Flood Rescue Boat as One of the Alternatives in Indonesia Waterways

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ABSTRACT

Flooding is the most frequent disaster that hit Indonesia, especially in big cities with poor urban planning. Infrastructure damage has occurred, the fatalities which are likely to occur, both during floods and after floods. So far, the fatalities caused by floods are very difficult to control and even tend to increase. This condition is getting worse with the lack of facilities that support the evacuation process of flood victims. The aim of the study was to design a lifeboat that was able to evacuate flood victims and be able to overcome other problems that might arise when the evacuation process runs more efficiently. By collecting data from several agencies related to flood mitigation problems, interviews with experts, as well as several other references, it is hoped that relevant data can be collected, which can provide solutions to the problems faced. The stages of the research included the creation of concepts and the design of a hull shape that was adjusted for a flood rescue boat, a boat with high stability. By using of the Maxsurf V.8.5 and Hydromax V.8.5 program, it is expected that the design process and calculation of boat stability can be done more quickly and accurately. The results of research for several areas affected by floods, the existence of a rescue boat as a means to evacuate victims is urgently needed. So that the provision of a multifunctional flood rescue boat is the perfect solution to overcome this problem. To carry out this function, the stability of the rescue boat flood is one of the factors that must be considered so that the evacuation process can be carried out safely.

KEY WORDS: *Flood rescue boat, Maxsurf V.8.5, Hydromax V.8.5, Stability.*

1.0 INTRODUCTION

For many years, a metropolitan city in Indonesia has many disasters. From earthquake, tsunami, flood and other things that people in the area of disasters lost various things, including their lives. There are various types of disasters that could occur in this case, one of those is the disaster that could be predicted and one that is happening periodically. Based on the type, Indonesian people and the government could do a preventive action to least minimize the damage that might happen in the area. Apparently, this preventive action still not as effective as people hoped. There are various preventive actions to ensure that disasters not happening, but people could forget that the first-aid action is as important as preventive action to minimize the damage.

Based of the observations, it shows that the challenge of the periodical disaster (like flood) is the responsiveness of the first-aid help. Looking at flooding in Indonesia, especially in Jakarta around the year 2000, it is seen that the current drainage system still needs more improvement. A heavy rain that goes non-stop makes the volume of the water from 13 rivers from around Jakarta-Bogor-Puncak-Cianjur and with addition of the high tide makes almost 60% of Jakarta to be submerged with flood. This flood has water with a height reach 5m on several locations. Damage that happens in this state is astronomical. This is happened due to many reasons, such as not enough personnel and not enough facilities.

Based on those experiences, the idea to design a flood rescue boat as one of the alternatives to minimize the damage from flooding came. This boat will be equipped with various facilities needed including the first aid help for the victim of the flooding. The main purpose of this boat is to evacuate the people who are trapped in a tight street, alley or even small pathway around their

homes/location. This flood rescue boat also equipped with a fire extinguisher. We are hopeful that the realization of this boat could minimize the life victim and material losses.

Research Main Point

This research is focusing on designing the hull from the flooding rescue boat. Those design needs to have a high stability and needs to be suitable with the environment and condition at the site the boat will be operated. In order to gain a better calculation in the stability, each factor that correlated with stability will be calculated using a CFD program. After the design of the hull is finished, the design will be added until the General Arrangement of the ships. This General Arrangement of the boat is to ensure that based on the design, this boat could move and operated around the alley and it could be operated with a flood height around 0.5 m minimum. This flood rescue boat is focused in area in Jakarta with the height of the building around 8 meter minimum (2 stores building) with the minimum of flood height is around 2 meters.

The design of this boat construction is made with class register of the Lloyd Register. The Fire classification that is used the class a classification (Fuel will leave carbon and ashes when burned). The firefighting tools will be used a portable pump, and we will ignore the influence of the dynamic movement of the pump to the boat motion.

2.0 DESIGN REQUIREMENT

2.1 Boat Design

Based on [1] by Gerard Dijkstra, the methodical approach used for designing the boat is not much different from designing ships or other marine vessel. In general, there are 4 design process, which are:

1. Make and state the design requirement
2. Formulating the design concept (design problem-solving)
3. Determination of ship design characteristic
4. Evaluate the solution

Steps 2-4 will be evaluated and revised over and over until the requirement stated in step 1 is fulfilled. In special cases, which there is no problem solving to fulfilled the regulation or there are some issues for the requirement, then the design requirement needs to be recheck and revised until the required terms could be tolerated.

2.2 Planned Design

Based on the design process, there are several things that we need to set up for our design:

a) Capacity

This requirement is including deadweight, cargo load, cargo capacity, amount of crew and estimated passenger and others. This requirement will be correlated with the setup and basic design of the space area, accommodation for the passenger, and placement of safety equipment. Based on the survey of Search and Rescue Team in Surabaya, for boat with the operational in the main city land, it needs to be able to carry passenger around 8-10 people with equipment such as life jacket, first aid kit, fire extinguisher and paddle in it. However, based on Australian Emergency Manuals Series (AEMS) the boat also

needs several equipment in it. Those equipment is shown in the Table 1.

