Fire and Rescue Boat Design in Tanjung Perak Waters

Aldrin Ferdiansyah[1,*] and Erifive Pranatal[1]
[1]Naval Engineering. Institut Teknologi Adhi Tama Surabaya, Indonesia

Article Info

Article history:
Received August 15, 2024
Revised October 19, 2024
Accepted month 10. 2024

Keywords:
Fire and Rescue Boat
Tanjung Perak Waters
Safety

ABSTRACT

Tanjung Perak is the name of a port located on Jalan Jamrud Utara, Perak Utara. Pabean Cantian District, Surabaya, East Java. 60165. Geographically. Tanjung Perak port is located between 112-30’-13’’ East Longitude and 07-70’-30’’ South Latitude, precisely in the Madura Strait. North of Surabaya. The number of ships passing through Tanjung Perak waters is very large so the number of ships passing increases the potential for accidents. It is conducted to minimize ship accidents that cause fatalities or losses. Shipbuilding in the maritime world involves stages ranging from determining ship geometry, conducting resistance and stability analysis and designing effective propulsion systems. In addition, ship design must also consider variables such as line plan which focuses on the physical aspects and hydrodynamic performance of the ship, while general arrangement focuses on the internal organization and function of the ship. Other safety support facilities are Life Buoy. Life Jacket and complete firefighter safety clothing. The researcher obtained the main dimensions with a ship length of 7.5 meters, width of 2 meter, height of 1.6 meters, draft of 0.5 meters and speed of 8 Knots. The ship is equipped with a water pump with a flow rate of 199 meters/minute or 3.316 meters/second. The ship has a specific speed of 157 rpm which functions to extinguish fires when a fire occurs on the ship.

**** Corresponding Author:***
Aldrin Ferdiansyah
Program Studi Teknik Perkapalan, Fakultas Teknologi Industri
Institut Teknologi Adhi Tama Surabaya
Surabaya, Indonesia
Email: ferdiansyahaldrin4@gmail.com

INTRODUCTION

The role of the port is vital in Indonesia's economic activities because it is the entrance and exit of goods from within the country and abroad (Mulya. n.d.). As a port, Tanjung Perak has one of the roles as a place of distribution, production, and for berthing ships that will load and unload. The facilities owned by the port of Tanjung Perak are basically good because with the swift flow of distribution, the port of Tanjung Perak can still be said to be able to manage it (Susanti Bunga, Ir. A. Isjudarto, & M. Sri Prasetyo, 2023) Tanjung Perak is also used for defense or marine establishment purposes and making it a major port.

With the large number of ships in the Tanjung Perak water area, it is very likely that ship accidents will occur. There are several types of ship accidents including: sinking ships, burning ships, colliding ships and running aground ships. There are many factors or causes contributing to the accidents, some of which is technical factors or human errors. Safety aspects at sea must be prioritized considering the Tanjung Perak port as the gateway to export-import of the East Java region (Fauzy et al.. 2016).

Therefore, facilities supporting safety aspects in Tanjung Perak waters need to be considered. So that, when a ship accident occurs, it can minimize casualties or losses. Those facilities such as fire and rescue boats must be added as needed in Tanjung Perak waters. The essential to begin preparations with the facilities and infrastructure that support safety measures in water, including the fire and rescue boat. According to (Hasil Karya Ilmiah et al, 2019), rescue boat functions as a means of transporting safety equipment in the waters and to transport passengers, victims who have fallen from the ship, boat into the water.

The first recorded fire boat was designed in the late 18th century, precisely in 1765 (Church. 2022). "Fire and rescue boat is a safety transportation tool equipped with pumps and nozzles to extinguish ship fires" (Delgado. 1988). Not only does it extinguish ship fires, but it can also carry victims on an open foredeck that provides space for ship fire victims. There are lockers at the bow and stern provide watertight storage space and can be adapted to the needs of firefighting inventory, rescue and other equipment. Therefore, the design of fire and rescue boats is an interesting research topic for the author, so that it can be a reference in the context of developing the design of fire and rescue type ships.

Based on this background, the purpose of this research is to determine the main size of the fire and rescue boat line plan, general plan and determine the needs of the fire and rescue boat. This research focuses on designing a fire and rescue boat that is in accordance with the characteristics of Tanjung Perak waters, the work of this thesis is the design of a line plan, general plan, without the prototype results of the ship and no development or economic costs.

METHODS

The initial stage in this research is to conduct a literature study. Literature study is an approach or process carried out to investigate and analyze existing literature, research, or previous papers in a particular field or topic. The literature study aims to get the appropriate theoretical basis so that the research results can answer all research objectives properly. Data obtained to support this research is obtained from journals and articles that have been published on the

Wave: Jurnal Ilmiah Teknologi Maritim
Vol 18 No 01, June 2024: page: 10-22
p - ISSN: 1978-886X
e - ISSN: 2614-641X

internet. The data required in the process of working on this research including: main size. line plan, general arrangement, ship construction, shipbuilding costs and data that can be used to assist in the work of this study. Determination of the main size of this ship is obtained using the ship comparison method where data is collected from 10 similar ships that have been made which then use displacement as a variable so that the main size of the ship will be obtained, if the main size is still not in accordance with the restrictions used, the main size of the ship is adjusted.

