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A Study of the effectiveness Fin Stabilizer on Unsada Water Tour Bus to Comfort the Rolling Period to Support Toba Lake Tourism

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Abstract. Lake Toba is one of the five super priority national tourist destinations. To support Lake Toba tourism. a suitable and safe mode of transportation is needed and to be able to provide an attraction for tourists. See this opportunity. we plan to make this mode of transportation. The Air Unsada Tourism Bus is one of the modes of transportation that is a pioneer of new modes of tourism transportation in Indonesia. especially on Lake Toba. North Sumatra. The Unsada Water Tourism Bus is an amphibious bus that can move both on land and in water. The Unsada Air Tour Bus is specially designed using *fin stabilizers* on the bus body. like the hull of a ship in general. The purpose of this research is to design a Water Tourism Bus that can provide comfort and safety for tourists. in this case that is how to minimize the rolling time on the Air Unsada Tourism Bus to pay attention to the condition of Lake Toba's waters which is quite extreme. In designing this bus using the dimensions of a conventional bus with a length of 13.115 meters. 2.5 meters wide. As high as 3.8 meters. and a double decker used for the roof so that tourists can enjoy views of Lake Toba. The method used for the calculation is IMO stability level 2 and also uses Indonesian land transportation regulations contained in government regulation no 55 chapter 3 part 3d 2012. For calculations and analysis using the *Maxsurf* software. Meet the IMO standard parametric rolling level 2. The results obtained are 0,000239 below the 0.06 standard.

1. Introduction
Lake Toba is one of five super priority destinations in Indonesia located in North Sumatera [1]. From the Ministry of Tourism foreign tourists visiting North Sumatera in January - September 2019 were 181,510 visitors. the total experienced a growth of 5.32% from 2018. So to support Lake Toba tourism a convenient and safe mode of transportation is needed and can provide an attraction for tourists. Currently the transportation used to get to Lake Toba is buses. taxis. and travel. In addition Lake Toba Tourism requires transportation in the form of ships. Currently in Lake Toba there are 4 LCT (Landing Craft Tank) crossing vessels. traditional wooden vessels. and ferry for tourist transportation to Samosir Island [2]. Besides transportation. there are several airports that are used to reach Lake Toba. such as Kualanamu. Silangit and Sibisa.

Based on this background. an alternative mode of transportation is needed that can be used is the Unsada Water Tour Bus. Unsada Water Tour Bus is an amphibious vehicle in the form of a bus that is specially designed by using a *fin stabilizer* on the body of the bus such as a ship's hull in general and a double decker that is used for a rooftop so that tourists can enjoy views of Lake Toba. Unsada Water Tour Bus can also function as a means of water tourism such as Lake Toba. for example. which uses this transportation to surround the lake for tourists who want to enjoy the natural scenery of the area in addition to crossing the island of Samosir.

Some of the objectives of this research are to get the best design that can provide comfort and safety for tourists in this case and to figure out how to minimize the rolling period on the Unsada Water Tour Bus to see the condition of Lake Toba's waters is fairly extreme. In designing this bus using the dimensions of a conventional bus with a length of 13.115 meters. a width of 2.5 meters. a height of 3.8 meters and redesigning the *fin stabilizer* will add to the rolling period of Unsada Water Tour Bus.

Figure 1. Toba lake tourism location.

1.1. Toba Lake

Lake Toba is located in Bukit Province of North Sumatra. with a geographical position between 2º 21'32" – 2º 56' 28" North Latitude and 98º 26 '35 "- 99º 15 '40" East Longitude. The distance is approximately 176 km south of the city of Medan. the capital of North Sumatra Province. The lake is bordered by seven regency government areas namely Samosir. Toba Samosir. Simalungun. North Tapanuli. Humbang Hasundutan. Dairi and Karo. Lake Toba's surface area is 1,124 km^2 which is the largest lake in Asia. The land area of the Catchment Area is 2,486 km^2. Lake surface at an altitude of 903 m above sea level (surface above the sea). The maximum length is approximately 50 km and the maximum width is around 27 km

The maximum depth of Lake Toba is 508 m (which is the 9th deepest lake in the world) including the northern basin. while the maximum southern basin reaches 420 m. The approved depth is 228 m. The total water volume of the lake is estimated at 256.2 km^3. In the middle of Lake Toba. including

Samosir Island with an area of 630 km^2. which is the largest island in the world that is in an island. the outflow is around 100 m^3 / s. so that it can be estimated that the retention time or time needed to flush the entire lake volume is around 81 years. which is quite long compared to other lakes in Indonesia.

