DESIGNING A BOAT HOTEL (BOTEL) FOR MARINE TOURISM ON TABUHAN ISLAND, BANYUWANGI REGENCY, EAST JAVA

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Received: April 12, 2023 | **Accepted:** May 12, 2023 | **Published:** May 15, 2023

DOI: 10.12962/j27745449.v4i1.675 | **Issue:** Volume 4 Number 1 2023 | **E-ISSN:** 2774-5449

ABSTRACT

Tabuhan Island is one of the tourist islands in Banyuwangi Regency, which in 2020 was proclaimed by the Banyuwangi Regency government to become an international tourist destination. One of the efforts needed to make an international-class destination is to complete tourist objects with good infrastructure. One of the infrastructures that need to be completed is resorts and hotels. Design of Boat Hotel Catamaran (Botel Catamaran) is innovated with facilities equivalent to a 3-star hotel following the Ministry of Tourism and Creative Economy standards. This selection uses general dimension design parameters, which are then used in extensive travel and Botel facilities. Based on the calculations, the converted resistance of the engine has met the required power of 156 Hp. In addition, the calculation of the displacement-weight difference also showed a result of <9%, meeting the small ship margin requirement. The trim calculation also met SOLAS regulations with a result of 0% LWl < trim < 0.5% LWl. The freeboard calculation also met NCVS regulations with a result of Fb<(H-T). The tonnage calculation showed GT<500 GT, allowing the application of NCVS regulations. Finally, the comfort calculation (MSI) met the applicable ISO regulations. With these standardized calculation results, the engine is expected to operate optimally and safely. It was found that this ship has the final main dimensions, namely LoA = 29.26 m; Lpp = 28 m; B = 11.5 m; Height = 4 m; T=1.1m; B1 = 2.77; S = 6 m2 with a total of 6 rooms with a size of 30 m2 each and has been equipped with a restaurant and lounge. Then, the outline plan, general plan, and 3D model are drawn.

Keyword: Tourism, Tabuhan Island, BoTel, Catamaran

Introduction

Tourism is a potential resource that significantly contributes to Indonesia's development. However, it faces several obstacles, such as financing, promotion, and natural disasters, resulting in poor management. Therefore, this study aims to identify tourist attractions in Banyuwangi Regency, a newly developing district in Indonesia [1]. Banyuwangi Regency is located on the eastern tip of Java Island and offers a wide variety of natural tourist destinations, especially those related to nature tourism. Tabuhan Island is one of this district's most promising marine tourism destinations. It is an uninhabited island in Bengkak, Wongsorejo District, Banyuwangi Regency, East Java, and lies in the Bali Strait. This island is renowned for its white sandy beaches, clear light blue sea, shady trees, and breathtaking sunset and sunrise panoramas. Furthermore, the island features beautiful coral reef spots, making it an ideal location for diving and snorkeling [2].

Figure 1. Tourism Tabuhan Island [3]

The Banyuwangi Regency plans to develop Tabuhan Island into a world-class destination with unique resorts that maintain local wisdom. This development will be done through partnerships with private companies from abroad through a leasing agreement system [4].

Boat hotels have become a new tourist attraction developed by several researchers. The concept of a boat hotel allows tourists to stay overnight on a ship and enjoy the beauty of the surrounding sea. BoaTel appeals to tourists who want to experience a different kind of stay and connect with nature. The concept of boat hotels has been implemented in several countries, including at the Canal du Faux-Rempart in Strasbourg, France [5]. The concept of boat hotels and environmentally friendly tourism has become a necessity and trend worldwide [6][7].

The traditional Boat Hotel concept, named Le Pirate Boatel, has long been present in Indonesia, located in Labuhan Bajo [8]. However, the traditional design has not yet paid attention to the knowledge of naval architecture and ship safety. Therefore, this research discusses a new Boat Hotel design that is safe, comfortable and uses the principles of Naval Architecture. The hull concept uses a catamaran to provide a spacious deck and safe stability in slightly choppy waters.