The line plan drawing process is carried out after the main size is obtained and then the general plan of the ship is drawn, as well as a 3-dimensional model of the ship to be made (Suhardjito G. n.d.). Technical calculations are carried out based on references that have been studied. This process includes the calculation of ship resistance, ship power calculation, ship weight calculation, stability calculation and construction calculation. After completing all stages, the next step is to evaluate the results of the analysis and calculations that have been carried out.

RESULTS AND DISCUSSION

Displacement will be the independent variable (X). Meanwhile, Length Over All (LOA), overall ship width (B), ship height (H) and ship ladder (T) will be the independent variables (Y). A comparison ship is used to determine the function of each pair of independent variables. The number of comparison ships used is 10 units as shown in Table 1.

Table 1 Ship Comparison Data

No	Ship Name	L (m)	B (m)	H (m)	D (m)	Displ (ton)
1	m3 fire rescue	11	3.4	1.9	0.9	5.83
2	hdr420	4.2	1.8	1.0	0.9	1.06
3	pp 601	9.5	3	1.3	0.6	5.43
4	hdr475	4.8	2	0.8	0.7	1.54
5	Merlin 415	8.5	2.5	1.4	0.9	2.72
6	M3 Harbour	11	3.6	1.8	0.8	5.80
7	Pauanui Rescue	8.9	2.9	1.1	0.5	5.33
8	hdfr600	6.0	2.3	1	0.9	2.19
9	hdr570	5.7	2	1	0.9	1.90
10	KingFisher28 Patrol	8.5	2.6	1.2	0.5	3.79

After the comparison ship data for each (X) with each main size variable, the corresponding linier regression correlation values are obtained and shown in Figures 1.2.3 and 4.

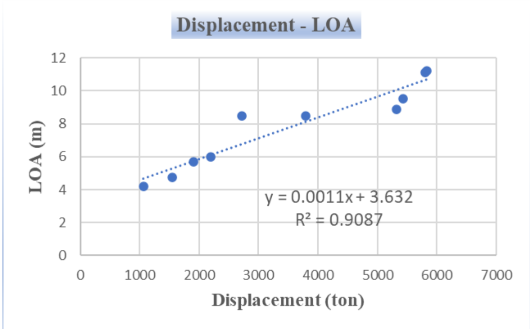

Figure 1. LOA-Displacement Correlation Value

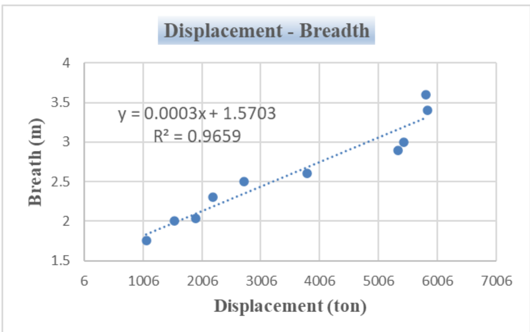

Figure 2. Breadth-Displacement Correlation Value

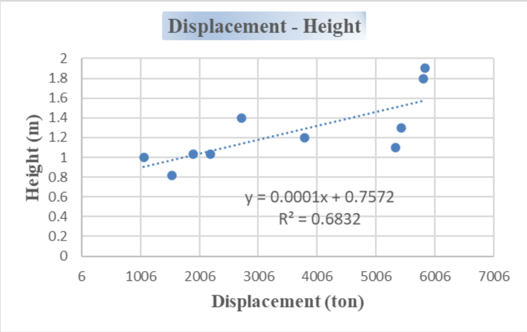

Figure 3. Height-Displacement Correlation Value

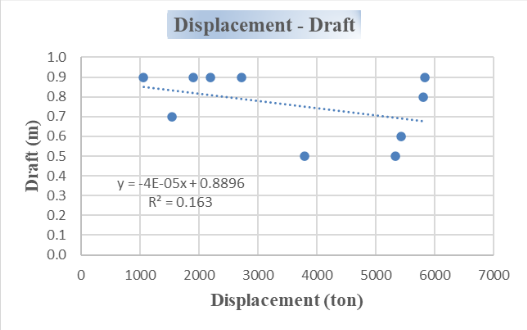

Figure 4. Draft-Displacement Correlation Value

After that, the results of the regression calculation are used as a reference to determine the initial main size. It should be noted that the preliminary main size is not the final size of the ship. If the regression results meet the constraints of the main size used, it can be directly used as the initial main size. However, if the regression results do not meet the constraints, then the initial main size can be increased or decreased until it meets the constraints. After the data for each displacement (X) with each main size variable, so that a linear regression equation is obtain according to Table 2.

