$

A small block coefficient means less resistance and consequently the possibility of attaining higher speeds.

Table 2.1: Examples of block coefficients

Ship type	**Block Coefficient, Cb**	**Approximate Speed (Knots)**
Lighter	0.9	5-10
Bulk Carrier	0.80 - 0.85	12-17
Tanker	0.80 - 0.85	12-16
General Cargo	0.55 - 0.75	13-22
Container Ship	0.50 - 0.70	14-26
Ferry Boat	0.50 - 0.70	15-26

Sources: Sv. Aa. Harvald, 1983

Table 2.1 shows some examples of block coefficient sizes and the pertaining service speeds on different types of ships. It shows that large block coefficient correspond to low speeds and vice versa.

2.3.2 Water plane area coefficient, Cwl

The water plane area coefficient Cwl expresses the ratio between the vessel's waterline area Awl and the product of the length Lwl and the breadth Bwl of the ship on the waterline, see Figure 2.4.

.

$$Cwl = \frac{Awl}{Lwl \times Bwl} \tag{2.4}$$

Generally, the water plane area coefficient is some 0.10 higher than the block coefficient:

$$Cwl \approx Cb + 0.10 \tag{2.5}$$

This difference will be slightly larger on fast vessels with small block coefficients where the stern is also partly immersed in the water and thus becomes part of the "water plane" area (Sv. Aa. Harvald, 1983).

2.3.3 Midship section coefficient, Cm

A further description of the hull form is provided by the midship section coefficient Cm , which expresses the ratio between the immersed midship section area Am (midway between the foremost and the aft most perpendiculars) and the product of the ship's breadth Bwl and draught D, see Figure 2.4 (Sv. Aa. Harvald, 1983).

$$Cm = \frac{Am}{Bwl \times D} \tag{2.6}$$

2.3.3 Longitudinal prismatic coefficient, Cp

The longitudinal prismatic coefficient Cp expresses the ratio between displacement volume V and the product of the midship frame section area Am and the length of waterline see Figure 2.4 (Sv. Aa. Harvald, 1983),

$$Cp = \frac{V}{Am \times Lwl} = \frac{V}{Cm \times Bwl \times D \times Lwl} = \frac{Cb}{Cm} \qquad (2.7)$$

As can be seen, Cp is not an independent form coefficient, but is entirely dependent on the block coefficient Cb and the mid ship section coefficient Cm.

2.3.4 Longitudinal Centre of Bouyancy, LCB

The Longitudinal Centre of Bouyancy (LCB) expresses the position of the centre of buoyancy and is defined as the distance between the centre of buoyancy and the mid-point between the ship's foremost and aft most perpendiculars. The distance is normally stated as a percentage of the length between the perpendiculars and is positive if the centre of buoyancy is located to the fore of the mid-point between the perpendiculars, and negative if located to the aft of the mid-point.For a ship designed for high speeds, will normally be negative whereas for slow speed it will normally be positive. The LCB is generally between -3% and +3% (Sv. Aa. Harvald, 1983).

2.4 SHIP RESISTANCES

To move a ship, it is first necessary to overcome resistance that is the force working against its propulsion. The calculation of the resistance R plays a significant role in the selection of the correct propeller and in the subsequent choice of main engine.

Generally a ship's resistance is particularly influenced by its speed, displacement and hull form. The total resistance RT, consist of many source-resistance R which can be divided into three main groups :

1) Frictional resistance
2) Residual resistance
3) Air resistance

The influence of frictional and residual resistances depends on how much of the hull is below the waterline, while the influence of air resistance depends on how much of the ship is above the waterline (Sv. Aa. Harvald, 1983). In view of this, air resistance will have a certain effect on container ships which carry a large number of containers on the deck.

Water with a speed of V and a density of ρ has a dynamic pressure of:

$$1/2 \times \rho \times V^2 \quad (2.8)$$

Thus, if water is being completely stopped by a body, the water will react on the surface of the boday with the dynamic pressure, resulting in a dynamic force on the body.

This relationship is used as a basis when calculating or measuring the source-resistances R of a ship's hull, by means of dimensionless resistance coefficients C. Thus, C is related to the reference force K, defined as the force which the dynamic pressure of water with the ship's speed V exerts on a surface which is equal to the hull's wetted area As. The rudder's surface is also included in the wetted area. The general data for resistance calculations is thus :

$$Reference\ Force: K = {}^{1}\!/_{2} \times \rho \times V^2 \times As \qquad (2.9)$$

$$Sources\ Resistances: R = C \times K \qquad (2.10)$$

2.4.1 Frictional resistance, Rf

The frictional resistance Rf of the hull depends on the size of the hull's wetted area As, and on the specific frictional resistance coefficient Cf . The friction increase with fouling of the hull, in example by growth of algae, sea grass and barnacles.

When the ships is propelled through the water, the frictional resistance increase at a rate that is virtually equal to the square of the vessel's speed (Sv. Aa. Harvald, 1983). The frictional resistance is found as follows:

$$Rf = Cf \times K \qquad (2.11)$$

2.4.2 Residual resistance, Rr

Residual resistance Rr comprises wave resistance and eddy resistance. Wave resistance refers to the energy loss caused by waves created by the vessel during its propulsion through the water, while eddy resistance refers to the loss caused by flow separation which creates eddies, particularly at the aft end of the ship.

Wave resistance at low speed is proportional to the square of the speed, but increases much faster at higher speeds. In principle, this means that a speed barrier is imposed, so that a further increase of the ship's propulsion power will not result in a higher speed as all the power will be converted into wave energy. The residual resistance normally represents 8-25% of the total resistance for low-speed ships, and up to 40-60% for high-speed ships (Sv. Aa. Harvald, 1983).

Incidentally, shallow waters can also have great influence on the residual resistance, as the displaced water under ship will have greater difficulty in moving aft wards.

The procedure for calculating the specific residual resistance coefficient Cr is described and the residual resistance is found as follow:

$$Rr = Cr \times K \tag{2.12}$$

2.4.3 Air resistance, Ra

In calm weather, air resistance is, in principle, proportional to the square of the ship’s speed, and proportional to the cross-sectional area of the ship above the waterline. Air resistance normally represents about 2% of the total resistance.

For container ships in head wind, the air resistance can be as much as 10%. The air resistance can be similar to the foregoing resistances that can be expressed as Ra = Ca + K , but is sometimes based on 90% of the dynamic pressure of air with a speed of V (Sv. Aa. Harvald, 1983) :

$$Ra = 0.90 \times {}^{1}/_{2} \times \rho, air \times V^{2} \times A\,, air \tag{2.13}$$

Where ρair is the density of the air, $A,_{air}$ and is the cross-sectional area of the vessel above the water.

2.4.4 Towing resistance, RT and Effective (towing) power, PE

The ship's total towing resistance RT is thus found as :

$$RT = Rf \; + Rr \; + Ra \tag{2.14}$$

The corresponding effective (towing) power, PE, necessary to move the ship through the water to tow the ship at the speed V, is then:

$$PE = V \; \times RT \tag{2.15}$$

The power delivered to the propeller, PD, in order to move the ship at speed V is however, somewhat larger. This is due, in particular, to the flow conditions around the propeller efficiency itself (Sv. Aa. Harvald, 1983).

2.4.5 Total ship resistance in general

When dividing the residual resistance into wave and eddy resistance, as earlier described, the distribution of the total ship towing resistance RT could also, as a guideline, be stated as shown in Figure 2.5.

The right column is valid for low-speed ships like bulk carriers and tankers, and the left column valid for very high-speed ships like cruise liners and ferries. Container ships may be placed in between the two columns.

The main reason for the difference between the two columns is, as earlier mentioned, the wave resistance. Thus, in general all the resistances are proportional to the square of the speed, but higher speeds the wave resistance increases much faster, involving a higher part of the total resistance.

In practice, the increase of resistance caused by heavy weather depends on the current, the wind, as well as the wave size, where latter factor may have great influence. Thus, if the wave size is relatively high, the ship speed will be somewhat reduced even when sailing in fair seas.

