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The Development of Design and Construction Procedure of Hilsa Research Vessel for the Contribution of Enriching Hilsa Production in Bangladesh Riverine Areas

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ABSTRACT

Bangladesh being a riverine country depends on her 230 rivers and Bay of Bengal for her economic growth to a considerable degree from time immemorial. Fishing is an important industry throughout the region in terms of generating employment, foreign exchange earnings, food supply and providing income for local communities. Hilsa is an important diadromous fish considered as national fish in the country and contributes to the national economy, employment and export. Hilsa has more than 13.4% contribution to the country's fish production as the single fish species. Keeping in view of the immense potential of Hilsa sector requires a new hull design and construction thought of such a high-tech Hilsa Research Vessel to survey underwater river bed to find Hilsa enriched region, collect samples, process research and interpret previous data to enhance the Hilsa harvest from riverine areas of Bangladesh. From the shipyard point of view, there is used trained professional team with rich industry expertise and highly customized flexible supply chain solutions for the client with unified technology systems. Becoming a leading maritime power through this high-tech research vessel, it is possible to know the nature of the movement of Hilsa, where it lays its eggs, whether it is migrating or not and the level of oxygen in the river bed which is equipped with a Hilsa research laboratory, netting system and a portable mini hatchery. Besides that, the ship will also help protect other fish biodiversity. Most important, it will act as a game changer in Hilsa research. Meanwhile, developing a new design for a Hilsa research vessel requires considering various factors, such as the scientific objectives, the operational requirements, the environmental conditions, the safety standards, the cost-effectiveness, and the sustainability of the vessel. In this paper, the authors propose a design method for a small research vessel of 25 meters in length which will be cost-effective and meet the operational requirements of users at a 10 knots research speed.

1. Introduction.

In Bangladesh, Hilsa is the largest and most important single species of our 'national fish'.

Hilsa fish has been playing an important role in the country's economy, employment and non-vegetarian food supply since time immemorial. In recent times exports are also playing a very important role in earning foreign exchange and alleviating poverty in the country. The contribution of hilsa fish to the total fish production of the country is about 13.4%.

The annual average production is about 2.0 (two) lakh million tonnes and the value is BDT 4,000 thousand crores [1]. The contribution of Hilsa fish to GDP is more than 1 percent. About 4-5 lakh fishermen are engaged in Hilsa extraction either full-time or part-time on 712 km long coastline and 700 rivers [2]. Fish provides 60% of national animal protein consumption. Fisheries sector also plays an important role in rural

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employment generation and poverty alleviation.

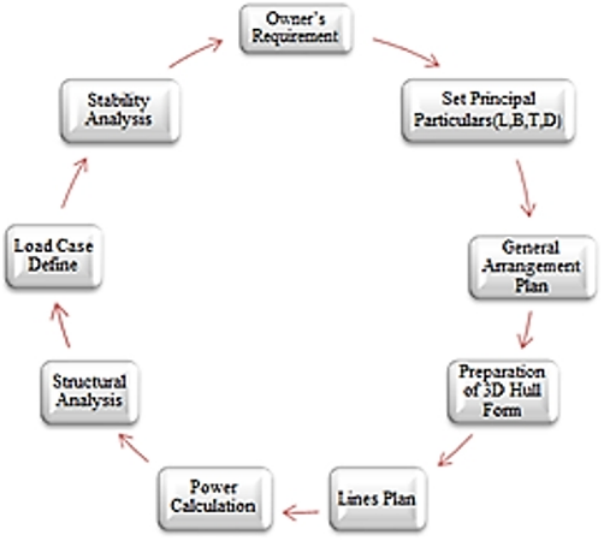
Bangladesh is a riverine country. The pride of Bangladesh is its rivers with one of the largest networks in the world with a total number of about 230 rivers including tributaries, which have a total length of about 24,140 km [3]. The ship repair [11,12,13] and new shipbuilding sector in Bangladesh are of great significance to both the nation's economy and its maritime industry. Given Bangladesh's strategic position along the Bay of Bengal, it is exceptionally well-suited for ship repair and construction activities. This industry plays a pivotal role in job creation, offering opportunities for skilled labor and contributing substantially to the country's GDP. Furthermore, as the need for maritime transportation steadily increases, a strong ship repair and new shipbuilding sector becomes indispensable for preserving and extending Bangladesh's influence in maritime affairs, promoting economic development, and safeguarding national security.

