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DEVELOPMENT OF SUITABLE DESIGN FOR FISHERY RESEARCH VESSEL FOR THE CONTRIBUTION TO THE BLUE ECONOMY OF BANGLADESH

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ABSTRACT

Bangladesh being a littoral nation depends on the Bay of Bengal for her economic development to a great extent. Her inherited and historic dependency on sea focuses towards the recently emerged concept of blue economy. One of the important components of blue economy for Bangladesh is the marine fishery. The contribution of fish to supply animal-based protein in Bangladesh is 52 per cent and the fishing industry in the Bay of Bengal provides employment and sustenance to large numbers of people. Moreover, Bay of Bengal is considered as a potential ground for natural growth of various fishes. But such connotation is not fully agreeable to many stake holders due to non-availability of required data, and the fisheries department is unable to quantify the real economic value of potential marine fishery sector for future planning purpose. As such a deep necessity is felt to have suitable research vessels to carry out a holistic survey in the Bay of Bengal. This paper presents a design and construction thought of such a fishery research vessel to collect, store, process and interpret fishery related data for enhancement of fish harvesting Bangladesh waters, which will in turn suggest for better farming technology leading to enhanced fish production.

Keywords: *Blue Economy, Marine Fishery, Research Vessel.*

1.0 INTRODUCTION

Bangladesh, being a maritime nation with 1,10,000 sq km exclusive economic zone (EEZ) ,712 km coastline and 700 rivers [1], and having potentiality of sea resources, has adopted the concept of blue economy to become a middle income nation. The opportunities that come with the perspective of blue economy framework in Bangladesh include: shipping, shipbuilding, ship recycling, salt production, marine fishing, deep sea mining, offshore oil and gas, etc. and accordingly she is trying to harness all such possible sectors in this regard. Here, fishing had been the profession of coastal belt population since ancient time. A good number of people even today are living through fishing and the fishery sector plays an important role in the national economy of Bangladesh contributing her 3.69% to the Gross Domestic Product (GDP) [2-3]. Out of many, around 511 marine species, together with shrimps, exist within Bangladesh waters are known only [3-4]. Besides our EEZ and adjacent continental shelf (CS) areas have innumerable species of fishes which are yet to be explored. However, fish resources in Bangladesh marine waters are extracted in three tiers, i.e., up to 40 m in depth from the coastline , from 40 m to 200 m in depth; and from 200 m in depth to the end of the EEZ [4-5]. At the same time everybody admits that fish provides the much needed

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protein of our people. Over 57,000 artisanal mechanized and non-mechanized boats and 200 industrial built steel body trawlers are engaged in fishing in the coastal waters up to 60 km [6]. Since there is no realistic record of survey to assess the fishery potentiality and their detailed data, adequate fishery survey is essential to know about the safe heavens of most known fish species and their quantity, their breeding season etc. and identify less known but potential species, their habits and feasible regions of their existence or migration.

Therefore, it is necessary to have a few well-equipped fishery survey and research platforms/vessels to develop the nation through blue economy. Considering such importance, this paper is an initiative to develop the design of a fishery research vessel suitable to be operated in the Bay of Bengal, which will pave the way for building/procuring few such vessels for Bangladesh. It is expected the fishery research vessel built on the basis of the developed design will be able to substantially contribute to the blue economy of Bangladesh.

2.0 RESEARCH METHODOLGY

The methodology followed in this research is of little heterogynous type. For few cases data were collected talking directly to concerned personnel of fishery department, sometimes generated using ship design software, and sometimes borrowed from relevant organizations. Based on experienced people's opinion, the principal particulars for a fishery research vessel to be operated in the Bay of Bengal were selected considering the duty nature, plying area, weather condition of the sea round the year and voyage duration. In this regard the present research team paid number of visits to Bangladesh Fisheries Department, Chittagong Port Authority, Fishing Fleet and relevant harbors. The optimum effort has been made to fulfill all the requirements of the stake holders [7-9]. After reaching to the principal particulars of the vessel, the design works proceeded with the preliminary general arrangement plan drawn using AutoCAD. Then, the three-dimensional hull was generated from the selected principal particulars using Maxsurf Modeler, and buttocks and waterlines were also obtained to develop the lines plan. Thereafter, item wise weight of hull elements were calculated, which in turn provided the weight distribution of the vessel as well as the hydrostatic parameters. Once the hull form was visualized, the resistance components were calculated to find out propulsion power requirement using software solutions. Then the load case definition was obtained and the stability analysis was carried out using Maxsurf Stability enterprise. Accordingly the hull form and the general arrangements are modified as felt feasible and realistic; the modification was giving indication of improvement. By this way, the design spiral for a fishery research vessel went on as shown in figure 1.

