

PRODUCTION DEVELOPMENT OF GRP PERAHU KOLEK

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ABSTRACT

Perahu Kolek is a traditional Malaysian boat building made of wood and is usually used in coastal areas. The design and fabrication of wooden Kolek required a high level of workmanship and skills, and most of the process was done manually by skilled workers. This results in a high production cost of material, labor cost, and production time. Glass-reinforced plastic (GRP) is used in the production of modern hull boats as it has several advantages, for example, being a cheaper, stronger, and waterproof material. Generally, the fabrication of the modern fiberglass boat starts with the construction of the hull boat plug, followed by the mould fabrication, and finishes with the production of the boat using fiberglass. In this project, the simplified development of GRP Kolek hull mould using Computer Aided Manufacturing (CAM) using Rhinoceros software, Power Mill software, and application of 5-axis Computer Numerical Control (CNC) machining will be discussed. The Kolek hull plug process is required in order to produce a hull mould. Somehow, in this production process, it directly produces the hull mould using a 5-axis Computer Numerical Control (CNC) machine. Then, the fabricated mould made of foam will be used for GRP Kolek production. The result of this new technology development can be used as an aid to the new material and concept, high quality and cost saving traditional boats at the same time supporting the preservation of traditional boat building.

Keywords: Kolek, Glass Reinforced Plastic, Computer Aided Manufacturing

1.0 INTRODUCTION

The traditional Perahu Kolek, a symbol of Malay maritime heritage, faced extinction due to the high cost of wood and the diminishing craft of skilled boatmakers. The lack of proper blueprints contributed to this boat's end and is becoming increasingly forgotten. This project is motivated by the need to revive and preserve this maritime heritage by creating a comprehensive reverse engineering blueprint. This prototype was scaled down from its original size by a scale factor of 2.45. The project is to revive the heritage by preserving the traditional Perahu Kolek. It is about restoring a conventional boat and reviving a part of history, culture, and craftsmanship. Next is for educational Significance; the Lines Plan is a valuable educational tool, aiding the younger generation in understanding the intricate art of boat design. It is also for a sustainable practice by using modern technology, such as CNC machines and alternative materials; the project ensures the sustainability of traditional boatbuilding practices.

2.1 Perahu Kolek

The traditional Malay boat is one of the heritages slowly forgotten by Malaysians, especially the younger generation. Malay traditional boats have existed since ancient times. There are different types of boats depending on their functions and unique designs. Kolek is a traditional Malay boat with unique art and heritage used as a fishing boat. The usage is not only for water transportation but also as symbolic of Malay thought and civilization [1]. The invention of technology and techniques in boat construction reflects Malay society's intellectual thought in producing things. However, the technological progress and development of machinery-propelled transport systems led to the declining usage of a Kolek. [2]

Kolek, the Malay traditional boat, is made of wood and uses the traditional method without any design blueprint during the construction stage are alterations made based on the rule of thumb and trial and error [3]. Indonesian researchers [4] support the idea that the construction of fishing boats does not use design drawings. The boat draft or design is only imagined in the boat builder's mind and verbally communicated to the boat builder's assistants in the form of instructions for building fishing boats. These situations lead to difficulty in the reconstruction and identification of the traditional boat by the future generation, leading it to diminish in the future[5].

2.2 Glass Reinforced Plastic (GRP)

Glass Reinforced Plastic (GRP) is used to reinforce a polymer matrix in the composite material known as glass-reinforced plastic. Boat building is one of the many businesses that make extensive use of this material. Compared to metallic alternatives, GRP, also known as fiber-reinforced plastic (FRP), offers developers a few of advantages. The GRP is a durable, non-conductive, and cost-effective material with strong tensile strength, corrosion resistance, and chemical resistance [6].

Even in the harshest environments, GRP has exceptional resistance to corrosion. Its endurance is demonstrated by its resistance to chloride ions and harsh environments [6]. The inherent corrosion problems that conventional materials like steel and aluminum encounter on a daily basis could be overcome by GRP. A highly corrosive solution is part of GRP.

The structure of the glass is amorphous, and its characteristics remain constant throughout the fiber. GRP resists long-term deformation. It provides resistance against extreme and abrupt point loading. GRP regains its former shape after being suddenly impacted [7]. Because of the nature of GRP, expensive fixes or replacements are avoided. GRP is simple to cut and assemble on-site with common hand tools.

