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SUSTAINABLE GROWTH IN INLAND WATERWAYS OF BANGLADESH THROUGH INNOVATION: A WAY FORWARD!

Arun Kr Dev[1]

[1]School of Marine Science and Technology, Newcastle University, United Kingdom
Newcastle University Marine International (NUMI) - Singapore
E-mail: a.k.dev@ncl.ac.uk

ABSTRACT

Bangladesh is covered by a network of about 24,000 km of rivers, canals, creeks and haors that together amount about 7% of the country's surface. At present, the navigable river routes in Bangladesh during the monsoon stretch about 6,000 km, although this is reduced to about 3,800 km in the dry season. What else can be so important other than these precious inland waterways of Bangladesh? It is now time for a planned and systematic future roadmap for these valued waterways in various diversified uses with new and innovative ideas. The author highlights a few important milestones that Bangladesh Government, through its various agencies' expertise along with academics and marine industry, may take due interest and thus initiate a long term planning and later execute them over a few stages. In this paper, an innovative idea of designing large passenger vessels is presented. It clearly demonstrates that even with overcrowding of passengers, the new type of vessels will have less possibility of capsize compared to existing monohull vessels. Finally, the author has described many challenging ideas where innovation and new technology are required but all these will help achieving them in low cost not only at the beginning but also throughout the life cycle management of the developed products. It may not be possible to pick up all these new and innovative ideas at one time but over the years, in a systematic panned manner, the goals can be achieved.

Keywords: inland waterways, navigable routes, safety against capsizing, landing station pontoons, floating warehouses, inland cargo fleet, maritime education & training, carbon foot print, climate change, shipbuilding materials, dredging, fuel efficient, carbon footprint

1. INTRODUCTION

The author of this technical paper, who comes from Bangladesh and spent his early carrier in BIWTA, keeps him well informed about development of maritime activities in Bangladesh including accidents of passenger ferries happening almost every year. The author highlights a few important milestones that Bangladesh Government, through its various agencies' expertise along with academics and marine industry, may take due interest and thus initiate a long term planning and later execute them over a few stages. The important features for growth in inland waterways are as follows:

- Navigable waterways to be classified in both dry and monsoon based not only water depth but also on the sea state conditions clearly indicating suitability of type of vessels especially passenger vessels plying at night.
- Dredging of rivers and estuaries are already ongoing efforts in Bangladesh. Efficiency and effectiveness in this sector require closer attention. There might be possibility of exporting sands to countries, which do not have such resources.
- Innovative design of passenger launches and passenger vessels on an idea based on KISS (keep it simple but not simpler) to be introduced.
- Introduction of inland and coastal classification of vessels under Bangladesh Government perhaps under a proposed name "Class BG" may be implemented soon having its branch offices in major rivers and coastal ports in Bangladesh.
- In addition to existing ports, many other new river and coastal ports to be opened. Port facilities like landing station pontoons for both passenger and cargo vessels are to be introduced again with innovative designs. Building them with steel materials and maintaining them yearly is a huge expenditure for any Government.

- Large floating warehouses can be constructed with innovative designs and placed in major ports. Similar to passengers, business entrepreneurs will be encouraged to use new type of inland and coastal cargo vessels to transport goods including refrigerated ones from ports to ports resulting less pressure on road transport, which only increases carbon footprints and even more expensive. If necessary, Bangladesh will have its own standard containers (geometry & size) to suit its needs in terms of cost, handling, etc.
- Innovation has to be applied even in designing self propelled cargo vessels, dumb barges, etc. with alternative materials as steel is not available in Bangladesh and even so, it is expensive.
- There are even possibilities of renewable energy in marine propulsion technology and also using gas (CNG) in marine diesel engines. Such initiatives will certainly reduce carbon footprints and help climate change.
- Different housing schemes and cyclone shelters in the form of floaters may be made available to people living in offshore islands where cyclones have devastating effects in terms of tidal waves, etc.
- All mechanized country crafts or even various types of wooden boats may be built from different materials alternative to timber and steel; both of which are in fact scarce in Bangladesh. Usage of wood in building of marine mechanized boats, launches and vessels should in fact be banned to reduce logging.

2. GROWTH IN INLAND WATER WAYS

2.1 Classification of Inland Water Ways

The present classification of various rivers may require further review in terms of water depth, and sea state condition in monsoon and dry season. Such information is necessary for designers and operators for smooth operation of inland and coastal fleet of Bangladesh.