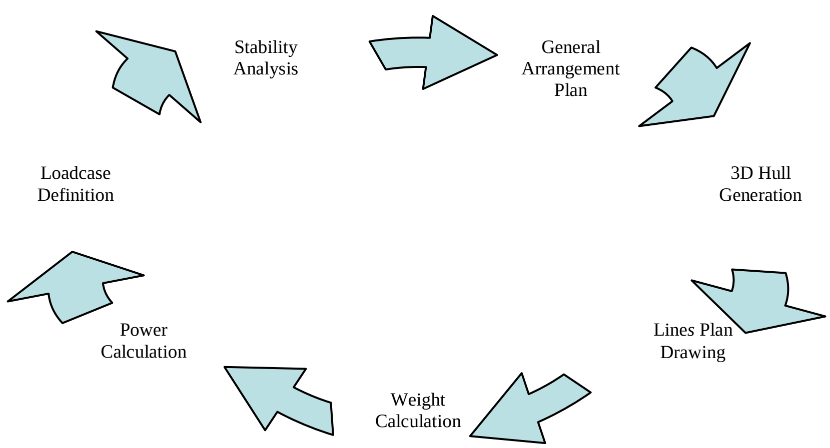


Figure 1: Design spiral for proposed fishing research vessel

3.0 DEVELOPMENT OF DESIGN

As mentioned in the research methodology, the design of fishery research vessel began with the looking for stake holders' requirements and aspirations. At the same time the requirements had to be matched with operational ability of the said vessel in the Bay of Bengal where the sea remains rough for more than eight months in a year. Sea sustainability of the vessel, comfortable stay of crew, smooth performance of onboard sophisticated equipment for acquiring, storing and processing huge amount of data etc. are the driving factors to select principal particulars. Besides the parameters of various research vessels around the world have been taken into consideration in this regard [10-14]. The selected particulars for the target vessel are: Length overall (LOA) = 70m, Breadth (B) = 15 m, Depth (D) = 6.4 m, Draft (d) = 4.4 m and Displacement = 2700 ton.

3.1 General Arrangement plan

With the principal particulars in mind and choosing a displacement hull type, the preliminary general arrangement drawing was sketched. Since the vessel is to operate at deep sea area, bulbous bow is used with an intention to reduce the wave making resistance. The proposed design has been developed to be a ship of hybrid structure: the hull is to be made of mild steel and the superstructure is to be of Aluminum.

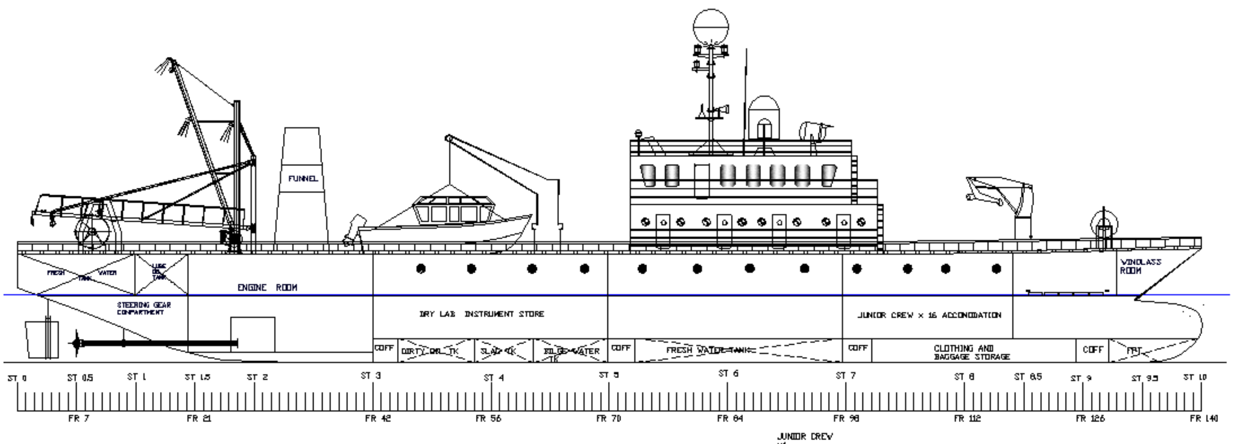
The general arrangement drawing is presented in figure 2. Here the framing distance is taken as 500 mm. Fig 2(a) shows the outline of the vessel in profile view where there are two decks above the main deck and three below. On the main deck, there are two workboats (each of 10.3m length) and two boat davits for their handling. The workboats will be utilized in data acquisition and survey purposes. A small crane of 2 ton capacity is planned to be placed on main deck at the fore part. The middle portion of the main deck will be covered by superstructure to have accommodation arrangements for the captain, chief engineer, and two senior researchers as indicated in figure 2(b). The main deck houses the wet lab, where initial processing of the specimens are done before taking them to the dry lab. It is considered that the sum total of scientists, researchers, crew members is to be 48. So, to fullfill the guideline of SOLAS convention, there will be two 25 men auto-inflatable life rafts. At the rear part of the main deck there are two rotating trawl winches, corresponding net drums and two small working winches to collect the sample fish species.