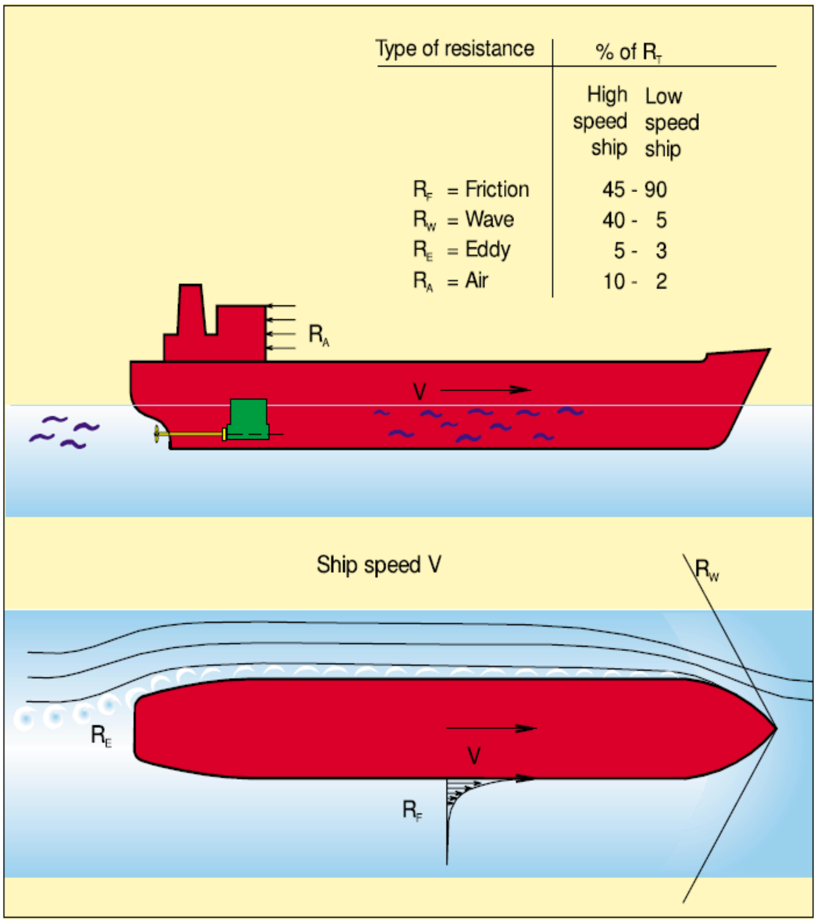

Figure 2.5: Total ship towing resistance RT = RF + RW + RE + RA

Source : Sv. Aa. Harvald, 1983

2.5 DESIGN DRAWING

2.5.1 Lines Plan

The lines plans of a boat provide an immediate indication of her looks, performance, and sea-worthiness. They typically consist of three perpendicular views of the hull: the profile, or sheer plan, is the view from one side; the half-breadth plan is the view from directly above; and the body plan consists of views from directly in front of and behind the boat .Horizontal lines pass through the hull parallel to the base line, and are called waterlines. Diagonal lines pass through the plan lengthwise at arbitrary angles to delineate the shape of the hull more completely. Buttock lines are slices through the hull from top to bottom, running parallel to the keel .When the waterlines, diagonals, and buttocks are in place, you can develop the lines of a hull and create the stations, or sections. There are usually 10 stations along the waterline of a boat; when they're drawn one inside the other, they produce the body plan, which contains the important mid ship section .The stations in the body plan are usually drawn as half-sections, with the after sections on the left and the forward sections on the right. (www.answers.com/topic/lines-plans).

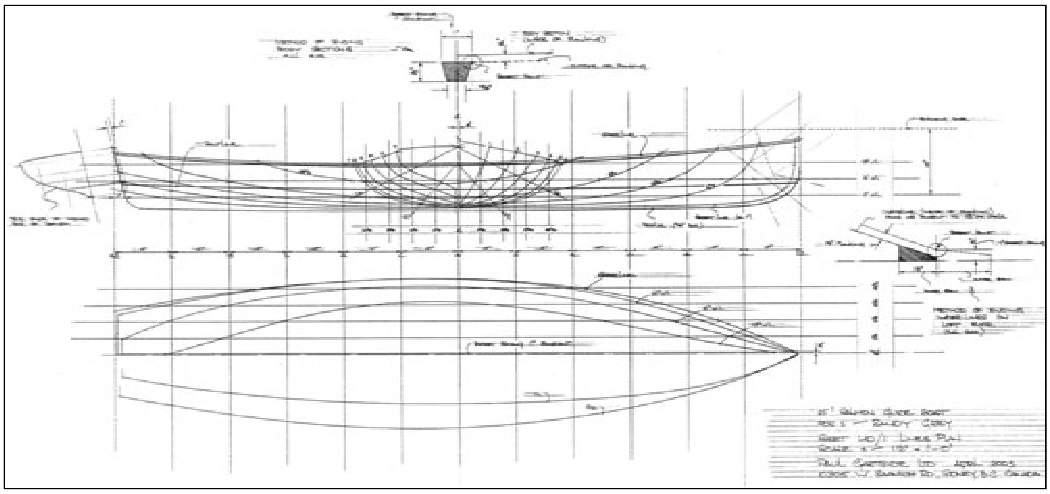

Figure 2.6: Example of lines plan drawing

Sources : http://newboatbuilders.com/pages/design_logo.html

2.5.2 General Arrangement

The general arrangement is a naval architecture drawing showing the inside of a ship and where the main elements are placed.

This drawing shows overall views of the equipment and provides all of the information to produce transportation, layout and installation drawings. It includes a list of the arrangement drawing such as dimensions, installation details, overall weight or mass, weight of subsystem and service supply details (www.roymech.co.uk/Useful.../Mech_Drawings.html).

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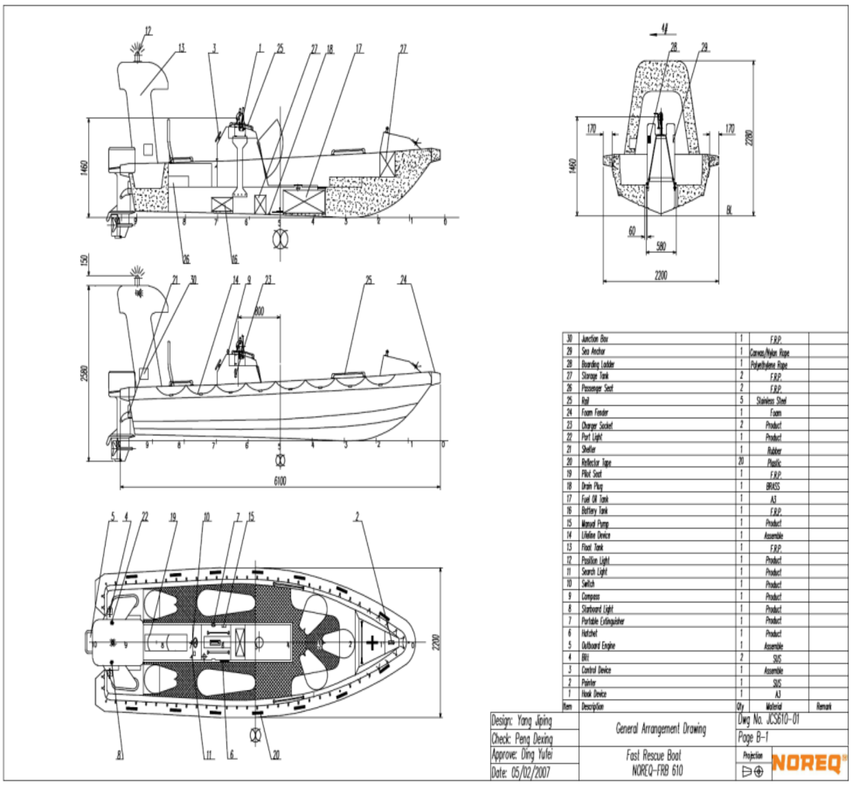