2.2 Dredging

To keep rivers and estuaries including large canals, constant dredging is essential in Bangladesh every year. Especially after monsoon, large sand banks require to be dredged out. When liquid fuel powered dredger is expensive OPEX, CNG powered diesel engines may be used in all dredgers. Instead of always using cutter suction dredgers, TSHDs (Trailer Suction Hopper Dredger) may be introduced so that dredged materials could be recycled to reclaim new lands or to increase existing small islands (chars). But this requires a master planning for a country like Bangladesh where population density is on extremely high side. Following every floods, large sand banks accumulated in rivers needs to be taken care regularly by systematic dredging activities.

2.3 Innovative Ship Design

Traditional ship design based on long time experiences should now be re-assessed and deficiencies to be pointed out. With introduction of extensive IT based ship design methodologies, new efficient hull to be introduced for fuel efficiency including better manoeuvring capability. Monohull passenger launches or passenger vessels where overcrowding, collision accidents, etc. cause very often loss of passengers' lives should now be given a new idea so that such accidents are reduced to minimum. The author will later show an example how stability can be increased with a different hull concept and can save capsizing of passenger launches and passenger vessels in Bangladesh.

2.4 Inland and Coastal Ports

More inland and coastal ports are to be constructed and existing inland and costal ports to be redesigned for safe and efficient loading and unloading of both passenger and cargoes. Transportation of consumer goods should now be used by inland and coastal vessels reducing dependence on road transport. Landing station pontoons of all kinds should be built of concrete materials and NOT of steel any longer. This will save huge revenue by Govt every year from maintenance of steel plates. Inland and coastal container ships may be introduced and all new and existing ports should be supported with container logistics. Bangladesh can even invent its own standard containers and handling devices. Innovations are required in this sector.

2.5 Floating Warehouses

Concept of large floating ware houses may easily be introduced for transhipment from large inland and coastal ports to smaller ports. These large floating warehouses can also be built with concrete materials instead of steel. Floating warehouses have an added advantage of not being affected by rising flood waters, which is a natural phenomenon in Bangladesh.

2.6 Shipbuilding Materials

Traditionally, now steel is being used for shipbuilding mainly for self propelled barges, passenger launches or vessels and also coastal vessels. Time has now come that a new and cheap alternative material and also in terms of less or zero maintenance be introduced. All barge shaped floating structures now can easily be built with concrete. Even there is a possibility of building self propelled barges using concrete materials. Smaller boats should start using Ferro cement in place of steel and wood.

2.2 Renewable Energy

In the past, many country boats have used sails instead of manual rowing. With the introduction of smaller engines (main source from irrigation engines), suddenly this tradition has gone away. Even these boats are diesel powered; sail should be used as a hybrid propulsion technique. Even large self propelled vessels can use sail power when such favourable wind is available. Owners and operators should be encouraged by innovative ideas. All these efforts will make inlands boats or vessels more fuel efficient and at the same time reduce emission.

2.7 Offshore Islands

Large or small offshore islands' population should start using floating houses made of concrete materials or Ferro cement. Planned embankments along with canals inside such offshore islands can save both farming and human life when there is a tidal surge with cyclonic storm. Man has to co-live with the nature and NOT fighting the nature. Pilot project for one or two islands may be tried to see its effectiveness practically.

2.8 Mechanized Country Crafts

As said earlier, all mechanised country crafts building materials should now be changed to Ferro cement and sail power be added again to make them fuel efficient and maintenance free. Additionally, basic safety gear for their crew and safe navigational means to be fitted for these boats. At present, they pose serious dangers in river traffic especially where there is a densely population of criss-cross country boats.

2.9 Maritime Education and Training

While new and innovative ideas can be generated and timely applied, a large new workforce is needed too. Hence education and training is important to educate new players in the game and also to train the existing players. It is time that Bangladesh Government may now start thinking in establishing a large and comprehensive Maritime University having its HQ at Dhaka and satellite campuses at major cities like Chittagong, Barisal, Khulna, Sylhet and Rajshahi. Under one umbrella, all marine people of different disciplines like Naval Architecture, Marine Engineering, Marine-Mechanical, Marine-Electrical, Marine Transportation, Marine Logistics, etc. can be dealt with. Crews for inland waters and coastal waters including sea going can share common resources. This will certainly be more effective than what now exist as fragmented. Depending on the students' backgrounds, Diploma, Advanced Diploma and Degree could be offered including postgraduate degrees for creating an environment of research and development. Even manpower development in marine trades for both home and overseas demands can also be met by giving simple certificate and advanced certificate courses, which are not offered in local polytechnics and vocational training institutes.

