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Traditional Ship Stability Evaluation in Toba Lake

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Abstract

Toba Lake is a major tourist destination in Indonesia, and traditional boats are a popular mode of transportation for residents and tourists alike. However, these traditional ships have been involved in multiple accidents with significant casualties. This study aims to evaluate the stability of the ship according to the conditions of the local water area. The results showed that traditional boats that have been modified to have double decks (to allow for higher customer capacity) have poor stability, especially in bad weather conditions. To maintain sailing safety, it is recommended to recondition the ship into a single deck, avoiding overloads and bad weather.

Keywords: Ship Stability; Toba Lake; Evaluation.

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1. Introduction

Toba Lake is the largest caldera lake in the world, located in North Sumatra Province, 176 km to the west of Medan City as the provincial capital. Toba Lake (2.88o N - 98.5o 2 E and 2.35o N - 99.1o E) is the largest lake in Indonesia (90 x 30 km2) and is also a volcanic-tectonic caldera (giant volcanic crater) in this world. As the largest tectonic volcano lake in the world, Toba Lake has a length of 87 km to the northwest-southeast with a width of 27 km with an altitude of 904 meters above sea level and the deepest lake depth of 505 meters. Toba Lake is considered as the unifying node of the land area inhabited by individuals and ethnic groups of the Batak Toba, which are situated at an altitude of 900 m above sea level. This lake is formed from volcanic Mount Merapi which results from the eruption to form a lake, whose eruption has the impact of spitting out a crater which is then filled with very large water discharge (http://bpiw.pu.go.id/product/download_attachments?file=Dokumen%20Profil%20Pengembangan%20Kawasan%20Strategis%20-%20Resume%20Kawasan%20Danau%20Toba.pdf. Accessed on 28 June 2018 at 14.30 WIB). Toba Lake is one of the pride of the Batak Toba community as a lake that is very useful for the source of life from the produce in this lake, such as clean water sources, fish and as a tourism asset because of its charming scenery around this lake. If optimized, some of this potential will make Toba Lake as one of the economic supports both at the local and national levels so that through government programs in the tourism sector, Toba Lake is designated as one of the "10 Priority Tourism Destinations" (http://presidenri.go.id/wp-content/uploads/2017/10/KEMENPAR-LReport-3-Th-Jkw-JK.pdf. Accessed on 28 June 2018 at 15.00 WIB).

Based on Geographically Condition, Toba Lake in the form of a water area with several centers of tourism attractions located on Samosir Island absolutely requires accessibility support in the form of transportation facilities and infrastructure, especially connectivity between modes of transportation at the nearest entry point such as the nearest airport or big city to the need for advanced transportation such as crossing and land transportation (Sitorus, Budi (2017). Peran Transportasi dalam Mendukung Kawasan Strategis Pariwisata Nasional Danau Toba, Jurnal Manajemen Transportasi & Logistik - Vol. 04 No. 01, Marh 2017). In addition to the availability of basic transportation facilities and infrastructure, information to support accessibility is also needed, such as alternative transportation, brochures, pamphlets, and information on road conditions (Siregar, Rizky Arimazona. (2018). Pengembangan Kawasan Pariwisata Danau Toba, Kabupaten Samosir, TATALOKA - Volume 20 Nomor 2 - May 2018, Undip Planology Publishing Bureau).

Water transportation is one of the modes that plays an important role in supporting mobility in the Toba Lake area (Soebiyantoro, Ugy. (2009). Pengaruh Ketersediaan Sarana Prasarana, Sarana Transportasi terhadap Kepuasan Wisatawan, Jurnal Manajemen Pemasaran, Volume 4 Nomor 1, April 2009) both for the tourism sector and for other economic activities such as trade. The urgency of the water transportation mode (crossing) is one of the alternative modes of transportation that offers time and distance efficiency when compared to land transportation modes to one of the entry points such as Silangit Airport and the cities of Medan and Siantar, where in land transportation modes must go through temporary detours by ferry, only need to go through the port or dock that connects the closest point to the intended location (Tambunan, Nani. (2009). Posisi Transportasi dalam Pariwisata, Majalah Ilmiah Panorama edition VI, January-June 2009). Crossings on Toba Lake are supported by various types of transportation, including ferries, fast boats, and a traditional passenger ship which is one of the icons for water transportation on Toba Lake. The existence of traditional passenger-cargo ships cannot be separated from the history of transportation on Toba Lake because it is the transportation that pioneered the existing crossing routes (Sinaga, Rosita. (2016). Kajian Pelayanan Kapal Ferry Penyeberangan untuk Mendukung Pariwisata di Kawasan Danau

Toba, Puslitbang Transportasi Laut SDP). Traditional passenger ships are a means of transportation made in traditional shipyards which are spread over several villages and sub-districts and are further modernized by using machines as propulsion.