Though 57000 mechanized and non-mechanized boats and 200 industrial built steel body trawlers are engaged in fishing the coastal waters up to 60km [4-5], there is no high tech research vessel is available in riverine areas for hilsa research to know about the safe heavens of Hilsa and identify feasible regions of their existence, breeding areas along with new migration areas in different rivers, estuaries and sea tributaries of the country. Also, a deep research can be conducted on their habits and bio diversity of their life.

2. Research Methodology.

The methodology followed in this research is on user requirement based. The basic requirement comes from the demand of concerned personnel of fishery department. Based on user requirement and experienced crews opinion the principal particulars of a Hilsa research vessel which will be operated in riverine areas of Bangladesh was selected considering the plying area, weather condition, draft limitation and voyage duration. The efforts are given to fulfill all requirements of Bangladesh Fisheries Research Institute (BFRI). After finalize the principal dimensions, the design work is started to generate preliminary General Arrangement Plan using AutoCAD. After that, the three-dimensional hull was generated using Rhino3D hull modeling software. Then, the stations/frames, buttocks, waterlines and body plan are obtained to develop the lines plan. In the meantime, the weight of hull is calculated by item wise weight calculation of hull elements, section modulus and thickness of stiffeners are calculated based on Department of Shipping (DOS) rules and regulations. Once the hull form is finalized by checking all criteria, then the resistance components were calculated to find out propulsion power requirement using software. Then the load cases are defined and stability analysis was carried out using Maxsurf software analysis for confirming IMO intact stability criteria. And checked the hydrostatic data for stability in different load cases. In this consequence, the hull form and general arrangement plan is finalized. So, the design spiral of a Hilsa research vessel is as shown in Figure 1:

Figure 1: Design Spiral for Hilsa Research Vessel.



Source: Authors.

3. Development of Design.

Pursuant to research methodology, the design of Hilsa research vessel began with the owner's requirement and aspirations. At the same time the requirements were matched with operational ability of the said vessel in the riverine stations in Bangladesh. Smooth research works, comfortable stay of scientists & crew, smooth performance of onboard sophisticated equipment, the length available in quay, river operational draft are the prime factors to select principal particulars. Besides this, some research vessels around the works have taken into consideration [6-9]. Here, multiple relevant ships concept are used to generate new hull [10]. The selected principal particulars for the target vessel are: Length overall (LOA) = 25.00 m, Breadth (B) = 6.00 m, Depth (d) = 2.80 m and Draft (t) =1.40 m.

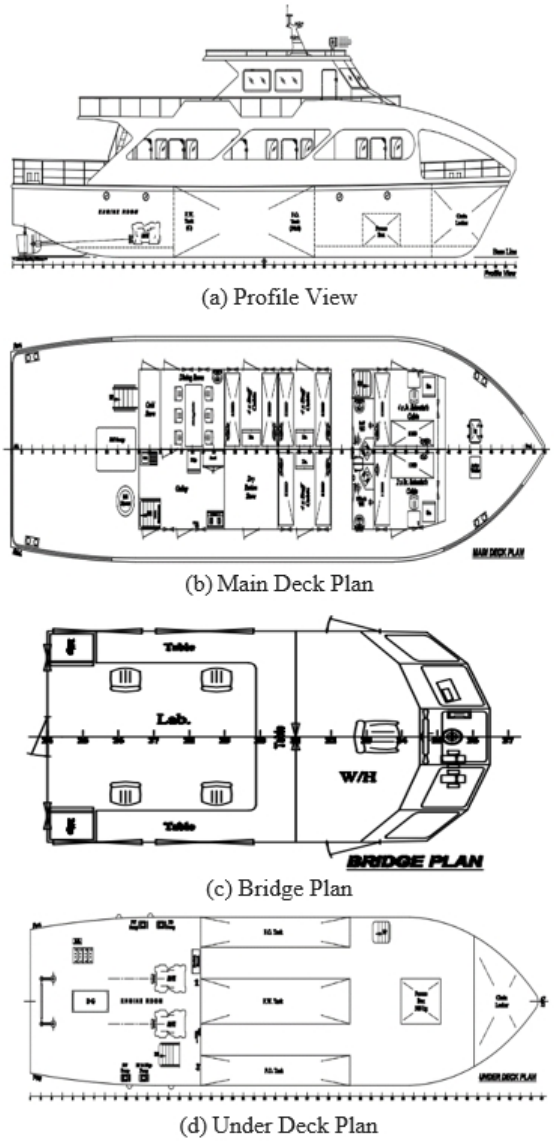
3.1. General Arrangement Plan.