The annual rainfall in the Lake Toba Air Catchment area ranges from 1,700 to 2,400 mm / year. while the peak of the rainy season occurs in November - December with rainfall between 190 - 320 mm / month and the peak of the dry season occurs during June - July with rainfall falling 54 - 151 mm / month [3].

2. Methodology

Maxsurft Stability is used to calculate the stability of the Air Unsada Water Tour Bus and check using the *IMO Stability Level 2* [4] method. In addition to using IMO regulations, Unsada Water Tour Bus also use Indonesian land transportation regulations contained in government regulation no 55 chapter 3 part 3d 2012.

2.1 Stability

Maxsurft Stability is used calculating the stability of the Unsada Water Tour Bus and checking using the method of IMO *Stability Level* 2 [4].

$$C2 \leq R_{PRO} \tag{1}$$

Where :

$$C2=\frac{[\sum_1^3 C2_H(Fn_i)+0.5C2_h(0)+\sum_1^3 C2_f(Fn_i)+0.5\,C2_f(0)]}{2N+1} \tag{2}$$

R_{PRO} = 0.06

$C2_h(Fn_i)=\sum_{i=1}^{N} W_iC_i$ with the ship in head waves with a speed equal to V_i;

$C2_f(Fn_i)=\sum_{i=1}^{N} W_iC_i$ with the ship in following waves with a speed equal to V_i;

$C_i = \begin{cases}1 \\ 0\end{cases}$ if max.roll amplitude exceeds 25 deg. else

N = total number of waves cases for wich the maximum roll angle is evaluated for a combination of speed and ship heding

Fn_i = $V_i/\sqrt{(Lg)}$;

V_i = $V_s\,K_i$ means the ship speed (m/s)

V_s = ship service speed (m/s) ;

g = gravity ;

L = Length of ship

$K_i \begin{cases} 1.0 & i=1 \\ 0.866 & i=2 \\ 0.5 & i=3 \end{cases}$

2.2 Design

In designing Unsada Water Tour Bus using *Maxsurf* software. For the size used is the size of conventional buses with the bus brand is Mercedes-Benzn Tourismo M/2 [5] and according to Indonesian land transportation standards. For *fin stabilizers* use the size of Kongsberg products Aquarius A25 type [6]. Laying *fin stabilizers* are on both sides of the bus left and right. The stabilizer fin is 7.5 m from the back of the bus. Precisely between the front and rear wheels.

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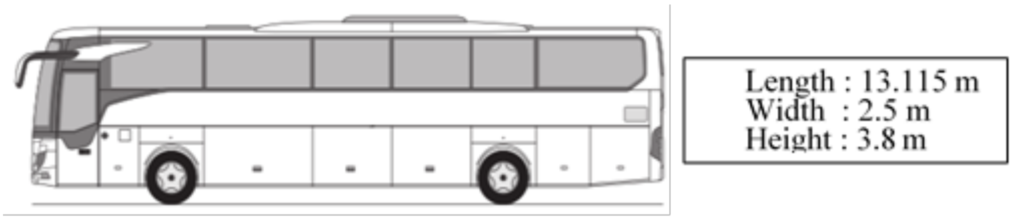

Figure 2. Mecedes-Benzn Tourismo M/2.