Traditional passenger ships still play a big role today because they are an alternative to ferries, which are limited in number and only serve a few ferry ports. On the other hand, the high public demand for crossings with point to point routes at a certain period while the number and capacity of passenger-cargo ships available in a limited location makes ship overload a sight that is already considered commonplace by the local community and ship operators (KNKT, (2003-2008). Sea Accident Trend Analysis Report). The condition of Toba Lake's wide and open waters makes weather conditions one of the factors that are susceptible to ship accidents, which when combined with human error and ship technical factors are the main causes of ship accidents (Rahman, Harnoli. (2017). Penentuan Faktor Dominan Penyebab Kecelakaan Kapal di Kesyahabandaran Utama Tanjung Priok, ALBACORE, Volume I Nomor 3, October 2017). The ship accident that occurred on Toba Lake was a series of shipping disasters recorded from 1955 to 2018 and always caused significant casualties and material and often involved traditional passenger ships (http://aceh.tribunnews.com/2018/06/21/selain-km-sinar-bangun-ini-deretan-kecatuh-kapal-yang-pernah-terjadi-di-danau-toba?page=2. Accessed on 7 July 2018 at 08.00 WIB). Some of the initial assumptions regarding the KM ship accident. Sinar Bangun which occurred on 18 June 2018 stated that the combination of weather factors, human error (overload loading) and the technical condition of the ship (poor stability) simultaneously made the accident unavoidable (https://www.cnnindonesia.com/nasional/20180621142055-20-307795/jk-sebut-tiga-kemlikely-penyebab-kecatuh-km-sinar-bangun. Accessed 24 June 2018, 09.30 WIB).

2. Research Methods

2.1. Theoretical review

Ship stability is the ship's ability to return to an upright position after being affected by forces from various positions. The factors that affect the balance of the ship can be grouped into 2 major groups, namely:

a. Internal factors

Internal factors are factors caused by the inner force of the ship, such as the ship's load. Shape of ship size, and leakage due to aground / collision.

b. External factors

External factors are factors caused by external forces such as ocean waves, winds, currents and storms.

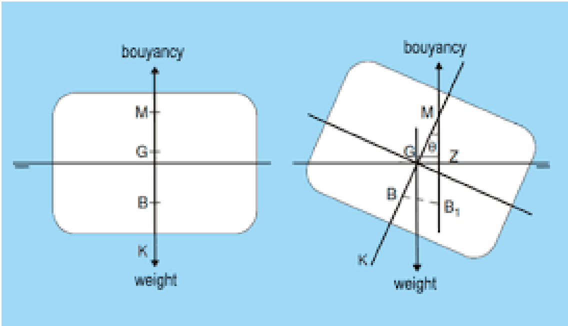

Figure 1: Ship stability graph (Source: IMO, 2002)

Ship stability diagram in the picture above shows the location of the points that affect the stability of the ship, where center of gravity (G), center of buoyancy (B), and Metacenter (M) at the position of the ship upright and tilt. For the record G is in a fixed position while B and M move when the ship tilts. In principle, there are three states of stability, namely Positive Stability (stable equilibrium), Neutral stability (Neutral equilibrium) and Negative stability (Unstable equilibrium).

a. Positive Stability (Stable Equilibrium)

A condition where the point G is above the point M, so that a ship that has steady stability while experiencing tilt and has the ability to stand back up.

b. Neutral Stability (Neutral Equilibrium)

A state of stability where point G coincides with point M. Then the moment of the ship's erection has neutral stability is equal to zero, or even does not have the ability to straighten again when experiencing a tilt. In other words, if the ship is tilted, there is no MP or moment of succession so that the ship remains tilted at the same tilt angle, the cause is point G is too high and coincides with point M because there is too much cargo on the top of the ship (Hind, Anthony. (1982). Stability And Trim Of Fishing Vessel And Other Small Ships. Fishing News Book Ltd. England).

c. Negative Stability (Unstable Equilibrium)

A state of stability where point G is above point M, so that a ship that has negative stability when experiencing a tilt does not have the ability to straighten up again, even the tilt angle will increase, which causes the ship to tilt again and even capsize. A condition when the ship tilts due to outside forces, a moment called the heeling moment arises, so the ship will tilt more (Barras, Bryan. (2012). Ship Stability for Master and Mates, 7th edition, Butterworth-Heinemann).

To enrich the literature in this study, also use a primary reference in the form of research results that have relevance to be carried out both according to theme and analysis method. The results of the related research state that traditional ships operating in Toba Lake have not identified their hull form with precision so that direct measurements are needed as a reference for describing the ship's lines plan which is the object of research (Parlindungan, Manik. (2008). Studi Hull Form Kapal Barang-Penumpang Tradisional Di Danau Toba Sumatera Utara. Jurnal KAPAL, Vol. 5, No.3, October 2008). Other studies show that the initial review of the stability characteristics of ships can be seen from the ratio of the comparison between the main sizes of the ship (Paroka, Daeng. (2018). Karakteristik Geometri Dan Pengaruhnya Terhadap Stabilitas Kapal Ferry Ro-Ro Di Indonesia. Jurnal KAPAL, Vol. 15, No.1 February 2018. University of Diponegoro Semarang).

2.2. Location and time of research

Research held in the period June - September 2018 at Nainggolan Port, Nainggolan District, Samosir Regency. The sampling method used purposive sampling method with the object of research for primary data, namely KM. Petrus Sianturi. To complement the data, secondary data is used in the form of references from theory and related research results.