Figure 2.7: Example of general arrangement drawing

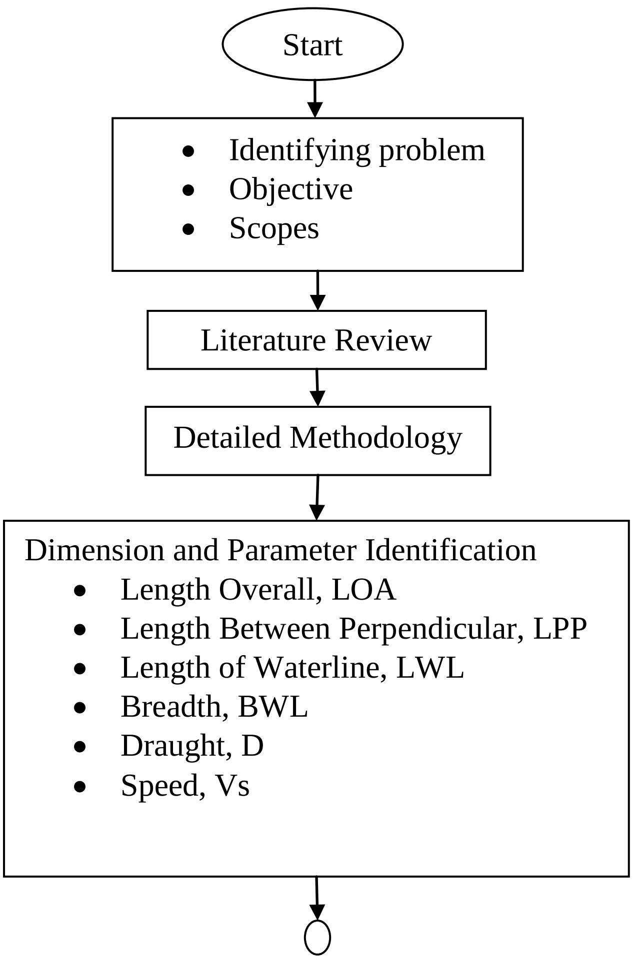
Sources: www.offshore-technology.com/contractors/safety/noreq2/

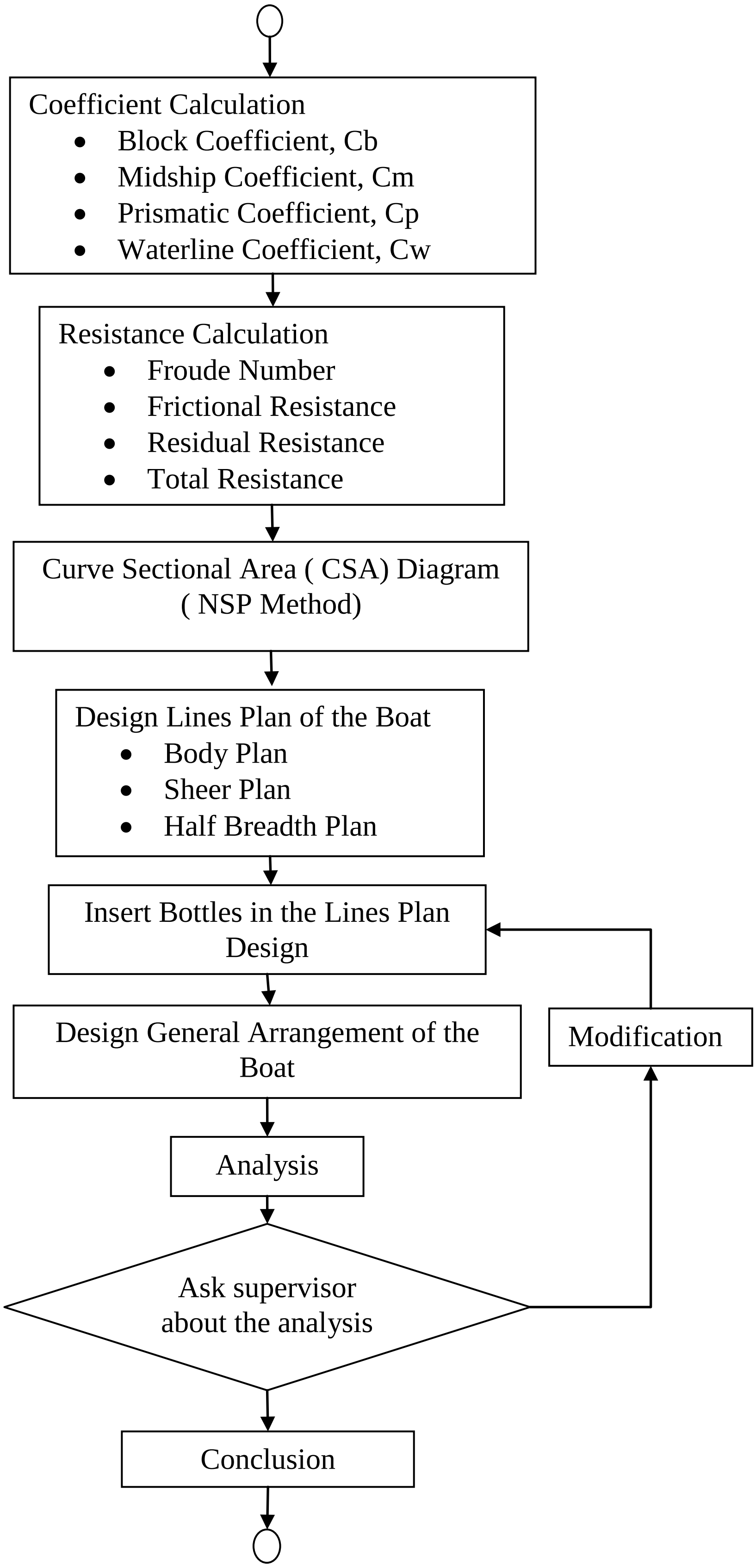
CHAPTER 3

METHODOLOGY

3.1 PROJECT PROCESS FLOW

This flow chart display on the plan design of the project start from the research up to the design analysis.




Coefficient Calculation
Block Coefficient, Cb
Midship Coefficient, Cm
Prismatic Coefficient, Cp
Waterline Coefficient, Cw
Resistance Calculation
Froude Number
Frictional Resistance
Residual Resistance
Total Resistance
Curve Sectional Area (CSA) Diagram (NSP Method)
Design Lines Plan of the Boat
Body Plan
Sheer Plan
Half Breadth Plan
Insert Bottles in the Lines Plan Design
Design General Arrangement of the Boat
Modification
Analysis
Ask supervisor about the analysis
Conclusion

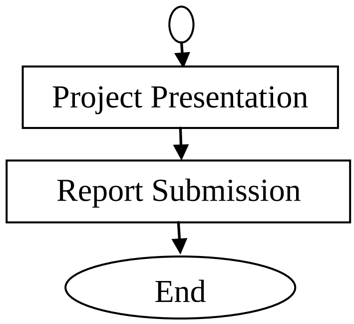


Figure 3.1: Project process flow chart

3.2 PARAMETER IDENTIFICATION

Start the design by deciding the desirable dimension and speed of the rescue boat. The parameters are as follows:

Length Overall, LOA (m)
Length Between Perpendicular, LPP (m)
Length of Waterline, LWL (m)
Breadth, B (m)
Draught, D (m)
Speed, Vs (knots)

3.3 COEFFICIENT CALCULATION

After identify all the parameters for the boat dimension, all coefficients must be calculated. The coefficient includes block coefficient, midship coefficient, prismatic coefficient and waterline coefficient.