Table 1: Equipments in the ship

EQUIPMENT	QUANTITY
Basic Equipment	
Personal Floatation Devices(life jackets in accordance with AS1512)	1 for every person up to the anticipated loading
Oars with rowlocks (to match) (or) Paddles	1 pair of each
Anchors (complete with chain and line attached):	
Danforth or reef anchor	1
Galvanised metal bucket or bailer, (min 9 liter, fitted with lanyard of at least 2m)	1
First aid kit (waterproof)	1
Approved fire extinguisher	1
Torch (waterproof with spare batteries)	1
Spotlight (complete with batteries)	1
Drinking water	
Bolt cutters	1
Wire cutters	1
Axe/hatchet	1
Bow and stern lines (10m x 12mm)	1
Boat hook	1
Towing bridle	1
Knife (with sheath)	1
Fuel tank (complete with fuel lines)	2
Propeller	2 spare
De-watering spray (WD 40 or similar)	
Ropes	as required
Split pins	
Shear pins	
Spare bungs	
Tool kit (complete)	
Safety chain (motor to transom)	
Radio (complete with Antenna)	
Navigation lights	
Maps, charts and compass	
Special Equipment	
Stretcher	
Space blankets	

b) Principal Dimension

The main point of this boat is designed to be able to carry 9 person in it. Based on the calculation, the principal dimension of this boat is : $L_{pp} = 4.87$ m, $B = 1.87$ m, $L_{pp} = 0.17$ m

c) Hull Shape

The shape of hull is based on the area of the boat operation. Because the depth of the water from the flood could be too shallow, then the hull is shaped into a flat bottom. This is done with the purpose to reduce the draft dimension. With the same displacement and length, bottom flat tend to have a smaller draft rather than V shape hull or catamaran. Other than that, bottom flat also make the evacuation process smoother.

d) Pump Requirement

Head Pump is the height or space needed to be achieved by a pressurized fluid based on the pump pressure and losses in the system itself. Head will be calculated with the formula:

$$h = \frac{p \times 10.197}{SG} (m) \quad (1)$$

$$Q = 449 \times V \times A \quad (2)$$

$$BHP = \frac{Q \times h \times SG (\text{Specific Gravity})}{3960 \times \text{eff}} (HP) \quad (3)$$

e) General Arrangement

General arrangement of the ship will be designed based on the literature review and the experiment from previous studies. The design of the general arrangement will be measured and will be compared with existing data. In order to be designed perfectly, there is information to obtain:

• Ships Principal Dimension

- Crew Section:** Based on the field survey in Surabaya, there are two type of crew in the rescue boat. Those crew main job are:

- As the navigator of the boat
- As the evacuator for the victim

However, in the reality both of these crew needs to be able to do both of the tasks. The crew needs to be a multifunction crew.

- Main Propulsion:** Based on the field survey in Surabaya, the engine used in the rescue boat has 2 types. One that used with a 15 HP engine or one with the 25 HP engine. In the field itself, it is estimated to use the 15 HP engine due to its efficiency when rescuing people. When the evacuation process is started, the boat needs to have a relatively low speed to help people went overboard the rescue boat.

f) Deadweight Calculation

In order to calculate Deadweight (DWT), there are 3 conditions in this rescue boat. Those conditions are: Rescue, Supply and Firefighting. DWT itself is calculated based on several things, those are:

- Weight of Fuel oil M/E
- Weight of Fresh Water
- Weight of Pump & its equipment
- Weight of Food supply
- Weight of the Crew & its belonging
- Weight of residual (Emergency factor)
- Weight of Net Tonnage (Weight of the estimated victim)
- Weight of rescue equipment

g) Quick Riling System and Ladder Platform

In principle, Quick riling system has the same function with the *bollard* on ships. However in this case, quick riling system is used to binding one boat to another. Those united / bonded boat has a different purpose. One of those purposes is used as the bridge for other people to cross in the flooding condition.

Ladder Platform is also used as the main tool to help the people get onboard of the rescue boat in evacuation process. The ladder is located in front of the boat. This placement of ladder is set on the front in order to keep the stability of the boat in a good region.

3.0 DESIGN CALCULATION & ANALYSIS

3.1 Calculation

For DWT in this boat, there are 3 stage of the operation mode. Those modes are:

- Rescue condition
- Distribute & Supply condition
- Fire fighting condition mode

From that entire operation mode, the heaviest condition is on the evacuation mode. Because of this reason, the calculation of DWT will be estimated on evacuation mode with this calculation:

a. Weight of M/E Fuel (Wfo)

$$Wfo = 80 \% \times BHP \times 0.17 \times \text{days}$$

$$\begin{aligned} Wfo &= 80 \% \times 15 \times 0.17 \times 1/8 \\ &= 0.255 \text{ kg} \times 2 \text{ Engine} \\ &= 0.51 \text{ kg} \end{aligned}$$

b. Weight of Crew (Wcp)

$$Wcp = Ze \times Ccp$$

$$\begin{aligned} Wcp &= 2 \times 65 \text{ kg} \\ &= 130 \text{ kg} \end{aligned}$$

c. Weight of the Cargo - victim of Flood (Wpc)

$$Wpc = Ze \times Cpc$$

$$\begin{aligned} Wpc &= 9 \times 65 \text{ kg} \\ &= 585 \text{ kg} \end{aligned}$$

d. Weight of the equipment

$$W.Peral = W. \text{ Life Jacket} + W. \text{ First aid} + W. \text{ row tools} + W. \text{ main engine} + W. \text{ platform}$$

$$\begin{aligned} W. \text{ Life jacket} &= (\text{Crew} + \text{Victim}) \times W \text{ Life jacket} \\ &= 11 \times 2 \text{ kg} \\ &= 22 \text{ kg} \end{aligned}$$

$$\begin{aligned} W. \text{ Fisrt Aid Kid} &= \text{amount.} \times W \text{ First aid} \\ &= 9 \times 3 \text{ kg} \\ &= 27 \text{ kg} \end{aligned}$$

