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Design Optimization of a Modern Catamaran Using Dynamic Stability Criteria for Improved Safety in Jeneberang River Transport

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***Abstract*—** River transport on the Jeneberang River plays a vital role in supporting daily mobility between Gowa Regency and the city of Makassar. However, the traditional boats (katinting) currently in use still have low safety standards due to poor stability and a lack of safety equipment. This study aims to optimise the design of a modern catamaran vessel based on dynamic stability criteria to produce a safer and more stable ferry configuration. The method employed is the Parent Design Approach, utilising geometric modelling with AutoCAD and stability analysis using Maxsurf, evaluated under three loading conditions: empty, half-load, and full-load. The results show that a design with the main dimensions LOA = 12,00 m; B = 5,00 m; T = 0,55 m; and ratios L/B = 2,4; B/T = 9,09; H/T = 2,91 possesses good stability characteristics. All loading conditions met the criteria of the IMO Intact Stability Code (IS Code) with positive GM values and a stable GZ curve that remained consistent across load variations. The final 3D design accommodates 20 passengers and 15 motorcycles, and is equipped with safety equipment and a roof, thereby enhancing operational safety and comfort. Thus, this study demonstrates that the integration of empirical data with dynamic stability-based optimisation can yield practical, safe, and sustainable design solutions for small-scale river transport.

Keywords— *Catamaran Design, Dynamic Stability, Parent Design Approach, River Transportation, Safety Optimization.*

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I. INTRODUCTION

River transportation is a crucial mode of transportation for communities in Indonesia, particularly in areas with suboptimal land infrastructure. In Gowa Regency, particularly in the community of Taeng Village, where the majority of residents have low to middle incomes, river crossings are essential for their daily mobility, whether for economic activities, education, or accessing social services in Makassar City [1]. This trend is driven by the growth of land traffic, which has caused severe congestion, especially on the twin bridges connecting Makassar and Gowa [2]. Although the crossing distance is relatively short, about 200 meters, the high volume of traffic makes this route a key access point for the daily mobility of the local community [3].

Despite its strategic importance, the current ferry service is still dominated by traditional modes of transport, namely local motorized wooden boats (katinting). These boats typically have a capacity of approximately 20 passengers and 15 motorcycles, offering affordable fares ranging from Rp2.000 to Rp5.000. Although economical and easily accessible, katinting boat operations are still far from adequate safety standards. The absence of navigation equipment, safety gear, and the poor quality of construction lead to a high risk of accidents, such as hull leaks, capsizing, and even loss of life [4]. These conditions suggest that the existing ferry transportation system has not met the technical safety standards necessary to ensure the service's sustainability [5].

The main issue in this study lies in the low level of safety in traditional river crossings on the Jeneberang River. This is influenced by vessel designs that do not comply with marine engineering principles, particularly regarding dimensional proportions, load distribution, and stability characteristics. The katinting boat, as the primary mode of transport, exhibits suboptimal geometric configuration, uncontrolled load distribution, and the absence of an integrated safety system. Consequently, the vessel is highly susceptible to stability disturbances, particularly under varying operational conditions. This phenomenon reflects a significant gap between the community's mobility needs and the quality and safety of the available transportation infrastructure.

In naval architecture, ship stability is a fundamental parameter that determines operational safety under various hydrodynamic conditions [6] [7]. Ship stability includes the static and dynamic ability of a ship to return to equilibrium when faced with external disturbances, such as water currents, waves, uneven load distribution, and passenger interaction on deck [8] [9] [10]. Previous studies have shown that dynamic stability evaluation is a key requirement in passenger ship design to anticipate the risk of rolling and capsizing [11] [12].

The hull design also determines the overall stability characteristics of the ship [13]. The catamaran configuration has hydrostatic advantages in the form of greater beam width, smoother motion response in transverse roll conditions, and generally higher righting arm and metacentric height (GM) values compared to standard monohull designs [14] [15]. Research testing the stability performance of catamaran vessels using numerical analysis emphasises that optimised hull design can improve tolerance to load variations and small wave disturbances [16] [17].

Digital modelling of ship geometry and stability

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analysis has advanced significantly thanks to advances in computer-aided design applications such as AutoCAD for technical modelling, as well as specialised software such as Maxsurf for hydrostatic and dynamic stability evaluation of ships [18] [19]. The application of these numerical methods enables rapid and accurate examination of GZ curves, metacentric height, and other stability indicators [20] [21]. In addition, research on small to medium-sized ships based on numerical simulation has also proven that design optimisation can help formulate hull shapes that meet operational safety criteria [22] [23].

However, the majority of studies currently available focus on large commercial vessels, offshore speedboats, or tourist boats [24] [25] [26]. The application of catamaran design for short-distance river transportation modes traditionally operated by low-income communities, such as the Jeneberang River crossing model, is still rarely discussed in recent literature [27]. Several studies have examined the stability of small vessels and river ferries, but few have integrated AutoCAD modelling and Maxsurf stability analysis approaches in the context of community river transportation needs [28] [29] [30]. Furthermore, the approaches used thus far have generally failed to comprehensively integrate empirical field data with dynamic stability analysis, particularly within the framework of the Parent Design Approach as a reference-ship-based design method.