On the upper deck of superstructure, front portion is the wheelhouse and the rest portion is basically an operations room to be used for the purpose of data processing, storing and transmitting. As this room will have the main server and processing arrangement, it will be of circumscribed nature so that data preservation and security can be properly maitained. This lab will have data transfer arrangement to dry lab and shore base station.

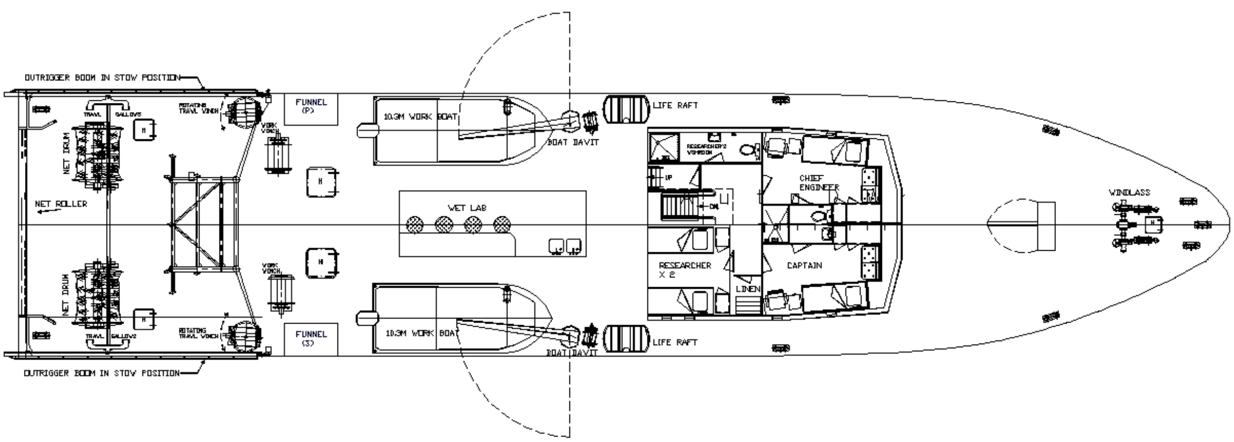
Figure 2(c) shows the 2^{nd} deck i.e. the deck just beneath the main deck, where the provision stores are placed at the forward part just abaft the chain locker followed by the ship's galley at port side and the mess room at the starboard side. Aft of mess, accommodations are given for 16 crew members at the starboard side, and on the portside there will be blast freezer, laundry room, bath rooms and water closets. At the parallel middle body area of this deck will have the dry lab containing various data collection equipment and research support arrangements. The dry room will include scientific split beam echo sounder, scientific multi-beam system, scientific multi-beam 4D sonar, omni-directional sonar, trawl monitoring system etc. The bathymetric module will also allow the operators to conduct seabed mapping. In between dry lab and crew accommodation area, 12 researchers will be accommodated at the port side; the starboard side area will be for necessary computers and interfacing arrangements to be connected to the operations room located at upper deck. It will also ensure data redundancy and provide handling/processing supports. Further aft, Engine room of length 11m, from frame 20 to frame 42, for the main engines and auxiliary machineries is located. There will be a small workshop within the engine room to provide emergency repair facilities at sea.