2.10 Vessel Classification

Bangladesh Inland and Coastal vessels may now come under a new classification called "BG". In line with this initiative, rules and regulations are formulated for design, building and survey of these ships so that class "BG" can be assigned. For smaller say less than 24m boats, a more basic class is also introduced from the point of view of safety of navigation as well as loss of life and properties. In order to achieve such initiative, DG Shipping can start working with any reputable International Classification Society as well as Flag Administration. One of the possibilities would be to talking to LR and MCA in UK.

3. PASSENGER VESSEL SAFETY

In this paper, an innovative idea of designing large passenger vessels is presented. It clearly demonstrates that even with overcrowding of passengers, the new type of vessels will have less possibility of capsize compared to monohull vessels.

3.1 Present Design

There are a lot of small monohull passenger launches/ferries in Bangladesh, which can easily capsize when over-loaded in inland water (moderate or light wave, or even in calm waters) due to overcrowding passengers or crowded at one side. Figure 1 shows us how serious crowding in Bangladesh inland water area. The safety of such vessels or any small passenger vessels can be dramatically increased by very inexpensive means, by simply installing two outriggers. Higher initial stability of the modernized ship means sufficiently smaller probability of overturning. A shorter natural roll period should be compensated by greater roll damping by outriggers of a special form.

Most of the passenger vessels in Bangladesh can be classified broadly in two types: open type (sunken deck; often termed as one and a half, 1½, Decker) and closed type (freeboard deck; double Decker and now some of them may be triple Decker). The overall height of the open type vessels are relatively low compared to closed type vessels, some of which have even a continuous deck, which was not allowed say two decades ago. The length of the closed type vessels have also become longer compared to many such vessels in eighties and nineties. Again, their propulsion is mainly twin screws with twin rudders (manual/mechanical type with no rudder stoppers).

Engine rooms are again open type with no or little safety measures. These are designed and built without any international classification society's rules. There have been many instances that these both types of vessels capsize either due to overcrowding or in bad weather or compounded by both.

Figure 1. Serious crowding condition in inland passenger launches and vessels in Bangladesh

Accordingly for safe the inland navigable waters of Bangladesh, designing a new inland passenger launch/ferry with multihull seem a good solution. From different kinds of multihull, finally choosing a concept based on "vessel with outriggers" as the core of new design. "vessel with outriggers" is convenient and economic to manufacture. Based on the previous research and based the main hull dimensions, it is decision making process to calculate the dimension and position of outriggers.

3.2 Design Methodology

The monohull vessel is designed to carry 560 passengers (42 tons): Deck A (red colour), Deck B (orange colour) and Deck C (yellow colour) could carry 200 persons (15 tonnes), 200 persons (15 tonnes) and 150 persons (12 tonnes) respectively.

Use of TRIBON Calc and Hydro is made to get the GZ curve of this condition and initial heel angle due to the overcrowding (when all passengers are crowding to one side).

For the multihull also carries same amount of passengers, then compare with the monohull under the same condition to compare whether the multi hull vessel has the higher initial stability.

Totally 2 sets of conditions for comparison for the stability: 560 passengers (42 tonnes) and 1120 passengers (84 tonnes) have been set.

From the TRIBON Calc and Hydro get the lightweight and deadweight LCG, VCG and TCG. Righting Lever (GZ) Curve, Drafts at equilibrium angle, Hydrostatics at equilibrium angle, Intact Stability criteria (checked whether the condition complies with the regulations or not). Use all the information to analysis the stability of each condition.

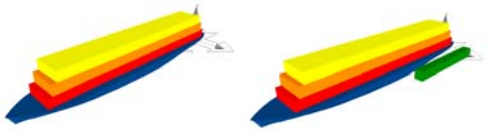


Figure 2. Monohull and Multihull ship models

3.3 Monohull vs. Multihull

For solving the problem of inland passenger ship capsizing due to overcrowding, the Author thinks the multi-hull is one of the best choices. The additional hulls provide stability, typically to hold the vessel upright against the sideways force. This is in contrast to monohulls which typically use a keel and/or ballast for this purpose.

