SOME SAFETY ISSUES INVOLVING INLAND WATER PASSENGER TRANSPORTS IN BANGLADESH

K. Hasegawa*, K. S. Iqbal*, and G. Bulian**

**Department of Naval Architecture and Ocean Engineering, Graduate School of Engineering, Osaka University, Osaka, Japan*
***Department of Naval Architecture, Ocean and Environmental Engineering (DINMA), University of Trieste, Trieste, Italy*

ABSTRACT

The factors involved in the inland water passenger transport accidents in Bangladesh were analyzed. Collecting accident data from various resources the causes behind the accidents were identified. Stormy weather, overloading and collisions were the main causes behind the accidents. Most of the accidents occurred during the season when tornadoes and storm were very frequent in the territory. An weather & crowding effect on the intact stability of a model ferry was checked and a simple method to improve the stability was proposed.

KEYWORDS

Water transport accidents, transport safety, weather & crowding criterion

INTRODUCTION

Water transport has always been the most important mode of transportation in Bangladesh. During past few decades, rapid expansions of the road transport facilities have been carried out at the cost of the environment. Even then the water transport is maintaining a healthy growth. It is still the cheapest mode and the only mode that can reach almost every corner of the country. In times of floods, the water transport, especially the country boats, are the only means of transportation in many places of the country.

But accidents involving passenger launches have brought disrepute to the sector. However, the large numbers of the people killed in single accident and the global media coverage given to such accidents have brought disrepute for the sector. This public impact is not felt only in Bangladesh but almost everywhere of the world.

Containing the spate of accidents involving inland passenger launches in Bangladesh requires a host of actions to be adopted. The problem has not only technical features but has strong socio-economic components as well. A solution or at least, reduction of the problems require a coherent action on all fronts to reduce the risk to the lives of the people using the water transport mode for going from one place to another.

WATER TRANSPORT ACCIDENT DATA COLLECTION AND ANALYSIS

It was very difficult to find reliable data on water transport accidents occurred in Bangladesh. No relevant organization was maintaining database of all these accidents. The authors collected the data from various resources like Accident Research Centre of Bangladesh University of Engineering and Technology, some journals and newspapers published from Dhaka. The data of twenty-five years, from 1981 to 2005, was collected and analyzed in this study.

A total of 359 passenger water transport accidents were reported in the period 1981-2005, in which passenger ferries (locally called as "launch") were involved in 219 occurrences, where small sized country boats' and trawlers' involvement was found in 159 cases. The numbers add up to 378 because in some collision cases both launch and boats/trawlers were involved. Fig. 1 shows the year-wise distribution of the number of accidents. To find the seasonal effect on the accidents, the total number of accidents occurred in a month was calculated. These numbers are shown in Fig. 2. A total of 7811 death and 1244 missing were recorded in these accidents, where the total number of injured persons was 1923. The death, missing and injured persons associated with passenger ferries were 80%, 72% and 63% respectively. The death, missing and injury related to the passenger ferry accidents and boat /trawler accidents are shown in Fig. 3 and Fig. 4.

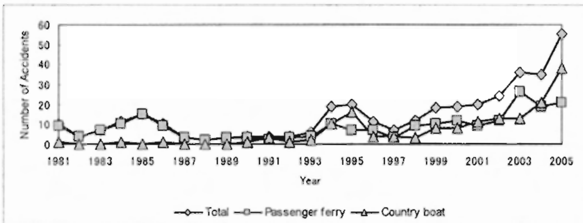

Fig. 1 Total number of accidents; by year

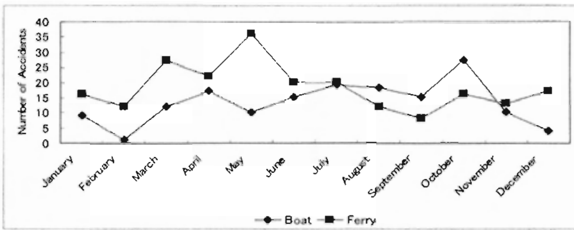

Fig. 2: Total number of accidents; by months

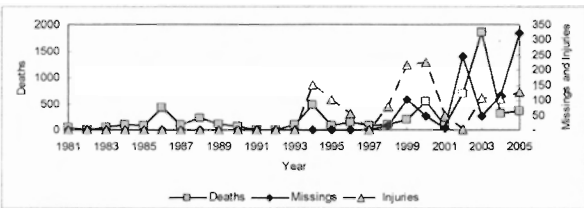

Fig. 3: Total number of Death, injured and missing in passenger ferry accidents; by year