In this paper, BoTel is a vessel designed to serve the Ketapang Port to Tabuhan Island in Banyuwangi. It adopts the BoTel design, which has been modified to meet the needs of maritime tourism in Indonesia. BoTel is designed to meet safety, security, and comfort standards according to passenger ship design standards. With its unique design and modifications, BoTel is expected to provide passengers with a comfortable and enjoyable travel experience while ensuring their safety and well-being.

Methodology

This research focuses on the location of marine tourism on Tabuhan Island, which was chosen for its international tourism potential. The construction of hotel facilities could improve the tourism standards in the area. Additionally, the waters around the island are characterized by calm and shallow conditions.

Research methodology is a framework to obtain accurate results following the research objectives. A structured and systematic research methodology is essential, as it can help researchers formulate problems, collect data, perform data analysis, and draw relevant conclusions. In research, a research methodology is created, which consists of several stages that must be carried out in a structured and sequential manner as figure 3.

Figure 2. Tabuhan Island Site [3]

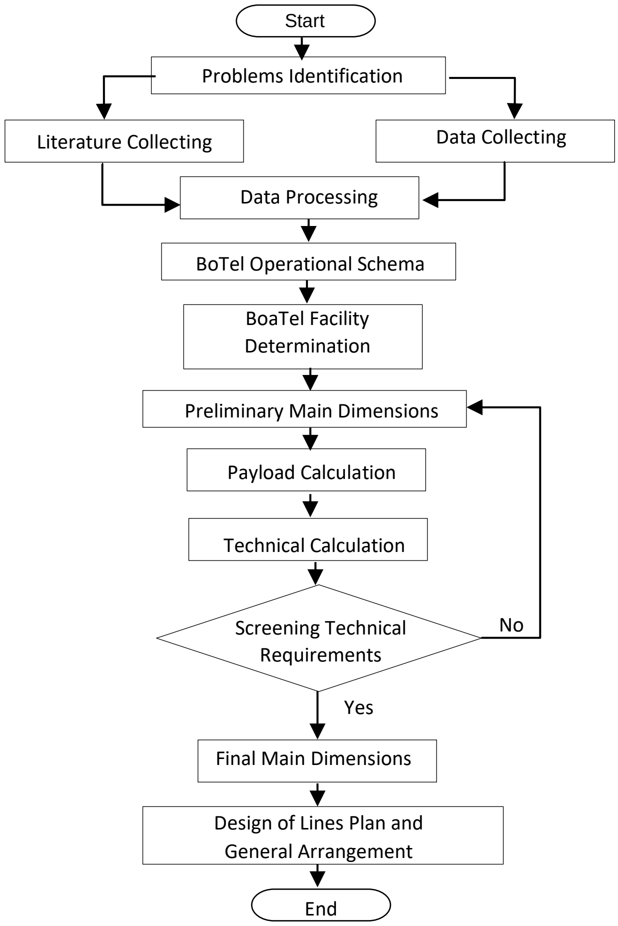

Figure 3. Flowchart of Research Methodology

Determination of Operational Scheme

The determination of the operational scheme is based on the natural conditions surrounding Tabuhan Island. Data on the island's natural conditions, such as its potential for superior tourism, is obtained from location surveys and literature studies. Based on this data, the best possible operational scheme for the ship can be determined. The results of the operational scheme can then be used in the following analysis.

Facility Determination for the Hotel

Before creating general and 3D plans, it is vital to determine the facilities that will be provided at Botel-Cat. This determination will affect the size of the building area above the main deck. The determination is based on standard hospitality rules issued by the Ministry of Creative Economy. The rules consist of two criteria: absolute and non-absolute. Due to the limited space on the ship, the focus will be on meeting the absolute criteria first in the ship's design [9].

Determination of Main Dimensions

At this stage, it is necessary to determine the depth of the water where the ship is anchored to set limits for its dimensions. The Parametric Design Approach method is used for this purpose, where researchers can decide the initial main dimensions of the ship. The primary size data is then divided into the first main dimensions and optimized through a spiral design process. The main dimensions that are decided include length (L), width (B), height (H), draft (T), mono-hull width (B1), width between demi hulls (S), and ship speed (Vs).