Given these conditions, this study offers novelty through several key aspects: (1) the application of the Parent Design Approach based on the actual conditions of existing vessels as the initial design reference; (2) the integration of ship geometry modeling using AutoCAD with dynamic stability analysis based on the Maxsurf software; and (3) the evaluation of ship stability performance under various loading conditions that represent actual operational conditions.

This study aims to optimize the design of modern catamarans based on dynamic stability criteria to produce a safer and more stable ship configuration for ferry operations on the Jeneberang River. This research is important because of the high safety risks in traditional ferry transportation due to ship designs that do not meet technical standards. Furthermore, the limited number of studies on catamaran designs for small-scale river transportation makes this research relevant as a practical and contextually applicable technical solution.

II. LITERATURE REVIEW

A. River Transport

River transport plays a vital role in supporting community mobility, particularly in areas with limited land infrastructure, such as along the Jeneberang River. However, various studies indicate that safety standards in river transport remain relatively low due to the use of traditional vessels that fail to meet technical standards in design, stability, or safety equipment [31]. Issues such as overloading and uneven load distribution are the main factors contributing to the increased risk of accidents on small-scale ferry vessels.

B. The Concept of Ship Stability

In ship architecture, stability is a fundamental parameter that determines a ship’s ability to return to a balanced position following an external disturbance. Initial stability is indicated by the metacentric height (GM), whilst advanced stability is analysed using the righting arm curve (GZ). International standards such as the IMO Intact Stability Code (IS Code) require a positive GM value, a sufficient area under the GZ curve, and a specific maximum angle of stability as indicators of ship safety. Compliance with these criteria serves as the primary benchmark in the evaluation of a ship’s design suitability.

C. Catamaran Design

Catamarans feature a twin-hull configuration that offers advantages in terms of transverse stability compared to monohull vessels. The greater effective beam results in a higher restoring moment, making the vessel more stable under wave action and load distribution. Furthermore, catamarans have a relatively shallow draught, making them suitable for shallow waters such as rivers. Several studies have also shown that catamarans exhibit less roll and are safer for passenger vessels [32].

D. Ship Design Methods

Modern ship design generally employs software-based numerical approaches, such as AutoCAD for geometric modelling and Maxsurf for hydrostatic and stability analysis. This approach enables more accurate and efficient design evaluation, particularly when analysing ship performance under various loading conditions. Furthermore, the Parent Design Approach is frequently used to develop new designs based on existing ships by modifying specific parameters, thereby producing more realistic designs [33].

III. METHOD

A. Data Types and Sources

This study employs a quantitative approach, utilizing a ship design engineering method that focuses on optimizing catamaran design based on dynamic stability criteria to enhance river transport safety. The design process in this study applied the Parent Design Approach, which is a ship design method that uses existing ships as the main reference (parent vessel) to develop new ship designs through modifications to the main dimensions, hull configuration, and load capacity according to operational needs [34] [35]. This approach is commonly used in ship architecture engineering because it can accelerate the design process while maintaining the operational characteristics of ships that have been proven in the field [36].

The study was conducted on the crossing route across the Jeneberang River, which connects the jetty in the Benteng Somba Opu area with the village of Taeng in Gowa Regency; the route is 200 metres long and takes 3 minutes to cross, and it serves as a means of transport for residents travelling to the city of Makassar. The traditional katinting boat operating on this crossing route was used as the parent vessel in this study. A detailed map of the crossing route and crossing locations can be seen in Figure 1.

Figure 1. Map of the Jeneberang River Crossing Location

The data used consists of primary and secondary data. Primary data was obtained through field observations, direct measurements of the vessels' dimensions, and technical documentation of the catamarans operating on the Jeneberang River crossing route, as illustrated in Figure 2

Figure 2. Current Condition of the Katinting Boat on the Jeneberang River

Physical measurement methods were used to determine the ship's principal dimensions accurately. The key parameters, which include Length Overall (LOA), Breadth (B), Depth (H), and Draft (T), are summarised in Table 1, which was then used as the basis for developing a new catamaran design [37].

TABLE 1.
MAIN DIMENSIONS OF THE JENEBERANG CATAMARAN

Principal Dimension	Symbol	Value	Unit
Length Over All	LOA	12,00	m
Breadth	B	5,00	m
Breadth of One Hulls	B	1,10	m
Distance Between Hulls	S	2,80	m
Depth	H	1,60	m
Load Draft	T	0,55	m
Deadweight	DWT	3,05	ton
Service Speed	Vs	2	knots

Meanwhile, secondary data was obtained from scientific literature, ship design standards, and small passenger ship safety guidelines related to ship stability analysis. This data included ship stability theory, catamaran design characteristics, and stability evaluation standards based on international safety guidelines such as the International Code on Intact Stability (IS Code) [38] [39]. In addition, technical references on the use of ship design software such as AutoCAD for geometric modelling and Maxsurf for hydrostatic and stability analysis were also used as a basis in the catamaran design optimisation process [40].