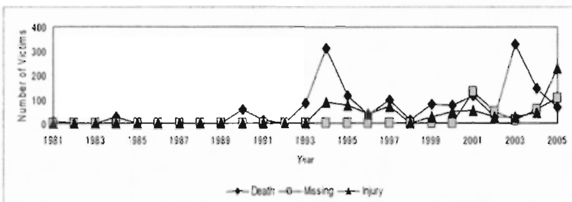

Fig.4: Total number of death, injured and missing in country boat / wooden trawler accidents; by year

The modes of failure of passenger ferries are shown in Fig. 5. The causes that were mentioned in the reports as responsible for the structural failure of the passenger ferries are shown in the Fig. 6. The loading condition and the weather condition during the intact stability failure of ferries are shown in Figs. 7 and 8.

According to the figures about 49% of the total ferry accidents were due to intact stability failure, of which 36% cases were overloaded and loading condition in other 64% cases were not reported. Since, according to most relevant news reports, overloading is very common in Bangladesh, it would be logical to believe that most of the cases where loading condition was not known were actually overloaded. Stormy weather condition was behind 60% of intact ship accidents. The weather condition was not reported for 14% of cases. These facts indicate that adverse weather condition and overloading were the main causes behind the intact stability failure of passenger ferries.

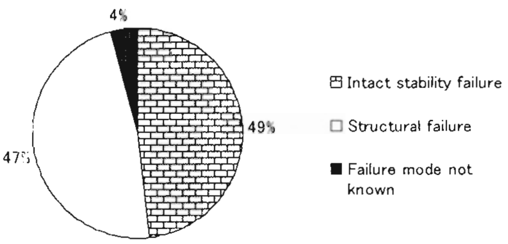

Fig. 5: Mode of passenger Ferry Accidents.

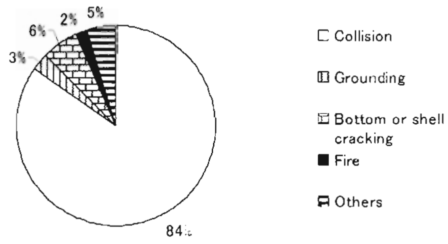

Fig. 6: Reported causes behind the structural failures

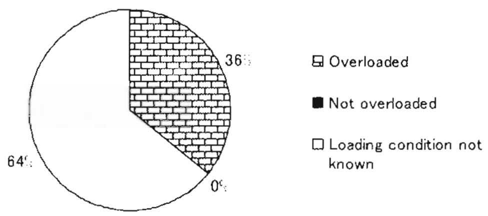

Fig. 7: Loading Condition of Ferries with Intact Stability Failure.

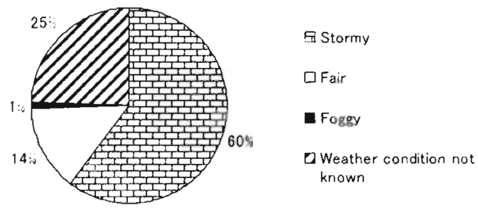

Fig. 8: Weather Condition during Intact Stability Failure of Ferries.

SOCIO-ECONOMICAL ASPECTS RELATED TO THE CAUSES OF ACCIDENTS

There are some remote places in Bangladesh for which water transportation is the only possible commuting means. Moreover, passenger ferries in Bangladesh are the transport means with the cheapest fares. So, low income people and people living in far remote areas mostly use this mode of transportation for traveling in the country. The demand for these transports in long route is very high in the night time, because low salary passengers, traveling for business, prefer to save the money that would be required for spending one night in the expensive hotels located in the big cities.

Though still safer than the road transport, a significant number of lives are lost every year in ferry accidents. Even though many of the causes behind the accidents are known, it is very difficult to reduce the risk people are exposed to because of the passengers' unawareness and poverty, the inadequate number of transportation means compared to what would be actually required, the tendency of the owners towards a higher profit, etc. Some of the most common causes of accidents and their socio-economic involvement are discussed below.