Moreover, the vessel is considered to have a water column and sub-bottom profiler, gravimeter, magnetometer, acoustic Doppler current profiler (ADCP), conductivity temperature-depth profiler, autonomous weather station and air quality monitors, as well as sampling gears such as A-frame, Gamma frame, CTD etc.

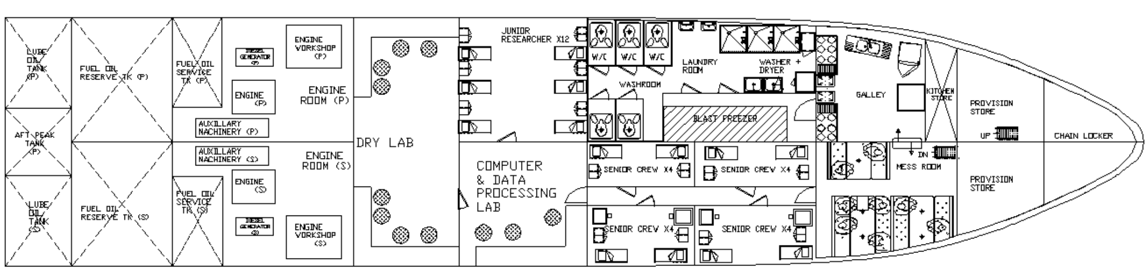
At the aft portion of the engine room, there are the two fuel oil reserve tanks, one at each side, followed by the lubricants tanks and the aft peak tank. Below the mess and crew accommodation there will be fresh water tanks and below the dry lab there will be spaces for machinery spare parts and miscellaneous items as indicated in the elevation [Fig 2(a)].



(a) Elevation



(b) Main deck (1 Dk)



(c) Under deck (2 Dk)

Figure 2: General arrangement plan

Based on general arrangements, weights of all items have been considered for further calculations keeping in mind the total weight obtained by calculation while hull modeling i.e. the maximum displacement was considered as 3000 tons. The weight distribution in this regard is as shown table 1.

Table 1: Weight distribution of major items

Item	Weight (ton)
Weight of hull/superstructure with plate and paneling	1640
Machinery weight	77
Deck fittings	27
Lightweight	1744
Consumable/Cargo	937
Total weight	2681

3.2 Hull modeling and Lines plan generation

The hull form has been generated using Maxsurf modeler and its analysis has been carried out by changing particulars. The final hull is presented in figure 3. Initially the beam of the ship was selected to be 15m and design draft of 4.4m. However, when modeling the hull, using parametric transformation, keeping the length and displacement unchanged and block coefficient above 0.65, the breadth became 15.5m and draft 4.0m. Therefore, the hull form in figure 3 depicts the corrected principal particulars as : L=70m, B=15.5m, D=6.4m, d=4m.

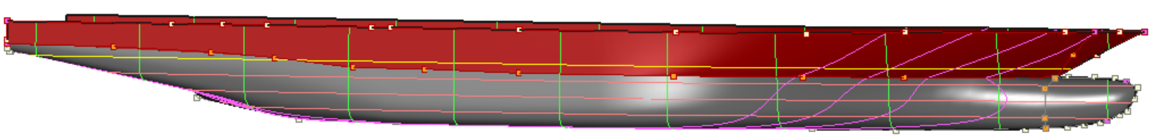


Figure 3: Hull Generated by Maxsurf

The design load water line is taken at 4.0m from the baseline and number of stations, buttocks and waterlines are 13, 4 and 5 respectively. The vessel hull was optimized to reduce the resistance and enhance the fuel efficiency. With this hull form, the lines plan and corresponding offset table have been generated of which profile, half breadth and body plan views are shown in figure 4.

