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Resistance and Intact Stability Calculation of Hull Form Tourism Boat Siak River for Passenger Safety

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***Abstract*—The purpose of this research is to design a tourism support boat in Siak Regency where the ship will be designed in the form of the royal ship of the sultan Syarif Kasim, as comfortable as possible to influence the emotional of the passengers on the ship, so that it can help them to enjoy the atmosphere of the sea and panoramic views of the enchanting natural beauty of the area of the Siak river. To prevent accidents caused by overloading, it is necessary to analyze the maximum load that can be loaded on the Tourism Boat. The calculation of ship stability uses the standards set by the IMO (International Maritime Organization). In calculating the stability, it is analyzed with outrigger and without outrigger. Analysis with outrigger shows the cargo results of 10,15,20 passengers still meet IMO standards code on Intact stability A.749 (18), Ch 3 - design criteria applicable to all ships. The results of the calculation of the stability of the ship show that in the condition the ship is loaded with the number of passenger weights, the smaller the MG value which makes the GZ value smaller so that the enforcer is getting smaller. It can be seen in the table that in criteria 3.1.2.1: Area 0 to 30. The area under the GZ curve is on a load of 10 people is 9,6168 m.deg. on a passenger load of 15 people is worth 8.3706 m.deg. on a passenger load of 20 people the GZ curve is worth 7.42002 m.deg. while for 25 passengers the value of the GZ curve is 6.4286 m.deg. This shows that the condition of the ship being loaded with a higher number of passenger weight results in a smaller MG value which makes the GZ value smaller.**

Keywords—tourism boat, siak river boat, resistance, stability, safety

I. INTRODUCTION

Tourism development in Riau, especially in Siak Regency, is the sixth largest district in Riau Province with the administrative center in Siak Sri Indrapura City. Geographically, Siak Regency has an area of 8,556.09 km2 or 9.74% of the total area of Riau Province and is a Regency that has tourism potential that has not been fully explored. The tourism potential in Siak Regency generally has a Malay nuance. This has led to the government's encouragement to develop Malay culture in Siak Regency to create Siak the Truly Malay. Based on Regional Regulation No.12 of 2012 concerning the Master Plan for Regional Tourism Development in Siak Regency, tourism development aims to increase regional development and encourage community economic development, by taking into account the aspects of religion, education, culture, environment, tranquility and order, as well as comfort in Public.

One of the tourism objects that are the pride of the Siak people and the symbol of the Regency is the Asseraiyah Al-Hasyimiah Palace, which is a heritage palace of the Siak kingdom in the past. In addition to the many historical tourism objects in Siak Regency, this regency also has a very promising marine tourism potential, namely river tourism where the Siak River is an icon of Siak Regency, tourists willbe presented with beautiful views along the Siak River. Someof the facilities that support marine tourism are tour boats, places to eat / restaurants, and places of rest (hotels / inns). One of the innovations that can support marine tourism in thewaters of the Siak River is a tour boat.

From the explanation above this study is focused on designing a tourism support ship in Siak Regency. Where the ship will be designed in the form of the royal ship of the sultan Syarif Kasim, as comfortable as possible to influence the emotional of the passengers on the ship so that it can help him enjoy the atmosphere of the sea and panoramic views of the enchanting natural beauty of the area of the Siak River. With this research, it is hoped that it can help related agencies in designing tourist ships that are more optimal and efficient on these shipping routes so that they can increase the flow of marine tourists in Siak Regency.

II. THEORY

A. Resistance

The calculation of total ship resistance is carried out in order to obtain the engine power required by the ship. Thus the ship can sail at the speed desired by the owner (owner requirements). In determining the ship resistance using the Holtrop method by empirical calculation and then compared with the Maxsurf resistance software. The choice of using this method is because the requirements of the ship meet to use this method for the calculation of ship resistance (6). To use the maxsurf resistance software, it is done in a fairly simple way, namely by opening our ship design file in the maxsurf resistance software, after that select the method that will be used to process the calculation of the resistance and speed of the ship we are designing.