$$\begin{aligned} W. \text{ Row tools} &= \text{amount.} \times W \text{ row} \\ &= 2 \times 5 \text{ kg} \\ &= 10 \text{ kg} \end{aligned}$$

$$\begin{aligned} W. \text{ Main Engine} &= \text{amount.} \times W. \text{ main engine} \\ &= 1 \times 50 \text{ kg} \\ &= 50 \text{ kg} \end{aligned}$$

$$\begin{aligned} W. \text{ platform} &= \text{amount.} \times \text{platform} \\ &= 1 \times 7 \text{ kg} \\ &= 7 \text{ kg} \end{aligned}$$

$$\begin{aligned} W. \text{ fire extinguisher} &= \text{amount.} \times \text{fire extinguisher} \\ &= 1 \times 5 \text{ kg} \\ &= 5 \text{ kg} \end{aligned}$$

$$\begin{aligned} W. \text{ equipment} &= 22 \text{ kg} + 27 \text{ kg} + 10 \text{ kg} + 50 \text{ kg} + 7 \text{ kg} + 5 \text{ kg} \\ &= 121 \text{ kg} \end{aligned}$$

$$\begin{aligned} DWT &= Wfo + Wcp + Wpc + W \text{ equipment} \\ &= 0.51 \text{ kg} + 130 \text{ kg} + 585 \text{ kg} + 121 \text{ kg} \\ &= 836.51 \text{ kg} \end{aligned}$$

$$\text{Planned DWT} = 836.51 \text{ kg}$$

For the LWT calculation and planned design, it will be calculated using another sister ship based on the same type with

the planned boat. The data about sister ship is shown on Table.2

Table 2: Rescue boat sister ship

No.	LOA (m)	B (m)	H (m)	T (m)	LWT (ton)	Cb	Displ (ton)
1	4.87	1.87	0.53	0.17	0.297	-	1.184

$$\begin{aligned}
 \Delta(p) &= 1.184 \text{ ton} \\
 \text{LWT}(p) &= 0.297 \text{ ton} \\
 \text{DWT}(p) &= \Delta - \text{LWT} \\
 &= 1.184 - 0.297 \\
 &= 0.887 \text{ ton} \\
 &= 887 \text{ kg} \\
 (\text{LWT} / \Delta) 100\% &= (0.297 / 1.184) 100\% \\
 &= 25.084 \% \\
 \text{LWT} (p) &= 25.084 \% \Delta (p) \\
 \Delta (p) &= \left(\frac{100}{25.084} \right) \text{LWT} (p) \\
 \text{LWT} (p) + \text{DWT} (p) &= \Delta (p) \\
 \text{LWT} (p) + \text{DWT} (p) &= \left(\frac{100}{25.084} \right) \text{LWT} (p) \\
 \text{DWT} (p) &= \left(\frac{100}{25.084} - 1 \right) \text{LWT} (p) \\
 \text{LWT} (p) &= \frac{\text{DWT}(p)}{\frac{100}{25.084} - 1} \\
 \text{In conclusion} \\
 \text{LWT (planned)} &= \frac{\text{DWT(planned)}}{\frac{100}{25.084} - 1} \\
 \text{LWT (planned)} &= \frac{836.51 \text{ kg}}{\frac{100}{25.084} - 1} \\
 &= 280 \text{ kg}
 \end{aligned}$$

After the value of LWT & DWT is calculated and planned, then the value of weight displacement could be obtained using:

$$\begin{aligned}
 \text{Displacement} &= \text{DWT} + \text{LWT} \\
 &= 836.51 \text{ kg} + 280 \text{ kg} \\
 &= 1116.51 \text{ kg}
 \end{aligned}$$

Displacement used in this design is 1150 kg. To make a new principal dimension, data from various sister ships in Table 3 is used.

Table 3: Recap of rescue boat sister ship

No.	LOA	B	H	T	Cb	Displ.
1	4.87	1.87	0.53	0.17	-	1.18
2	4.85	1.83	0.5	0.18	0.80	1.31
3	4.20	1.85	0.8	0.2	0.80	1.35
4	4.50	2.5	0.55	0.23	0.84	1.50

Length (Designed)

Using equation of the ship length and the function of the ship displacement, $L = f(\Delta)$

Displ - L	
$y = m.x + b$	
m =	0.3897
b =	4.3470
y =	$0.3897 X + 4.3470$
L for Displacement of 1150 kg	
L =	4.795108999

Figure 1: Length of Regression Displ - L

Based on the graph in Figure 1, it could used the formula:

$$\text{Length (L)} = 0.3897 (\Delta) + 4.3470$$

$$\text{So the L} = 4.795108999 \text{ m}$$

$$\text{L used} = 4.8 \text{ m}$$

Using the same principal, the value of B, T, H will be used the regression shown in Figure 2-4. Function of displacement, $B = f(\Delta)$.

Displ - B	
$y = m.x + b$	
m =	0.0608
b =	1.7216
y =	$0.0608 X + 1.7216$
B for Displacement of 1150 kg	
B =	1.791440217

Figure 2: Length of Regression Displ - B

Displ - H	
$y = m.x + b$	
m =	0.1070
b =	0.3818
y =	0.1070 X + 0.3818
Draft when displacement is 1150 kg	
H =	0.504923767

Figure 3: Length of Regression Displ – H

Displ - T	
$y = m.x + b$	
m =	0.0690
b =	0.0962
y =	0.0690 X + 0.0962
Height when displacement is 1150 kg	
T =	0.175534693

Figure 4: Length of Regression Displ-T

Based on the graph & table, the value of principal dimension are:

Loa = 4.8 m
B = 1.8 m
H = 0.5 m
T = 0.175 m

After the principal dimension based from the linear regression method for the rescue boat are obtained, then the lines plane will be made using our Maxsurf Professional V 8.5 software. This is made based on the the designed displacement. The making of

linesplan is for the basis of the boat general arrangement for rescue boat. The maxsurf programme will also give us the estimated stability calculation from our boat.