Keeping in mind the principal particulars, Mono Hull type V shaped and single chine was chosen from practical experience for this type of research vessel and a preliminary general drawing was sketched in AutoCAD. Since, the vessel will operate only in riverine areas and will never go to sea, wave making resistance is very less and provision of using Bulbous Bow is not kept during design. The design was developed with hybrid structure: the hull is to be made of mild steel and the superstructure is to be of Aluminum.

The General Arrangement drawing is shown in Figure 2. Here, framing spacing is kept 500 mm. Fig 2(a) shows the outline of the vessel in profile view where there are two decks above the main deck. On the aft of main deck, there is a hatchery compartment and one stern A-frame for net operational facility to collect the hilsa sample. The middle portion of the main deck is covered by superstructure to keep accommodation arrangements for 02 senior scientists, 04 junior scientists and 12 crews as indicated in figure 2(b). Galley, Dining space, cold

storage, dry ration store and washroom are also accommodated here. At the front side of main deck there is an anchor windlass for anchor operation and a freezing compartment under main deck.

Figure 2: General Arrangement Plan.



(a) Profile View

(b) Main Deck Plan

(c) Bridge Plan

(d) Under Deck Plan

Source: Authors.

On the bridge deck of superstructure, aft side is scientist's laboratory and front side is wheelhouse Figure 2(c). Scientist's wet lab will be equipped with different Hilsa research equipment where initial processing of the specimens is done. In scientist's lab, there are 04 high performance computers. To fulfill the requirement of SOLAS convention, there will be one 18 men auto inflatable life rafts for life savings. And the wheelhouse is equipped with different navigational and communicational equipment. Furthermore, the vessel is equipped with a high tech fish finder to detect fish school and provides various underwater information, such as water depth, distribution of fish school, and the condition of the riverbed. Also, have navigational radar aided to navigation used in identifying, tracking and positioning of vessels to safely navigate a ship. It is also equipped with a Single-Beam Echo Sounder (SBES) and a Multi-Beam Echo Sounder (MBES) to determine the depth of water, HF Set and Public Address (PA) system for communication.

Figure 2(d) shows the under deck arrangement which is just beneath the main deck, where the provision for engine and steering gear room, tank arrangement, freeze box are kept. At the Engine room (Frame 1 to 17) of length 8m, two in nos. main engines, one main generator and one Emergency generator, and 4 in nos. pump are placed along with steering system at the end of the engine room. Two in number fuel oil tank and one in number fresh water tank is placed in parallel middle body of under deck and separated by tank boundary. Chain locker room is also placed at the forward end.

Table 1: Weight Distribution of Major Items.

Item	Weight (Ton)
Lightship	71.74
Stores & provisions	2.7
Crew	1.35
FO tank(P&S)	30
FW Tank	27.5
Total Weight	133.3

Source: Authors.

3.2. 3D Hull Form & Lines Plan Generation.

The hull form has been generated using Rhino 3D and its analysis has been carried out by changing all of its parameters. After some trial and error process, optimized hull form is found. The block coefficient is found 0.45. The final hull is shown in figure 3. Principal Particulars as: L=25.0m, B=6.0m, D=2.8m.