B. Data Collection

The data collection technique employed in this study utilises purposive sampling, which involves the deliberate selection of samples based on specific criteria relevant to the research objectives, particularly within the context of ship design based on the Parent Design Approach [41]. The samples used were katinting boats operating on the crossing route on the Jeneberang River, which served as the parent vessel in the design optimisation process for the catamaran.

The sample selection criteria include: (1) vessels used regularly as a means of public transport; (2) with a carrying capacity of approximately 20 passengers and 15 motorcycles; and (3) operating on short-distance crossing routes of approximately 200 metres. This sample selection aims to ensure that the optimised vessel design remains consistent with operational requirements and user characteristics in the field [42].

Data collection was carried out through direct observation and technical measurements of existing vessels, covering the vessel's main dimensions, load capacity, and the distribution patterns of passenger and vehicle loads. This data was used as the basis for determining the initial design parameters of the catamaran to be developed [43]. Furthermore, this approach allows for the representation of the vessel's actual operational conditions, ensuring that the resulting design is more practical and realistic.

C. Data Analysis

The data analysis method in this study was carried out in stages using a design engineering and numerical analysis approach to obtain the optimal catamaran configuration [44]. The analysis began with the determination of initial design parameters based on reference vessel data, followed by the modelling of the vessel's geometry using AutoCAD to produce a representative hull form.

The geometric model created was subsequently analysed using Maxsurf software to obtain the vessel's hydrostatic and stability parameters. This analysis includes an evaluation of displacement, metacentric height (GM), and the righting lever curve (GZ) under various loading conditions to describe the vessel's dynamic stability response [45]. The analysis results were then compared with safety criteria based on international standards, such as the International Code on Intact Stability (IS Code), to assess the design's feasibility [46]. Subsequently, a design optimisation process was carried out, involving adjustments to the catamaran's main dimensions and hull configuration to improve stability performance without reducing cargo capacity. This process was conducted iteratively until a design was obtained that met safety criteria and was suitable for transport operations on the Jeneberang River.

D. Conceptual Framework

The research flowchart for this study is shown in Figure 3.

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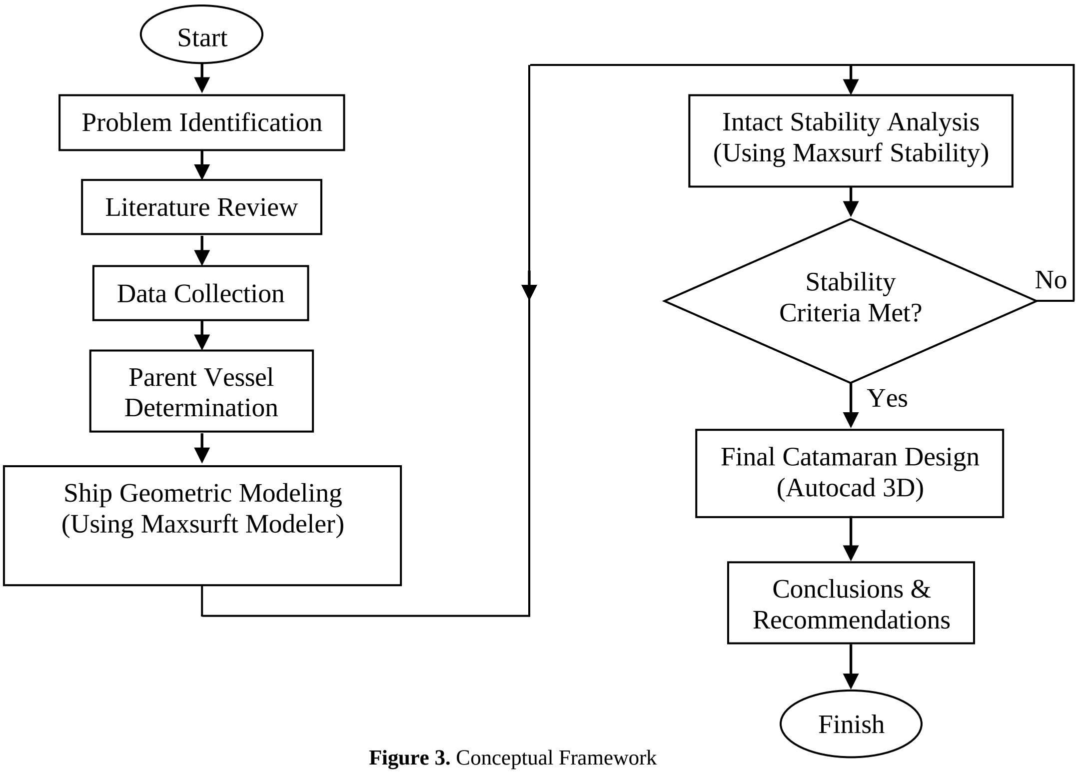


Figure 3. Conceptual Framework

IV. Results and Discussion

A. *Parent Vessel Determination*

The selection of the parent vessel in this study was carried out quantitatively using geometric ratios as the primary benchmark, rather than being based solely on observations of existing vessels on the Jeneberang River. The traditional vessels used as the initial reference exhibited an imbalance in dimensional ratios, which resulted in low stability.