Collision

Many vessels are operated by unskilled crews. There are about two thousand and five hundred registered passenger ferries operated in Bangladesh. The number of unregistered vessels is believed to be similar. But a sufficient number of certified crews is not available to operate such huge number of vessels. The owners often recruit unskilled crews to keep their vessels operating. Moreover, it is very common to see sort of speed competitions (intended to attract people by showing the performance of the vessels) among ferries sailing the middle channel. Many of the ferries are not equipped with navigational lights and signals specially required for safe operation in the night. The river banks and channels are also often out of markings and signals. All of these factors, combined or separately, are behind the collisions and grounding leading to structural failures.

Overloading

Overloading of ferries is a very common phenomenon in Bangladesh. Though it is known that the accidents due to overloading often cost the life of the passengers, many of the passengers do not have any other choice, as the number of ferries in the different routes is not sufficient to deal with the large demand. The owners also take illegal advantages of additional income through overloading.

Adverse Weather Conditions

Bangladesh is a highly tornado prone area. The coastal areas are often hit by cyclones formed in the Bay of Bengal. The inland areas also face locally formed tornadoes, which are difficult to forecast sufficiently in advance to provide any warning to the crews. These stormy weather conditions often cause capsizing of the ferries and consequent loss of lives, and should then be properly taken into account by the relevant national rules. Rules originally developed on the basis of geographical areas not characterized by such harsh and strongly localized phenomena cannot be considered suitable.

A "WEATHER & CROWDING" CRITERION

To analyze the intact stability failure of the ferry, a model ship, similar to one that capsized in Bangladesh, was taken into consideration and a weather & crowding criterion was checked with that model. The body-plan of the model is shown in Fig. 9. The reference loading condition are given in Table 1.

However, the analysis of accidents has shown a significant number of capsizes in stormy condition with overloaded ships. It is thus important, at the design stage and during the approval process, to take into account the possibility of concurrence of the above effects.

The Weather Criterion presently in force in Bangladesh (Zulfikar, 2005) only considers the effect of beam wind. In the authors' opinion, a compliance with such a criterion does not necessarily lead to a sufficiently safe ship, due to the lack in acknowledging the possible detrimental effect of the crowding of passengers to one side. In addition, the pressure to be taken into account in the present criterion is about 1.6 times smaller than the pressure that should be accounted for if a mean wind speed of 26m/s would be considered. We would like to recall that very localized storms (tornadoes) are not uncommon in Bangladesh, and they can be associated to much higher wind speeds than 26m/s.

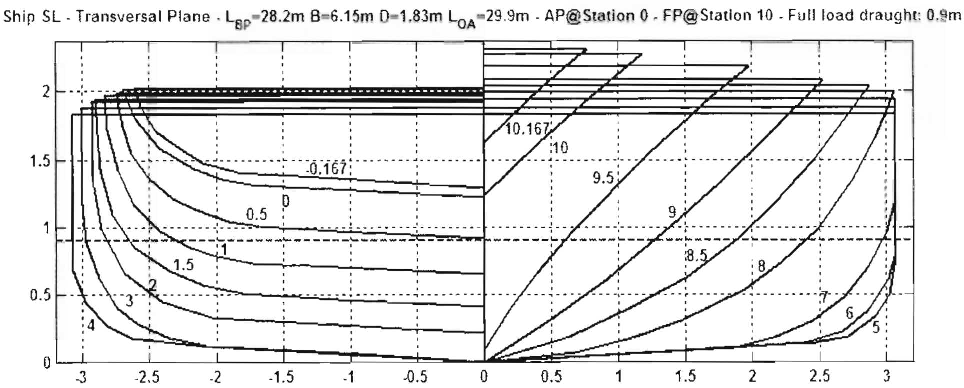

Fig. 9: Body-plan of the model ship

Table 1: Reference loading conditions

			Full Load
Length between perpendiculars	L_{BP}	[m]	28.2
Breadth	B	[m]	6.15
Depth	D	[m]	1.83
Draught	T	[m]	0.900
Volume	∇	[m^3]	88.0
Vertical position of the centre of buoyancy above the baseline	$\overline{KB}$	[m]	0.528
Transversal metacentric radius	$\overline{BM_T}$	[m]	4.002
Vertical position of the centre of gravity from the base line	$\overline{KG}$	[m]	2.061
Transversal metacentric height	$\overline{GM}$	[m]	2.469
Mass of passengers and crew		[kg]	19050
Lateral projected area exposed to wind	A_{lat}	[m^2]	71.6 (107.8)
Vertical distance between the assumed centre of application of the wind force and the centre of application of the drift reaction	Z	[m]	2.711

According to such reasoning, we would propose a criterion very similar to the present Weather Criterion concerning the application framework, but where the effect of mean wind and gust are combined with the effects of crowding of passengers to one side.