Payload Determination

The determination of the ship payload is based on the room space obtained from the facility plot method relative to the initial ship size. This plot will indicate the hotel rooms required to accommodate the passengers on the ship.

Determination of Technical Calculations:

The technical calculation of the ship consists of the following steps:

- **Calculation of coefficients and ship ratios**

Table 1. Main Dimension Ratio [11]

Ratio Main Dimension Comparison		
5,9 <	L / B1	< 11,1
6 <	L / H	< 11
0,7 <	B / H	< 4,1
0,19 <	S / L	< 0,51
0,9 <	S / B1	< 4,1
0,9 <	B1 / T	< 3,1
0,15 <	B1 / B	< 0,3

Geometry coefficient and primary dimension ratio are essential factors in determining a ship's characteristics. In the design of BoaTel, a catamaran hull with a geometry coefficient using a slender body is used to maximize the speed and stability of the ship. In addition, the primary dimension ratio of this ship follows the ratio of a catamaran hull based on the Molland ratio, which has been proven effective in improving the ship's performance. The ratio limit is as table 1.

- **Calculation of resistance and ship power:** The resistance of a catamaran hull has two main components, namely the resistance of the two catamaran hulls and the interaction resistance between the two hulls. The resistance of the two catamaran hulls is calculated using the same formula as a mono-hull ship, which involves calculating the wetted surface area and the ship's speed. Meanwhile, the interaction resistance between the two hulls is calculated based on the distance between them and the turbulence effect between them. The formula used to calculate the resistance of a catamaran hull is formulated as follows [11]:

$$R_T = 0.5 \times WSA \times V^2 \times C_{tot} \quad (1)$$

$$C_{tot} = (1 + \beta k) \times C_f + \tau \times C_w \quad (2)$$

After calculating the ship's resistance, the results can be converted into the required power of the main engine needed to achieve the desired speed. The appropriate main engine can then be searched for in the main engine catalog based on the calculated power requirement for the ship.

- **Calculation of weight margin:** The displacement of a ship is an essential component in marine engineering as it determines the ability of a ship to float on water. The weight of a ship consists of two main components, namely, the weight of steel (W_L) and the dead weight tonnage (DWT). The weight of steel refers to the weight of the ship's steel structure, while the dead weight tonnage refers to the weight of the cargo or goods that can be carried by the ship. The weight components can be formulated as follows:

$$\Delta = W = W_L + DWT \quad (3)$$

$$\Delta = (W_L + W_M + R) + (W_{Lo} + W_F + W_{PR} + W_P + W_{CR} + B) \quad (4)$$

The weight margin of a ship is given as an allowance or reserve weight for the ship because not all components are accounted for during construction, and often there are additions. This margin ensures that the ship can still float and operate safely. The weight margin is usually set at less than 10% of the calculated ship weight for small ships.

- **Calculation of ship trim:** this is the condition where a ship has a difference in elevation between the bow and the stern waterline. Trim is calculated so that the ship's propeller is permanently submerged in water while sailing, allowing the engine to operate efficiently and increase the ship's speed. Ship trim is calculated using the provisions of SOLAS Chapter II-1, Part B-1, Regulation 5-1, which ensures that the ship has the appropriate trim for its characteristics and meets established maritime safety requirements.

$$0\% \text{ Lwl} \leq (Ta - Tf) \leq 0.5\% \text{ Lwl} \quad (4)$$

- **Calculation of ship tonnage:** the tonnage of a ship refers to the maximum load capacity that a ship can carry. The tonnage of a ship is calculated based on the volume of enclosed spaces and the number of passengers or cargo that can be carried by the ship. The calculation of ship tonnage is critical because it will affect the safety requirements and equipment that must be met by the ship, including the number and types of safety equipment such as lifeboats and life jackets, as well as other requirements such as speed and distance between other ships at sea [10]. The formula for calculating tonnage is as follows:

$$GT = K_1 \times V \quad (5)$$

$$NT = a + K_3 \times \left(N_1 \times \frac{N_1}{10}\right) \quad (6)$$

- **Calculation of freeboard:** this is the vertical distance between the waterline and the main deck of a ship. A sufficient freeboard provides adequate reserve buoyancy to ensure the ship can sail safely, especially in rough weather conditions. The calculation of the freeboard can be done using various NCVS regulations. The formula for calculating freeboard is as follows.