Table 1. Regression Results Table

Parameters	y	x	Results
LOA	0.0011x + 3.632	3.28	7.240
B	0.0003x + 1.5703	3.28	2.554
H	0.0001x + 0.7572	3.28	1.085
T	-4e-05x + 0.8896	3.28	0.758

Subsequently, the regression results are used as a guideline to establish the initial main size. Although, initial main size value does not has to be the same as the regression result. If the regression result complies with the main size constraints used, it can be used as the initial main size. However, if the regression results do not meet the constraints, then the initial main size can be adjusted until it does. The main size and main size comparison constraints used in this study from (Lewis. E. V, 2021):

L/B = 3.5 < x < 10 ; 2.8
L/T = 10 < x < 30 ; 10
B/T = 1.8 < x < 5 ; 3.5

Since the initial L/B dimension does not comply with the set limitations, adjustments to the main dimensions of the ship are made:

L = 7.5 m
B = 2 m
H = 1.6 m
T = 0.5 m
So, the ratio will change to:
L/B = 3.5 < x < 10 ; 3.7
L/T = 10 < x < 30 ; 15
B/T = 1.8 < x < 5 ; 4

Drawing of Line and 3D Plan of the Ship

The main size of the ship that has been obtained by the ship comparison method is then continued by making a line plan. Drawing lines plan using AutoCAD program. This is done to facilitate the calculation of the hull area and get a more precise ship size. Figure 5 is a line plan generated from the AutoCAD program:

p - ISSN: 1978-886X
e - ISSN: 2614-641X

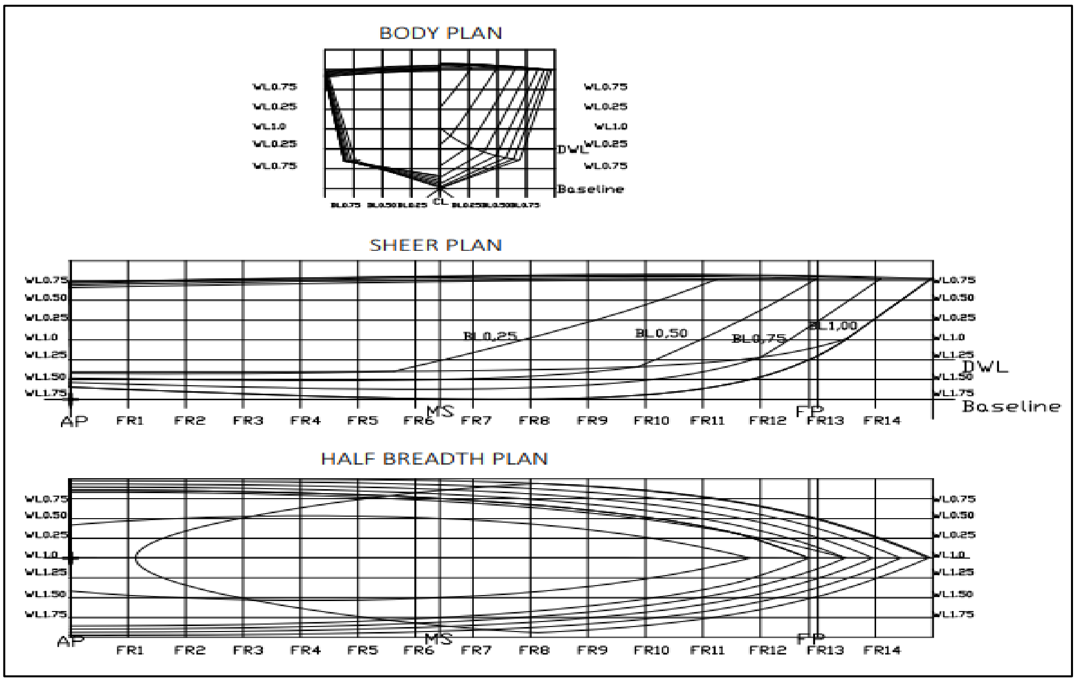

Figure 5. Lines Plan Drawing Results

After creating the line plan and general plan, the 3D model was created. SketchUp program was chosen as the primary choice for creating the 3D model shown in Figure 6.

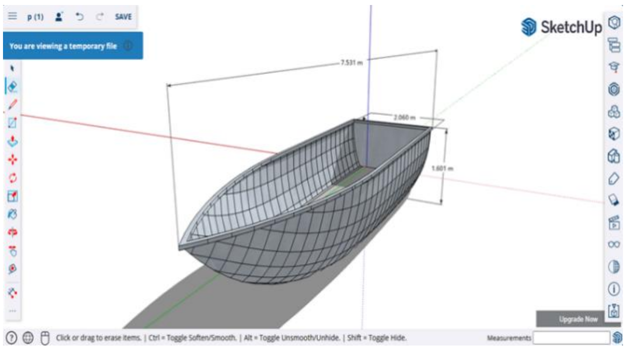

Figure 6. 3D Drawing of The Ship

General Arrangement Creation

In making a general design or general arrangement, an AutoCAD program is used. as well as making a line plan, the use of AutoCAD aims to get precise drawings and accurate picture of the ship's design. The thing that is taken into consideration in drawing a general plan is the layout of passenger seats because the ship is a type of tourist ship that must prioritize passenger comfort so that passengers can enjoy tours properly. Figure 7 is the result of a general plan drawing using the AutoCAD program:

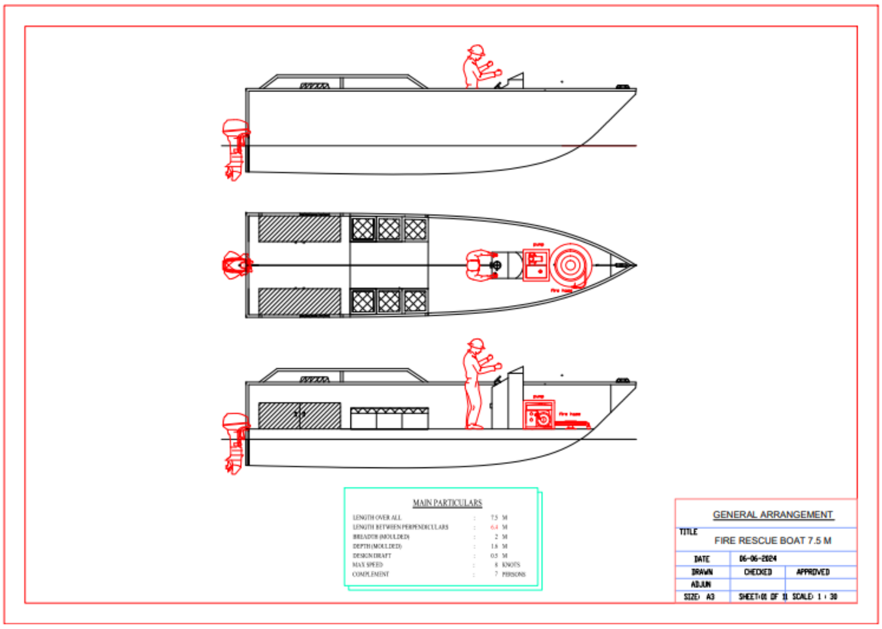

Figure 7. General Arrangement Drawing

Estimated Ship Weight

The ship's weight component consists of LWT (empty cargo weight) and DWT (weight of ship's cargo and components that can be removed from the ship), with a DWT weight of 1.17 tons listed below:

LWT = Δ - DWT

LWT = 3.28 – 1.17

LWT = 2.11 ton

Then,

Δ = DWT + LWT

Δ = 1.17 + 2.11

Δ = 3.28 ton (correct)

The details can be seen in Table 3.

Table 3. DWT dan LWT Details

(Payload)			
Crew and Passenger Weight	=	1	ton
Machinery fuel Engine and pump fuel	=	0.022	ton
Engine lubricating oil	=	0.018	ton
Engine and Pump weight	=	0.117	ton
Safety Equipment weight	=	0.020	ton
TOTAL DWT	=	1.17	ton
TOTAL LWT	=	2.11	ton
TOTAL DISPLACEMENT	=	3.28	ton

Power Calculation, Engine Selection and Water Pump Selection

Power calculation is done to determine the engine that will be used so that the ship can work at its service speed. Engine power must be above the required power so that the engine does not work too hard, which can shorten engine life or cause engine problems when the ship is sailing. Power calculation can be done using the formula below:

Effective Horse Power (EHP) Calculation

$$EHP = R_t \times v_s$$

$$EHP = 2.3 \times 8$$

$$EHP = 18.5 \text{ Kw}$$

$$EHP = 25 \text{ HP}$$

Vol 18 No 01, June 2024: page: 10-22
p - ISSN: 1978-886X
e - ISSN: 2614-641X

Outboard motors are selected for boat propulsion engines. For the installation of the outboard motor on the propeller motor should not be blocked by the ship's body, so as not to block the flow of water so that the motor can push the ship. The total power required is 25Hp. Therefore, the selected engine is Suzuki DT 30 L. To see the technical specifications of the Suzuki DT 30 L engine shows at Figure 8.

SPECIFICATIONS

Models	DT 30 L
Transom Height	508 mm
Starting System	Manual
Weight	57 kg
Engine Type	2-Stroke
Piston Displacement	499 cm3
Bore x Stroke	71 x 63
Maximum Power	22.1 kW (30HP)
Full Throttle Operating Range	5.000-5.600
Fuel Tank Capacity	25 liter

Figure 8. Main Drive Engine Specification

Seawater pumps on fire-fighting vessels are vital to maintain the smooth and safe operation of the vessel. Seawater pumps usually use centrifugal pumps and positive displacement pumps, both of which have reliable performance in moving seawater into and out of the ship. In last research, the author chose the qmp300 pump series shows in Figure 9.