The idea is to substitute the mean heeling lever due to wind (usually called l_{w1}) with the sum of the heeling lever due to passenger crowding to one side and beam wind for the "steady state" analysis. The wind contribution to the total heeling lever under gust is considered as usual as $l_{w2} = 1.5 \cdot l_{w1}$, without modifying the contribution due to crowding. The requirement of dynamic survival (based on the relative magnitude of the so called "Area b" and "Area a") are considered to remain the same, i.e. "Area b">"Area a".

The last parameter to be accounted for is the rolling amplitude. The formula presently available in the IMO Weather Criterion (IMO, 2002) is likely unsuitable for the typical passenger ships presently operating in Bangladesh due to the historical background of such formula (see the recent IMO Document SLF48/4/5 (IMO, 2005)). The very large B/T values and the usually large value of the parameter $\left(\overline{KG}-T\right)/T$ put typical Bangladesh' passenger ships outside the range of parameters used in the original regressions (see MSC.1/Circ.1200 (IMO, 2006b)). In addition, and this is likely much more important, the "s" factor in the IMO Weather Criterion, that is basically a design wave steepness for a given rolling period, is based on the work of Sverdrup&Munk (1947). This latter work is based on observations of waves at sea, and thus the factor s represents, in some way, an open sea environment, therefore suitable for seagoing ship. The environmental conditions in inland rivers are completely different, and from some aspects, much more complicated. In river navigation, hazards like strong current, whirlpools, turbulent waters are present, that usually do not occurs at sea. The response of a ship to such excitations is, basically, unknown, and likely to be very difficult to predict. For these reasons, the application of the IMO formula for the rollback angle φ_1 when dealing with inland water transportation is likely inappropriate, and is lacking of physical bases. At the same time it is very difficult to provide a rational alternative, because of the difficulties in a sounding prediction of the rolling behavior in rivers. Therefore, in this paper, we assume that a constant, ship independent value for the angle of roll φ_1 could be an appropriate choice. The biggest problem is to rationally decide a suitable value, due to the almost complete lack of available data from ships in operation. What can be guessed is, however, that strong synchronous rolling for ships sailing in rivers is not a likely situation, due to the limited fetch leading to not very developed waves and due to the quite irregular flow. According to these, maybe questionable, ideas, it is the authors' opinion that the actual rolling motion to be accounted for should not be extremely large, and, therefore, a value of 10deg is used here that seems to be reasonable.

It was found that curtains are often present to protect people from wind and rain, significantly obstructing the available apertures on the ship side through which the wind could in principle flow. For this reason, in the criterion, openings on passenger decks should be considered closed or, at least, significantly obstructed. In the following calculation we will consider the openings as fully obstructed. For the crowding of passengers we have assumed, for this ship, a movement of 100% of the passengers onboard to a position equal to 70% of the half breadth of the ship. The application of the proposed criterion in the case of the "full load" condition is shown in Fig. 10, with numerical data provided in Table2: the ship cannot pass the criterion. It can thus be said that, from the application of the proposed criterion, the analyzed design should be considered as not satisfactory and potentially dangerous.

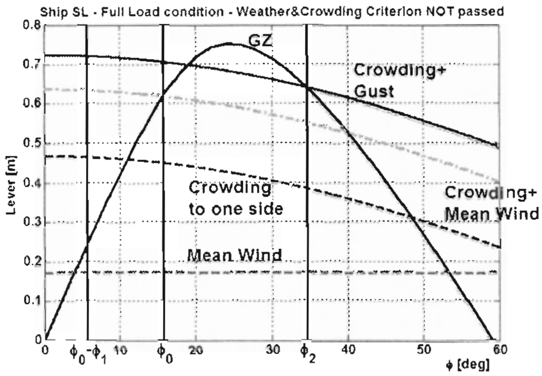

Fig. 10: Application of Weather & Crowding Criterion in the full load condition

Table 2: Application of Weather & Crowding Criterion in the full load condition: numerical data

ϕ_{fl}	ϕ_{ds}	ϕ_0	ϕ_1	ϕ_2	Area "a"	Area "b"	Passed?
58.8	18.2	15.7	10.0	34.6	0.049	0.013	NO
ϕ_{fl} : flooding angle; ϕ_{ds} : deck submergence angle; ϕ_0 : equilibrium angle under the action of steady wind and crowding to one side; ϕ_1 : assumed rolling amplitude; ϕ_2 : minimum between 50deg, the angle of vanishing stability and the flooding angle; Angles are measured in [deg] and areas in [m*rad].							