Multihulls are typically either catamarans, which have two similar hulls, or trimarans, which have a larger hull in the centre and two smaller outriggers on either side. In either case they are typically much wider than the equivalent monohull, it means that multihulls are less prone to sink than monohulls when their hulls are compromised.

Multihulls could be faster than monohulls, because the absence of ballast reduces their weight and the amount of drag through the water considerably. For inland waterways the speed of ship is not very high, the maximum ship speed is 12 knots. Multihulls have a shallower draft which is able to be utilized in shallower waterways, along with shallower moorings and reduces the risk of underwater collision. It means the multihull design is fit for inland waterways.

Most multihulls are positively buoyant. Should hull penetration occur the vessel is unlikely to sink thus enabling time for rescue or repair. In fact, most modern production multihulls are officially rated as unsinkable, by various regulatory agencies around the world. Multihulls give also a larger deck area.

Figure 3 shows the difference between monohull and multihull in respect of degrees of heel due to wind.

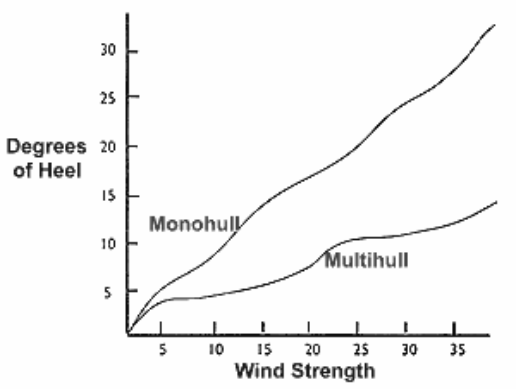


Figure 3. The difference between monohull and multi hulls heeling angles [1]

4. STABILITY ANALYSIS

4.1 Intact Stability Analysis

Use Tribon to build a monohull vessel and a vessel with outriggers and run the Tribon Calc and Hydro to do the analysis of ship static stability.

Table 1. Main Dimensions MONOHULL

Length Overall	50.00	metres
Length B.P	54.00	metres
Breadth mld.	9.000	metres
Depth mld.	2.000	metres
Design Draft (moulded)	1.000	metres
Summer Load Draft (extreme)	1.000	metres
Displacement at Load Draft	300	tonnes
Lightship Weight	160	tonnes
Deadweight at Load Draft	140	tonnes
Subdivision Length (Ls)	54.00	metres
Aft end of Ls aft of AP	0.000	metres
Subdivision Load Line (ds)	1.000	metres
Lightest Service Draft (d0)	0.700	metres

Dimensions of Decks

	Deck A (red)	Deck B (orange)	Deck C (yellow)
Length (m)	44	42	40
Breath (m)	6	6	6
Height (m)	2	2	2

Table 2. Main Dimensions MULTIHULL

Beam overall / main hull, m	15 / 9
Outrigger length / beam, m	20 / 2
Overall draft / outrigger draft, m	1 / 1
Distance between CL's of the main hull and outrigger, m	7
Advance of outrigger's midship to that of main hull, m	-15
FP of outriggers are placed at 0.5L aft of main hull FP	25
Main hull depth, m	2