$$Fb > (H - T) \quad (5)$$

- Calculation of ship stability: this is one of the measures of a ship's safety that indicates the possibility of the ship capsizing. Stability is measured by the restoring moment arm (GZ), a function of the heel angle. The greater the value of GZ at a heel angle, the greater the restoring moment arm of the ship, making the ship more stable. The calculation of stability uses the following formula:

$$GZ\ (\theta) = GZ_0\ (\theta)^1 + GZ_{10}\ (\theta)^2 + \cdots + GZ_{Vanishing}\ (\theta)^n \quad (5)$$

- **Comfort Analysis:** A comfort analysis is performed to determine the level of passenger comfort. The comfort indicator used is Motion Sickness Incidence (MSI). The analysis is designed so that the ship is in a sea state condition that does not cause sea sickness for passengers. The calculation of MSI uses the following formula:

$$MSI(\omega_{e\ centre}) = \int_{\omega_{e1}}^{\omega_{e2}} S_{vert\ accel}(\omega_e) d\omega_e \quad (6)$$

Linesplan Drawing

After obtaining the calculation results, the Botel-Cat design is drawn, which consists of a Lines Plan. This drawing must refer to the results of the main dimensions and technical calculations. The drawing process is assisted by CAD software.

General Arrangement and 3D drawing

Drawing the General Arrangement (GA) follows the planning of equipment and supplies used on the ship and the lines plan. CAD software applications assist the GA drawing process. Drawing the 3D design refers to the GA drawing with the help of 3D modeling software.

Result and Discussion

Operational Scheme Determination

The ship is designed to meet the hotel facility standards set by the Ministry of Tourism and Creative Economy while also being adjusted to the ship's capabilities and the needs of tourists. The standard level of facilities used follows a 3-star hotel standard [9].

The Botel design includes a hotel building, signage, lobby, front office, public restrooms, dining, and drinking facilities, guest bedrooms, kitchen, utilities, waste management, housekeeping, dining, and drinking areas, and health facilities. The operation distance between Mutiara Beach and Tabuhan Island is 1.62 nano miles. The ship is built to have a service speed of 7 knots. It can be reached in 15 minutes, twice as fast as a conventional existing boat.

The ship is designed to accommodate 12 passengers, determined by drawing the room layout on the ship's main deck while adhering to specified size limitations and minimum room area according to the chosen hotel type. The Botel Catamaran ship chosen is a 3-star hotel type, with consideration of the size and hotel facilities that fit the ship's size. Based on the Regulation of the Minister of Tourism and Creative Economy on hotel business, the required number of crew members is determined to be ten, consisting of 4 crews and six non-marine crews.

Main Dimension and Ratio Determination

The main size of the ship is determined using the parametric design method. The ship's ladder is limited to 1.1 m based on the water depth around Tabuhan Island, where the ship is anchored. The main dimensions are obtained from mean ratios in Table 1 as follows:

Length perpendiculars (Lpp)	= 28	m
Breadth overall (B)	= 11.5	m
Height (H)	= 4	m
Draft (T)	= 1.1	m
S(m)	= 6.0	m
Breadth Demi Hull (B1)	= (B-S)/2	
	= 2.75	m
Maximum Speed (Vmax)	= 10.0	knots
Service Speed (Vs)	= 7.0	knots

It is essential to note the significance of these results and their implications for the design and operation of the ship. However, it is also important to avoid extensive citations and discussion of published literature and instead focus on the practical applications and implications of the results. A combined Result and Discussion section can help achieve this goal.

The Catamaran hull's performance depends on the ratio of its main dimensions, such as length, width, and height. Designers should consider ratios like length-to-beam, beam-to-draft, and length-to-draft to optimize stability, speed, and fuel efficiency. The ratios improve performance and reduce accidents at sea—the main dimensions ratio values are as follows.