FITTING ADDITIONAL BUOYANCY TO INCREASE GZ

In order to improve the behavior of the sample ship in case of the hazards considered in the "Weather&Crowding" Criterion, we have investigated the possibility of modifying the ship design in order to improve the restoring capabilities of the vessel, bearing in mind the necessity of a relatively simple, and possibly cheap, modification.

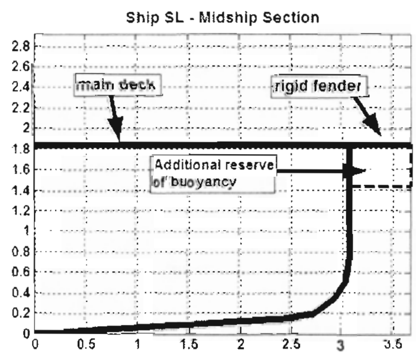

Fig. 11: Rigid fender at the midship section.

The basic idea is to supplement the ship with an additional reserve of buoyancy above the waterline, in such a way to increase, especially, the maximum $\overline{GZ}$. Typical passenger ferries operating in Bangladesh are fitted with a rigid fender at height of the deck, extending transversally with a length depending on the particular ship. For the ship under analysis, the breadth of such fender is 0.6m, as shown for the midship section in Fig. 11. Such rigid fender is used to protect the ship hull during berthing and during loading/unloading operation.

The idea is thus to provide additional buoyancy to the ship by exploiting the clear area below the fender. The requirements for the ship modification are:

- The modification must be simple and not too expensive.
- The modification must not interfere with the normal ship operation.
- The additional buoyancy must be effective in increasing the maximum righting lever.
- The modification must not involve modification of the hull.
- The modification must not excessively reduce the payload.

We have thus considered the possibility of adding such buoyancy through totally enclosed inflatable lifting bags, to be fit in position under the rigid fender. Such buoyancy aids could be easily filled with air by means of an air pump connected to the main engine. In addition to providing additional buoyancy, they could be also considered effective as protections from collisions, thus increasing the inherent ship safety with respect to this latter hazard. Moreover, in case of breach of the hull, the presence of such bags, if not damaged, could provide a safe, though limited, additional reserve of buoyancy.

The selection of the dimensions of such buoyancy reserve is governed by the actual breadth of the fender and by the freeboard at the maximum allowed draught. The ship under analysis has a maximum allowed draught of 1.2m, with a depth of 1.83m. If we assume that 0.2m should be left clear between the waterplane and the bottom of the lifting bags, a maximum height of about 0.4m is obtained. It is to be said that such height could be increased by reducing the maximum allowed draught: the reduction in the maximum payload that the ship could carry would be compensated by the additional safety. The geometry and the position of the additional reserve of buoyancy are shown in Fig11.

The longitudinal extension of the reserve of buoyancy has been assumed to cover 80% of the ship length, for a total of 22.6m. From a survey of commercially available lifting bags, we have estimated that, for the assumed dimensions, the weight of the bags for 1m of length is below 10kg comprising the necessary connections to the hull. This means that the total additional weight due to the modification is estimated to be below 0.5t. On the other hand, the total gained reserve of buoyancy is about 11t. Of course such estimations are, at this time, purely indicative.

In order to check the effectiveness of the proposed modification on a rational basis, we have again applied the proposed "Weather&Crowding" criterion to the modified ship at the full load condition. The results of the application are shown in Fig. 12 and Table3 where it can be seen that the modified ship is able to fulfill the requirements thanks to the additional restoring. For sake of comparison, in Fig. 12, the $\overline{GZ}$ curve of the original design is also reported. Therefore, from the obtained result, it seems that the proposed modification is worthy attention, due to its potential of improving the safety of the considered ship with limited efforts.

It is however important to underline that the proposed modification, although providing an improvement with respect to the original design, is not able to solve the issue of concurrent crowding to one side and gust in the overloaded condition. In the 50% overloaded condition, in fact, there is no intersection between the $\overline{GZ}$ curve and the lever of the moment due to crowding and gust, even after the fitting of the additional buoyancy reserve. A stable equilibrium angle of 18.7deg is found, on the other hand, if the gust effect is omitted: without the fitting of additional buoyancy, as already said, the ship would have statically capsized also in such situation.