SPESIFIKASI

Model	QMP300
Connection Diameter	80 mm
Delivery Volume	52 m^3/h
Total Head	65 m
Power Speed	3600 rpm
Fuel Tank Capacity	6.5 L
Oil Capacity	1.1 L
Gross/Net Weight	60.5 Kg / 59.5 Kg
Packing Size	595 x 492 x 510

Figure 9. Water Pump Specifications

External Fire Pump Calculation

External Fire is designed for the water spray capacity of the pump is 52m3/h. with a horizontal spray distance (throw range) of 65 meters, so the Total Head of the pump is selected as far as 65 meters with a shaft rotation of 3600 rpm.

- Flow Velocity Q/A

  Where:

  $A = \pi \times di^2/4$

  $A = 3.14 \times 0.08^2/4$

  A = 0.005024 m^2

  So, flow velocity:

  $V = \frac{Q}{A}$

  V = 1/0.005024

  V = 199 m/min or 3.316 m/sec

- Specific speed

  The specific speed value is obtained through the following equation:

  $Ns = n \times Q^{\frac{1}{2}}/H^{\frac{3}{4}}$

  Where:

  Ns = specific speed

  Q = capacity = 1 m^3/minute

  H = head total

  N = shaft rotation

  then:

  $Ns = 3600 \times 1^{\frac{1}{2}}/\ 65^{\frac{3}{4}}$

  $Ns = 157.260$ rpm

Construction Calculation

The calculation of this structure refers to the guidelines contained in the BKI Part 3 book on Special Ship Volume VII 2013. Sec 1 Page 1-5 with the main dimensions of the ship as follows:

Loa : 7.5 m	H : 1.6 m
Lwl : 6.4 m	T : 0.5 m
B : 2 m	V : 8knot

Calculation of Load on Ship Hull

- Load on the bottom of the hull
  < 0.4 L : aft = 2.16 > L + 2.63
  = 18.83 kN/m^2
  ≥ 0.4 L : fore = 2.7 > L + 3.29
  = 23.54 kN/m^2
- Load on the side of the hull
  < 0.4 L : aft = 1.5 > L + 1.41
  = 12.66 kN/m^2
  ≥ 0.4 L : fore = 1.88 > L + 1.76
  = 15.86 kN/m^2

Calculation of Load on Deck and Superstructure

- Load on the main deck of the ship
  PDd = 0.26 > L + 8.24
  = 10.19 kN/ m^2
- Load on deck cabins
  PDd = 0.235 > L + 7.42
  = 9.1825 kN/ m^2
- Load on wall cabins
  PDd = 0.26 > L + 8.24
  = 10.19 kN/ m^2

Correction Factor Due to Ship Speed

The ship speed factor is the most important part in the calculation of the construction of small vessels with high speed, so the author uses Correction factors for speed from the Rules for Small Vessel up to 24 m BKI, Volume III. 2021. Section 1. Page 1 until 6 is reference to calculate the correction load due to ship speed shown Figure 10.

Loading area	Correction factor
Shell bottom	$F_{VB} = 0{,}34 \cdot \sqrt{\frac{v}{\sqrt{L_{WL}}}} + 0{,}355 \geq 1{,}0$
Shell side	$F_{VS} = \left(0{,}024 \cdot \frac{v}{\sqrt{L_{WL}}} + 0{,}91\right)(1{,}018 - 0{,}0024 \cdot L) \geq 1{,}0$
Internal structural members Floors	$F_{VF} = \left(0{,}78 \cdot \sqrt{\frac{v}{\sqrt{L_{WL}}}} - 0{,}48\right)(1{,}335 - 0{,}01 \cdot L) \geq 1{,}0$
Web frame at WL Bottom longitudinal frames	F_{VBW}, $F_{VL} = 0{,}075 \cdot \frac{v}{\sqrt{L_{WL}}} + 0{,}73 > 1{,}0$
Transverse frames Webs at side	F_{VSF}, $F_{VSW} = \left(0{,}1 \cdot \frac{v}{\sqrt{L_{WL}}} + 0{,}52\right)(1{,}19 - 0{,}01 \cdot L) > 1{,}0$
Side longitudinal frames	$F_{VSL} = \left(0{,}14 \cdot \frac{v}{\sqrt{L_{WL}}} + 0{,}47\right)(1{,}07 - 0{,}008 \cdot L) > 1{,}0$
L_{WL} and v see A.5: $v_{max} = 12 \cdot \sqrt[4]{L}$	

Figure 10. Rules BKI Correction Factors for Speed

Then the calculation formula is obtained with reference to Table 4.5 with the results:

- Shell Bottom

$$F_{VB} = 0.34 \times \sqrt{\frac{V}{\sqrt{Lwl}}} + 0.355$$
$$= 0.34 \times \sqrt{\frac{20}{\sqrt{6.43}}} + 0.355$$
$$= 1.31 \text{ (accepted)} < 1.0$$