2.3. Method of Analysis

Analysis Ship stability is a series of quantitative analyzes with input in the form of the main size of the ship which is calculated according to an equation established internationally by the International Maritime Organization (IMO) which will then produce an evaluation of the ship stability criteria under various shipping conditions (International Maritime Organization (IMO). (2002). Stability Criteria for All Types of Ships).

3. Result and Discussion

3.1. Ship Dimensions

Stages pre-analysis begins with the determination of the main size of the ship with size specifications that refer to international standards. Based on secondary data in the form of a Registration Letter and Ship's Nationality issued by the Transportation Office of the Province of North Sumatra, the fact is that the size data listed has not shown the specific specifications of the main size needed for analysis where the letter only shows Length Overall (LOA), Breadth or ship width (B), and the height or height of the main deck (H), while the analysis process requires Length Between Perpendicular (LBP) and Draft (T) data. For this reason, primary data collection is carried out in the form of measuring the ship manually according to ship measurement rules by positioning the ship statically and stably which is then followed by measuring the dimensions of the ship which includes the hull and the entire deck (Regulation of the Minister of Transportation Number: PM 8 of 2013 concerning Ship Measurement). The measurement results of the ship are further depicted in a line plan depicting the imaginary shape of the ship on each waterline of the ordinate shown through 3 pictures, namely: a side view of the boat slice (profile plan), a half breadth plan, and slice image of the boat front view (body plan). The shape of the hull of the ship can be seen in the following figure. The measurement results of the ship are further depicted in a line plan that describes the imaginary shape of the ship on each waterline of the ordinate shown through 3 pictures, namely: a side view of the boat slice (profile plan), a half breadth plan, and slice image of the boat front view (body plan). The shape of the hull of the ship can be seen in the following figure. The measurement results of the ship are further depicted in a line plan depicting the imaginary shape of the ship on each waterline of the ordinate shown through 3 pictures, namely: a side view of the boat slice (profile plan), a half breadth plan, and slice image of the boat front view (body plan). The shape of the hull of the ship can be seen in the following figure.

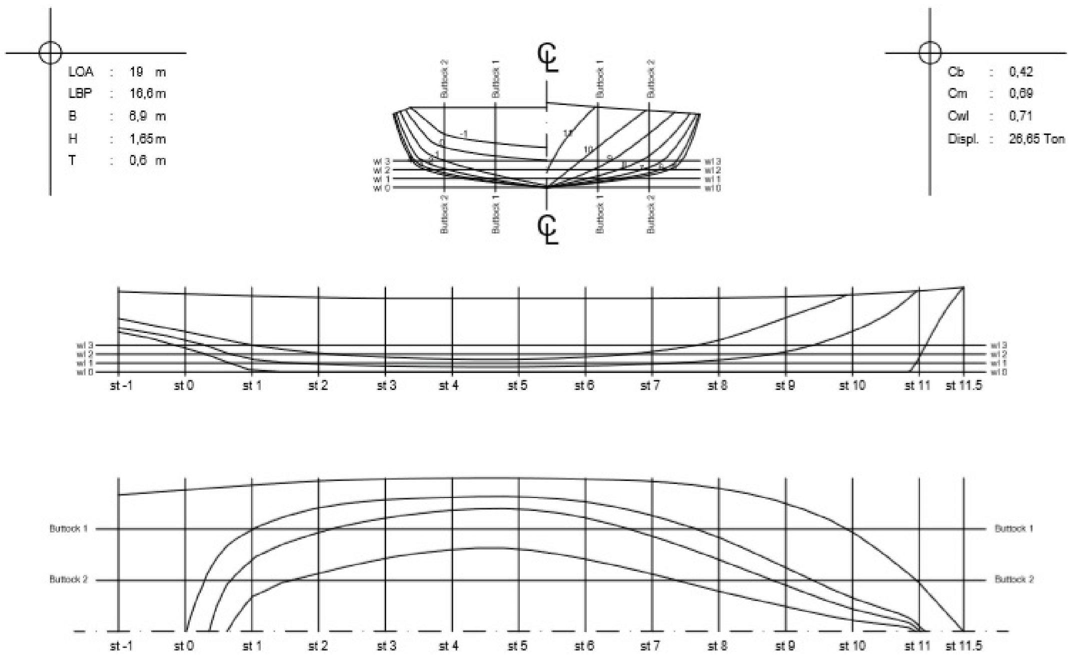

Figure 2: Line plan of KM. Petrus Sianturi (Source: Analysis, 2018)

Shape The base of the hull and passenger deck is then modeled with the help of software with the original single deck (OSD) and the modified double deck (MDD) ship condition scenarios including registered and actual loading conditions. The actual loading condition shows that there is a loading capacity almost three times the initial capacity because in addition to the increased number of passengers and estimated luggage there is also a loading of vehicles in the form of motorbikes of around ± 24 units per trip.