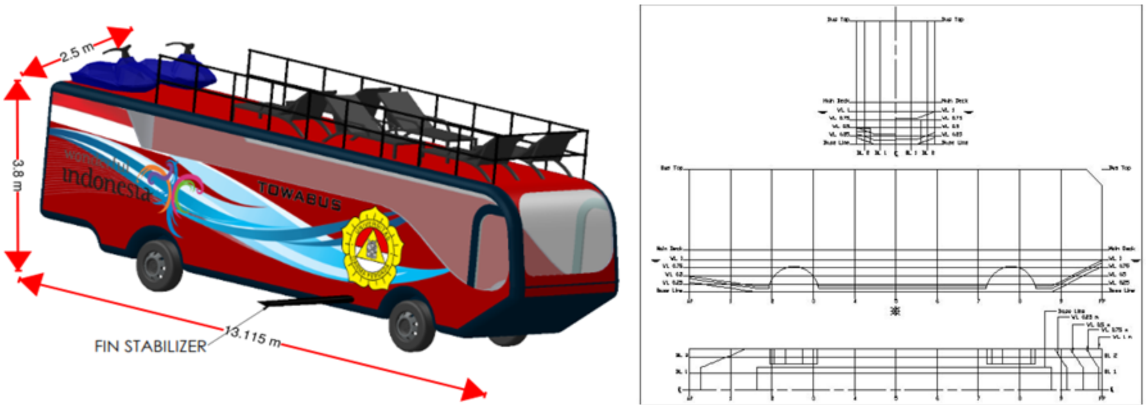

Figure 3. Unsada Water Tour Bus

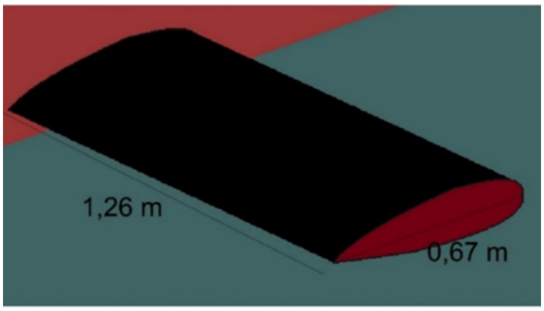

Figure 4. *Fin Stabilizer* Unsada Water Tour Bus

3. Result and Discussion

3.1 Calculation of DWT and LWT

The DWT calculation is adjusted from the total fuel, passenger, crew and fresh water requirements. For a total of 1.260 tons of fuel, 23 passengers with an average weight of 80 kg / person, 2 crew weighing 80 kg / person and 1.5 tons of fresh water. While for LWT it is adjusted to the weight of bus equipment in general and bus equipment when under water. LWT is divided into several items namely 2.5 tons of building, 2 units of Jetski weighing 1 piece, namely 0.16 tons, 1.104 tons of machinery and 8 tons of hull. For buses with *fin stabilizers*, a weight of 4.5 tons is added for each *fin stabilizer.*

3.2 Ship Stability

Bus stability analysis using *Maxsurf* software and checking using the *IMO Stability Level 2* rules. In checking stability is done with 2 different conditions. In condition 1 bus without *Fin Stabilizer* with 100% load and condition 2 bus using *Fin Stabilizer* with 100% load. For the location of *fin stabilizer* is between the front and rear wheels at a distance of 12,116 from the back of the Bus.

Table 1. Results of condition stability analysis 1.

Code	Criteria	Value	Units	Actual	Status	Margin %
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 0 to 30				Pass	
	from the greater of					
	spec. heel angle	0.0	deg	0.0		
	to the lesser of					
	spec. heel angle	30.0	deg	30.0		
	angle of vanishing stability	180.0	deg			
	shall not be less than (>=)	3.1513	m.deg	9.3796	Pass	+197.64
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 0 to 40				Pass	
	from the greater of					
	spec. heel angle	0.0	deg	0.0		
	to the lesser of					
	spec. heel angle	40.0	deg	40.0		
	first downflooding angle	n/a	deg			
	angle of vanishing stability	180.0	deg			
	shall not be less than (>=)	5.1566	m.deg	16.3826	Pass	+217.70
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 30 to 40				Pass	
	from the greater of					
	spec. heel angle	30.0	deg	30.0		
	to the lesser of					
	spec. heel angle	40.0	deg	40.0		
	first downflooding angle	n/a	deg			
	angle of vanishing stability	180.0	deg			
	shall not be less than (>=)	1.7189	m.deg	7.0030	Pass	+307.41
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.2: Max GZ at 30 or greater				Pass	
	in the range from the greater of					
	spec. heel angle	30.0	deg	30.0		
	to the lesser of					
	spec. heel angle	90.0	deg	90.0		
	angle of max. GZ	108.2	deg			
	shall not be less than (>=)	0.200	m	1.968	Pass	+884.00
	Intermediate values					
	angle at which this GZ occurs		deg	90.0		

Code	Criteria	Value	Units	Actual	Status	Margin %
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.3: Angle of maximum GZ				Pass	
	shall not be less than (>=)	25.0	deg	108.2	Pass	+332.73
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.4: Initial GMt				Pass	
	spec. heel angle	0.0	deg			
	shall not be less than (>=)	0.150	m	1.171	Pass	+680.67

Table 2. Results of stability analysis conditions 2.