From our displacement results and design in Maxurft, it is estimated that the calculation of displacement is around 1152.1 kg. It is in par with our planned displacement (1150 kg). Because there is a difference, then the correction of the displacement will be made using the formula of :

$$\Delta = \{ [\Delta(\text{Maxsurf}) - \Delta(\text{planned})] / \Delta(\text{Maxsurf}) \} \times 100 \% \quad (3.1)$$

$$= \{ [1152.156 \text{ kg} - 1150] / 1152.156 \text{ kg} \} \times 100 \%$$

$$= 0.187 \%$$

With that percentage, the correction of displacement is met with the requirement. Information from our Maxsurf is the data of the boat Hydrostatic. This information could be seen in Table 4 and Table 5.

Table 4: Hydrostatic of the rescue boat

Displacement	1152.156 kg	LCF from zero pt	-2.514 m
Draft	0.175 m	KB	0.09 m
Lwl	4.315 m	KG	135.4 m
Beam wl	1.735 m	BMt	1.596 m
WSA	8.647 m ²	BMI	9.1 m
Max cross sect area	0.301 m ²	GMt	-133.713 m
Water plane area	7.249 m ²	GMI	-126.21 m
Cp	0.889	KMt	1.687 m
Cb	0.879	KMI	9.19 m
Cm	0.99	Immersion (TPc)	0.072 tonne/cm
Cwp	0.968	MTc	-0.343 tonne.m
LCB from zero pt	-2.62 m	RM at 1deg = GMt.Disp. sin(1)	34.488 kg.m

Table 5: Hydrostatic of the rescue boat using hydromax

1	Draft Amidsh. mm	32.328
2	Displacement kg	192
3	Heel to Starboard degrees	0
4	Draft at FP mm	45.717
5	Draft at AP mm	18.938
6	Draft at LCF mm	31.621
7	Trim (+ve bow down) mm	26.779
8	WL Length mm	3895.558
9	WL Beam mm	1708.928
10	Wetted Area mm ²	6640831.094
11	Waterpl. Area mm ²	6415021.264
12	Prismatic Coeff.	0.709
13	Block Coeff.	0.707
14	Midship Area Coeff.	0.998
15	Waterpl. Area Coeff.	0.964
16	LCB to Amidsh. mm	40.414 Fwd
17	LCF to Amidsh. mm	113.852 Aft
18	KB mm	16.725
19	KG mm	135.400
20	BMt mm	8363.382
21	BML mm	39892.029
22	GMt mm	8244.704
23	GML mm	39773.352

24	KMt mm	8380.107
25	KML mm	39908.754
26	Immersion (TPc) tonne/cm	0.064
27	MTc tonne.m	0.018
28	RM at 1deg = GMt.Disp.sin(1) kg.mm	27629.341

Based on IMO, the height of the point of MG is 0.15 m (minimum):

$$MG = KB + MB - KG$$

From Hydromax obtained data as follows:

$$KB = 0.0167 \text{ m}$$

$$MB = 8.363 \text{ m}$$

$$KG = 0.135 \text{ m}$$

$$MG = 0.0167 + 8.363 - 0.135$$

$$MG = 8.2447 \text{ m (comply)}$$

3.2 Pump Calculation and Arrangement

In the pump firefighting, the firefighting team used several types of the pump. The general pump function is to transfer the liquid from one place to another place. In our firefighting pump, our primary need is to give it enough pressure to transfer the water on a certain height & length. In order to install the pump in our boat, we will use the basic standard from Indonesia fire fighting Department Service:

1. Maximum Capacity of the water is 3400 liter
2. NPSH of the pump is 1.5 m from the land surface
3. Minimum pressure is 4 bar and maximum pressure is around 8 bar
4. Inlet/outlet pipes is around 1.5-4 inch
5. Nozzle diameter is 1.5 inch
6. Fire Monitor (System for water spraying is not using a hose) is made from metal

The calculation of pump needed is:

- a. Planned height based on specific gravity, height and pressure

$$h = \frac{p \times 10.197}{\text{Specific Gravity}} \text{ (m)}$$

Where;

$$p \text{ (Pressure)} = 5 \text{ bar}$$

$$SG \text{ (Specific Gravity)} = 1 \text{ (for freshwater)}$$

$$h = \frac{5 \times 10.197}{1} \text{ (m)}$$

$$h = 50.985 \text{ m}$$

- b. Capacity

$$Q = 449 \times V \times A$$

Where;

$$V = 2 \text{ m/s} = 6.56 \text{ ft/s}$$

$$A \text{ (pipe area)} = \frac{1}{4} \pi D^2$$

$$A = \frac{1}{4} \times 3.14 \times 0.25^2 = 0.049 \text{ ft}^2$$

$$Q = 449 \times 6.56 \times 0.049$$

$$Q = 144.327 \text{ GPM (Gallon per minute)}$$

$$Q = 656.123 \text{ LPM (Liter per Minute)}$$

- c. Pump Power Needed

$$BHP = \frac{Q \times h \times SG \text{ (Specific Gravity)}}{3960 \times \text{eff}} \text{ (HP)}$$

Where;

$$Q = 144.327 \text{ gallons/minute.}$$

$$H = 50.985 \text{ m} = 167.27 \text{ feet.}$$

$$SG = 1$$

$$Eff = 80\% = 0.8$$

$$BHP = \frac{144.327 \times 167.27 \times SG \text{ (Specific Gravity)}}{3960 \times 0.80\%} \text{ (HP)}$$

$$BHP = 5 \text{ (HP)}$$

$$\text{power} = 3.73 \text{ kW}$$

Based on this data, we could make the pump operational procedure for pump calculation. This is could be seen on Table 6 and Figure 2 that shows the correlation between pump capacity and its head with the power from engine is fixed (assumption).