Table 1: Ship Loading Conditions

Load Space	OSD	MDD
Main deck	- 50 passengers - Luggage	- 50 passengers - Luggage - Motorcycles ± 24 units
Top deck	-	- 50 passengers - Luggage
Estimated total load weight	4 Tons	11.5 Tons (including additional construction weight of superstructure)

Source: Survey, 2018

3.2. Ship Stability Analysis

Analysis that carried out on the stability of the ship on the sampling vessel will be compared to the stability criteria of the IMO under various operational conditions and hull form. The limitation of the hull form condition analysis is the initial condition with a single deck based on the Registration Certificate and Nationality of the Ship, as well as with the addition of a multilevel passenger deck after modification. The operational conditions analyzed were lightship (C1), full load departure (C2), on navigation with crowded passengers (C3), and arrival with crowded passengers (C4). To facilitate reading, the two ship conditions are expressed in OSD and MDD notations, the analysis results can be seen in the following table.

Based on *resume* The results of the above analysis show that the MDD ship failed to meet the IMO stability criteria under various shipping conditions in the Max GZ category where the Intact Stability is required for Max GZ the ship must have a moment of return when experiencing a tilt above 250 but the analysis results show that the ship MDD is only able to experience a maximum critical slope of 22.70, on the other hand, the OSD ship is able to meet all the stability criteria required in various shipping conditions, especially C3 where in C3 the OSD ship is capable of experiencing a critical slope of 280 where this value is above the standard value of 250 The graph of the stability of the two vessels in the C3 category can be seen in the following figure.

Table 2: Ship Intact Stability based on IMO Criteria

IMO Criteria (Appendix 749 (18) Chapter 3)	C1		C2		C3		C4	
	OSD	**MDD**	**OSD**	**MDD**	**OSD**	**MDD**	**OSD**	**MDD**
3.1.2.1: Area 0 to 30	√	√	√	√	√	√	√	√
3.1.2.1: Area 0 to 40	√	√	√	√	√	√	√	√
3.1.2.1: Area 30 to 40	√	√	√	√	√	√	√	√
3.1.2.2: Max GZ at 25 or greater	√	√	√	√	√	√	√	√
3.1.2.3: Angle of maximum GZ	√	√	√	**X**	√	**X**	√	**X**
3.1.2.4: Initial GMt	√	√	√	√	√	√	√	√
3.2.2: Severe wind and rolling	√	√	√	**X**	√	**X**	√	**X**

Source: Analysis, 2018

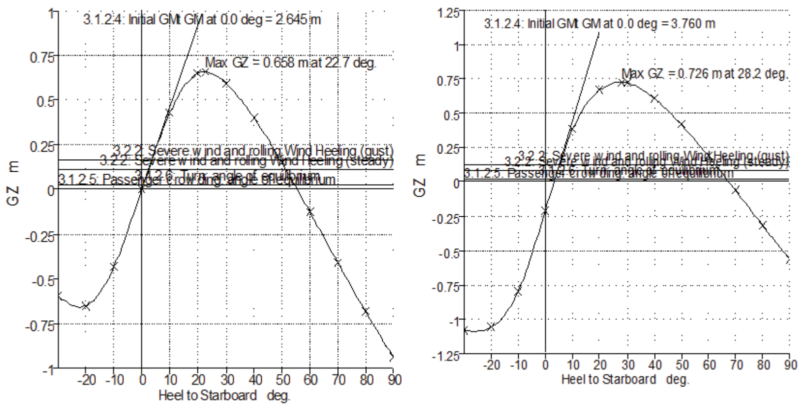

Figure 3: Graph of MDD and OSD Ship Stability in C3 Condition (Source: Analysis, 2018)

Based on the analysis of ship stability under various shipping conditions as shown in Table 2 and visualized in Figure 3, condition C3 and Figure 4, MDD vessels do not meet the IMO stability criteria, especially when the GZ slope is when the ship is on navigation with crowded passengers (C3). When juxtaposed with the hydro oceanographic data of Toba Lake, this critical condition is possible to occur at a wave height of 0.6 meters and above and is similar to the sinking situation of the KM Sinar Bangun ship where the influence of the waves hitting the ship and causing it to capsize until finally sinking also occurs when many movements crowded passengers who climbed down to the top deck while the ship was sailing and were hit by high waves.

To visualize the ship's ability to sail in local waters, a simulation process can be carried out using the help of Maxsurf software by positioning the ship against various wave directions and heights. In this study, a simulation was carried out on the condition of the ship in the original single deck condition (picture on the left) and after experiencing