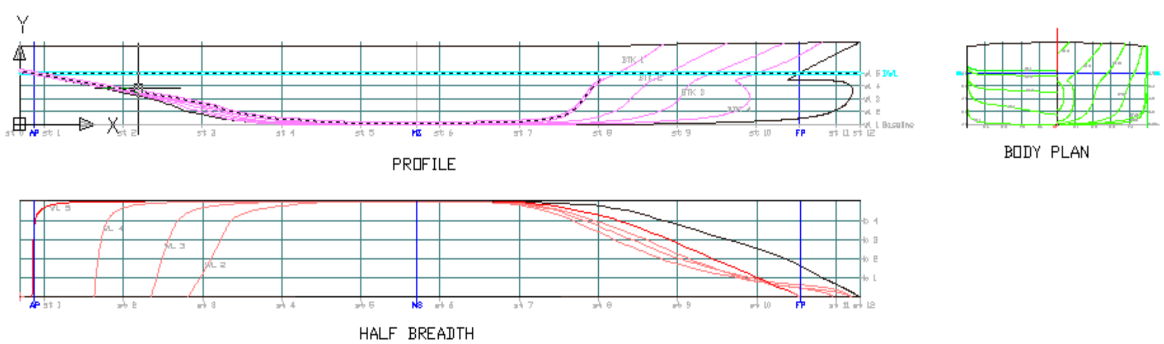


Figure 4: Profile, half breadth and body plan

4.0 POWER CALCULATION AND OPTIMIZATION

The resistance and power calculation was done using the resistance module of Maxsurf by four methods namely: Holtrop, Fung, Compton and the slender body method. Power is calculated at the maximum value, taking the cruising speed to be within the range 10-12 kt and the maximum speed range as 16-18kt. Since numerical simulation may content some erroneous result, there is a requirement to obtain maximum resistance value of using multiple methods, which can ensure safer selection of propulsion engine even at the inclement weather. It is observed that the slender body 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 which does not match with the thumb rule calculations even. As such the present design is following the resistance values obtained by slender body method. There might be a question of over estimating the power in this regard. By knowingly, the present research vessel is designed with minimum risk factor due to lone ship operation at deep sea for prolong period. The power graph is presented as figure 5.

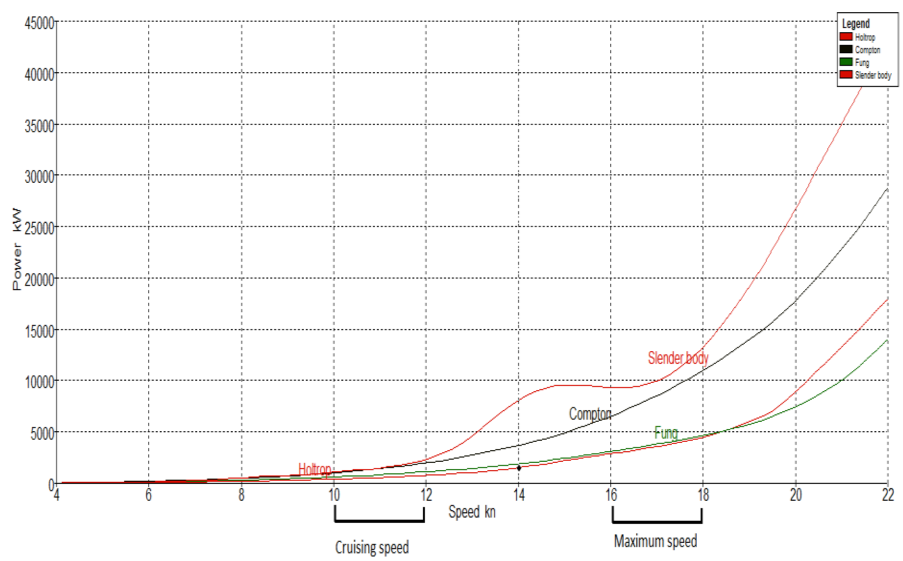


Figure 5: Power vs speed curve

The selection of propulsion plant, propeller and diesel generators are to be made with known critical revolutions so that proper damping arrangements to arrest the generation and transmission of vibration and noise. This criterion of fishery research vessel is the paramount. So, the suggested propulsion engines and generator engines are to be of concealed type.

5.0 LOAD CASES DEFINED

As the research vessel will not carry any cargo of significant weight, 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. The details are shown in the two tables at the end of the paper as annex A and annex B. For full load departure case, the collected sample is assumed to be zero tonne but the fresh water tanks, fuel oil service tanks 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 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 approximately forty percent. The reduction of provisions and fuel is made up by the fish samples collected for research.

6.0 STABILITY ANALYSIS

Upright hydrostatics analysis performed using the Maxsurf stability enterprise module is presented in figure 6. The compliance criterion in this regard is given as Annex C at the end of the paper. The result indicates that the displacement, transverse centre of buoyancy, wetted area and moment change to trim are increasingly linearly with the rise draft. On the other hand water plane area, metacenter, and longitudinal centre of buoyancy vary nonlinearly.