Table 6: Head, Pressure and Capacity on fixed power pump

Head		(Pressure)	Q	
m	feet	Bar	GPM	LPM
60	196.85	5.88	78.38	355.82
55	180.45	5.39	85.50	388.17
50	164.04	4.90	94.05	426.99
45	147.64	4.41	104.50	474.43
40	131.23	3.92	117.56	533.73
35	114.83	3.43	134.36	609.98
30	98.43	2.94	156.75	711.65
25	82.02	2.45	188.10	853.97
20	65.62	1.96	235.13	1067.47
15	49.21	1.47	313.50	1423.29
10	32.81	0.98	470.25	2134.94

Figure 5: Graph of the Head, Pressure and Capacity on fixed power pump

Based on this important, we could install the pump with TS6/6 Ultra Compact. The data for the pump is shown below:

Model	TS 6/6 Ultra-Compact
Pump Capacity	600 L/min at 6 bar
Pump Engine	Briggs & Stratton 1 cyl, petrol, air cooled Power 4.7 HP
Dim (LxWxH)	745 x 440 x 590 mm
Weight	94 kg (with electric starter)

3.3 Engine selection and Calculation of Various Mode

In this rescue boat, since the length of the boat is no more than 5 meter, the velocity of the boat also not too high when doing a rescue process, the engine rated power chosen is the engine with 15 HP. The engine is used with **Mercury Marine Engine 15 HP 4 Stoke**. The requirement of the engine is shown in Table 7.

Table 7: The requirement of the engine

HP @ Prop:	15
kW @ Prop:	11.1
Max RPM (WOT) :	4500-5500
Cylinders:	2 (in-line)
Displacement (CID/cc) :	19.7/323
Bore & Stroke (in) :	2.32 x 2.32
Bore & Stroke (mm) :	59 x 59
Cooling System:	Water-cooled w/thermostat
Ignition System:	CDI w/ electric spark advance
Starting:	Manual or electric
Gear Ratio:	2.00:1
Gear Shift	F-N-R
Steering:	Tiller or remote
Alternator Amp:	6 (manual)/10 (electric)
Alternator Watt:	76 (manual)/126 (electric)
Trim Positions:	5
Shallow Water Drive:	Standard
Exhaust System:	Through prop
Lubrication System:	Wet sump
Recommended Oil:	Mercury 4-Stroke Outboard Oil
Oil Capacity:	1.0 L / 1.1 Qt.
Fuel Induction System:	2-valve single overhead cam
Remote Fuel Tank:	Standard
Remote Fuel Tank (US Gal) :	3.2
Remote Fuel Tank (L) :	12
Shaft Length (inches) :	15/20
Shaft Length (mm) :	381/508
Dry Weight (lbs.) :	111
Dry Weight (kg.) :	50
Operator Warning System:	Low oil pressure
Available Propellers:	Standard equipment
CARB Star Rating:	2
Warranty:	3 years

Since this boat will be used in 3 different modes, the amount of DWT will be calculated on the different mode as well. This calculation will be shown below:

1. Rescue Condition

In this condition, it is assumed that boat will be evacuating the victim:

a. Wfo

$$\begin{aligned} Wfo &= 80 \% \times \text{BHP} \times 0.17 \times \text{days} \\ Wfo &= 80 \% \times 15 \times 0.17 \times 1/8 \\ &= 0.255 \text{ kg} \\ &= 0.51 \text{ kg} \end{aligned}$$

b. Wcp

$$\begin{aligned} Wcp &= Ze \times Ccp \\ \text{Where; } Ze &= 2 \text{ people (rescue); } Ccp = 65 \\ Wcp &= 2 \times 65 \text{ kg} \\ &= 130 \text{ kg} \end{aligned}$$

c. Wpc

$$\begin{aligned} Wpc &= Ze \times Cpc \\ \text{Where; } Ze &= 9 \text{ people; } Ccp = 65 \text{ kg} \\ Wpc &= 9 \times 65 \text{ kg} \\ &= 585 \text{ kg} \end{aligned}$$

d. Wr

$$\begin{aligned} Wr &= (0.5 - 2) \% \times \text{Disp} \\ \text{Where; } \text{Disp.} &= 1144.51 \text{ kg} \\ Wr &= 2 \% \times 1144.51 \text{ kg} \\ &= 23 \text{ kg} \end{aligned}$$

e. Weight of equipment

$$\begin{aligned} W. \text{ equipment} &= W. \text{ Life Jacket} + W. \text{ First aid} + \\ &W. \text{ paddle} + W. \text{ power machine} + \\ &W. \text{ Fire extinguisher} \end{aligned}$$

$$\begin{aligned} W. \text{ Life jacket} &= (\text{Crew} + \text{Victim}) \times W. \text{ Life jacket} \\ &= 11 \times 2 \text{ kg} \\ &= 22 \text{ kg} \end{aligned}$$

$$\begin{aligned} W. \text{ First Aid Kid} &= \text{Amount.} \times W. \text{ First aid} \\ &= 9 \times 3 \text{ kg} \\ &= 27 \text{ kg} \end{aligned}$$