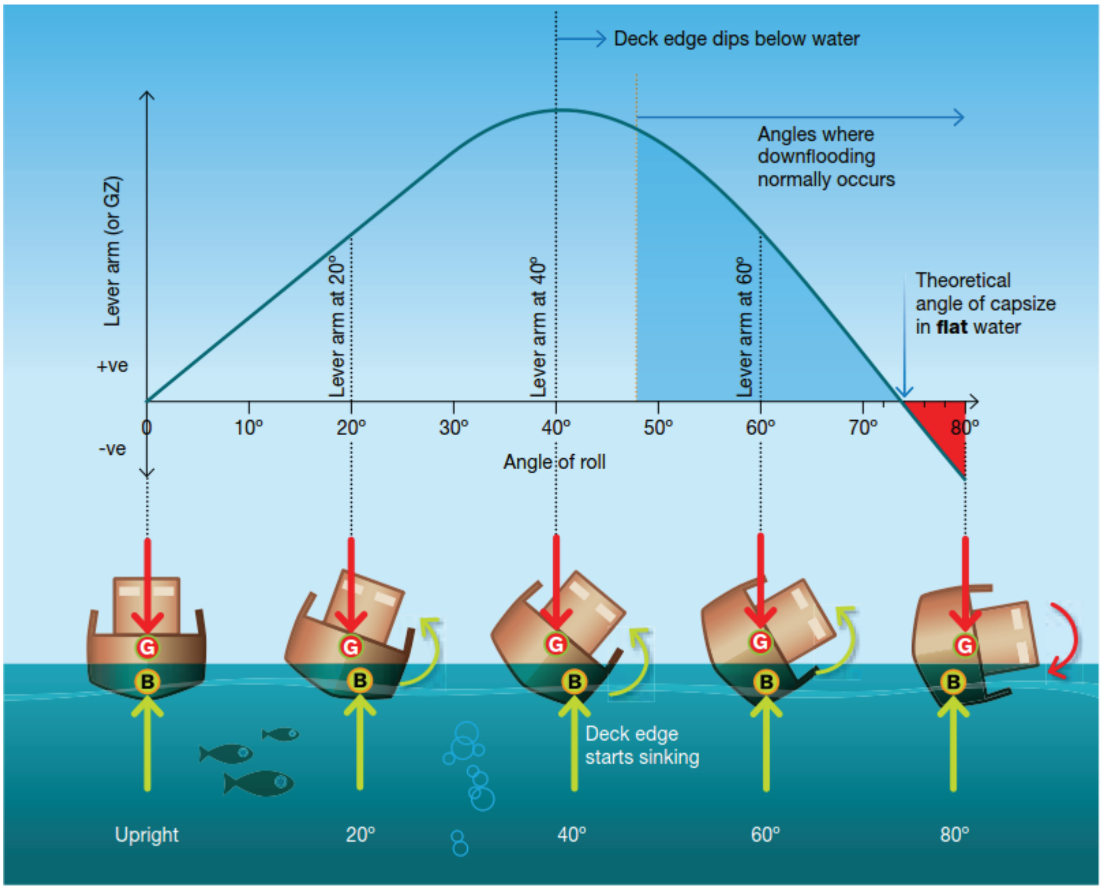

Figure 4: Graph of the ship's tilt stage against the stability curve (Source: Naval Architect and Marine Engineers (online), 2018)

modification the addition of the passenger deck at the top level (right image) using the average speed of the ship, namely 6 knots, and normal wave height of 0 3 meters and a critical 0.6 meters.

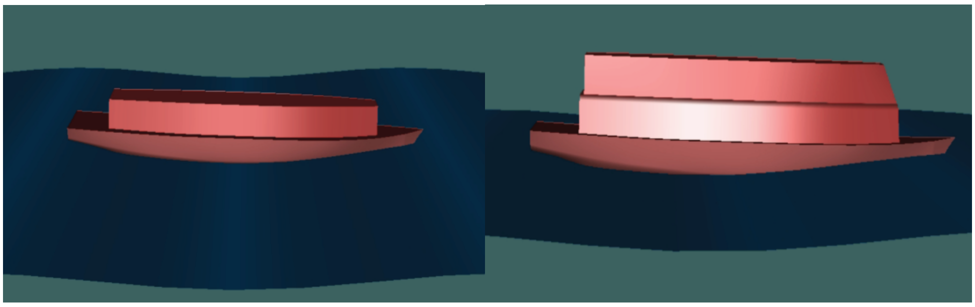

Figure 5: Simulation of ship stability on perpendicular normal waves (Source: Analysis, 2018)

Based on the simulation results, it can be seen that in the critical condition the ship still has good stability when facing waves from the bow direction, while the prone conditions can occur when the ship gets the influence of waves from the side direction both in the diagonal and perpendicular side of the ship.

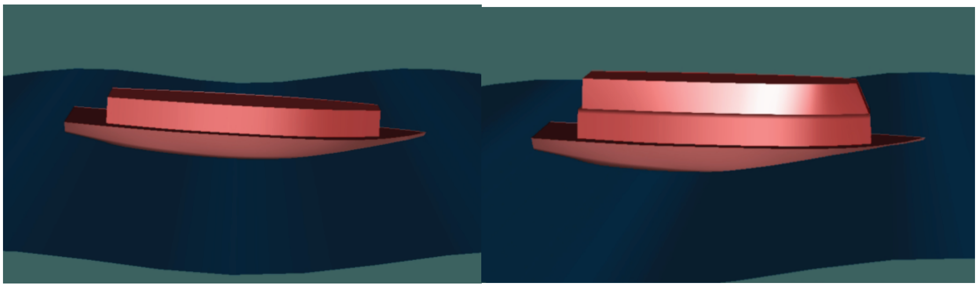

Figure 6: Simulation of ship stability at perpendicular critical waves (Source: Analysis, 2018)