- Shell Side

$$F_{VS} = \left[0.024 \times \frac{V}{\sqrt{Lwl}} + 0.91\right](1.018 - 0.0024 \times L)$$
$$= \left[0.024 \times \frac{20}{\sqrt{6.43}} + 0.91\right](1.018 - 0.0024 \times 7.5)$$
$$= 1.1 \text{ (accepted)} < 1.0$$

- Internal structural members Floors

$$F_{VF} = \left[0.78 \times \sqrt{\frac{V}{\sqrt{Lwl}}} + 0.48\right](1.335 - 0.01 \times L)$$
$$= \left[0.78 \times \sqrt{\frac{20}{\sqrt{6.43}}} + 0.48\right](1.335 - 0.01 \times 7.5)$$
$$= 2.15 \text{ (accepted)} < 1.0$$

- Web frame at WL Bottom longitudinal frames

Wave: Jurnal Ilmiah Teknologi Maritim
Vol 18 No 01, June 2024: page: 10-22
p - ISSN: 1978-886X
e - ISSN: 2614-641X

$$F_{VB} = 0.075 \times \frac{V}{\sqrt{Lwl}} + 0.73$$
$$= 0.075 \times \frac{20}{\sqrt{6.43}} + 0.73$$
$$= 1.32 \ \text{(accepted)} < 1.0$$

- Transverse frames Webs at side

$$F_{VSF} = \left[0.1 \times \frac{V}{\sqrt{Lwl}} + 0.52\right](1.19 - 0.01 \times L)$$
$$= \left[0.1 \times \frac{20}{\sqrt{6.43}} + 0.52\right](1.19 - 0.01 \times 7.5)$$
$$= 1.46 \ \text{(accepted)} < 1.0$$

- Side longitudinal frames

$$F_{VSL} = \left[0.14 \times \frac{V}{\sqrt{Lwl}} + 0.47\right](1.07 - 0.008 \times L)$$
$$= \left[0.14 \times \frac{20}{\sqrt{6.43}} + 0.47\right](1.07 - 0.008 \times 7.5)$$
$$= 1.59 \ \text{(accepted)} < 1.0$$

Material Factor Calculation

In the manufacturing process of the unmanned ship, the material used is aluminum alloy. Based on the choice of aluminum types that have been selected, the aluminum to be used has the 5083 series. List aluminum material properties shows at figure 11.

Aluminum alloys have properties that are resistant to all weather conditions and are non-flammable. In addition, this aluminum plate is also easy to shape and process. Aluminum Alloy has tk = 0 mm (corrosion additions)" according to Chapter F article 14.2 in the Indonesian Classification Bureau rulebook.

Alloy number	Material condition	Yield strength $R_{p0.2}$ [N/mm²] min.	Tensile strength R_m [N/mm²]	Thickness t [mm]	Elongation [%] min.	
					A_{50mm}	A
KI AW-5083	0/H111/H112	125	275 - 350	t ≤ 12.5	16	–
				t > 12.5	–	15
	H116	215	≥ 305	t ≤ 12.5	12	–
				t > 12.5	–	10
	H32/H321	215	305 – 380	t ≤ 12.5	10	–
				t > 12.5	–	9
KI AW-5086	0/H111/H112	100	240 – 310	t ≤ 12.5	17	–
				t > 12.5	–	16
	H116	195	≥ 275	t ≤ 12.5	10	–
				t > 12.5	–	9
	H32/H321	185	275 – 335	t ≤ 12.5	10	–
				t > 12.5	–	9

[1] The mechanical properties are applicable to both longitudinal and transverse specimens.

Source: (Biro Klasifikasi Indonesia, 2013)

Figure11. Aluminium Alloy Properties

For aluminum ship construction, corrosion factor can be eliminated. For yield strength and tensile strength values of the aluminum alloy material has a value:

$$k = \frac{635}{R_{p0.2} + R_m}$$
$$= 1.608$$

with:

$R_{p0.2}$ = 125 N/mm² (article 14.6)

R_m = 270 N/mm² (article 14.6)

Pedestal Structure Calculation

Therefore, modulus calculation of the wrang/floor to be used should not be less than:

W = 0.43 a l2 FVP PdBM k

W = 10.096 cm³ for positions ≥ 0.4 L

W = 8.076 cm³ for positions < 0.4 L

So that the selection of profiles can refer to the BKI Annex where the profile size and modulus of each profile are I 65x6 with a modulus of 9 cm3 for positions < 0.4 L and I 65x7 with a modulus of 11 cm3 for positions ≥ 0.4 L.

$$b = (530 + 5 \times L) \times \sqrt{k}$$

$b = (530 + 5 \times 7.5) \times (1.608)^{`0.5}$
$b = 719.62$ mm
$t = (3.3 + 0.5 \times L) \times \sqrt{k}$
$t = (3.3 + 0.5 \times 7.5) \times (1.608)^{`0.5}$
$t = 8.939$ mm

Thus, the keel plate used has a width dimension of 750 mm with a keel plate thickness of 9 mm. The planning of the base plate on the unmanned ship has a thickness calculation:

$t = 1.62$ a . F_{VB} . $\sqrt{PdBM} \cdot k$
$t = 1.62 \times 0.60 \times 1.31 \times \sqrt{23.54 \times 1.61}$
= 7.83 mm for position ≥ 0.4 L
$t = 1.62$ a . F_{VB} . $\sqrt{PdBM} \cdot k$
$t = 1.62 \times 0.60 \times 1.31 \times \sqrt{18.83 \times 1.61}$
= 7.01 mm for positions < 0.4 L

Thus, the base plate used is 8 mm thick along the length of the unmanned vessel. Bulkheads plating, bulkhead coating thickness shall not be less than:

The values given are as follows:
a = stiffener spacing in [m]
= 0.90 m
h1 = pressure height in [m] measured from the bottom edge of the bulkhead to the top of the bulkhead deck
= 1.12 m for Collision Bulkhead
= 0.90 m for Other Bulkhead
k = material factor
= 1.61

The values for C class vessels according to IMO. Part 1 General Hull Requirements - Chapter 8 Buckling can be seen in Table 4.

Table 4. Value for C Apply

	Collision Bulkhead	Other Bulkhead
Stiffeners simply supported both sides.	4.00	2.90
Stiffeners fixed both sides by bracket plates.	2.03	1.45

Source: (IMO, 2020)

So,
$t = a \times \sqrt{h1} \times k \times C$
$t = 0.90 \times (1.12 \times 1.608)'(0.5) \times 4.00$
for Collision Bulkhead
$t = 4.83$ mm
with:
t_{min} = 4 mm (welding)
t_{taken} = 5 mm

$t = a \times \sqrt{h1} \times k \times C$
$t = 0.90 \times (0.90 \times 1.608)'(0.5) \times 2.90$
$t = 3.14$ mm
with:
t_{min} = 4 mm (welding)
t_{taken} = 4 mm
Bulkhead stiffeners

The values given are as follows:
a = stiffener distance in [m]
= 0.90 m
h1 = pressure height in [m] measured from the bottom edge of the bulkhead to the top of the bulkhead deck
= 1.12 m for Collision Bulkhead
= 0.90 m for Other Bulkhead
k = material factor

= 1.61

h2 = pressure height in [m] measured from stiffener center to bulkhead deck.

= 0.23 m for Collision Bulkhead

= 0.35 m for Other Bulkhead

So,

$$W = k \times C \times a \times (h2 + 0.5) \times I^2$$

for Collision Bulkhead

$$W = 1.608 \times 4.00 \times 0.90 \times (0.23 + 0.5) \times 0.92^2$$

$$W = 3.538 \text{ cm}^3$$

Profile Selection

Modulus: 5 cm^3

Profile I with dimension: 50 x 5 cm

Side Structure Calculation

Shell Side

The calculation of the thickness of the plates used in the planning of the side plates on the unmanned ship must meet the minimum standard set.

$$t = 1.62 \times a \times F_{VS} \times \sqrt{P_{dSM}} \times k$$

$$t = 1.62 \times 0.60 \times 1.1 \times \sqrt{15.86} \times 1.608$$

$$t = 5.40 \text{ mm for positions} \geq 0.4 \text{ L}$$

$$t = 1.62 \times a \times F_{VS} \times \sqrt{P_{dSM}} \times k$$

$$t = 1.62 \times 0.60 \times 1.1 \times \sqrt{12.66} \times 1.608$$

$$t = 4.82 \text{ mm for positions} \geq 0.4 \text{ L}$$

As such, the side plates used has a thickness of 6 mm along the length of the unmanned vessel.

CONCLUSIONS

The design of the fire rescue boat includes the main size of LOA 7.5 m. B 2 m. H 1.6 m and T 0.5 m. With the acquisition of a rescue boat resistance value = 2.3 kN. With the main size of the ship being small and having a speed of 8 knots, use an engine with the Suzuki DT 30 L series with a maximum power of 30HP weighing 57 kg.

The ship design will be focused on rescue in the event of an emergency at sea. With specification for life buoy is weight = 2.5 kg, external diameter = 720 mm, internal diameter = 440 mm, height = 105 mm, standard for lifeboy from SOLAS (approved).

Specification for life jacket is weight: 0.9 kg, buoyancy = 147 N, loss of buoyancy = 5% (for 24 hours), size = 560 mm*340 mm*140 mm, buoyancy material = EPE foam, standard for life jacket = SOLAS (approved). And specification for fire hose and water pump with a shaft rotation of 3600 rpm, weight = 60 kg and total head of 650 mm.

REFERENCE

Aeni. S. N. (2021. August 23). *Mengulas Pelabuhan Tanjung Perak yang Penuh Nilai Historis*. Retrieved January 20. 2024. from katadata: https://katadata.co.id/safrezifitra/berita/6120ca3814f47/mengulas-pelabuhan-tanjung-perak-yang-penuh-nilai-historis

Ahmad Nur Hasim Alfiyan. A. W. (2022). ANALISA STABILITAS KAPAL RESCUE CRAFT YANG TELAH DIMODIFIKASI MENJADI KAPAL RIGID HULLED INFLATABLE BOAT. *JURNAL INOVTEK POLBENG*. 30.