The GRP's resistance and durability result in cost-cutting [8]. GRP has a fifty-year lifespan and requires minimum repair work. Glass-reinforced plastic (GRP) is utilized in various products, including car parts and civil infrastructure [8]. The bulk of GRP waste, like other industrial wastes, is buried underground. GRP waste is regularly dumped after its usable life is exhausted. The tiny dust and improper disposal produced by this process harm human health and the environment [9]. GRP is made up of two or more key components that have considerably distinct chemical or physical characteristics. GRP, as the name implies, is essentially plastic reinforcement reinforced with fine glass fibers. It has been discovered that thermoplastic has a high buckle strength in comparison to its tensile strength. The most frequent disposal options for thermoplastic polymer composite waste, including GRP composite waste, are dumping and burning. With the huge market value and rising new developments, GRP composites are in high demand. In this project, GRP is used to replace wood as the main material traditionally used to build the Perahu Kolek.

2.3 Computational Aided Manufacturing (CAM)

Computer-Aided Manufacturing (CAM) is a technique that automates and facilitates manufacturing operations using machines and computer software. By converting virtual design models into instructions for machines to follow during the manufacturing of real components, CAM enhances Computer-Aided Design (CAD). CAM and CAD systems frequently interact with one another. The production instructions generated by CAM are based on the design created in CAD software.

Toolpaths specify the paths that cutting instruments or other machinery will follow to mould the raw material into the required shape. CNC (Computer Numerical Control) machines are guided by numerical control (NC) code produced by CAM systems. The motions and functions of the machine tools are specified in this code. In addition, simulation elements are commonly included in CAM software. This helps manufacturers detect possible problems and maximize productivity by enabling them to see and validate the complete machining process before it starts.

Accuracy, product quality, and production rate are just a few of the escalating demands that are placed on manufacturing technologies, techniques, and methods. Manufacturers have been able to develop numerical control (NC) programs for new items and significantly reduce production times thanks to the

incorporation of CAD/CAM in the manufacturing process. With the use of CAD/CAM technologies, manufacturers can now swiftly modify their designs to satisfy client demands and do away with tedious tasks. Computer-aided manufacturing plays a vital role in modern manufacturing, enhancing precision, efficiency, and the overall productivity of the production process [10].

3.0 Project Phases

This project is divided into 4 phases as in Figure 1, from the measurement activity of the artifact to the production process of a GRP Perahu kolek.

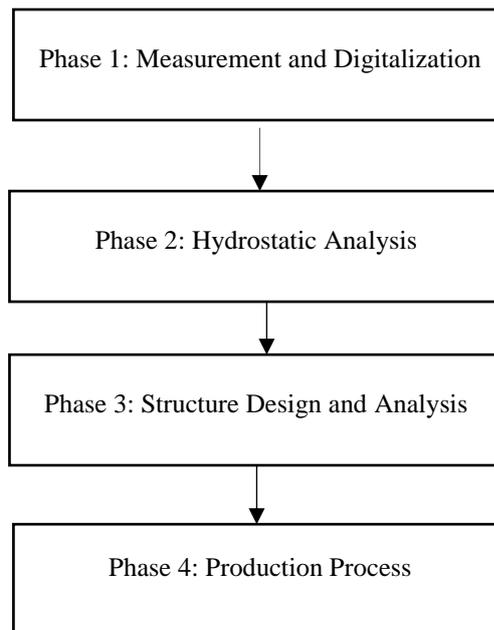


Figure 1: Project Phase

3.1 Measurement and Digitalization

Measurement activity in Figure 3.2 was conducted manually in the stem profile, stern profile, and cross-sections. A 3-D "Perahu Kolek" model was created using Rhinoceros software, allowing for precise measurements and accurate digitization.



Figure 2: Measurement activity

From the 3-D modeling in the digitization phase, a 2-D drawing known as the Lines Plan, as in Figure 2, has been produced. This Lines Plan modeling consists of 3 projections: Body Plan, Profile, and Half Breath Plan, to visualize a boat's shape. The Kolek principal dimension, as in Table 3.1

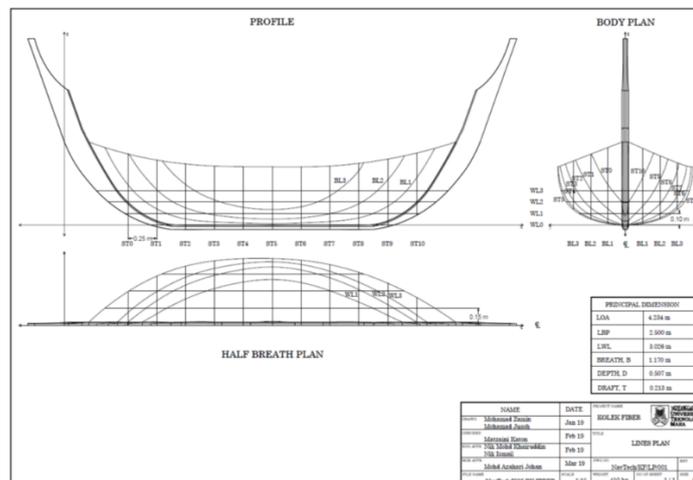


Figure 3: Lines Plan

Table 1: Model Dimension

	Actual Dimension (m)	Prototype Dimension (m)
Length Overall (LOA)	10.30	4.20
Length Between Perpendicular (LBP)	5.80	2.50
Length Waterline (LWL)	7.00	3.00
Breath (B)	1.80	1.15
Depth (D)	0.85	0.50
Draft (T)	0.50	0.20

3.2 Hydrostatic Analysis Phase

Performed using PolyCAD, this provided crucial geometric properties of the Perahu Kolek. These hydrostatic data are essential to be used in stability and resistance analysis.