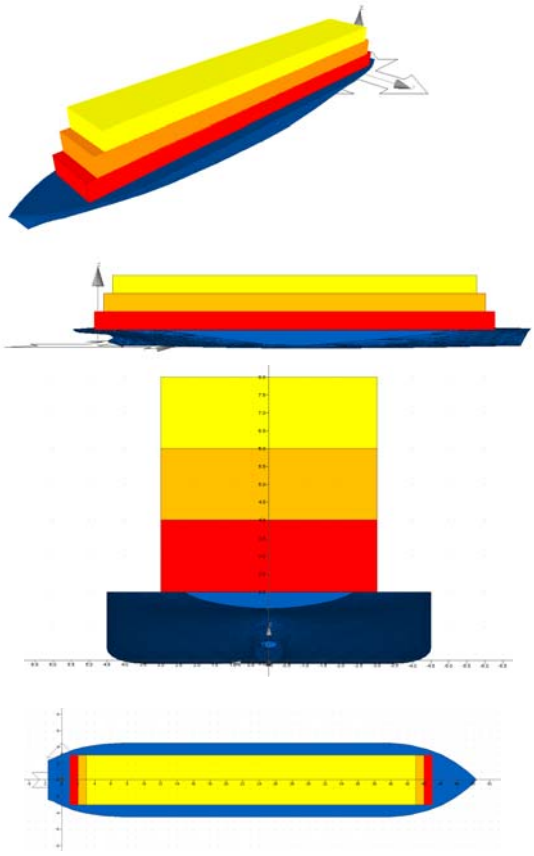


Figure 4. Various Sections of the monohull

Condition 1: Basic Monohull for 560 passenger

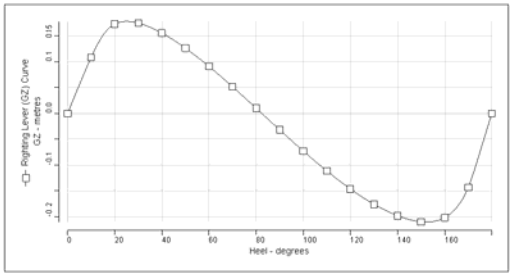


Table 3. IMO A167 Intact Stability criteria

#	Criterion	Actual	Critical	
		Value	Value	
1	Area under GZ curve up to 30 degrees > 0.055	0.665	0.055	
2	Area under GZ curve from 30 to 40 deg. or down flood > 0.03	0.291	0.030	
3	Area under GZ curve up to 40 deg. or down flood > 0.09	0.956	0.090	
4	Maximum GZ to be at least 0.20 metre at 30 degrees or above	0.179	0.200	
5	Maximum GZ to be at an angle > 25 degrees	25.049	25.000	
6	Initial GM to be at least 0.15 metres	6.388	0.150	

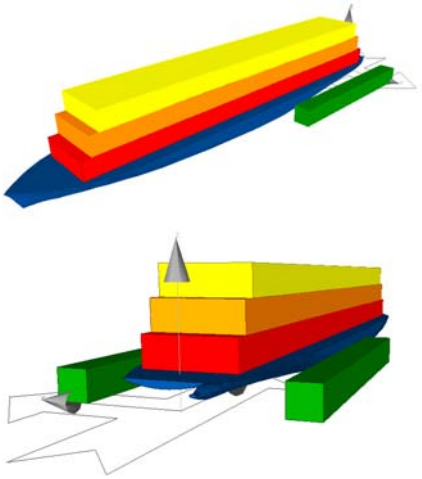
Condition complies with the regulations

Condition 2: Basic Monohul for 1120 passengers

Table 4. IMO A167 Intact Stability criteria

#	Criterion	Actual	Critical	
		Value	Value	
1	Area under GZ curve up to 30 degrees > 0.055	0.540	0.055	
2	Area under GZ curve from 30 to 40 deg. or down flood > 0.03	0.212	0.030	
3	Area under GZ curve up to 40 deg. or down flood > 0.09	0.752	0.090	
4	Maximum GZ to be at least 0.20 metre at 30 degrees or above	0.142	0.200	F
5	Maximum GZ to be at an angle > 25 degrees	22.095	25.000	F
6	Initial GM to be at least 0.15 metres	0.529	0.150	

**** Condition does not comply ****



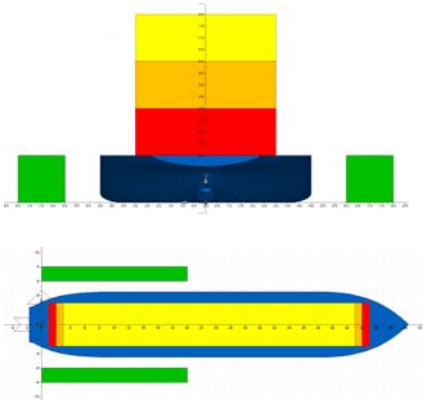


Figure 5. Various Sections of the multihull

Condition 3: Basic Multihull for 560 passengers

Table 5. IMO A167 Intact Stability criteria

#	Criterion	Actual	Critical	
		Value	Value	
1	Area under GZ curve up to 30 degrees > 0.055	0.150	0.055	
2	Area under GZ curve from 30 to 40 deg. or down flood > 0.03	0.630	0.030	
3	Area under GZ curve up to 40 deg. or down flood > 0.09	0.213	0.090	
4	Maximum GZ to be at least 0.20 metre at 30 degrees or above	0.368	0.200	
5	Maximum GZ to be at an angle > 25 degrees	27.421	25.000	
6	Initial GM to be at least 0.15 metres	1.997	0.150	