Amaritasari. I. (2015). Keamanan Nasional dalam Konsep dan Standar Internasional. *JURNAL KEAMANAN NASIONAL*. 160-161.

Anderson. J. D. (2015). *Computational Fluid Dynamics*. New York: McGraw-Hill.

Baudrillard. J. (. (1998). The Consumer Society: Myths and Structures. London: Sage Publication Inc.

Bentley. (2024. April 25). *Maxsurf*. Retrieved from Maxsurf: https://maxsurf.net/

Church. E. (2022. February 3). *Everything You Need to Know About Fireboats*. Retrieved January 20. 2024. from MARTIDE: https://www.martide.com/en/blog/all-about-fireboats

Delgado. J. (1988. June 30). *Duwamish Fireboat*. Retrieved January 20. 2024. from Archive: https://web.archive.org/web/20090505234053/http://www.nps.gov/history/maritime/nhl/duwamish.htm

Herdiyanto. N. (2020). IMPLEMENTASI INTERNATIONAL SHIP AND PORT FASILITY SECURITY CODE . *Keamanan Maritim*. 159.

Idris. M. (2023. May 5). *Profil dan Sejarah Pelabuhan Tanjung Perak Surabaya*. Retrieved January 19. 2024. from Kompas.com: https://money.kompas.com

IMO. (2022). *Interim Guidelines for Evacuation Analyses for New and Existing Passenger Ships.* London: International Maritime Organization.

Kramer. J.. & Chen. J. (2022. January 1). *Datum Corporation*. Retrieved from Datum Corporation: https://doi.org/10.29122/jurnalwave.v12i2.3461.

KUSBIYANTO. D. (2017. January 1). *RENCANA STRATEGIS (RENSTRA)*. Retrieved January 20. 2024. from dindamkar.bojonegorokab: https://dindamkar.bojonegorokab.go.id/menu/detail/37/Renstra

Lewis. E. V. (2021). *Lewis. E. V.. & Society of Naval Architects an Principles of naval architecture. Volume II. Resistance. propulsion and vibration.* U.S: Edward V. Lewis .

Lillyana Mulya. D. M. (2013). KEBIJAKAN MARITIM INDONESIA MASA KOLONIAL DAN PASCA KOLONIAL. *KEBIJAKAN MARITIM INDONESIA MASA KOLONIAL DAN PASCA KOLONIAL*. 5-6.

Matafi. S. D. (2015). Simulasi Pengaruh Trim terhadap Stabilitas Kapal Purse Seine. *Jurnal Ilmu dan Teknologi Perikanan Tangkap 2. 13–18.*. 13-18.

Muhamad Amar Jadid. D. C. (2019). Perancangan Kapal Rescue boat Di Wilayah Perairan Rawa Pening . *Jurnal Teknik Perkapalan*.

Muhamad Amar Jadid. D. C. (2019). Perancangan Kapal Rescue boat Di Wilayah Perairan Rawa Pening . *Jurnal Teknik Perkapalan. V*. 131.

Oossanen. J. M. (1988). *Principles of Naval Architecture* (Vol. II). (E. V. Lewis. Ed.) New Jersey: Edward V. Lewis.

Perhubungan. I. K. (2006). *Peraturan Menteri Perhubungan Nomor KM 55 Tahun 2006 Tentang Tata Cara Pemeriksaan Kecelakaan Kapal.* Jakarta: Biro Hukum Kementerian Perhubungan.

PNA. (1988). *Principles of Naval Architecture* . United States: EDWARD V. LEWIS.

Poundra. G. U. (2017). Optimizing trimaran yacht hull configuration based on resistance and seakeeping criteria. *Procedia Eng. 194*. 112-119.

Qin. L. Z. (2021). Shaft Power Measurement for Marine Propulsion System Based on

p - ISSN: 1978-886X
e - ISSN: 2614-641X

Magnetic Resonances. *IEICE Electron. Express 9*. 50-62.

Riza. A. (2015. April 12). *Sejarah Singkat Pelabuhan Tanjung Perak Surabaya*. Retrieved January 19. 2024. from Kompasiana: https://www.bing.com/search?q=aril+riza+2012&qs=n&form=QBRE&sp=-1&ghc=1&lq=0&pq=aril+riza+2012&sc=11-14&sk=&cvid=ABF9E44188514F389C499FF7E262573B&ghsh=0&ghacc=0&ghpl=

Rusdi. M. (2009). *A Novel Fuzzy ARMA Model for Rain Prediction.* Surabaya: Disertasi Universitas Brawijaya.

Suhardjito. G. (2006). Tentang Rencana Umum. *Tentang Rencana Umum*.

Syarifuddin. M. F. (2016). Pentingnya Pelabuhan Tanjung Perak Bagi Perekonomian Jawa Timur. *Jurnal Administrasi Bisnis*. 35.