$$\begin{aligned} W. \text{ paddle} &= \text{Amount.} \times W. \text{ paddle} \\ &= 2 \times 5 \text{ kg} \\ &= 10 \text{ kg} \end{aligned}$$

$$\begin{aligned} W. \text{ power machine} &= \text{Amount.} \times W. \text{ Engine} \\ &= 1 \times 50 \text{ kg} \\ &= 50 \text{ kg} \end{aligned}$$

$$\begin{aligned} W. \text{ Fire extinguisher} &= \text{Amount.} \times W. \text{ Fire extinguisher} \\ &= 1 \times 5 \text{ kg} \\ &= 5 \text{ kg} \end{aligned}$$

$$\begin{aligned} W. \text{ equipment} &= 22 \text{ kg} + 27 \text{ kg} + 10 \text{ kg} + 50 \text{ kg} + 5 \text{ kg} \\ &= 114 \text{ kg} \end{aligned}$$

$$\begin{aligned} DWT &= Wfo + Wcp + Wpc + Wr + W. \text{ equipment} + W. \text{ lader} \\ &= 0.51 \text{ kg} + 130 \text{ kg} + 585 \text{ kg} + 23 \text{ kg} + 114 \text{ kg} + 7 \text{ kg} \\ &= 848 \text{ kg.} \end{aligned}$$

$$DWT \text{ in Rescue Condition} = 848 \text{ kg}$$

2. Supply Condition

In this condition, it is assumed that boat will be distributing the help, first aid and another supply:

a. Wfo

$$\begin{aligned} Wfo &= 80 \% \times \text{BHP} \times 0.17 \times \text{days} \\ Wfo &= 80 \% \times 15 \times 0.17 \times 1/8 \\ &= 0.255 \text{ kg} \\ &= 0.51 \text{ kg} \end{aligned}$$

b. Wcp

$$\begin{aligned} Wcp &= Ze \times Ccp \\ \text{Where; } Ze &= 3 \text{ people (rescue); } Ccp = 65 \text{ kg} \\ Wcp &= 3 \times 65 \text{ kg} \\ &= 195 \text{ kg} \end{aligned}$$

c. Wr

$$\begin{aligned} Wr &= (0.5 - 2) \% \times \text{Disp.} \\ \text{Where; } \text{Disp. (planned)} &= 1144.51 \text{ kg} \\ Wr &= 2 \% \times 1144.51 \text{ kg} \\ &= 23 \text{ kg} \end{aligned}$$

Whereas:

$$DWT(\text{planned}) = 836.51 \text{ kg}$$

$$DWT(\text{planned}) = W_{fo} + W_{cp} + W_r + W_{po} \text{ (food, first aid, etc)}$$

$$W_{po} = DWT - (W_{fo} + W_{cp} + W_r)$$

$$= 836.51 - (0.51 + 195 + 23)$$

$$= 618 \text{ kg}$$

$$DWT \text{ in Supply Condition} = 618 \text{ kg}$$

3. Fire Fighting Condition

In this condition, it is assumed that boat will be used as fire fighting vehicle:

a. W_{fo}

$$W_{fo} = 80 \% \times BHP \times 0.17 \times \text{days}$$

$$W_{fo} = 80 \% \times 15 \times 0.17 \times 1/8$$

$$= 0.255 \text{ kg}$$

$$= 0.51 \text{ kg}$$

b. W_{cp}

$$W_{cp} = Z_e \times C_{cp}$$

$$\text{Where; } Z_e = 3 \text{ people (fungsi rescue); } C_{cp} = 65 \text{ kg}$$

$$W_{cp} = 3 \times 65 \text{ kg}$$

$$= 195 \text{ kg}$$

c. W_r

$$W_r = (0.5 - 2) \% \times \text{Displ}$$

$$\text{Where; } \text{Displ. (planned)} = 1144.51 \text{ kg}$$

$$W_r = 2 \% \times 1144.51 \text{ kg}$$

$$= 23 \text{ kg}$$

d. Weight of Portable pump

Based on the selection in chapter 3.2, it is used *double stage pump* with 94 kg weight W.

$$\text{Portable Pump} = \text{Amount of. Pump} \times W_{\text{Portable Pump}}$$

$$= 1 \times 94 \text{ kg}$$

$$= 94 \text{ kg}$$

e. Fire extinguisher

Used *fire extinguisher* 5 kg.

$$W_{\text{Fire Extinguisher}} = \text{Amount.} \times \text{Fire Extinguisher}$$

$$= 1 \times 5 \text{ kg}$$

$$= 5 \text{ kg}$$

$$DWT = W_{fo} + W_{cp} + W_r + W_{\text{Portable Pump}}$$

$$+ W_{\text{fire extinguisher}}$$

$$= 0.51 \text{ kg} + 195 \text{ kg} + 23 \text{ kg} + 94 \text{ kg} + 5 \text{ kg} = 317.5 \text{ kg}$$

$$DWT \text{ in Fire fighting Condition} = 317.5 \text{ kg}$$

function is called as the quick riling system where the boat makes a unity to create pathways. This condition could be seen in Figure 6.