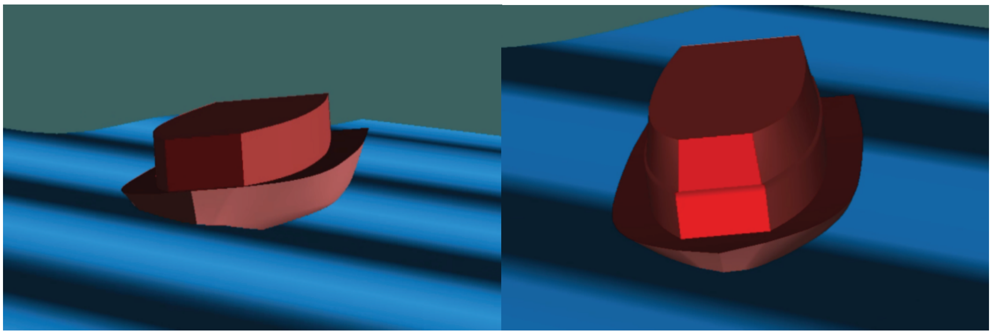

Figure 7: Simulation of ship stability on diagonal normal waves (Source: Analysis, 2018)

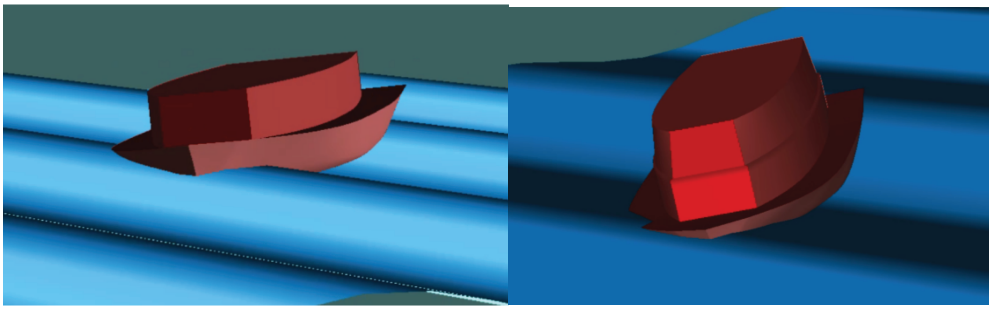

Figure 8: Simulation of ship stability on diagonal critical waves (Source: Analysis, 2018)

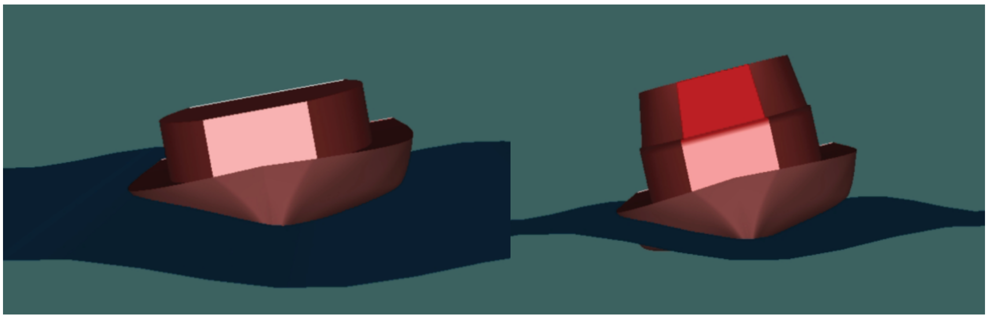

Figure 9: Simulation of ship stability on horizontal normal waves (Source: Analysis, 2018)

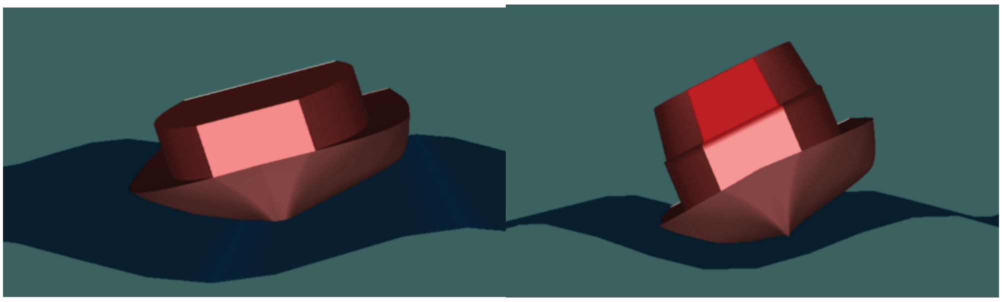

Figure 10: Simulation of ship stability on horizontal critical waves (Source: Analysis, 2018)

4. Ship Stability based on Local Hydro Oceanographic Conditions

Windrose is diagram used by stakeholders to determine the percentage of wind gusts from each cardinal direction during the observation period at a particular location. Often times the windrose shows the amount of wind speed and the percentage of calm winds. Windrose usually has eight line directions according to the general cardinal pattern. Based on the similarity of the infographic function, information about the direction and average height of the wave can also be displayed in the same form and can then be described as waverose. Depiction of windrose and waverose specifically can provide information about representative wind and wave conditions in a water area or port. Representative illustration of wind and wave conditions around the southern side of the waters of Toba Lake which can be seen in the following figure.