Based on the optimisation results, the primary vessel dimensions have an L/B ratio of 2,4, a B/T ratio of approximately 9,09, and an H/T ratio of approximately 2,91, which technically indicate improved transverse stability, suitability for shallow waters, and a safe freeboard. These findings confirm that the transition from a traditional monohull to a catamaran configuration based on a measured ratio is capable of delivering a measurable and consistent improvement in stability performance.

The Parent Design Approach enables the selection and modification of the parent vessel to be carried out in a systematic and quantifiable manner, rather than through trial and error as in conventional practice. Furthermore, these results indicate that geometric ratios can serve as an initial indicator for predicting stability performance before further numerical analysis. In terms of discussion, these findings reinforce the results of previous research stating that ratio parameters have a significant influence on ship stability; however, this study goes a step further by integrating them directly into the process of determining the parent vessel.

B. *Linesplan Analysis*

The line plans shown depict three main views: the profile view, the body plan, and the plan view, which represent the complete geometric form of the catamaran, as shown in Figure 4.

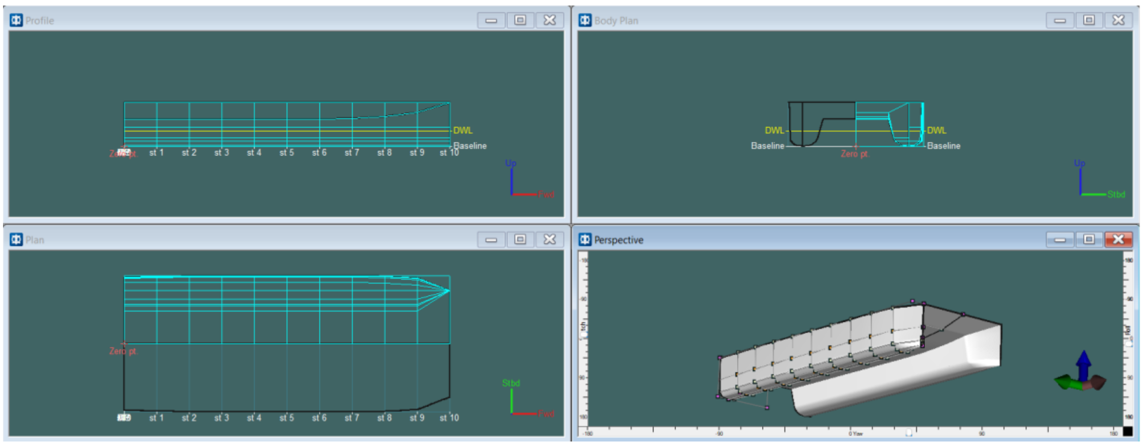


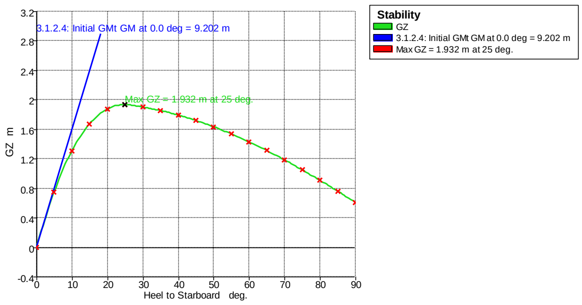
Figure 4. Linesplan of the Jeneberang Catamaran

The body plan shows two symmetrical hulls, whilst the plan view illustrates a consistent distance between the hulls (S = 2.80 m), and the profile view depicts a stable waterline.

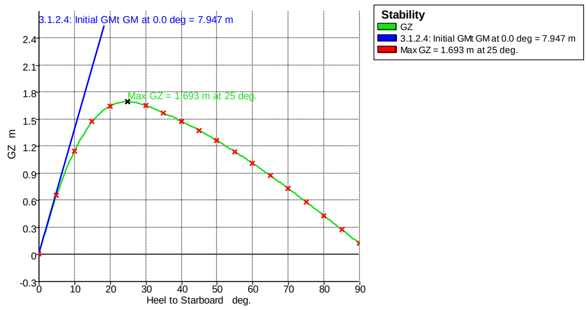
Visually, the model in Figure 4 shows a smooth hull form (fair hull form) without discontinuities, thereby supporting an even volume distribution and improved stability. This is consistent with the design ratios, so the geometric model shown is deemed valid and suitable for further stability analysis.

C. Intact Stability Analysis

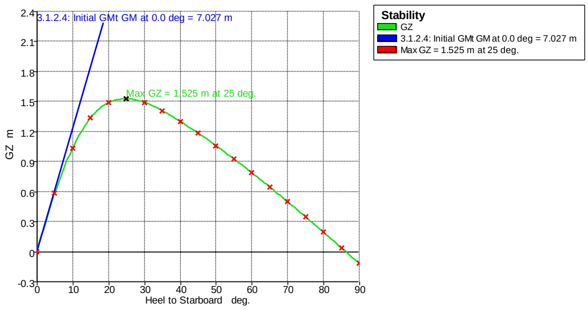
Based on the stability curves shown in Figure 5, an analysis was conducted for three loading conditions: empty, half-load, and full-load on the Jeneberang River.