Condition complies with the regulations

Condition 4: Basic Multihull for 1120 passengers

Table 6. IMO A167 Intact Stability criteria

#	Criterion	Actual	Critical	
		Value	Value	
1	Area under GZ curve up to 30 degrees > 0.055	0.131	0.055	
2	Area under GZ curve from 30 to 40 deg. or down flood > 0.03	0.528	0.030	
3	Area under GZ curve up to 40 deg. or down flood > 0.09	0.183	0.090	
4	Maximum GZ to be at least 0.20 metre at 30 degrees or above	0.316	0.200	
5	Maximum GZ to be at an angle > 25 degrees	25.076	25.000	
6	Initial GM to be at least 0.15 metres	1.722	0.150	

Condition complies with the regulations

When ship with outriggers even the double amount of passengers on each decks, she still can suffer. And the stability result is satisfied the criteria.

Condition 5: Basic Multihull for 1450 passengers

Table 7. IMO A167 Intact Stability criteria

#	Criterion	Actual Value	Critical Value
1	Area under GZ curve up to 30 degrees > 0.055	0.125	0.055
2	Area under GZ curve from 30 to 40 deg. or down flood > 0.03	0.505	0.030
3	Area under GZ curve up to 40 deg. or down flood > 0.09	1.750	0.090
4	Maximum GZ to be at least 0.20 metre at 30 degrees or above	0.301	0.200
5	Maximum GZ to be at an angle > 25 degrees	25.050	25.000
6	Initial GM to be at least 0.15 metres	1.622	0.150

Condition complies with the regulations

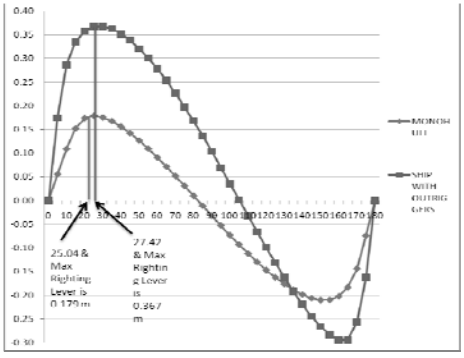


Figure 6. Stability Comparison between monohull vs. multihull for 560 passengers

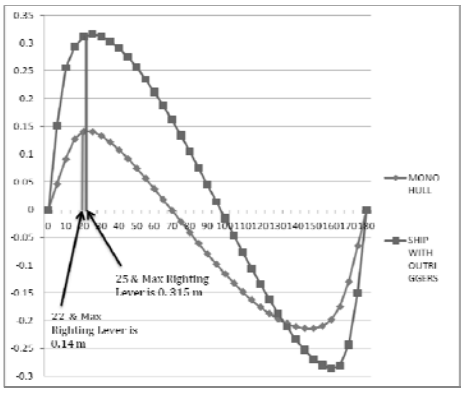


Figure 7. Stability Comparison between monohull vs. multihull for 1120 passengers

4.2 Heel Angle

Under same loading conditions if the entire passengers crowd at one side, the hell angle of the monohull is 2.16 degrees much larger than the heel angle of multihull 0.6 degree. And it shows that the stability criteria for monohull are not complied also when the multihull still complies with sufficient margin.

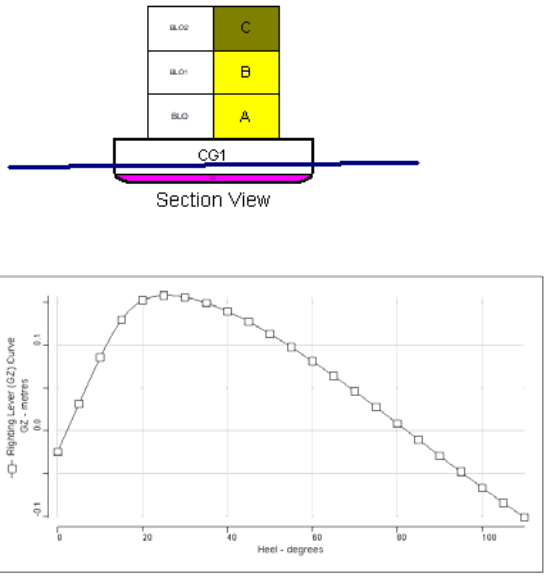


Figure 8. Sectional view showing overcrowding and the associated stability curve (monohull)