Based on data of hydro oceanography condition at Sipinggan Port, Toba Lake, North Sumatra Province as the closest port from the data collection location was identified by the fact that the dominant representative waves and winds point to the northwest (NW) and west (W) and southwest (SW). The height of the representative waves leading to these three directions is predominantly in the range 0.2 - 0.6 meters. Even though the percentage is small, there is a chance that waves will occur with a height between 0.6 meters and above 0.8 meters. Generally, the wave period is 3 seconds. The most dominant representative wind conditions are to the northwest (NW) in the range of 5-7.5 knots and above 7.5 knots. In addition, the wind is also evenly distributed at a lower percentage in the north (N), west (W), northeast (NE) and southwest (NW) (Sinaga, Rosita. (2017). Studi Penyusunana Rencana Induk Pelabuhan Sipinggan Kabupaten Samosir, Puslitbang Transportasi Laut, Sungai, Danau dan Penyeberangan, Badan Penelitian dan Pengembangan Perhubungan).

The original analysis of the ideal ship stability criteria according to the IMO criteria in Table 2 shows that in a single deck ship condition, it shows that at full load conditions

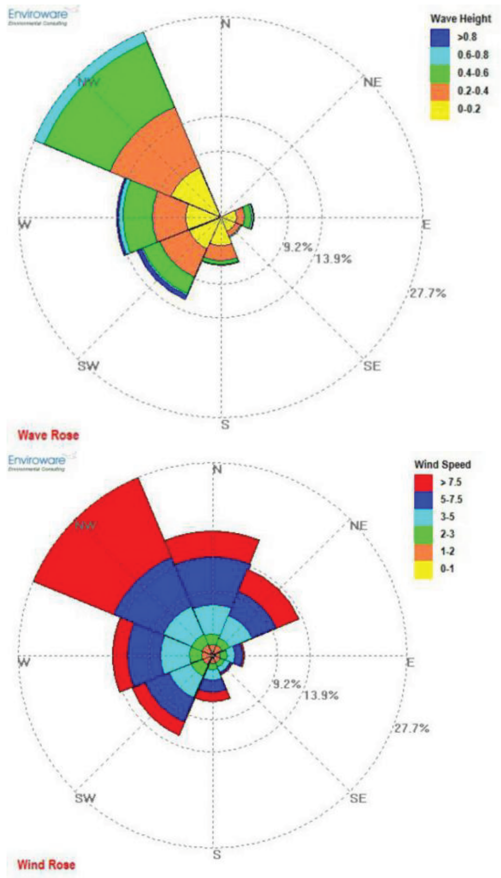

Figure 11: Waverose and Windrose at Sipinggan Port (Source: Sinaga, 2017)

in various operational conditions the two vessels show excellent stability performance, especially in the criteria 3.1.2.3: Angle of maximum GZ which requires a maximum degree of tilt so that the ship still has a moment to return to an upright position. These criteria require a minimum slope of 25 ° while the analysis / simulation results show that the ship can still return to its initial position after experiencing a tilt of up to 28.2 °.

Result analysis on the condition of the MDD ship plus the loading conditions which add to the loading of two-wheeled vehicles in large numbers and are placed on the gangway of the ship and the stern shows that in full load conditions in various operational conditions the stability performance of the ship does not meet the minimum standards, especially in conditions 3.1.2.3: Angle of maximum GZ, which requires a maximum degree of tilt so that the ship still has a moment to return to an upright position. These criteria require a minimum slope of 25 ° while the analysis / simulation results show that the ship begins to lose its return moment at an average slope of 23 °. Likewise with criteria 3.2.2: Severe wind and rolling where the addition of the passenger deck level makes the ship have a large wind catchment area.

Other conditions that Very disturbing stability is the presence of crowded passengers or the movement of passengers while the ship is sailing. A condition that can cause the ship to suddenly enter a critical tilt is when many passengers move to one side of the ship, while on the opposite side of the ship is hit by waves and strong winds. The analysis results show that the ship can experience a critical slope if it gets hit by a wave from the side of the ship with a height of 0.6 meters and above. Based on the division of wind and wave conditions expressed in the Beaufort scale, the vulnerable conditions in the water area according to the ship's technical capabilities are when the wind blows constantly at a speed of 6 knots and above which is capable of producing waves with an average height of 0.

Ratio size of main vessel also indicates that it has poor stability and less buoyancy reserves. The results of the comparison between laden (T) and the width of the vessel (B) are in the value range 0.1 and 0.12 where these values are below the ideal criteria which require a value between 0.35 ~ 0.45. The greater the ratio of the width to the load, the greater the stability arm. Thus, the area under the curve up to a certain angle of inclination will also be greater. The change in the stability arm tends to get smaller with the increase in the ratio of the width and the load of the ship. The smaller the load, the bigger the hull of the ship, so that the angle of inclination until the edge of the deck sinks into the water will also be greater. The width of the waterline of the ship will increase as the angle of inclination increases to the angle of inclination where the edge of the deck is immersed in water. As a result of this phenomenon, the metacentral radius (MB) is getting bigger so that the stability arm is also getting bigger with the increase in the ratio of the width and load of the ship. The tilt angle with the maximum stability arm also tends to increase with increasing the width and load ratio of the ship. The increase of the angle of inclination with the maximum stability arm is getting smaller the larger the ratio of the width to the weight of the ship. At small width-to-draft ratios or relatively large ship-laden ratios, the angle at which the maximum stability arm occurs is strongly influenced by the embossed hull. When the shipload is reduced or the ratio of the width and load becomes large, the slope angle at which the bottom of the ship appears above the water level also affects the slope angle at which the maximum stability arm occurs. The angle of vanishing stability increases with increasing the width and load ratio of the ship.