3.3.1 Block Coefficient

$$Cb,pp = \frac{V}{Lpp \times Bwl \times D} \tag{3.1}$$

Cb,pp : *Block coefficient*

V : *Displaced Volume*

Bwl : *Breadth at waterline*

D : *Draft*

3.3.2 Midship Coefficient

$$Cm = \frac{Am}{Bwl \times D} \tag{3.2}$$

Cm : *Midship coefficient*

Am : *Midship Area*

Bwl : *Breadth at waterline*

D : *Draft*

3.3.3 Waterline Coefficient

$$Cwl = \frac{Awl}{Lwl \times Bwl} \tag{3.3}$$

Cwl : *Waterline coefficient*

Awl : *Area at waterline*

Bwl : *Breadth at waterline*

3.3.4 Prismatic Coefficient

$$Cp = \frac{V}{Am \times Lwl} = \frac{V}{Cm \times Bwl \times D \times Lwl} = \frac{Cb}{Cm} \quad (3.4)$$

Cp : *Prismatic Coefficient*

Cm : *Midship Coefficient*

V : *Displaced Volume*

Lwl : *Length at waterline*

Bwl : *Breadth at waterline*

D : *Draft*

3.4 DETERMINATION OF RESCUE BOAT RESISTANCES

3.4.1 Frictional Resistance, RF

$$Rf = Cf \times K \quad (3.5)$$

Rf : *Frictional Resistance*

Cf : *Resistance Coefficient*

K : *Reference Force*

3.4.2 Residual Resistance, RR

$$Rr = Cr \times K \quad (3.6)$$

Rr : *Residual Resistance*

Cr : *Residual Coefficient*

K : *Reference Force*

3.4.3 Total Resistance, RT

$$RT = RF + RR + RA \tag{3.7}$$

Rt : *Total Resistance*
Rf : *Frictional Resistance*
Rr : *Residual Resistance*
Ra : *Air Resistance*

3.5 CURVE SECTIONAL AREA (CSA) DIAGRAM

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

3.5.1 Midship Area (Am)

$$Am = B \times D \times Cm \tag{3.8}$$

Am : *Midship Area*
B : *Breadth*
D : *Draft*
Cm : *Midship Coefficient*

3.5.2 Longitudinal Centre of Buoyancy

The Longitudinal Centre of Buoyancy (LCB) expresses the position of the centre of buoyancy and is defined as the distance between 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.

3.5.3 Prismatic Coefficient for boat's foremost and aft most

After determining the Longitudinal Centre of Buoyancy (LCB), further the analysis by calculating the boat's Aftmost Prismatic Coefficient and Foremost Prismatic Coefficient. The value for (Cpf – Cpa) must be get first.

3.5.3.1 Foremost Prismatic Coefficient, Cpf

$$Cpf = Cp + \frac{(Cpf - Cpa)}{2} \tag{3.9}$$

Cpf : *Foremost Prismatic Coefficient*
Cp : *Prismatic Coefficient*
Cpa : *Aftmost Prismatic Coefficient*

3.5.3.2 Aftmost Prismatic Coefficient, Cpa

$$Cpf = Cp - \frac{(Cpf - Cpa)}{2} \tag{3.10}$$

Cpf : *Foremost Prismatic Coefficient*
Cp : *Prismatic Coefficient*
Cpa : *Aftmost Prismatic Coefficient*

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

Nederlandsch Scheepbouwkundig Proefstation (NSP) is one method that can be used to get 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 get by multiply area percentage of each section from NSP diagram with Midship Area, Am. In order to get area percentage in the NSP diagram (Appendix 3), Vs/ Lpp is calculated and the 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.

3.6 DESIGN THE BODY OF THE BOAT

Based on the dimension the designed rescue boat, draw the body of the rescue boat by using DELFT SHIP MARINE software. This software is user friendly as it can do orthographic projection based on the dimension and curve sectional area created in the previous section.

Starting the design by drawing the body of the rescue boat is to visualize the shape of designed rescue before doing the lines plan.

3.7 WASTE PLASTIC BOTTLES PROPERTIES

Figure 3.1: Waste plastic bottles

Take several samples of waste plastic bottles and measure the properties on mass and volume of the boat. Measure dimension for each bottle and convert it into AutoCAD 2009 drawing.

3.8 DESIGN THE BOAT

Design Software

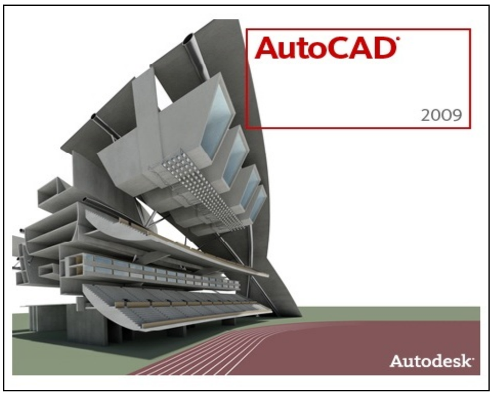


Figure 3.2: AutoCAD 2009 Software

<u>AutoCAD 2009</u>

Description:

- Used as a medium to draw the design for Lines Plan and General Arrangement.

3.81 Lines Plan Drawing

Step for lines plan drawing:

i. Based on the body design in DELFT SHIP MARINE software, export the design in AUTOCAD 2009.
ii. Create the Body Plan, Sheer Plan and Half Breadth Plan.
iii. Convert the dimension of waste plastic bottle selected and convert the drawing into AutoCAD drawing.
iv. Make the orientation arrangement of the waste plastic bottles.
v. Fill the arrangement of waste plastic bottles into the lines plan drawing under the waterline area

3.8 General Arrangement

From the lines plan drawing, general arrangement can be drawn. Design the general arrangement that include seat for 6 victims, engines spaces and storage tanker than can store foods and first aid kits for the victims.

3.9 ANALYSIS

Quantity of the waste plastic bottles used been analyze. The mass of the arrangement is the to be calculated. The analysis is to check whether overall mass exceed the displaced volume. If the total mass exceeds the displaced volume, the design boat will sink. Further modification need to be done if so.

3.10 SUMMARY

In summary, the design process starts from setting the dimension for the rescue boat. After setting up the dimension, calculation on some coefficient related and resistance of the boat must be done. This is to make sure that the parameter for the dimension is compatible for the design boat to float on water. The process then follow by sketching curve sectional area diagram by using NSP method. This diagram will determine the parabolic curve at the bottom of the rescue boat. After sketching up curve sectional area of the boat, the design body of the boat can be draw by using DELFTSHIP Marine Software. Orthographic projection of the design body of the boat is draw and then converts the drawing into AUTOCAD 2009. After that, Lines Plan of the designed boat can be draw. The arrangement of the waste plastic bottles at under waterline volume of the rescue boat is to be designed. If the arrangement of the waste bottles does not fit the displaced volume, the arrangement must be redesign. After that analysis on mass design of the boat is to be made. Finally, the general arrangement of the rescue is to be design.

CHAPTER 4

RESULTS & ANALYSIS

4.1 INTRODUCTION

This chapter will present all the design drawing from start of the design until the General Arrangement. All analysis of the design been shown in this chapter.

4.2 DESIGN OF THE RESCUE BOAT

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

4.2.1 Design Dimension of the Rescue Boat

Tables 4.1 are listed the dimensions of designed rescue boat.

Table 4.1: Dimension of Rescue Boat

Parameter	**Value**
Length Overall, LOA	6.000 m
Length between perpendicular, LPP	4.692 m
Length of waterline, LWL	4.837 m
Breadth, B	1.400 m
Breadth on waterline, BWL	1.177 m
Draft, D	0.250 m
Speed, V	20 knots

4.2.2 Design of Rescue Boat Body

Figure 4.1 showed the design of the preliminary body of the rescue boat before it is further design using waste plastic bottles. It is based on the design dimension showed in Table 4.1. The drawing applied orthographic projection.