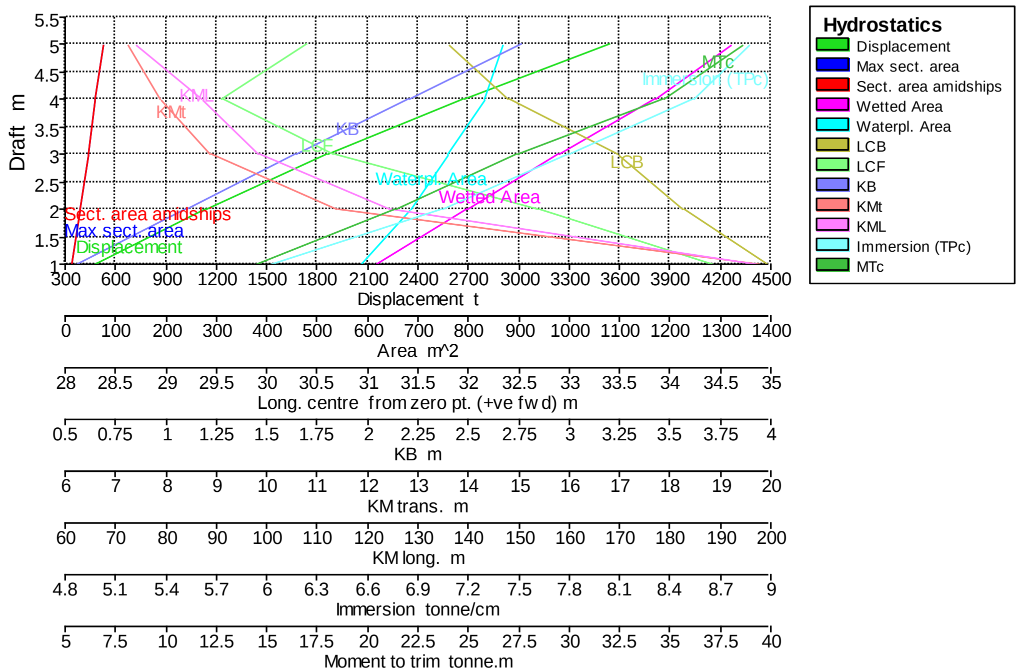
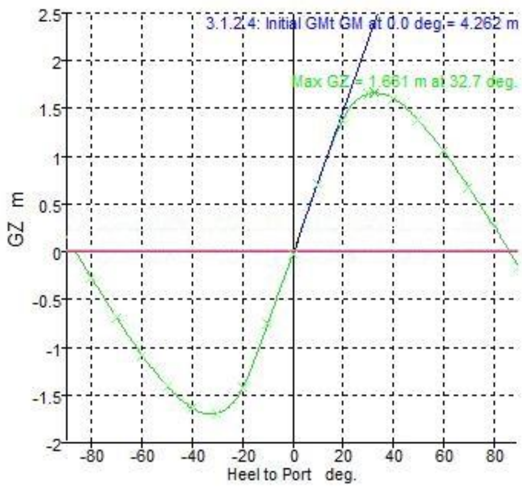
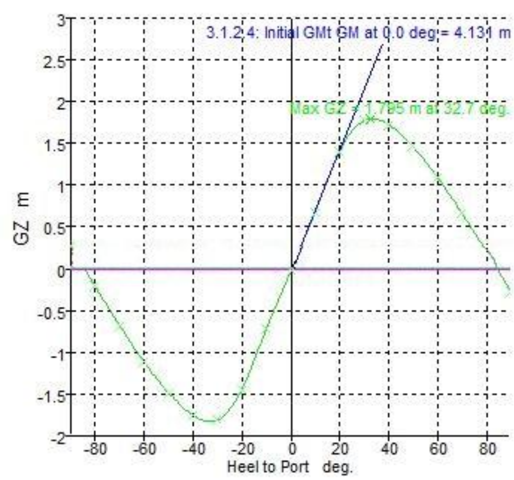