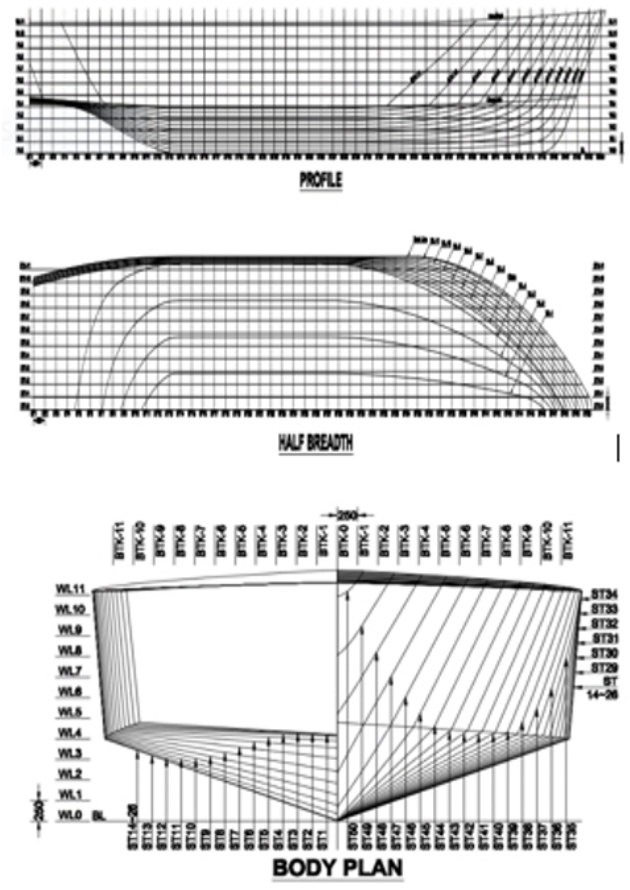
Figure 3: Hull Generated by Rhinoceros.

Source: Authors.

The design load waterline is taken at 1.40m from the baseline and number of stations, buttocks and waterlines are 50, 11 and 11 respectively. The vessel hull is optimized to reduce the resistance and increase the fuel efficiency. With this hull form

the lines plan and corresponding offset table have been generated of which profile, half breadth plan and body plan are shown in figure 4.

Figure 4: Profile, Half Breadth and Body Plan.



Source: Authors.

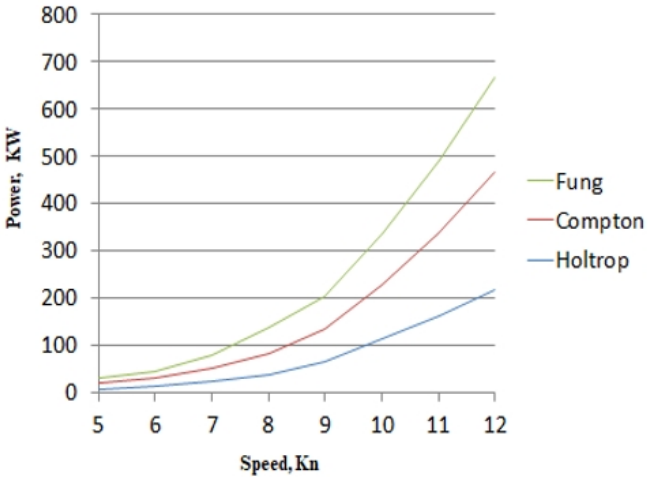
4. Resistance and Power Calculation.

The most accurate and reliable method for calculating a ship's resistance is by performing a model test. But in design stage, using software (resistance module of Maxsurf) the resistance and power requirement can be assumed.

In Maxsurf software three methods namely: Holtrop, Compton and Fung method are used. Then, power is calculated at the maximum value, taking the cruise speed 6-8 knots and maximum speed 10-12 knots. Since numerical simulation may content some erroneous result, there is a requirement to obtain maximum resistance value using multiple methods, which will ensure safer selection of propulsion engine.

It is seen that Fung method is demanding the highest power requirement in comparison to other three methods. If we would follow the most popular Holtrop method, the predicted power would be quite less. The power graph is presented as figure 5.