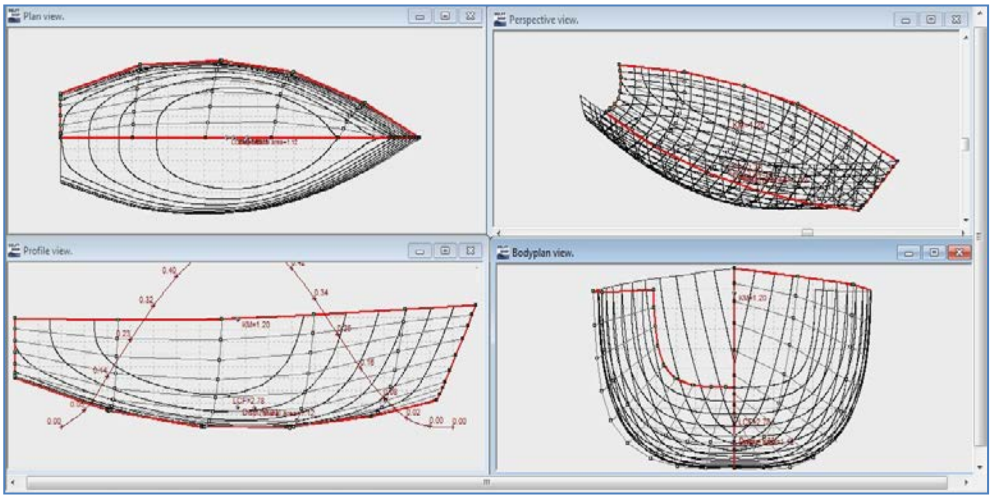


Figure 4.1: Preliminary design of rescue boat body

Figure 4.2 showed the profile view of the rescue boat. It is drawn based on the curve section sectional area as shown in the figure.

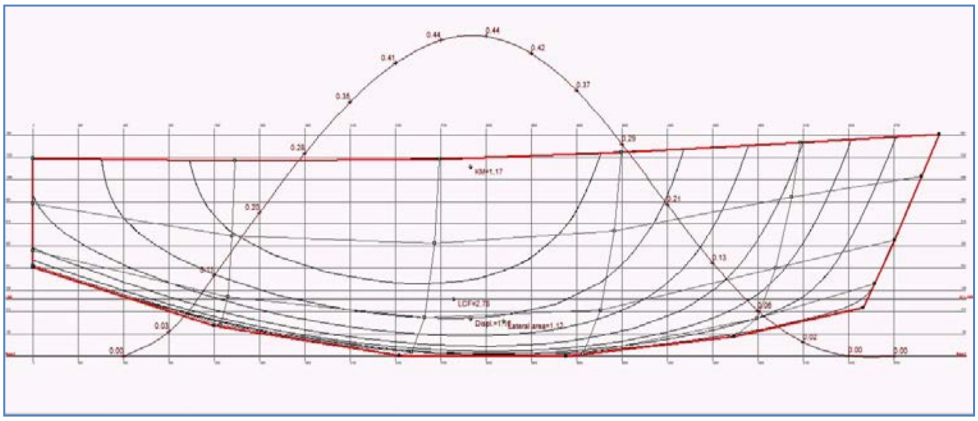


Figure 4.2: Profile view of rescue boat

Figure 4.3 showed the body plan view of the rescue boat. While Figure 4.3 showed the plan view of the rescue boat. It is an orthographic projection form the profile view in Figure 4.1. Figure 4.5 is the perspective view of the rescue boat body to visualize how the boat looks like.

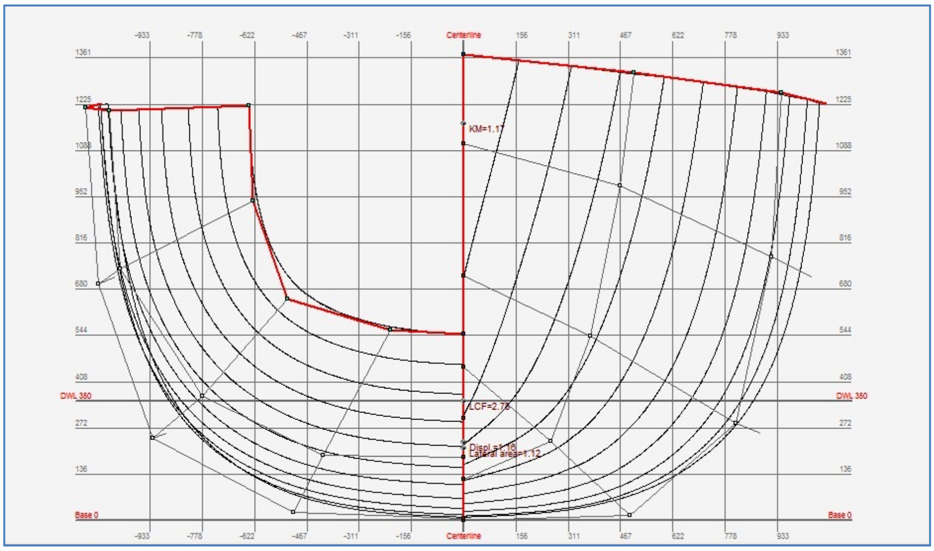


Figure 4.3: Body Plan view of rescue boat

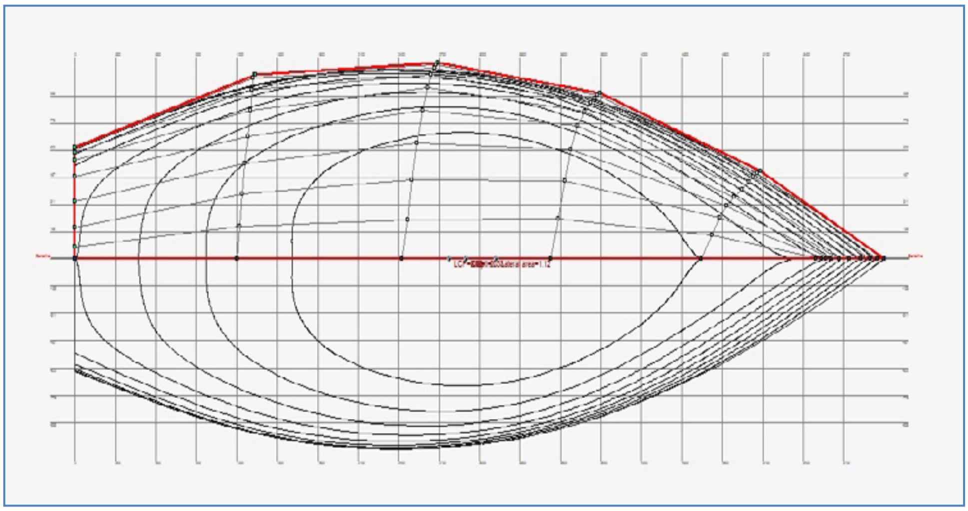


Figure 4.4: Plan view of rescue boat

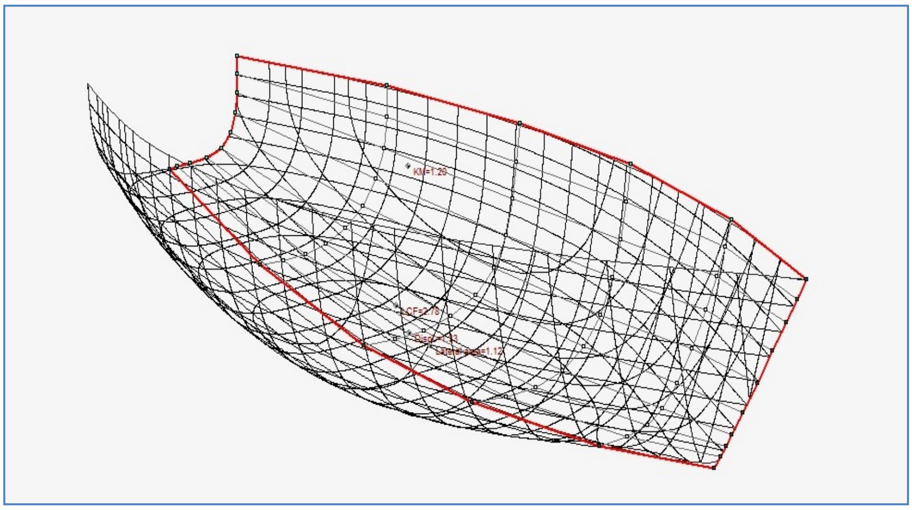


Figure 4.5: Perspective view of rescue boat

4.2.3 Hydrostatic Analysis

Hydrostatic analysis of the design was analyzed by DELFT SHIP MARINE software based on the design dimension of the rescue boat.