Figure 6: Hydrostatic curves

Based on hydrostatic particulars and load case definitions, large angle stability analysis was performed in both full load departure and full load arrival condition for intact conditions. During this stability analysis, the even-keel condition is presumed i.e trim is kept to be at zero and the fluid analysis method is considered as to simulate fluid movement. Operational performance and safety of the ship are taken into consideration through determination of its dynamic behaviour in waves and during manoeuvring. An effort is made for the investigation of the dynamic behaviour as could be possible to a limited extend. The values of righting lever are coupled with their corresponding heeling angles for two load case defined conditions are presented in figure 7. Figure 7(a) and (b) indicate that the initial GM_T values are 4.262 m and 4.131 m respectively. The maximum GZ values are found to be 1.661m and 1.795m respectively at the heeling angle of 32.7 degree.





(a) Full load departure analysis (b) Full load arrival analysis

Figure 7: Stability curve for full load departure and arrival

7.0 CONCLUSION

The vessel designed for the fishery survey and research to operate in the Bay of Bengal is of medium size with displacement hull. Its principal particulars have been optimized considering the climatic conditions in the region, the sea sustainability and operational effectiveness. The ship will be able to function without difficulty up to sea state 6 and can sustain up to sea state 8. Worthy operations of sophisticated equipment/ gadgets and comfort of crew and onboard researchers for prolong stay sea have also been prioritized for space management, weight distribution, foundation selection, noise reduction etc. For the same reason, the accommodations are provided with all facilities for prolong activity at sea. Here, the preference has been given to the minimization of electromagnetic interference, and almost all machineries are to have shock and vibration mountings to minimize data error. So, the technical specifications of marine systems/machinery/equipment to be installed onboard have been considered in such a way that the ship becomes really suitable one to fulfill the demand of stake holders.

REFERENCES

1. 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.
2. Islam,M.S., 2003. Perspectives of the coastal and marine fisheries of the Bay of Bengal, Bangladesh, Ocean & Coastal Management 46 (2003) 763–796, doi:10.1016/S0964-5691(03)00064-4
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. Shamsuzzaman, M.M., Xiangmin, X., Islam, M.M., Alam,M.W. and Karim,E., 2017. Sustainable Marine Fisheries Resources of Bangladesh: A Strategic Response for Economic Security, Indian Journal of Geo Marine Sciences Vol. 46 (04), April 2017, pp. 757-765.
5. Jahan,K.M., Belton, B.,and Viswanathan, K. K., 2014. Communication strategies for managing coastal fisheries conflicts in Bangladesh. Ocean & Coastal Management, 92, 6 5 e73, doi.org/10.1016/j.ocecoaman.2014.01.003.

6. Alam,M.K., “Ocean/blue economy for Bangladesh” MAU,MOFA, pp. 1-13.
7. Hartley,T.W. and Robertson,R.A. 2006. Stakeholder Engagement, Cooperative Fisheries Research and Democratic Science: The Case of the Northeast Consortium, Human Ecology Review, Vol. 13, No. 2, pp 161-171.
8. Hartley,T.W. and Robertson,R.A. 2009. Stakeholder Collaboration in Fisheries Research: Integrating Knowledge Among Fishing Leaders and Science Partners in Northern New England, Society and Natural Resources, 22:42–55, doi:10.1080/08941920802001010
9. Mackinson,S.,Wilson,D.C., and Deas,P., 2011. Engaging stakeholders in fisheries and marine research, Marine Policy 35 (2011) 18–24, doi.org/10.1016/j.marpol. 2010.07.003
10. 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.
11. Lurås, S. and Nordby, K.,2015. Shaping Designers’ Sea Sense: a guide for design-driven field research at sea, Marine Design, 2-3 September 2015, London, UK.
12. Yoshimura, Y. and Koyanagi, Y., 2004. Design of a small fisheries research vessel with low level of underwater-radiated noise, J. Marine Acoust. Soc. Jpn. Vol. 31 No. 3.
13. Rajasekhar,D., Narendrakumar, D., Deepaksankar, P.S., Ananthakrishna, Ramasundaram,K. and Ravi, N., 2014. Indian Research Ships: Features and Future, Science Reporter.
14. Cattrijsse, A., Rogers, R., Vliet, H. and Huyskens, P., 2013. Eco-Design of Research Vessels, The Journal of Ocean Technology, Vol. 8, No. 2.