(a) Right-arm curve in condition 1 (lightship)



(b) Right-arm curve in condition 2 (half load)



(c) Right-arm curve in condition 3 (full load)

Figure 5. Right Arm Curve of Jeneberang Catamaran

Visually, all three curves show a consistent pattern with a peak of stability at an angle of approximately 25°, although the values decrease as the load increases. Under the empty vessel condition, GM = 9.202 m and maximum GZ = 1.932 m were obtained, indicating very high stability. At half load, the values decreased to GM = 7.947 m and maximum GZ = 1.693 m, whilst at full load, GM = 7.027 m and maximum GZ = 1.525 m were obtained.

When assessed against the stability criteria of the IMO Intact Stability Code (IS Code), all three conditions meet the primary requirements, namely:

1) Positive GM values across all conditions indicate that initial stability is satisfied.
2) The GZ curve has sufficient area across the range of heel angles to meet the stability area requirement.
3) The maximum GZ angle is above 20° (approximately 25°), satisfying the maximum stability angle criterion.

In terms of the findings, an interesting pattern emerged: although the GM and GZ values decreased as the load increased, the shape of the GZ curve remained consistent and did not shift at its maximum angle. This indicates that the catamaran configuration possesses stable stability characteristics, whereby changes in load do not significantly alter the vessel's fundamental stability behaviour. These findings reinforce the catamaran's advantage in maintaining stability performance under varying loading conditions.

Furthermore, the refinement of these findings was carried out using a comparative analysis of multiple loading conditions directly linked to the stability curve characteristics, rather than merely focusing on compliance with IMO criteria. This study demonstrates that the design not only 'meets the standards' but also exhibits resilience to load variations, which is a key indicator in river transport operations.

D. Final Catamaran Design

The 3D image shown depicts the final configuration of the catamaran, which has been optimised for operation on the Jeneberang River, as illustrated in Figure 6.