3.3 Structure Design and Analysis

Design the Perahu Kolek framing system and structure before performing the calculations, including loaded displacement, weight estimation of hull and deck laminates, and other vital parameters. Strength analysis focused on strength calculations, constructing diagrams, and stress analysis, considering buoyancy, weight, load, shear force, bending moment, moment of inertia, section modulus, yield stress, and safety factor.

3.4 Production Process

The hull mould was developed using a 5-axis rapid manufacturing Computer Numerical Control (CNC) machine. High-quality foam was used as the material, ensuring durability and preserving the traditional essence. Glass Reinforcement Plastic (GRP) has been used as an alternative material to replace the wooden material in this "Perahu Kolek" production.

4.0 PRODUCTION PROCESS OF GRP KOLEK

To produce GRP Perahu Kolek, the essential tool required is a mould. The mould is prevalent in that it acts as an inverted or mirrored version of the finished hull to enable the laying up of GRP materials on its inside. Constructed from Glass-reinforced plastic (GRP), this component originates from crafting a "plug" that adheres to every size and detail, just like the eventual deck or hull. Somehow, the step of producing a "plug" is skipped, where the 5-axis rapid manufacturing Computer Numerical Control (CNC) machine in Figure 4 is used to produce the mould of Perahu Kolek.

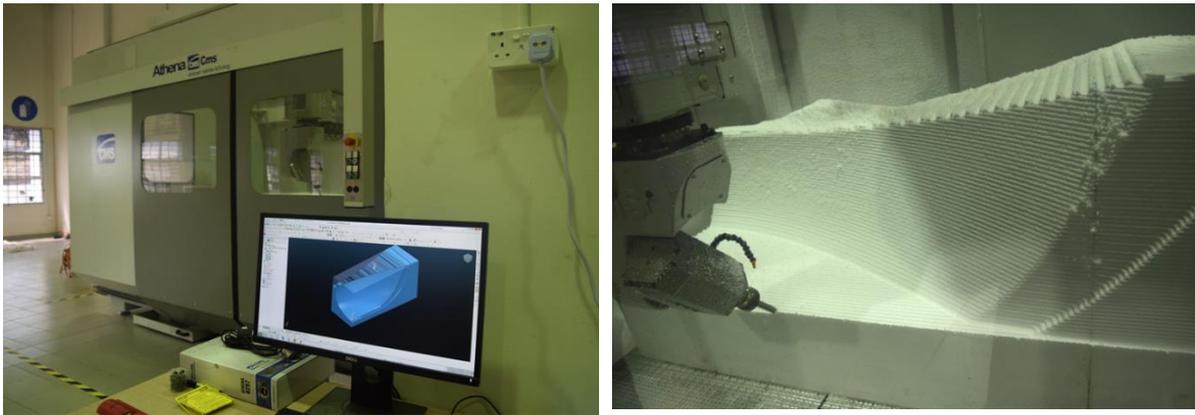


Figure 4: Manufacturing Computer Numerical Control (CNC) machine

A release agent is applied to the mould to help with the later removal of the GRP Perahu Kolek hull from the mould. Then the mould surface is coated with a gel coat, as in Figure 5. Gelcoat is a colorful, pigmented compound that makes up the outermost coating of the GRP Perahu Kolek hull. In addition, it offers a flawless finish. It shields the underlying layers from UV and water damage.

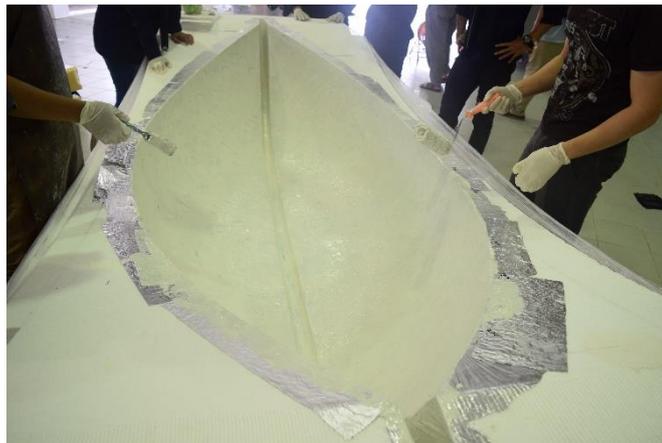


Figure 5: Gelcoat Coating Process

After applying the gel coat, the structure is strengthened by the process of layering the fiberglass mat, as shown in Figure 6. As it cures, the resin absorbs the fiberglass, combining the layers and creating a sturdy, solid framework. The resin is left to harden and cure. Maintaining the humidity and temperature is crucial during this stage. The boat hull should be carefully de-mould when the resin has completely set. The release agent that was previously applied aids in the damage-free separation of the hull from the mold.