Figure 5: Power vs. Speed Curve.



Source: Authors.

5. Defining Load Cases.

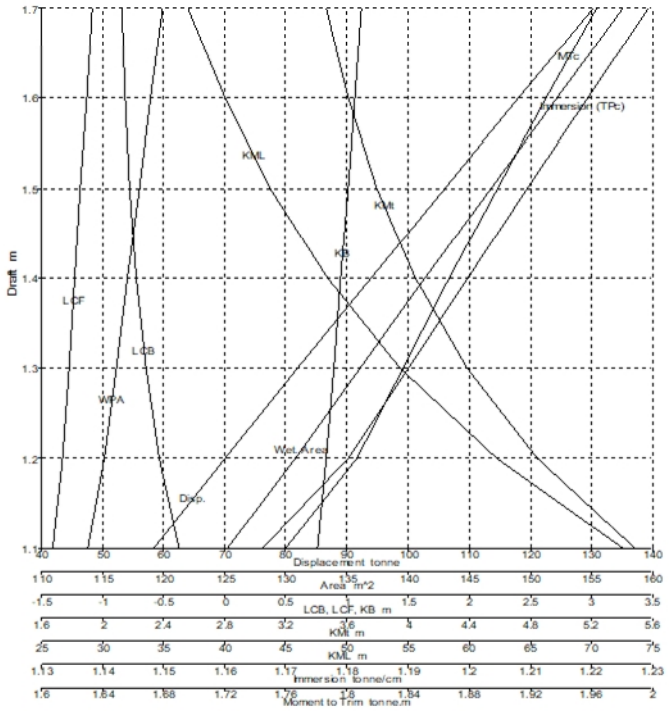
Since this vessel will carry very small amount fish, the change in loading condition is not remarkable too. Therefore, two load cases can be defined for this vessel, i.e., Full load departure and full load arrival. For full load departure case, the collected sample is assumed to be zero tonne but the fresh water tanks, fuel oil service tank and reserve tanks are considered to be completely filled up. The dry and fresh provisions required for a 15 days voyage have to be loaded during sailing of the vessel. On the other hand, for the full load arrival case, the provisions are considered to be partly consumed while the fuel oil service tanks are about half filled and the reserve remains 30 percent. The deduction of provisions and fuel is filled up by the fish samples collected for research activities.

6. Stability Analysis.

The upright hydrostatics analysis performed using the Maxsurf stability module is presented in figure 6. The result indicates that the displacement wetted surface area, moment change to trim be increasing linearly with the rise of draft. On the other hand water plane area, metacenter and longitudinal center of buoyancy vary nonlinearly.

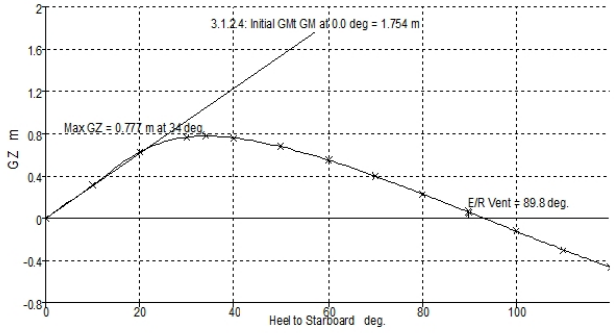
Based on hydrostatics analysis and load case definitions, large angle of stability calculations was performed in both for full load departure and full load arrival conditions for intact conditions. During this stability analysis, the even keel condition is presumed i. e. trim is kept to be at zero. The values of righting lever are coupled with their corresponding heeling angles for two load cases defined conditions are presented in figure 7. Figure 7(a) and 7(b) indicate that the initial GMT values are 1.754 m and 2.413 m respectively. The maximum GZ values are found to be 0.777 m and 1.058m respectively at the heeling angle of 34 and 40 degree.

Figure 6: Upright Hydrostatics Analysis.