Table 2. Checking Main Dimension Ratio [11]

Main Dimension Comparison				
L / B1	5,9 <	10,182	< 11,1	**Accepted**
L / H	6 <	7	< 11	**Accepted**
B / H	0,7 <	2,875	< 4,1	**Accepted**
S / L	0,19 <	0,214	< 0,51	**Accepted**
S / B1	0,9 <	2,182	< 4,1	**Accepted**
B1 / T	0,9 <	2,5	< 3,1	**Accepted**
B1 / B	0,15 <	0,239	< 0,3	**Accepted**

Machine Selection

The ship resistance calculation employs the theory of Insel and Molland because this particular ship falls within the scope of these calculations [11]. Consequently, the ship's resistance is determined to be 14.4 kN. Based on the known ship resistance, it is possible to calculate the necessary power and determine which main engine is suitable for this ship. In this case, two units of the Weichai WP4C120-18 engine, with the following specifications, are selected:

- Engine type: Weichai WP4C120-18
- MCR (kW): 120 HP (88 kW)
- Speed: 1800 rpm

To determine the power requirements for the ship's generator, the per-unit electricity needs of the ship are taken into account until the required electrical power value of 152.8 kW is reached. One engine requires 95.55 kW. As a result, the selected generator engine is:

- Engine type: Yxxxxr 4HAL2-TN
- MCR (kW): 156 HP (115 kW)
- Speed: 1800 rpm

Weight Calculation:

The method used for calculating a ship's weight and center of gravity involves breaking down the weight of the ship's skin and construction using a position-by-position method. Ship weight calculations consist of two parts: LWT and DWT. The ship's LWT is calculated by adding the weight of the ship, machinery, and Outfitting.

For this ship, the LWT is 70.61 tons. The DWT is calculated based on the consumables and the number of people on board. The DWT weight is 25.06 tons, making the ship's total weight 95.67 tons. The maximum acceptable difference between the ship weight and displacement is 10%. This ship's weight and displacement have a difference of 8.97%, which is within the acceptable limit, making it an acceptable ship.

Tonnage Calculation

The tonnage calculation formula refers to the Indonesian Flagged Non-Convention Vessel Standard (NCVS) [10]. As this ship design is classified as a small vessel for coastal crossing, the tonnage value of this ship is as follows:

- Gross Tonnage = 327.124 GT
- Net Tonnage = 98.137 NT

Since the NT value is greater than or equal to 0.3GT, it is accepted. Regulations to determine safety, stability, and freeboard for vessels with a GT value below 500 GT refer to NCVS regulations.

Stability Analysis

Ship stability refers to a vessel's ability to return to its original position after being affected by external disturbances, such as waves or wind, and its ability to avoid capsizing or overturning. The Maxsurf Stability Education Version software aids the stability analysis. According to the criteria established by the Non-Convection Vessel Standard (NCVS) [10], this ship meets the following criteria.

Table 3. Criteria stability of BoTel

Code		Criteria	Value	Units
NCVS Ch. 5A	Ch.5A - Comprehensive criteria of general application to all vessels	5A.3 - Area 0 to 40	5.1623	m.deg
		5A.6a - Initial GMt - Class 1	0.15	m.deg
NCVS Ch. 5B	Ch.5B - Alternative comprehensive criteria of general application to catamarans in operational areas B, C, D and E	5B.1- Area from 0 to 30	6.4996	m.deg
		5B.2 - Angle of maximum GZ	10	deg
		5B.3 & 4 - Angle of equilibrium - multiple heeling arms	16	deg
		5B.5: Area between GZ and HA	1.61	m.deg

Next, the stability calculations are compared to the stability criteria in **Table 4** for seven different load cases. The results indicate that all criteria for the seven load cases meet the following passing requirements.