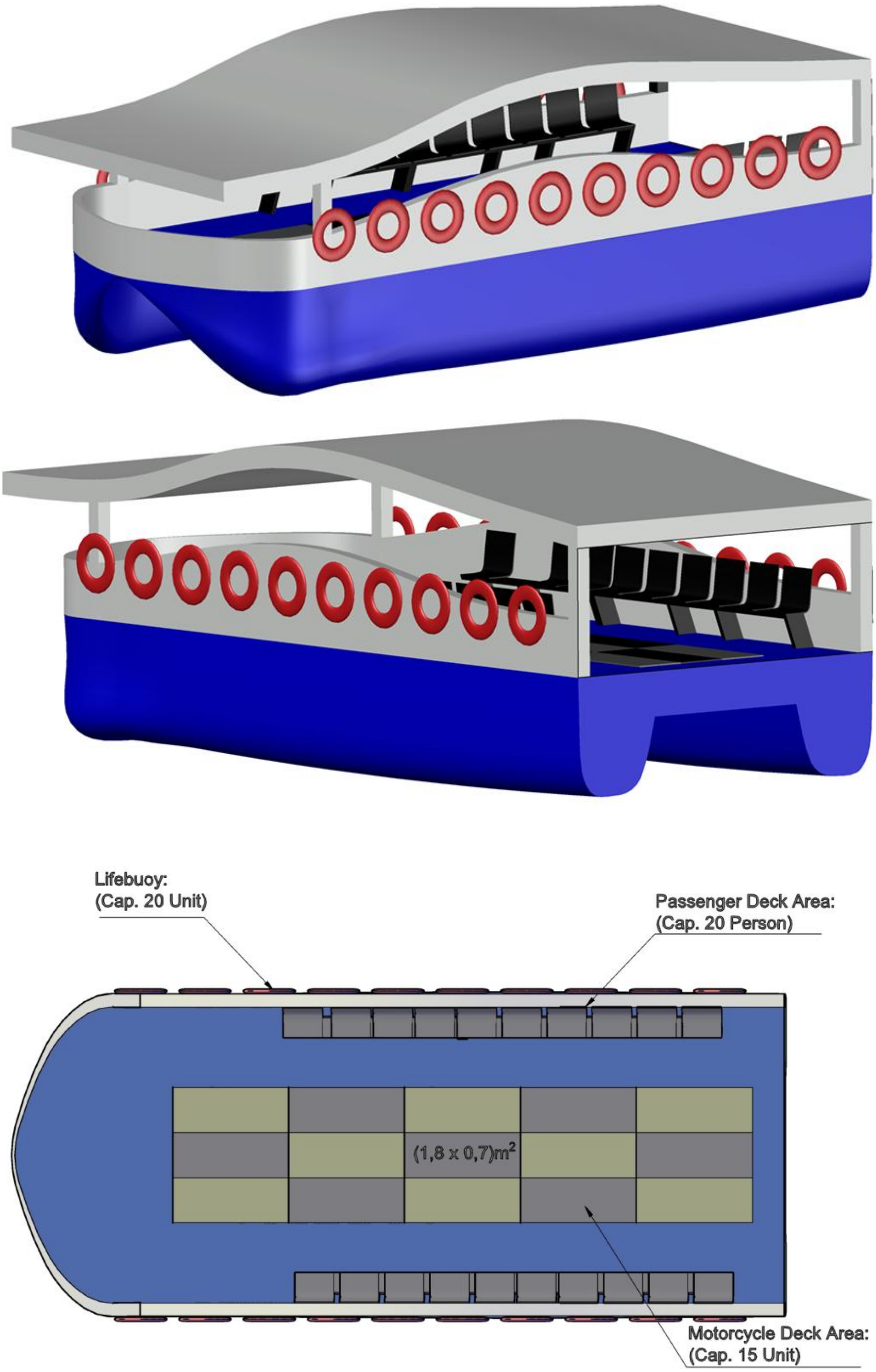


Figure 6. Final Catamaran Design for Jeneberang River

Visually, the design features a structured deck layout with 20 passenger seats on the sides, as well as a central area for 15 motorcycles, which helps to ensure a more balanced load distribution. Furthermore, safety equipment (20 lifebuoys) is positioned on the sides of the vessel for easy access, whilst the roof deck serves to protect passengers. This 3D model confirms that the design not only meets stability requirements but also integrates safety, capacity, and comfort.

The novelty of this study lies in its design approach, which is not only focused on ratio and stability parameters but also incorporates user-needs-based operational layouts into the design optimisation process. Compared to previous studies, which generally stopped at technical analysis, this study demonstrates that optimisation results can be translated into practical designs.

V. CONCLUSION

This study aims to optimise the design of a modern catamaran based on dynamic stability criteria to produce a safer and more stable vessel configuration for ferry operations on the Jeneberang River. Based on the results obtained, design optimisation using the Parent Design Approach and stability analysis indicates that a catamaran configuration with an L/B ratio of 2,4; B/T ratio of 9,09; and H/T ratio of 2,91 is capable of enhancing transverse stability and is suitable for shallow water conditions.

Findings from the stability analysis under three loading conditions (empty, half-load, and full) indicate that all parameters comply with the IMO Intact Stability Code (IS Code), with consistently positive GM values and a stable GZ curve at a maximum angle of approximately 25°. Furthermore, the consistency of the curve's shape across various conditions demonstrates that the design possesses stability characteristics resistant to load variations. The 3D visualisation results also confirm that the design is capable of optimally accommodating operational requirements, with a capacity of 20 passengers and 15 motorcycles, and is equipped with safety facilities and a roof, thereby enhancing safety and comfort.

The main contribution of this research is the successful integration of an empirical data-driven design approach (parent vessel) with dynamic stability analysis, which has hitherto been limited to studies of small-scale vessels. This research also addresses a research gap regarding the design of catamarans for river transport that is practical and based on community needs.

Consequently, the resulting design has the potential to be adopted by river transport operators, local authorities, and the shipbuilding industry as a reference for the development of safer and standardised ferry vessels. Recommendations for future research include conducting further analysis of resistance, seakeeping, and economic viability (cost-benefit analysis) to ensure the comprehensive and sustainable implementation of the design.

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REFERENCES

[1] Tamira, I. Abbas, and E. Syarif, "The Efficiency of Motorboats in Saving Time and Living Costs for Users of Ferry Services in Taeng Village, Pallangga Sub-district, Gowa Regency," *UNM Geogr. J.*, vol. 3, no. 2, pp. 90–99, 2020, [Online]. Available: ojs.unm.ac.id

[2] Mardiana, A. I. Kesuma, and Bahri, "The Socio-Economic Life of the Pappalimbang People on the Jeneberang River in Gowa Regency (1985–2020)," *Phinisi Integr. Rev.*, vol. 5, no. 2, pp. 567–576, 2022, doi: 10.26858/pir.v5i2.33740.

[3] Imanuddin, A. Mahsyar, and A. Muhiddin, "The Effectiveness of the Management of the Jeneberang River Ferry as an Alternative for Public Transport," *J. Sci. Res. by Public Adm. Students*, vol. 5, no. 5, pp. 1088–1100, 2024, doi: 10.26618/kimap.v5i5.16277.

[4] M. S. S. Kuba, I. Suryana, and D. Lisnawati, "A Study of the Effect of the CD 1-1 Consolidation Dam on Sedimentation Rates in the Jeneberang River," *J. Hydraul. Eng.*, vol. 12, no. 1, pp. 54–64, 2019.

[5] I. M. Organization, "International Code on Intact Stability, 2008 (2008 IS Code)," IMO Publishing, London, 2009.

[6] T. Manderbacka *et al.*, "An overview of the current research on stability of ships and ocean vehicles: The STAB2018 perspective," *Ocean Eng.*, vol. 186, p. 106090, 2019, doi: https://doi.org/10.1016/j.oceaneng.2019.05.072.

[7] L. Liu, C. Yao, D. Feng, X. Wang, J. Yu, and M. Chen, "Numerical study of the interaction between the pure loss of stability, surf-riding, and broaching on ship capsizing," *Ocean Eng.*, vol. 266, no. 3, p. 112868, 2022, doi: https://doi.org/10.1016/j.oceaneng.2022.112868.