Code	Criteria	Value	Units	Actual	Status	Margin %
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 0 to 30				Pass	
	from the greater of					
	spec. heel angle	0.0	deg	0.0		
	to the lesser of					
	spec. heel angle	30.0	deg	30.0		
	angle of vanishing stability	179.5	deg			
	shall not be less than (>=)	3.1513	m.deg	4.0944	Pass	+29.93
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 0 to 40				Pass	
	from the greater of					
	spec. heel angle	0.0	deg	0.0		
	to the lesser of					
	spec. heel angle	40.0	deg	40.0		
	first downflooding angle	n/a	deg			
	angle of vanishing stability	179.5	deg			
	shall not be less than (>=)	5.1566	m.deg	7.1947	Pass	+39.52
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 30 to 40				Pass	
	from the greater of					
	spec. heel angle	30.0	deg	30.0		
	to the lesser of					
	spec. heel angle	40.0	deg	40.0		
	first downflooding angle	n/a	deg			
	angle of vanishing stability	179.5	deg			
	shall not be less than (>=)	1.7189	m.deg	3.1002	Pass	+80.36

Code	Criteria	Value	Units	Actual	Status	Margin %
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.2: Max GZ at 30 or greater				Pass	
	in the range from the greater of					
	spec. heel angle	30.0	deg	30.0		
	to the lesser of					
	spec. heel angle	90.0	deg	90.0		
	angle of max. GZ	112.7	deg			
	shall not be less than (>=)	0.200	m	1.271	Pass	+535.50
	Intermediate values					
	angle at which this GZ occurs		deg	90.0		
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.3: Angle of maximum GZ				Pass	
	shall not be less than (>=)	25.0	deg	112.7	Pass	+350.91
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.4: Initial GMt				Pass	
	spec. heel angle	0.0	deg			
	shall not be less than (>=)	0.150	m	0.434	Pass	+189.33

3.3 Parametric Rolling

Ship motion analysis using the *Maxsurf Software*. This analysis uses 2 Unsada Water Tour Bus models. The first model is a bus without *fin stabilizers*. The second model is a bus with *fin stabilizers*. In this test the speed data is entered 0 knots. For wave height taken 1.5 m. In the experiment each bus is analyzed in two conditions, namely condition one with a full load and condition two a bus without a load. The following are the results of RAO graph analysis on 900 waves on all models

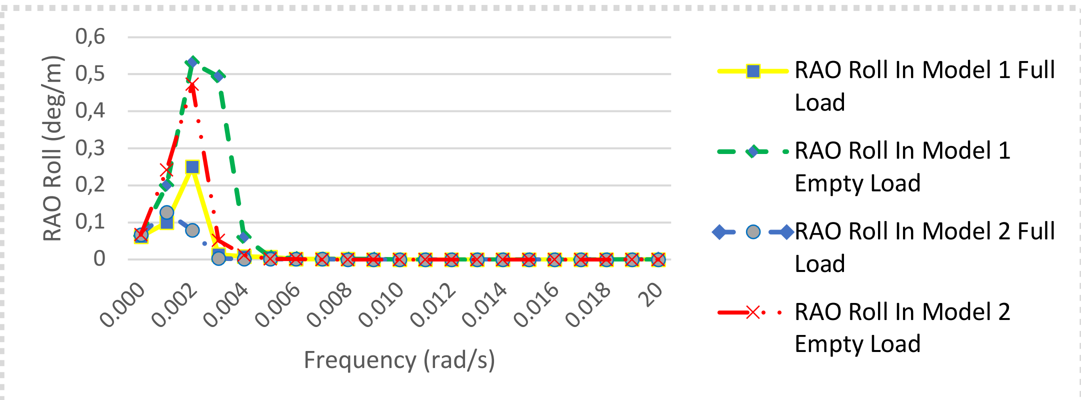

Figure 5. RAO rolling on all models and conditions.

The highest wave peak is the highest movement value of the ship.
Following is a table of comparison of RMS values for model 1 and model 2 vessels

Table 3. RMS value on models 1 and 2.

Model	RMS Roll (deg)
RAO Roll In Model 1 Full Load Without Fin Stabilizer	1.16
RAO Roll In Model 1 Empty Load Without Fin Stabilizer	2.99
RAO Roll In Model 2 Full Load With Fin Stabilizer	0.42
RAO Roll In Model 2 Empty Load With Fin Stabilizer	1.85

From Table 3 shows the best RMS Of Roll value is in model 2 with a value of 0.920.

3.4 Parametric Rolling IMO level 2

Table 4 is the result of calculation of level 2 parametric rolling Unsada Water Tour Bus with Fn 0.3173.

Table 4. Results of parametric rolling level 2.

Level 2 Parametric Rolling			
Model	R_{pro}	C2	Criteria
2	0.06	0.000239	Pass

4.Conclusion

The results of the experiment show that the addition of *Fin Stabilizer* can reduce the rolling period significantly without the *Fin Stabilizer*. From the analysis results obtained RAO Roll value for model 1 is 1.16 deg for full load while for model 2 RAO Roll is obtained 0.42 deg. The results of the stability analysis have fulfilled all the criteria. the standards of Parametric rolling IMO level 2 meet. the results obtained are 0.000239 under the 0.06 standard

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