Figure 3: General arrangement of the rescue boat

Figure 4: Design of the platform (Side View)

Figure 5: Design of the platform (Top View)

Figure 6: Design of the quick riling system

4.0 DESIGN ARRANGEMENT

4.1 General Arrangement

For the General arrangement of the rescue boat, the boat will have an efficient and aesthetic accommodation room. This is shown in Figure 3. The rescue boat will also have rescue platform and quick riling system. On the platform ladder is as shown in Figure 4. There are hinges that will connect the edge of the platform with the boat surface. When the boat is operating, this ladder could be spin with the hinges as its center. When it is not used, the ladder will be put on the topside of the boat. On a certain condition, this platform could be released. When it is released and the edge of the boat where the previous platform is connected could be installed with the row so the boat could be connected and created a new function. This is used as a bridge from the boat. This

4.2 Construction Calculation

1. Material Propertis

0.2 % proof stres (minimum) 125 N/mm²
Tensile Strength (minimum) 260 N/mm²
Modulus of elasticity 69 x 10³ N/mm²

2. Frame Spacing

$$a = (350 + 5.L) \text{ mm}$$

Where:

L = length of construction (m)

L = 4.65 m

a = (350 + 5.4.65) mm

= 373.25 mm, used a = 380 mm

3. Hull Plate

a. Rasio

$$A = \frac{V}{\sqrt{LWL}}$$

V = 9.5 knots

LWL = 4.5 m

$$A = \frac{8}{\sqrt{4.5}}$$

= 3.7, used a = 3.6

L.R ; tb = 3.5 mm ; ts = 3 mm

b. Thickness of bottom plate (minimum)

$$tb_{(min)} = (0.075.L + 2.75) \geq 3.5 \text{ mm}$$

$$= (0.075.4.5 + 2.75)$$

$$= 3.08 \text{ mm}$$

c. Thickness of side plate (minimum)

$$ts_{(min)} = (0.06.L + 2.5) \geq 3 \text{ mm}$$

$$= (0.06.4.5 + 2.5)$$

$$= 2.77 \text{ mm}$$

d. Keel plate thickness and breadth of keel plate

$$tk_{(min)} = 3.5 \text{ mm}$$

$$b = 400 \text{ mm}$$

or

$$tk_{(min)} = (0.125.L + 2.75) \geq tb$$

$$= (0.125.4.5 + 2.75)$$

$$= 3.31 \text{ mm}$$

$$\text{Breadth} = (10.L + 340) \text{ mm}$$

$$= (10.4.5 + 340)$$

$$= 385 \text{ mm}$$

4. Internal Hull Stucture

Finding the thickness of plate inside the engine, ased on frame spacing, height of the engine and its ratio.

$$D_{motor} = 1.25 \text{ m}$$

$$a = 380 \text{ mm (Frame spacing)}$$

$$A = \frac{V}{\sqrt{LWL}} = 3.6$$

$$tb = 5.2 \text{ mm}$$

$$ts = 2.2 \text{ mm}$$

5. Shell Framing Transverse

Bottom,

$$Z_{BF} = 4.74 s l^2 F_{BF} (102.5 h + 7.7 L) 10^{-3} \text{ cm}^3$$

$$I = 1.85 l Z_{BF} \text{ cm}^4$$

Side,

$$Z_{SF} = 4.74 s l^2 F_{SF} (102.5 h + 5.08 L + 14.6) 10^{-3} \text{ cm}^3$$

$$I = 1.85 l Z_{SF} \text{ cm}^4$$

$$A = \frac{V}{\sqrt{LWL}} = 3.6 \text{ for } L < 24 \text{ m}$$

$$F_{VBF} = (0.837.\sqrt{A} - 0.648) \times (2.61 - 0.246\sqrt{L}) \text{ for } L < 30 \text{ m}$$

$$= (0.837.\sqrt{3.6} - 0.648) \times (2.61 - 0.246\sqrt{4.8})$$

$$= 0.94 \times 2.071$$

$$= 1.947$$

$$F_{VSF} = (0.724.\sqrt{A} - 0.433) \times (1.91 - 0.17\sqrt{L}) \text{ for } L < 30 \text{ m}$$

$$= (0.724.\sqrt{3.6} - 0.433) \times (1.91 - 0.17\sqrt{4.5})$$

$$= 0.94 \times 1.537$$

$$= 1.44$$

$$Y = 0.83 \text{ for flat bars}$$

$$\Delta = \text{Displacement} = 1144.51$$

$$\Delta k = 0.125(L^2 - 15.8)$$

$$= 0.125((4.5)^2 - 15.8)$$

$$= 0.556 \text{ ton}$$

$$f_{AS} = \frac{0.5\Delta}{\sqrt{\Delta k}} + 0.5$$

$$= \frac{0.5.1.364}{\sqrt{0.556}} + 0.5$$

$$= 1.415$$

$$F_{AS} = f_{AS} [(0.074 - 0.39.\sqrt{A}) \times (\frac{\Delta k - \Delta}{0.3\Delta k}) + 1.0]$$

$$= 4.22$$

$$F_{BF} = (F_{VBF} \times F_{AS} \times Y) \geq 1.0 \text{ for motor boat}$$

$$= (1.947 \times 4.22 \times 0.83)$$

$$= 6.819$$

$$F_{SF} = (F_{VSF} \times F_{AS} \times Y) \geq 1.0 \text{ for motor boat}$$

$$= (1.44 \times 4.22 \times 0.83)$$

$$= 5.044$$

So,

$$Z_{BF} = 4.74 s l^2 F_{BF} (102.5 h + 7.7 L) 10^{-3} \text{ cm}^3$$

$$= 4.74 0.38 (1.6)^2 6.819 (102.5 0.25 + 7.7 4.5) 10^{-3}$$

$$= 1895.2 \times 10^{-3} \text{ cm}^3$$

$$= 1.8 \text{ cm}^3$$

$$I = 1.85 l Z_{BF} \text{ cm}^4$$

$$= 1.85 1.6 1.8$$

$$= 5.328 \text{ cm}^4$$

$$Z_{SF} = 4.74 s l^2 F_{SF} (102.5 h + 5.08 L + 14.6) 10^{-3} \text{ cm}^3$$

$$= 4.74 0.38 (0.4)^2 5.044 (102.5 0.25 + 5.08 4.5 + 14.6) 10^{-3} \text{ cm}^3$$