[8] S.-M. Jeong and S. Park, "Dynamic Stability and Safety of Ships in Waves," *J. Mar. Sci. Eng.*, vol. 13, no. 10, p. 1950, 2025, doi: https://doi.org/10.3390/jmse13101950.

[9] A. D. Saputra and A. N. Yulianto, "A Study on Stability and Passenger Capacity of Traditional River and Lake Boats," BIO Web of Conferences, 2025, p. 03005. doi: 10.1051/bioconf/202515703005.

[10] P. YANG and Y. ZHOU, "Safety level of dynamic stability in waves of coastal sea-going ships in domestic waters," *Chinese J. Sh. Res.*, vol. 20, no. 3, pp. 45–52, 2025, doi: 10.19693/j.issn.1673-3185.03643.

[11] A. A. Ghyferi, A. Bahatmaka, R. F. Naryanto, L. S. Won, and J. H. Cho, "Enhancing Ship Stability : A Comparative Analysis of Single and Double Chine Hull Configurations of Semi-Planning Hull at High Speed," *Maj. Ilm. Mek.*, vol. 23, no. 2, pp. 156–167, 2024, doi: https://dx.doi.org/10.20961/mekanika.v23i2.90734.

[12] M. W. Wirawan, A. Fauzi, N. Oloan, A. G. Surbakti, and J. R. Batosai, "CFD-Preliminary Design and Stability Analysis of a High-Speed Firefighting Boat for Remote Island Waterways," *Indones. J. Marit. Technol.*, vol. 2, no. 2, pp. 68–81, 2024.

[13] A. Pusaka, L. Syahdan, S. Manullang, A. Buwono, and R. Irvana, "Preliminary Design of a Catamaran Ship for Water Tourism in Lake Sunter," *Int. J. Mar. Eng. Innov. Res.*, vol. 10, no. 2, pp. 297–309, 2025.

[14] K. I. E. H. A, M. A. Budiyanto, and W. R. Sari, "Optimization of Ship Stability through Response Surface Methodology : Enhancing Safety and Performance via Cross Curve Analysis," *Int. J. Mar. Eng. Innov. Res.*, vol. 9, no. 2, pp. 340–348, 2024.

[15] "Small waterplane area twin hull," Wikipedia. Accessed: Mar. 06, 2025. [Online]. Available: en.wikipedia.org

[16] M. J. Putra, E. Oguz, and N. S. Uzol, "Aerodynamic and hydrodynamic investigations on linear upscaling and optimization of floating offshore wind turbines," *Ocean Eng.*, vol. 287, no. 1, p. 115728, 2023, doi: https://doi.org/10.1016/j.oceaneng.2023.115728.

[17] I. Turna, "A Fuzzy Bayesian approach for 'Appraisal' of ship voyage plans," *Ships Offshore Struct.*, vol. 18, no. 6, pp. 859–866, 2023, doi: https://doi.org/10.1080/17445302.2022.2077279.

[18] D. L. Blount and L. T. Codega, "Dynamic Stability of Planing Boats," *Mar. Technol.*, vol. 29, no. 1, pp. 4–12, 1992.

[19] K. Oludi, "Intact Stability Analysis of a Catamaran Vessel," *Greekline J. Sci. Technol. Eng. Math.*, vol. 1, no. 2, pp. 164–177, 2024.

[20] S. M. R. Hasan and M. Karim, "CFD-Based Hydrodynamic Optimization of Inland Ships," *J. Mar. Sci. Appl.*, pp. 1–17, 2026, doi: https://doi.org/10.1007/s11804-026-00861-2.

[21] A. B. Biran, *Ship Hydrostatics and Stability*, 1st Edition. Oxford: Butterworth-Heinemann, 2003.

[22] Z. Ye, S. Su, Y. Wu, F. Guo, H. Liu, and Q. Cheng, "Research on Hull Form Design and Numerical Simulation of Sinkage and Trim for a New Shallow-Water Seismic Survey Vessel," *J. Mar. Sci. Eng.*, vol. 12, no. 7, p. 1205, 2024, doi: https://doi.org/10.3390/jmse12071205.

[23] M. Iqbal, M. Terziev, T. Tezdogan, and A. Incecik, "Hull form optimisation to minimise the total resistance and dynamic responses of small fishing vessels," *Ocean Eng.*, vol. 321, no. January, p. 120357, 2025, doi: 10.1016/j.oceaneng.2025.120357.

[24] M. Iqbal, M. Terziev, T. Tezdogan, and A. Incecik, "Operability analysis of traditional small fishing boats in Indonesia with different loading conditions loading conditions," *Ships Offshore Struct.*, vol. 5302, pp. 1060–1079, 2023, doi: 10.1080/17445302.2022.2107300.

[25] Sunardi, M. A. Choiron, Sugiarto, P. H. Setyarini, and A. Nurwahyudy, "Fishing Vessel Safety in Indonesia : A Study of Accident Characteristics and Prevention Strategies," *Int. J. Saf. Secur. Eng.*, vol. 14, no. 2, pp. 499–511, 2024, doi: https://doi.org/10.18280/ijsse.140217.