Table 4. Stability of BoTel

No.	Load Case		5A.3 (m.deg)	5A.6a (m.deg)	Status
	Penumpang	Consumables			
1	0%	10%	33.48	23.44	*Pass*
2	50%	10%	33.71	23.28	*Pass*
3	50%	50%	39.30	20.97	*Pass*
4	50%	100%	138.60	26.34	*Pass*
5	100%	10%	33.94	23.13	*Pass*
6	100%	50%	39.46	20.84	*Pass*
7	100%	100%	138.40	26.21	*Pass*

No.	Load Case		5B.1 (m.deg)	5B.2 (deg)	5B.3 (deg)	5B.4 (m.deg)	Status
	Penumpang	Consumables					
1	0%	10%	15.43	10.00	3.9	26.79	*Pass*
2	50%	10%	15.47	10.00	3.9	26.89	*Pass*
3	50%	50%	18.704	10.90	3.3	28.855	*Pass*
4	50%	100%	41.696	14.50	2.2	43.667	*Pass*
5	100%	10%	15.524	10.00	3.9	0.1	*Pass*
6	100%	50%	18.702	10.90	3.3	28.87	*Pass*
7	100%	100%	41.593	14.50	2.1	43.561	*Pass*

Comfort Analysis

The comfort analysis method utilizes Maxsurf Motion software by inputting required variables such as wave height, significance, heading, and desired location to analyze the MSI value [12]. In this study, the areas analyzed for comfort include passenger rooms 1 (front), 2 (middle), and 3 (back), crew accommodation room, restaurant, and lobby. These locations were selected based on the frequency of visits by passengers and crew. The variation of wave direction used against the ship's angle of incidence includes 0 degrees (following sea), 45 degrees (quartering sea), 90 degrees (beam sea), and 180 degrees (head sea).

The analysis was conducted in various areas where visitors spend their time, such as rooms, crew rooms, restaurants, and lobbies. The comfort standard is used for an operational time of 30 minutes, adjusted to the estimated time the ship sails on one trip. Based on the inputs, the results are presented in Figures 7, 8, 9, and 10. The results from the curves indicate that the encounter frequency value for all areas checked for comfort remains below the discomfort limit for a 30-minute cruise time (gray line). Therefore, it can be concluded that the Botel design provides good comfort.

Design of Lines Plan and General Arrangement

After obtaining all the necessary calculations, the ship's design can be finalized. The ship's design drawings include a Lines Plan, General Arrangement, and a 3D model. These drawings are created using Maxsurf Modeller, AutoCAD, and 3D modeling software. Figures 4, 5, 6, and 7 depict the Lines Plan, General Arrangement, and 3D model drawings.

Conclusion

Maritime tourism using fuel-efficient and environmentally friendly ships has become increasingly important worldwide. Various research and scientific publications have addressed this issue, including studies on using renewable energy in tourist ships, reducing carbon emissions in the shipping industry, and waste management strategies on tourist ships. This paper presents the design of the BoaTel ship, which is a development of previous research and meets the market demand on Tabuhan Island with the following results:

1. The operational scheme planning for the Botel Catamaran ship is as follows: the ship will sail from Mutiara Beach of Tabuhan Island to Tabuhan Island, with a maximum sailing time of

15 minutes. The ship will stay overnight on Tabuhan Island for 18 hours before sailing back to the initial departure point at Mutiara Beach Tabuhan,
2. The facilities on this ship have been established according to the standards set by the Ministry of Tourism and Creativity,
3. The main dimensions final of the BoTel are as follows: Loa = 29.26 m, Lwl = 28 m, B = 11.5 m, B1 = 2.75 m, H = 4 m, T = 1.1 m, S = 6 m, Vs = 7 knots, Crew = 10 persons, Passengers = 12 persons,
4. Design drawings of the line plan and general plan have been created to align with the characteristics of the Tabuhan Island waters.

Acknowledgements

We want to express our deepest gratitude to the Banyuwangi Tourism Office and Sofware Maxsurf Education Version for their invaluable assistance and support in completing this paper. The data provided by the Banyuwangi Tourism Office was instrumental in providing a more comprehensive and accurate overview of tourism in Banyuwangi. Meanwhile, Sofware Maxsurf Education Version greatly aided the data analysis and visualization process, allowing us to obtain optimal results. Without the assistance of both parties, this paper may not have been completed successfully. Therefore, once again, we extend our heartfelt thanks for the help and support provided.

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