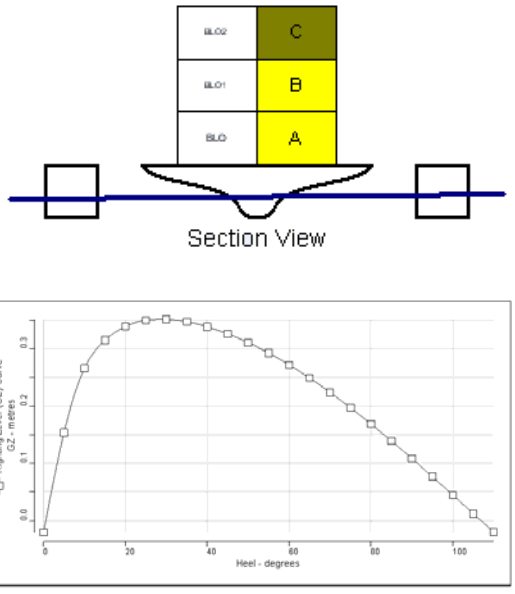


Figure 9. Sectional view showing overcrowding and the associated stability curve (multihull)

4.3 Discussion

Based on a monohull vessel geometry to design a vessel with outriggers, the dimension and position of outriggers are very important and will affect the resistance and stability of ship. There are many aspects which need to be improved and perfect in this concept design project. The adequate water plane area of outriggers will provide the transverse stability of symmetric outrigger ships. Here just assumed the outrigger/main hull displacements ration is 5%.

Table 1 and Table 2 show dimensions of the monohull and multihull respectively. Besides, Table 3 through Table 7 shows the details of the IMO intact stability criteria for both monohull and multihull vessels for various passenger numbers including taking account of overcrowding.

The two type ships' GZ curves under same loading condition have an identical characteristic which is GZ curve increase sharply during heel angle 0 to 20 degree. And maximum GZ values can all be read around heel angle 25 to 30 degree. But usually GZ curve increases gently until the maximum GZ which occurs at the heel angle larger than 30 degree. The flat hull form may be one of the reasons, which leads to the situation. See Figure 6 and Figure 7 respectively.

4.4 Remarks

The "vessel with outriggers" is the best way to against passenger vessels capsizing due to overcrowding in inland waterways. Just doing some simple modification and adding two more outriggers at each side of ship, the stability can be improved. Shape of outriggers need not be used as main hull ship. They are easier and faster to install. It is a convenient and economic way to solve the vessels capsizing for third world countries and developing countries like Bangladesh.

For this case against passenger vessels capsizing due to overcrowding in inland waterways in the third world countries and developing countries like Bangladesh, need to find out an economic way. So being utilized existed vessel is the fundamental of the concept design. It is easier and faster to build and not cost too much. It satisfied the requirements of this case "convenient and economic". "Ship with outriggers" also provides large deck area and higher stability satisfying for this concept design.

The main components of TRIBON that have been used for this design process was (1) Surface and Compartment and (2) Calc and Hydro.

The vessel with outriggers has the range of stability is wider than monohulls; the angle of vanishing stability is larger than monohulls; the maximum GZ is larger than monohulls and the initial metacentric height (GM) is larger than monohulls.

The considerable amount of stability information shows higher initial stability of the ship with outriggers which has sufficiently smaller probability of overturning. However, damage stability of the multihull especially for the outrigger's damage to be studied also carefully. If necessary, the outriggers to have small compartments to reduce flooding and thus reducing heeling moment.

5. CONCLUSIONS

Bangladesh having its enormous inland waterways has tremendous potential to harness its growth in long term development plan. Introducing new initiatives, there is ample opportunity to get most of the benefits out of these inland waterways.

New policies along with research and development augmented by innovative ideas can see the better results out of these vast inland waterways.

Immediate attention could be drawn to problems like safe passenger vessels, fuel efficient inland waterways, using concrete for building new landing station pontoons, introducing Bangladesh Class, Planning for a comprehensive Maritime University, etc. Overall, a robust national maritime policy could now be debated and put on place.

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