Ratio size Another major effect on stability is the T / H or the ratio between the laden vessel and the ship's height. Based on the results of the analysis, it can be seen that the final value of the ratio is only 0.42 where the value is below the ideal criteria of 0.56 ~ 0.72, meaning that with this low ratio value the ship will decrease its buoyancy reserve because the freeboard is also getting lower. The effect of ship modification in the form of a multi-storey passenger deck is carried out with the intention of increasing the cargo of the ship but directly it reduces the shipload where in the original condition the ship has an average load of 0.6 meters while after being modified it changes to about 0.7 meters. The addition of laden directly reduces the height of the freeboard which is one of the early indicators for the reserve's buoyancy because the lower the freeboard, the easier it is for the water to reach the surface of the main deck when it is tilted. If on the main deck there are openings or holes that are not watertight, the more frequent shaking occurs, the greater the chance for water to enter the hull and flood the cargo space.

Assessment end related to the stability of the ship is carried out cumulatively based on the results of the previous analysis. To see a ship's ability to sail in local waters, a simulation process can be carried out using the help of Maxsurf software by positioning the ship against various wave directions. In this study, simulations were carried out in three directions, namely the bow perpendicular, the bow diagonal, and the ship side perpendicular. Based on the simulation results, it can be seen that the ship in single deck condition and after modification is able to sail stably in various conditions at an average wave height of 0.3 meters.

The ship condition of next simulation in Figure 7 and Figure 8 shows that when the ship is on a diagonal wave with a multilevel deck even though it still has a return moment at a slope of up to 24 °, the prone condition that occurs is that the wave height becomes the same as the main deck so that water can enter the passenger cabin from side of the bow starting from midship to the bow. On the other hand, when a single deck vessel faces a diagonal critical wave, the water level also easily reaches the main deck, but the water does not flood or enter the passenger cabin.

The most vulnerable condition is when the ship gets hit by waves perpendicular to one side of the ship, especially for ships with multilevel decks which can be seen in Figure 9 and Figure 10.In this condition, once the ship is at the crest of the wave, the ship will immediately tilt. and placing the entire side of the ship on the bottom of the wave so that the crest of the next wave is above the main deck. There are two conditions that may occur in this critical situation, The first condition is that the ship does not experience a tilt above 23 ° so that the ship still has a return moment during the shaking period even though when the ship moves back to its upright position the water has flooded the main deck, but if there are no openings that cause water to flood the passenger cabin on the main deck then conditions can still be said to be safe. The second condition is that the ship experiences a critical tilt at the bottom of the wave and no longer has a moment of return due to the transfer of the load at the same time to one side of the ship which is tilted, the second condition is prone to occur because generally ships on Toba Lake also load two-wheeled vehicles in large numbers and are placed in the gangway on both sides of the ship so that the initial load on both sides of the ship is approximately 2, 5 tonnes where the load when accumulated with the weight of the superstructure and the load will immediately become an additional downward pressure when the ship experiences an incline which accelerates the ship to reach a critical slope and can cause the ship to capsize in a short time. On the other hand, for single deck ships, even though the water easily reaches the main deck, the ship still has a return moment because it is able to reach a critical slope of up to 280 where this value is above the standard criteria of 250.

5. Conclusion

Based on The background of the research and the stages of analysis carried out can be concluded that in actual conditions the traditional passenger-cargo ships operating in Toba Lake have undergone a modification of the addition of the superstructure to be a double deck while in the Registration Letter and the Nationality of the ship is registered in the single deck category. Modifications also resulted in an increase in payload almost three times the initial capacity, this condition resulted in increased ship weight, reduced buoyancy reserves, and a lower critical angle when tilting. This is in accordance with the results of the analysis which shows that the stability of the ship is not good because it does not meet the criteria for the angle of inclination required by IMO and its stability is easily affected by strong winds. To improve shipping safety, it can be recommended to the Transportation Office of North Sumatra Province and Samosir Regency to re-measure all traditional passenger-cargo ships as a condition for extending the Registration Letter and Nationality of the Ship and to identify the main size of the ship which is the guide for calculating stability in coordination with the Port of the Main Port. Belawan. Every vessel that has been re-measured must display a load line marking on its hull for the loading control function. The control function of port postal officers and skippers before granting a sailing permit needs to be based on accurate and actual weather information. To restore the ship's condition to ideal stability, it can be done by removing the top deck, especially for ships with 3-storey decks. Enforcement of the ship recondition policy from double deck to single deck needs support and a policy brief because it cannot be separated from other factors, such as legal and economic / financial considerations. To improve the quality of traditional crew human resources can be improved with official training such as Basic Safety Training. Further research on a similar topic needs to be done with sample variations from various sizes of ships.

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