Annex A: Loadcase definition for full load departure

Item Name	Quantity	Unit Mass Tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3
Lightship	1	1744	1744		
Dry Provision for crew	1	2.25	2.25		
Fresh provision for crew	1	1.25	1.25		
Collected sample	0	2	0		
Crew & belonging	1	10	10		
APT	10%	49.006	4.901	47.811	4.781
NO-1 FOST(P)	100%	58.327	58.327	69.437	69.437
NO-2 FOST(S)	100%	58.327	58.327	69.437	69.437
NO-3 AUX FOST(P)	100%	106.627	106.627	126.937	126.937
NO-4 AUX FOST(S)	100%	106.627	106.627	126.937	126.937
LUBE OIL TK(P)	100%	32.836	32.836	35.691	35.691
LUBE OIL TK(S)	100%	32.836	32.836	35.691	35.691
FPT	10%	49.177	4.918	47.977	4.798
FRESH WATER TK 1(P)	100%	99.354	99.354	99.354	99.354
FRESH WATER TK 2(S)	100%	99.354	99.354	99.354	99.354
FRESH WATER TK 3(P)	100%	62.949	62.949	62.949	62.949
FRESH WATER TK 4(S)		62.949	62.949	62.949	62.949
NO-5 FORT(P)	100%	106.646	106.646	126.96	126.96
NO-6 FORT(S)	100%	106.646	106.646	126.96	126.96
DIRTY LUBE OIL TK(P)	0%	37.727	0	41.008	0
DIRTY LUBE OIL TK(S)	0%	37.727	0	41.008	0
Total Loadcase			2700.797	1220.46	1052.24

Annex B: Loadcase definition for full load arrival

Item Name	Quantity	Unit Mass Tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3
Lightship	1	1744	1744		
Dry Provision for crew	0.5	2.25	1.125		
Fresh provision for crew	0	1.25	0		
Collected sample	1	2	2		
Crew & belonging	1	10	10		
APT	100%	49.006	49.006	47.811	47.811
NO-1 FOST(P)	50%	58.327	29.164	69.437	34.719
NO-2 FOST(S)	50%	58.327	29.164	69.437	34.719
NO-3 AUX FOST (P)	35%	106.627	37.319	126.937	44.428
NO-4 AUX FOST (S)	35%	106.627	37.319	126.937	44.428
NO-5 FORT (P)	40%	32.836	42.658	126.96	50.784

NO-6 FORT (S)	40%	32.836	42.658	126.96	50.784
LUBE OIL TK (P)	40%	49.177	13.134	35.691	14.277
LUBE OIL TK (S)	40%	99.354	13.134	35.691	14.277
FRESH WATER TK 1 (P)	50%	99.354	49.677	99.354	49.677
FRESH WATER TK 2 (S)	50%	62.949	49.677	99.354	49.677
FRESH WATER TK 3 (P)	30%	62.949	18.885	62.949	18.885
FRESH WATER TK 4 (S)	30%	106.646	18.885	62.949	18.885
FPT	100%	106.646	49.177	47.977	47.977
DIRTY LUBE OIL TK (P)	60%	37.727	22.636	41.008	24.605
DIRTY LUBE OIL TK (S)	60%	37.727	22.636	41.008	24.605
Total Loadcase			2282.256	1220.46	570.535

Annex C: Compliance with the criterion

Code	Criteria	Value	Actual	Status	Margin %
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 0 to 30	3.1513	29.63	Pass	+840.46
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 0 to 40	5.1566	46.09	Pass	+793.90
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 30 to 40	1.7189	16.45	Pass	+857.49
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.2: Max GZ at 30 or greater	0.200	1.6	Pass	+730.50
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.3: Angle of maximum GZ	25.0	32.7	Pass	+30.91
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.4: Initial GMt	0.150	4.26	Pass	+2741.33
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.5: Passenger crowding: angle of equilibrium	10.0	0.3	Pass	+96.76
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.6: Turn: angle of equilibrium	10.0	0.3	Pass	+96.76
A.749(18) Ch3 - Design criteria applicable to all ships	3.2.2: Severe wind and rolling			Pass	
	Angle of steady heel shall not be greater than (<=)	16.0	0.5	Pass	+96.96
	Angle of steady heel / Deck edge immersion angle shall not be greater than (<=)	80.00	3.15	Pass	+96.06
	Area1 / Area2 shall not be less than (>=)	100.00	269.63	Pass	+169.63