[26] H. Umar, "Analysis Of Restriction Rules Of Gross Tonnage Fishing Ship On The Sunda Sea Coast," *Marit. Technol. Soc.*, vol. 1, no. June, pp. 64–69, 2022, doi: https://doi.org/10.62012/mp.v1i2.21955.

[27] M. Arfin and M. Ridwan, "Master Plan for the Development of the Jeneberang River as a Maritime Tourist Attraction in the City of Makassar," Makassar, 2022. [Online]. Available: http://repository.poltekparmakassar.ac.id/623/

[28] B. Santoso, R. Romadhoni, Z. Ariany, and M. Ridwan, "Assessment of the Stability and Response of a Catamaran-Hull Ferry to Operational and Environmental Conditions," *J. Mar. Sci. Technol.*, vol. 21, no. 3, pp. 204–216, 2024, doi: 10.14710/kapal.v21i3.64789.

[29] M. A. A. Setia, A. D. Lestari, and M. M. Danial, "Design and Stability of the Galaherang Tourist Boat Using Maxsurf Software," *Sensistek Mar. Sci. Technol. Res.*, vol. 8, no. 2, pp. 60–69, 2025.

[30] R. A. Nabawi, Syahril, and Salmat, "Stability Study of Flat Hull Ship for Fishing Tourism," *Teknomekanik*, vol. 3, no. 2, pp. 75–80, 2020, doi: https://doi.org/10.24036/teknomekanik.v3i2.9272.

[31] S. . Satoto and H. Widiastuti, "The Response of Traditional Boats to Sea Waves under Operational Conditions," *Int. J. Mar. Eng. Innov. Res.*, vol. 10, no. 3, pp. 944–957, 2025, doi: https://doi.org/10.12962/j25481479.v10i3.

[32] Y. Y. E. Darma *et al.*, "Motions Analysis Investigation of a 12 Meter Catamaran Tourism Boat on Passenger Comfort Criteria Case Study 'MV Garuda Ngelayang,'" *Int. J. Mar. Eng. Innov. Res.*, vol. 8, no. 2, pp. 179–190, 2023, doi: https://doi.org/10.12962/j25481479.v8i2.

[33] Suardi, A. I. Wulandari, P. M. A. Uswah, and T. Hidayat, "Patrol Ship Design to Guard the Natuna Seas," *Int. J. Mar. Eng. Innov. Res.*, vol. 7, no. 3, pp. 171–179, 2022.

[34] K. J. Rawson and E. C. Tupeer, *Basic Ship Theory*, 5th ed. Oxford: Butterworth-Heinemann, 2001. doi: 10.1016/B978-0-7506-5397-8.X5000-5.

[35] E. V. Lewis, *Principles of Naval Architecture: Volume I - Stability and Strength*, 2nd Revision. Jersey City, NJ: The Society of Naval Architects and Marine Engineers, 1988. [Online]. Available: communities.sname.org

[36] D. J. Eyres and G. J. Bruce, *Ship Construction*, 7th Edition. Oxford: Butterworth-Heinemann, 2012. doi: 10.1016/B978-0-08-097239-8.00001-5.

[37] T. I. Fossen, *Handbook of Marine Craft Hydrodynamics and Motion Control*. Chichester, West Sussex: John Wiley & Sons, Ltd., 2011. doi: 10.1002/9781119994138.

[38] I. M. Organization, *International Code on Intact Stability, 2008 (2020 Edition)*, 2020 Edition. London: IMO Publications, 2020. doi: 10.62454/KC874E.

[39] A. Francescutto, "Intact stability criteria of ships – Past, present and future," *Ocean Eng.*, vol. 120, pp. 312–317, 2016, doi: https://doi.org/10.1016/j.oceaneng.2016.02.030.

[40] N. Matthews, K. F. Joiner, and W. F. Smith, "Stability Assessment of a Catamaran Using Sea Trials," *J. Mar. Sci. Eng.*, vol. 12, no. 8, p. 1436, 2024, doi: 10.3390/jmse12081436.

[41] Hardani *et al.*, *Qualitative & Quantitative Research Methods*. Yogyakarta: CV. Pustaka Ilmu, 2020.

[42] A. Papanikolaou, E. Boulougouris, S. Erikstad, S. Harries, and A. A. Kana, "Ship Design in the Era of Digital Transition: A State-of-the-Art Report," *J. Mar. Sci. Technol.*, vol. 29, 2024.

[43] T. I. Fossen, *Handbook of Marine Craft Hydrodynamics and Motion Control*, 2nd Edition. Chichester, UK: John Wiley & Sons, 2021.

[44] S. Guo *et al.*, "Numerical Study on the Influence of Catamaran Hull Arrangement and Demihull Angle on Calm Water Resistance," *J. Mar. Sci. Technol.*, vol. 13, no. 4, p. 815, 2025, doi: https://doi.org/10.3390/jmse13040815.

[45] R. J. Kusuma, B. Arswendo, and D. Chrismianto, "Stability Analysis of a 10,850 DWT Oil Tanker in the Waters Between Bintan - Lhokseumawe," *J. Mar. Eng.*, vol. 12, no. 4, 2024.

[46] International Maritime Organization, *International Code on Intact Stability, 2008: 2020 Edition*. London, UK: IMO Publishing, 2020.