Table 4.2: List of Coefficient of Rescue Boat

Coefficient	Value
Block Coefficient, *Cb*	0.2441
Midship Coefficient, *Cm*	0.5760
Prismatic Coefficient, *Cp*	0.4239
Waterline Coefficient, *Cw*	0.4400

Based on the coefficient listed in Table 4.2, the entire coefficients is in the range of standard size rescue boat.

Table 4.3: Volume properties of rescue boat

Volume Properties	Value
Moulded Volume	1.128 m^3
Total Displaced Volume	1.123 m^3
Displacement	1156 kg
Wetted Surface Area	6.543 m^3
Longitudinal Center of Buoyancy	2.899 m
Vertical Center of Buoyancy	0.229 m

Based on Table 4.3, the displacement of the rescue is 1156 kg. The designed the rescue boat estimated to carry 6 persons of victim that have an average weight of 100kg. The designed arrangement of waste plastic bottles will be in the moulded volume.

Table 4.4: Waterplane properties of rescue boat

Waterplane Properties	Value
Length on Waterline	4.803 m
Beam on Waterline	1.749 m^3
Entrance Angle	13.381 degree
Waterplane Area	5.808 m^2
Waterplane Center of floatation	2.784 m

The design of waste plastic bottles arrangement in the lines plan will be under waterline surface. Table 4.4 listed all the water plane properties of the designed rescue boat.

4.3 LINES PLAN DESIGN

The lines plan design of the rescue boat was drawn in AutoCAD 2009 software based on the design created in the DELFT SHIP 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 body plan, sheer plan and half breadth plan.

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4.3.1 Waste plastic Bottles Properties

Waste plastic bottles dimension was showed in Figure 4.6. Mass for dried waste plastic bottles is 39.69 grams.

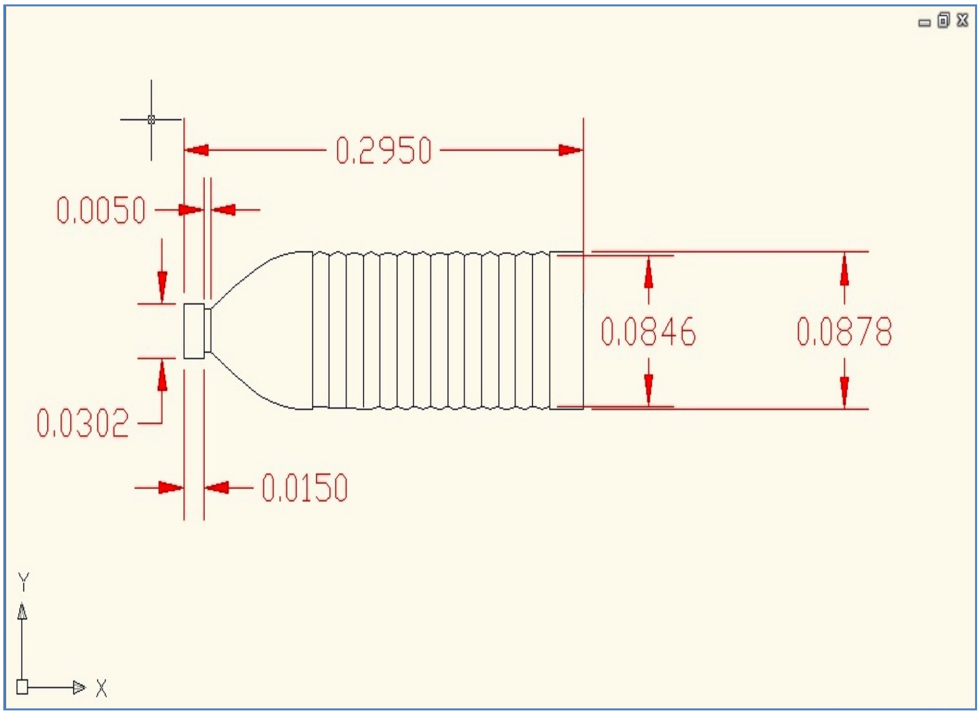

Figure 4.6: Dimensions of waste plastic bottles

4.3.2 Lines Plan of Designed Rescue Boat

Figure 4.7 shows the lines plan of the rescue boat with arrangement of waste plastic bottles in the volume under waterline surface. There are 3 layers of waste plastic bottles arrangement vertically at the center of body plan. (See Figure 4.8)