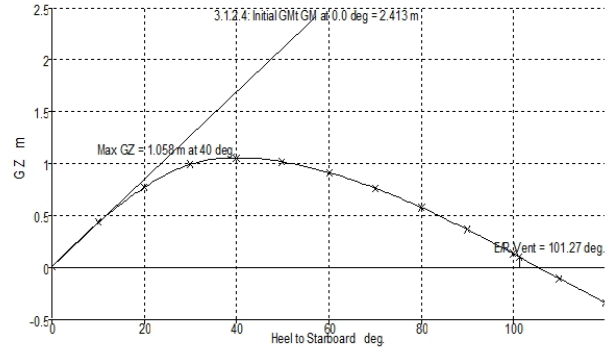


Source: Authors.

Figure 7: Stability Curve for full load departure and arrival.



(a) Full Load Departure Analysis



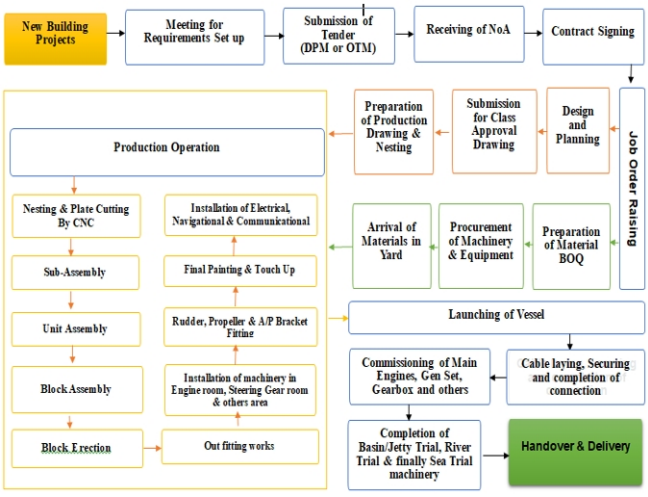
(b) Full Load Arrival Analysis

Source: Authors.

7. Construction Procedure.

Ship construction is the sum of designing and fabrication works. It is also a total combination of architectural works and engineering. In Construction site, from which the vessel is launched fabrication process is chosen to assemble the blocks depends on the facilities and logistics support available in the yard. A shipbuilder carries out construction activities to deliver the vessel within a stipulated time period that is mentioned in contract. To meet the contractual obligation the yard can take either the conventional ways or block construction process. Block constriction is the most effective process in shipbuilding which is proving in recent years at worldwide shipbuilding company. In block construction process, initially the GA plan is segmented into some unique blocks keeping mind the weight of each block to handle during erection process. Then block wise nesting & coding is prepared for CNC machine. The cut plates are sub-assembled and assembled according to production drawing. Mentionable that, the blocks are assembled on previously made Jig as like top side down to ease the overhead welding[14] on decks. When all blocks are ready for erection then erection process started. Bottom blocks are erected at first then side shell blocks and deck blocks are placed on bottom blocks. When underwater hull blocks erection will be completed, the superstructure blocks will be placed on main deck and erection work is completed. Then outfitting works and machinery installation works can be started. After fitting the propulsion system and painting the vessel will be ready for launching. After launching the vessel, the remaining works needs to make complete and commissioning works started. When main engines, gen set, gearbox, steering gear system, navigational items are ready, the jetty or river trial may be started. After successful completion of river trial, the sea trial is completed in presence of Class surveyor and owner representatives. Finally, the vessel is handed over to owner.

Figure 8: Construction Procedure.



Source: Authors.

The function of a shipyard is to fabricate the ship engaging required steelworkers, welders, ship-dockers, plumbers, en-

gine fitters, electricians painters etc. as per approved design and drawing. The summarized construction process in shipyard is as below:

Conclusions.

The vessel designed for the hilsha research will be operated in the riverine stations of Bangladesh where scientists are able to carry out research activities incessantly for almost 15 days and more. The vessel equipped with a hilsa research laboratory, netting system and a portable mini hatchery will help to play an effective role in getting a real picture of the hilsa population and its behavior. This 25 m long vessel is well suited for research activities in our narrow riverine areas; the big ships may have obstructed in entering shallow water. The ship will also be able to continue its research activities during monsoon and bad weather in rainy season due to its very good stability conditions. Hence, the preference has been given to ease the comfort of researcher. For this purpose, modern sophisticated equipments are set up to help researchers for assessment the kind of impact climate change would have on reproduction of hilsa in future. The ship can be used to go to all relevant places, including the sea bay and collect information. Also the vessel would enhance the strategies and skills of the hilsa research team. So, the technical specifications of all machinery and equipment and design will be very much well suited to fulfill the demand of hilsa researchers.