$$= 91702.9 \times 10^{-5} \text{ cm}^3$$

$$= 0.917 \text{ cm}^3$$

$$I = 1.85 l Z_{SF} \text{ cm}^4$$

$$= 1.85 . 0.4 . 0.917$$

$$= 0.678 \text{ cm}^4$$

Table 8: Weight of consttruction

No	Areas	area (m ²)	Thickness (mm)	SG (kg/m ³)	Weight (kg)
1	Bottom plate	8.738	3.0	2700	70.778
2	Side plate	4.350	3.0	2700	35.235
3	Floor plate	5.004	3.5	2700	47.288
4	Floor plate in E/R	1.021	5.0	2700	13.784
5	Transom	1.193	3.0	2700	9.663
6	Profile in bottom side	0.776	5.0	2700	10.469
7	Profile in side side	0.400	5.0	2700	5.395
8	Chairs for the passenger	4.862	3.0	2700	39.382
9	Crew chair	1.430	3.0	2700	11.583
10	Front chair	2.040	3.0	2700	16.524
11	Straith side (p/s)	0.338	3.0	2700	5.473
12	Bottom Straith	0.378	3.0	2700	18.347
Σ=					283.921

For the final stability of the rescue boat, it will be analyzed based on a several condition. It is shown on Table. 9.

Table. 9: Analysis based on a several condition of the rescue boat

Condition of the cargoes	KB (m)	KG (m)	BMt (m)	BML (m)	KMt (m)	KML (m)	GMt (m)	GML (m)
25%	0.051	0.275	2.931	13.539	2.981	13.590	2.706	13.315
50%	0.067	0.334	2.240	10.737	2.307	10.804	1.973	10.470
75%	0.075	0.368	1.889	10.031	1.965	10.106	1.597	9.738
100%	0.089	0.390	1.655	9.633	1.744	9.722	1.655	9.633
3 victim on side	0.052	0.377	2.458	12.145	2.509	12.197	2.143	11.831
6 victim on side	0.065	0.404	2.035	10.974	2.100	11.039	1.704	10.643
Supply	0.093	0.234	1.540	8.557	1.634	8.650	1.399	8.416
Fire Fighting	0.054	0.304	2.613	12.986	2.667	13.040	2.636	12.986

After all the data are obtained. The figure, drawing, design and arrangement will be shown on the figure 7–figure 14:

Figure 7: CSA Curve

Figure 8: Lines Plan

Figure 9: 3D Model

Figure 10: 3D Model

Figure 11: Hydrostatic in 25 % Cargo

Figure 12: Hydrostatic in 50 % Cargo

Figure 13: Hydrostatic in 100 % Cargo

Figure 14: Installed Fire Monitor (radius 15-60°)

Figure 15: Installed Fire Monitor (360°)

5.0 CONCLUSION

- Based on the various condition and simulation, the principal dimension (fixed) that used is :
 - LOA (Length Over All) : 4.8 m
 - B (Breadth) : 1.8 m
 - d (draft) : 0.175 m
 - H (Height) : 0.5 m
- This boat have the value of good stability. It is based on the criteria from IMO regulation, which are :
 - MG value is no less than 0.15 m. MG is measure in various condition which is in empty cargo load, 25%, 50%, 75%, and 100%. It has the values of MG with: 57.84 m, 24.16 m, 18.57 m, 15.20 m, 12.51 m.
 - The opening of a water-resistant vessel begins to touch water at an angle of 40° or more, in this boat design is of value: 104.2°, 73.7°, 68.6°, 64.6°, 64.3°.
 - The maximum arm occurs between 25° - 30°, at this boat design all maximum arms are at the condition of empty loads, 25%, 50%, 75%, and 100% occur at an angle of 30°.
 - At a slope of 30° or more, the moment arm (GZ) is 0.2 m or more, at this boat design the moment arm values (GZ) are: 0.62 m, 0.44 m, 0.41 m, 0.39 m, 0.39 m.

- The area under the static stability curve at 0 - 30° is greater than 0.055 m. Rad, in this boat design the values are: 0.269 m. Rad, 0.168 m. Rad, 0.151 m. Rad, 0.138 m. Rad, 0.142 m. Rad.
- The area under the static stability curve at 0 - 40° is greater than 0.09 m. Rad, in this boat design the values are: 0.373 m. Rad, 0.242 m. Rad, 0.220 m. Rad, 0.203 m. Rad, 0.207 m. Rad.
- 3. Based on the standard fire extinguisher pump at the Fire Department The pressure needed for the fire extinguishing process is 5-8 bar with the condition of the permanent building (Wall) for the resident condition. So the pressure chosen in the final assignment is the minimum pressure of 5 bars.
- 4. Based on the calculation of the height and pressure relationship obtained from the height of sprayed water of 50,985m with a pressure of 5 bar and the pump power is 3.73 kW with a capacity of 656 LPM (Liter Per Minute)
- 5. *Dead Weight or Consumable*;
 - a. *Rescue* condition = 848 kg
 - b. *Supply* condition with DWT planned 836.51 kg = could carry supply with maximum weight of 618 kg
 - c. *Fire Fighting* condition = 317.5 kg
- 6. The profile used is type I with details:
 Bottom frame planned = 30 x 5
 Side frame planned = 30 x 5
 Calculation of the weight of the construction obtained 284 kg.

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