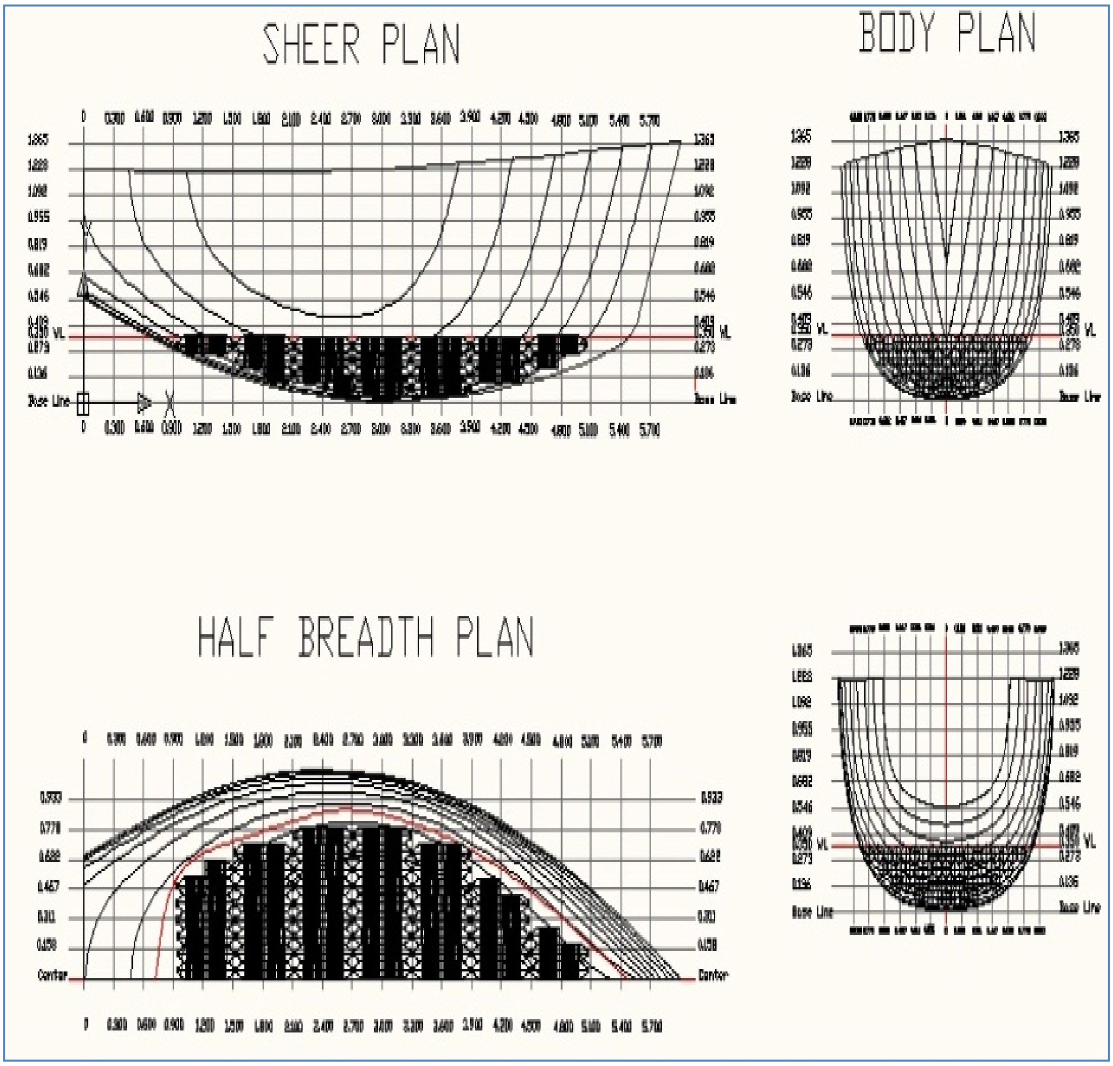

Figure 4.7: Lines of rescue boat

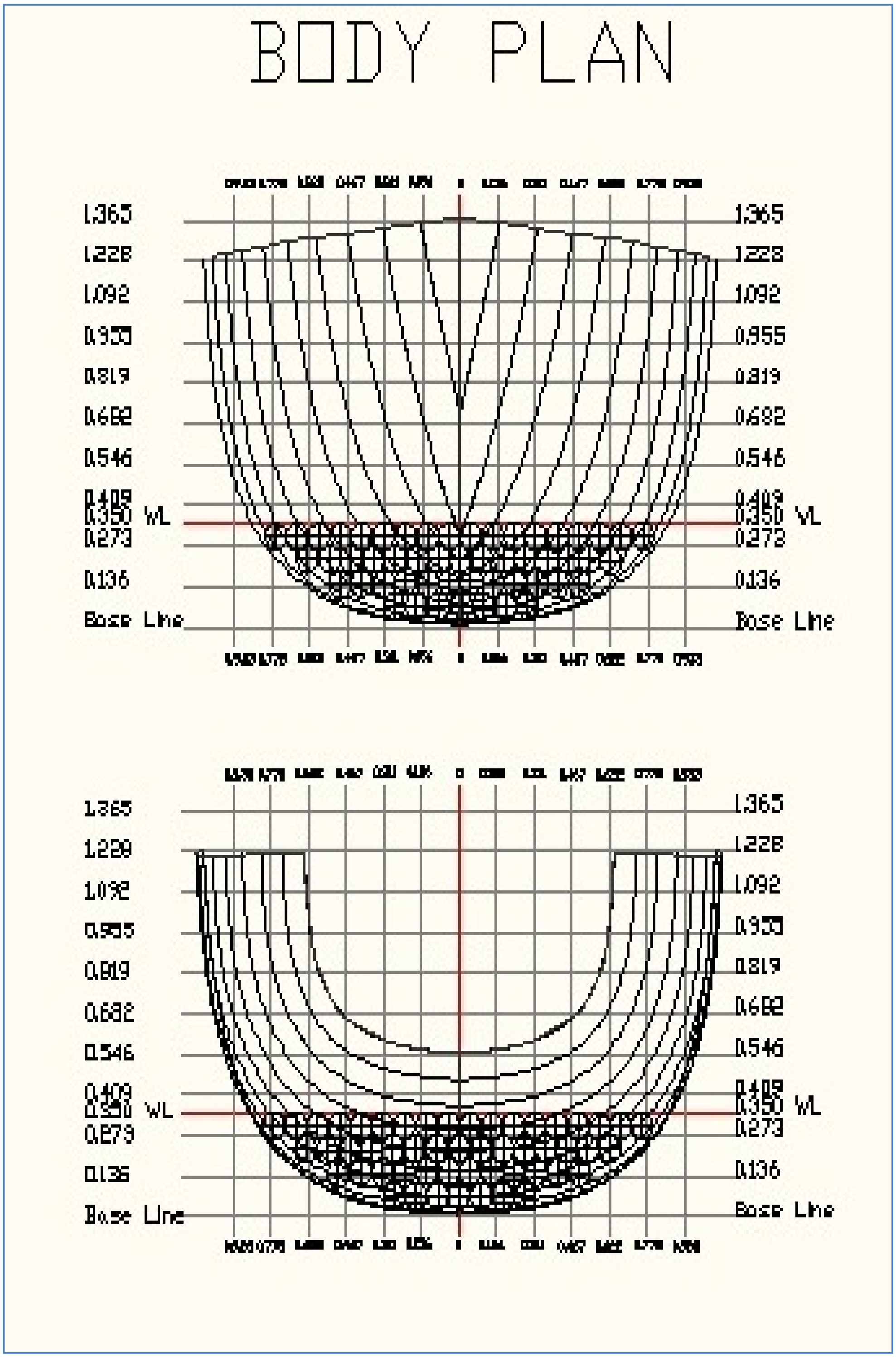

Figure 4.8: Body plan of rescue boat with waste plastic bottles arrangement

Figure 4.9 shows the sheer plan of rescue boat. It visualized the side view of the rescue boat and arrangement of waste plastic bottles horizontally. Figure 4.10 shows the top view of half breadth of the rescue boat.

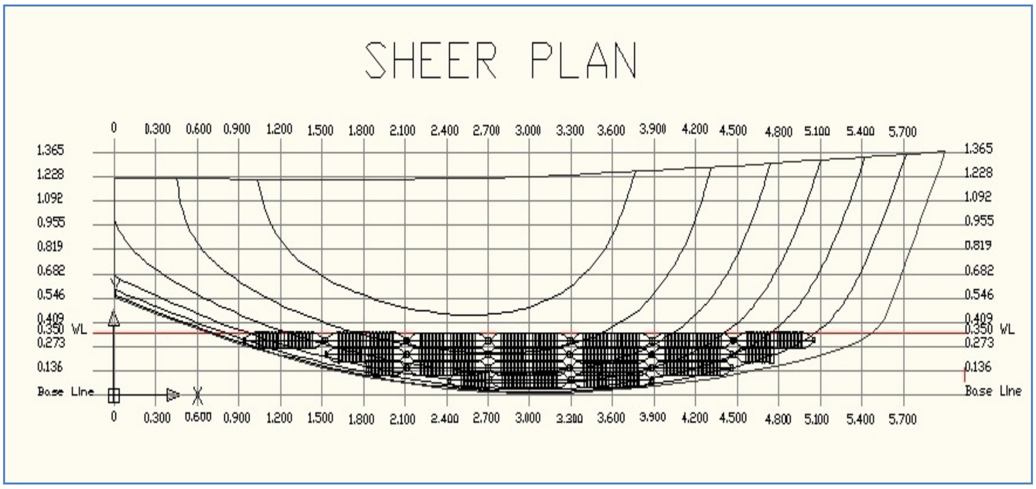

Figure 4.9: Sheer plan of rescue boat

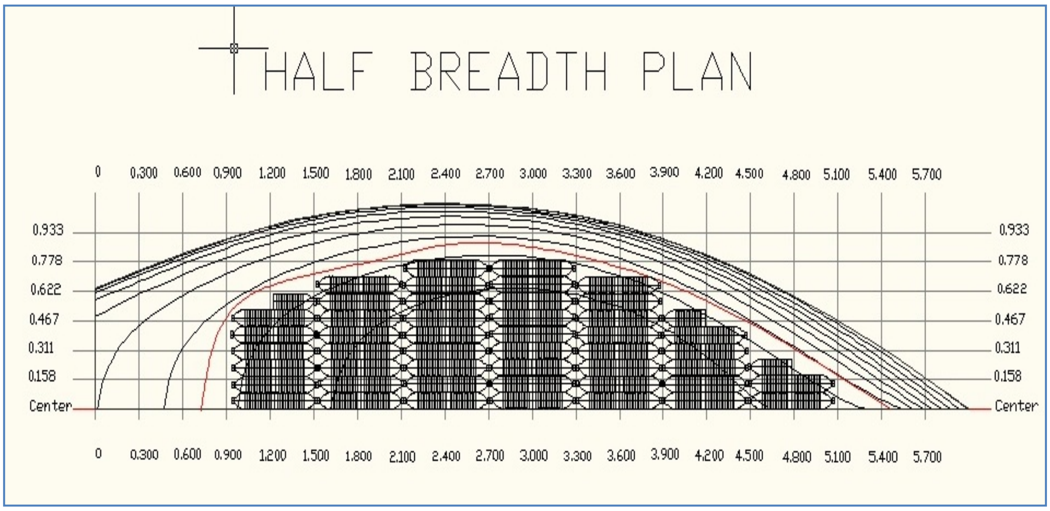

Figure 4.10: Half breadth plan of rescue boat

4.3.2 Mass Design Analysis

The analysis of the lines plan design was to calculate the total mass of waste plastic bottles been used in the design. Vertically, the arrangement of waste plastic bottles has 4 layers. This 4 layer been used as a base point to calculate the total mass in the arrangement.