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References.

[1] Dr.Yahia Mahmud "Hilsa Fisheries Research and Development in Bangladesh", *Bangladesh Fisheries Research Institute (BFRI), Ministry of Fisheries and Livestock.*

[2] Rahman,M.M., 2016. "An Appraisal of Shipbuilding Prospects in Bangladesh", Procedia Engineering 194 (2017) 224–231, doi.org/10.1016/j.proeng.2017.08.139.

[3] Shamsuzzaman, M.M., Islam, M.M.,Tania, N.J. Mamun, M.A. Barman, P.P. and Xu, X., 2017. "Fisheries resources of Bangladesh: Present status and future direction, Aquaculture and Fisheries", Volume 2, Issue 4, July 2017, Pages 145-156, doi.org/10.1016 /j.aaf.2017.03.006.

[4] Alam, M.F., 1993. "An Economic Study on the Utilization and potential of Marine Fisheries in Bangladesh". Research Report submitted to the Winrock International, BARC Complex, Dhaka.

[5] Y. Koyanagi, "Design and construction of the fisheries research vessel [AL AMIR MOULAY ABDALLAH]", Journal of Fishing Boat and System Engineering Association of Japan, 1(2), 27-38 (2002).

[6] Alam, M.K.,"Ocean/Blue economy for Bangladesh"MAU, MOFA,PP. 1-13.

[7] Griffin,J.J. and Sharkey, P.I., 1987. "Design of the Next Generation of Research Vessels",Graduate School of Oceanography, University of Rhode Island, U.S.A.

[8] Y. Hatayama, "Fisheries research vessel of national research institute of fisheries engineering Taka-maru", Journal of Fishing Boat Association of Japan, 318, 74-94 (1995).

[9] Rajasekhar,D.,Narendrakumar,D.,Deepaksankar, P.S., Ananthakrishna, Ramasundaram,K. and Ravi, N., 2014. "Indian Research Ships: Features and Future", Science reporter.

[10] Riad Khan, Ariful IslamAhammad, Abdullah Ahammad Abdullah, 2021. "Time and cost effective ship design process using single parent design approach with considerable dimension difference", 12th International Conference on Marine Technology MARTEC 2020.

[11] Abdullah, A. (2021). Development of a mathematical model for ship repair time estimation [Master's Thesis, Bangladesh University of Engineering and Technology (BUET)]. BUET Central Library. http://lib.buet.ac.bd:8080/xmlui/handle/-123456789/5943.

[12] Abdullah, A., Rahman, H., Uddin, M. I., & Mia, M. J. (2022) A General Method to Develop Mathematical Model for Estimating Ship Repairing Man-Hour. 1st International Conference on Mechanical, Manufacturing and Process Engineering (ICMMPE 2022), DUET. [Online] Available:https://scholar.google.com/citations?view_op=view_citation&hl=en&user=X9rlUxMAAAAJ&citation_for_view=X9rlUxMAAAAJ:iH-uZ7U-co4C.

[13] Awal, Z. I., & Abdullah, A. (2021). Multiple linear regression model for ship repair time estimation. 12th International Conference on Marine Technology (MARTEC 2020), Ambon, Indonesia. [Online]Available:https://scholar.google.com/citations?view_op=view_citation&hl=en&user=X9rlUxMAAAAJ&citation_for_view=X9rlUxMAAAAJ:j3f4tGmQtD8C.

[14] Dhar, U. K., Rahman, M. F., Ayanoglu, M. O., & Abdullah, A. (2023). Welding on C67 steel grade sheet: Influence of the parameters and post welding heat treatment. AIMS Materials Science, 10(3), 453-464.