Figure 6: Fiberglass Layering Process

Then, Perahu Kolek goes through the launching process. The launching process involves releasing a newly constructed Kolek into the water for the first time. The launching process is a significant milestone in this construction; it is marking the transition from the land to the water, where the GRP Perahu Kolek in Figure 4.4 will undergo further testing and sea trials.



Figure 7: The GRP Perahu Kolek

5.0 CONCLUSION AND RECOMMENDATION

This project is a testament to the commitment to safeguarding our maritime heritage. Through meticulous measurements, advanced technology, and a deep understanding of traditional craftsmanship, the conventional "Perahu Kolek" has found a way to preserve which is a symbol of Malay maritime heritage richness. It is proposed to produce other Malay traditional boat by using GRP and applying modern methods, so that the younger generation can build the Malay traditional boat in the future as well as preserving the heritage.

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REFERENCES

- [1] M. R. A. Wahab, Z. Ramli, N. N. A. Ismail, N. A. Bakar, and W. N. S. W. Azhar, "Symbolism in traditional Malay boat crafting in the East Coast," *Journal of the Malaysia Institute of Planners*, vol. 16, no. 1, pp. 294–302, 2018, doi: 10.21837/pmjournal.v16.i5.432.
- [2] A. Fernandes, J. Figueira de Sousa, and V. Tânia Vicente, "The Preservation of the Tagus Estuary Traditional Boats : New Issues and the preservation of the Tagus Estuary Traditional Boats : new issues and challenges," *Journal of Spatial and Organizational Dynamics*, vol. VI, no. Issue 2, pp. 153–173, 2018.
- [3] Mohd Zamani and K. Vijaynathan, "Cultural Influence on Hull Form Geometrical Features of Malaysian Trawler Fishing Boats," *Proc. 7th International Marine Design Conference*, no. May, 2000, [Online]. Available: http://www.academia.edu/766645/Cultural_Influence_on_Hull_Form_Geometrical_Features_of_Malaysian_Trawler_Fishing_Boats
- [4] S. Eko, Triyanto, and Mujiyono, "Design and Construction of Traditional Fishing Boat in Jepara in the Context of Cultural Ecology: The Implication as Arts Learning Resources," *International Journal of Indonesian Society and Culture*, vol. 12, no. 2, pp. 209–215, 2020, doi: 10.15294/komunitas.v12i2.18937.
- [5] N. A. A. Rahman, M. A. Johan, N. M. K. N. Ismail, and S. Ahmad, "Constructing a Blueprint of a Kolek," *IOP Conf Ser Mater Sci Eng*, vol. 1176, no. 1, p. 012028, Aug. 2021, doi: 10.1088/1757-899x/1176/1/012028.
- [6] M. Gupta, S. Yadav, A. A. Kasar, and M. U. Khan, "An overview of engineering properties and durability of glass fibre reinforced mixed plastic waste composite," *Mater Today Proc*, vol. 60, pp. 760–764, Jan. 2022, doi: 10.1016/j.matpr.2022.02.513.
- [7] T. Yuanjian and D. H. Isaac, "Combined impact and fatigue of glass fiber reinforced composites," *Compos B Eng*, vol. 39, no. 3, pp. 505–512, Apr. 2008, doi: 10.1016/J.COMPOSITESB.2007.03.005.
- [8] P. Asokan, M. Osmani, and A. D. F. Price, "Assessing the recycling potential of glass fibre reinforced plastic waste in concrete and cement composites," *J Clean Prod*, vol. 17, no. 9, pp. 821–829, Jun. 2009, doi: 10.1016/J.JCLEPRO.2008.12.004.
- [9] J. Broekel and G. Scharr, "The specialities of fibre-reinforced plastics in terms of product lifecycle management," *J Mater Process Technol*, vol. 162–163, no. SPEC. ISS., pp. 725–729, May 2005, doi: 10.1016/J.JMATPROTEC.2005.02.226.
- [10] P. P. Ikubanni *et al.*, "Present and Future Impacts of Computer-Aided Design/ Computer-Aided Manufacturing (CAD/CAM)," *Journal Europeen des Systemes Automates*, vol. 55, no. 3, pp. 349–357, Jun. 2022, doi: 10.18280/jesa.550307.