Table 4.4: Mass analysis of waste plastic bottles

Layer	Mass of Bottle (kg)	Total Bottle	Total Mass (kg)
Layer 1	0.03969	127	5.04063
Layer 2	0.03969	89	3.53241
Layer 3	0.03969	56	2.22264
Layer 4	0.03969	31	1.23039
Total		**303**	**12.02607**

Based on Table 4.4, total quantity of waste plastic bottles need to be used for the design is 303 bottles. The total mass is 12.02607 kg.

As mentioned earlier, the total number of people on the rescue boat at 1 time is 6 peoples of an average 100kg. It shows the design of waste plastic bottles arrangement not exceeding the total displacement of the rescue boat which is 1156 kg.

Thus, the arrangement of waste plastic bottles will save the boat from sinking when the fiberglass layer cracks.

4.4 GENERAL ARRANGEMENT

Figure 4.11 show the details arrangement of the rescue boat. The rescue has 6 seats, 1 engine space and 1 storage tanker for rescue. The storage tanker is designed to store some foods, first aid kit, medicine, torchlight, compass and other relevant things.

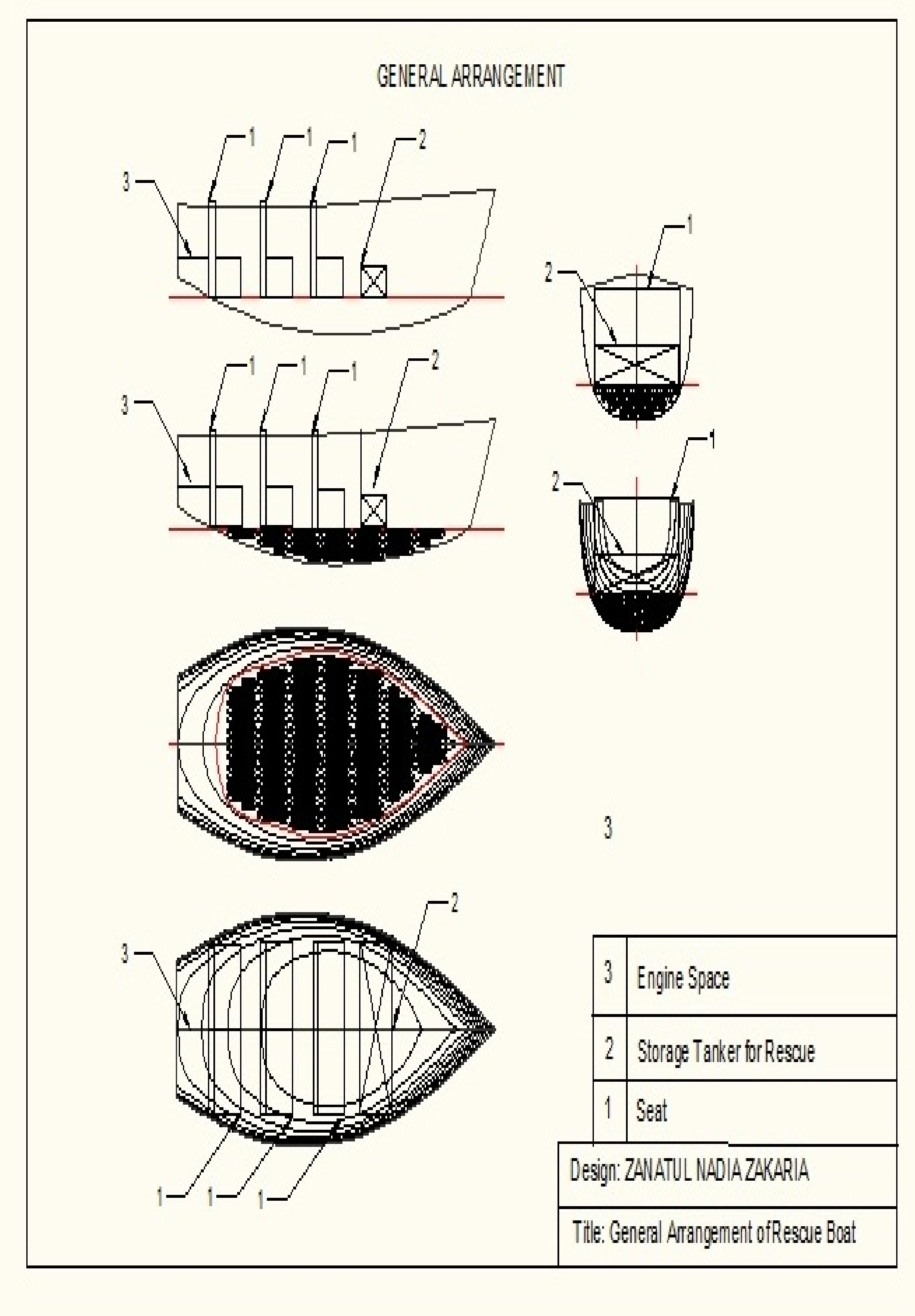

Figure 4.11: General arrangement of rescue boat

4.5 SUMMARY

In summary, the rescue boat is 6 metre in length overall, 4.692 metre in length between perpendicular and 4.837 in length at waterline. The breadth of the rescue boat is 1.4 metre while draft of the rescue boat is 0.250 metre. The rescue boat is design to move at 20 knots speed. The design of fiberglass rescue boat in uses 303 of 1.5Litres waste plastic bottles to be fit at the displaced volume of the boat. As the displaced volume of the rescue boat is 1156 kg, the rescue compatible for 6 persons on an average weight of 100 kg. Total mass of the waste plastic bottles been used in this design is 12.0261kg. The designed rescue boat has 6 seats, 1 engine space and 1 storage tanker for rescue purpose such as to store foods, first aid kit, torchlight, compass and other relevance things.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Designed of fiberglass rescue boat that have arrangement of waste plastic volume at the under waterline volume of the boat was done. The rescue boat is 6 metre in length overall, 4.692 metre in length between perpendicular and 4.837 in length at waterline. The breadth of the rescue boat is 1.4 metre while draft of the rescue boat is 0.250 metre. The rescue boat is design to move at 20 knots speed. The design of fiberglass rescue boat in uses 303 of 1.5Litres waste plastic bottles to be fit at the displaced volume of the boat. As the displaced volume of the rescue boat is 1156 kg, the rescue compatible for 6 persons on an average weight of 100 kg. Total mass of the waste plastic bottles been used in this design is 12.0261kg. The designed rescue boat has 6 seats, 1 engine space and 1 storage tanker for rescue purpose such as to store foods, first aid kit, torchlight, compass and other relevance things.

5.1 RECOMMENDATION

The design in this thesis is only a preliminary design of the rescue boat. Further detailed design need to be made before the design undergo for production. Stability and bongeance of the ship also need to be calculate before it can be fabricated. In order to get accurate design of waste plastic bottles same as volume displaced by the boat, fabricator should rearrange the bottles to fit the space unfilled. This can be done by try and error method. Other than that, fabricator can combined the bottles and glue it tight so that the unfilled of volume displaced can the new volume of waste plastic bottle made. Fabricator must make sure that the new volume of waste plastic bottles is tight and there no leaking point at the bottles. If so, the boat will sink. Besides that, fabricator can use different size of waste plastic bottles so that the small unfilled space can be filling with small size of waste plastic bottle.

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