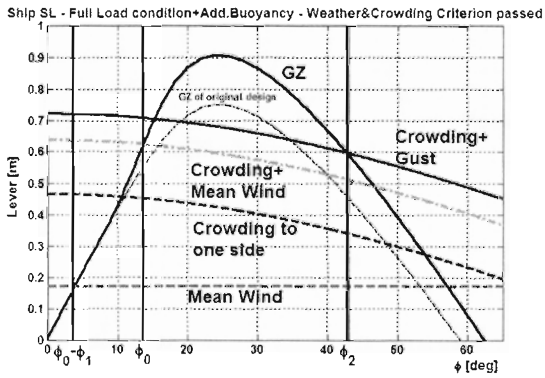

Fig. 12: Application of Weather & Crowding Criterion to the modified SL at full load condition.

Table 3: Application of Weather & Crowding Criterion to the modified SL at full load condition: numerical data.

ϕ_{fl}	ϕ_{ds}	ϕ_0	ϕ_1	ϕ_2	Area "a"	Area "b"	Passed?
64.8	19.1	13.7	10.0	42.9	0.060	0.072	YES

FINDINGS AND DISCUSSIONS

Analyzing Fig. 1, it was found that the frequency of accidents increased with time. This was obvious because the number of passenger vessels (motor launches) were increased with the increased demand from passengers, but the safety measures were not enough to accommodate all the new vessels in the fleet.

Fig. 4 show that May was the most vulnerable period for accidents. March and October were the next. These were the periods when storms, tornadoes and cyclones hit Bangladesh very frequently. At that time the wind blew with much higher speed than the speed that was usually considered during the design of vessels. Moreover overloading and crowding effect accelerated the capsizing by reducing the stability. Though there were regulations for not operating vessels during the storms, it was often violated. During storms the visibility became worse, vessels controlling became difficult due to high wave and strong wind. So many times the crews could not avoid collision in the river channel leading to structural failure and capsizing/sinking.

The collision was the main reason behind structural failure, where stormy wind and overloading/crowding to one side had severe effects on intact stability failure.

The considered pressure for current weather criterion effective in Bangladesh is not adequate. A weather&crowding criterion checked with a model ship similar to one capsized in Bangladesh showed intact stability associated with the design. An improvement with some additional buoyancy is proposed for the current ferries being operated in Bangladesh.

CONCLUSION

Rough weather including sudden storms and overloading were the most severe cause behind the intact stability failure of inland water transport in Bangladesh. It means that, a large number of passenger vessels that were being operated in Bangladesh were not suitably designed for plying in rough weather. So, to avoid the accidents, the regulation of not plying in rough weather should strictly be followed unless the designs are properly improved.

Collision was the severe cause behind Structural failure. These were the problems of proper management and ship operation. Strict monitoring of loading condition at ports and appointing skilled crews for ship operation could be effective measures to reduce such accidents as well as the loss of valuable lives. The navigable routes should also be marked with proper signals for various inland vessels.

The intact stability of the contemporary inland passenger ferries in Bangladesh can be improved by fitting some additional buoyancy under the rigid fender of the ferries.

ACKNOWLEDGEMENT

This work is a part of the second and third author's post-doctoral research supported by Japan Society for the Promotion of Science (JSPS). The authors like to express their gratitude to JSPS.

REFERENCES

IMO (2002) "Code on Intact Stability for All Types of Ships Covered by IMO Instruments", London.

IMO, Document SLF48/4/5 (2005) "Proposal on draft explanatory notes to the severe wind and rolling criterion", Submitted by Japan, 10 June, London.

IMO, Document SLF 49/5 (2006a) "Revised Intact Stability Code prepared by the Intersessional Correspondence Group (Part of the Correspondence Group's report)", Submitted by Germany, 23 January.

Sverdrup, H. U., Munk, W. H., (1947) "Wind, Sea and Swell. Theory of Relations for Forecasting", U.S. Navy Hydrographic Office, Washington, Pub. No. 601.

Zulfikar M. M.; (2005) "Preventing Accidents of Inland Ships: Law & Ordinance; Inland Ship (Stability) Rules 2001", (In Bengali), H. A. Publishers, Dhaka, August.