The following is an empirical formula for the Holtrop method (3):

Total Resistance (RT)

$$RT = ½ .ρ. V^2. Stot. (CF (1 + k) + CA) + (Rw / W). W \quad (1)$$

1) Viscous resistance: Viscosity resistance is a resistance component obtained byintegrating the tangential stresses of the entire wet surface of the ship according to the direction of the ship's movement. theequation is:

$$Rv = ½ .ρ .V^2 .CFO. (1 + k1). S \quad (2)$$

Where:
1 + k1 = hull form factor
1 + k1 = 0.93 + 0.4871. C. (B / L) 1,081. (T / L) 0.4611. (L3 / V) 0.3649. (1-Cp) -0.6042
1 + k = 1 + k1 + [1 + k2 - (1 + k1)] Sapp / Stot
1 + k2 = coefficient due to the shape of the protrusion on thehull

2) Wave resistance: Wave resistance is a resistance component related to the energy released due to the influence of the waves when the ship is traveling at a certain speed. The equation is:

$$Rw / W = C1 .C2 .C3 .e (m1Fn \wedge d + m2 \cos (λ Fn \wedge -2)) \quad (3)$$

3) Model ship correlation allowance:
CA = 0.006 (LWL + 100) -0.16 - 0.00205

$$\text{for } Tf / Lwl > 0.04 \quad (4)$$

B. Effective House Power

The calculation of the main propulsion powerrequirements so that the ship can operate in accordance with the plan is as follows:

Effective Horse Power (EHP)

$$EHP = RT \times Vs \quad (5)$$

RT = Total resistance of the ship (N)

VS = Ship service speed (m / s)

Delivery Horse Power (DHP)

$$DHP = EHP / ηD \quad (6)$$

$$ηD = ηH \times ηO \times ηRR \quad (7)$$

ηH = Efficiency of the hull

ηO = The efficiency of the propeller

ηRR = relative rotative efficiency

Break Horse Power (BHP)

$$BHP = DHP + (X\% \times DHP) \quad (8)$$

X = Additional factors (engine room layout correction and shipping area correction)

C. Ship Stability

To find out whether a ship is able to sail with safe conditions or not, it is necessary to analyze the stability of the ship. As a guideline in analyzing, it is necessary to follow the criteria that have been determined by a world organization body concerning the stability of the ship that is International Maritime Organization [1] (figure 1). As explained in IMO 2008- Annex: Explanatory Notes to the International Code on Intact Stability, 2008 IMO code on Intact stability A.749 (18), Ch 3 - design criteria applicable to all ships.

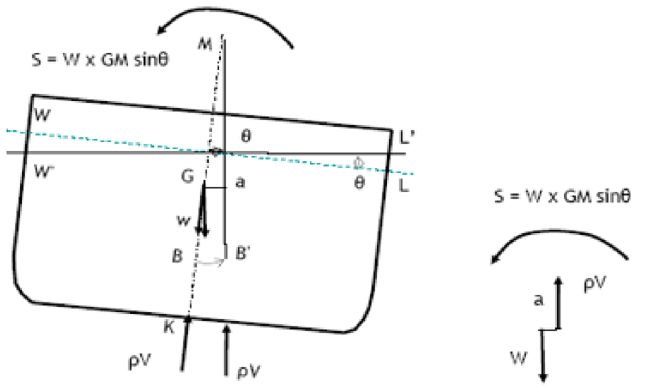

Fig. 1. Total resistance Vs speed.

$$S = W \times a , a = GM \sin θ \quad (8)$$

Then : S = W x GM sinθ, positif stability.

III. Results

Tourism Boat is one of the tourist facilities that provide a different sensation. Tour ships are different from transportation ships which function is to move passengers from one place to another. Tour boats function is more than only visiting to a place. On board, the tour boat exactly, tourists will be provided with services with existing facilities. For example, a place to relax, a place to eat, a place to stay which is all adapted to the atmosphere of the sea, namely, to enjoy the atmosphere of sailing in the middle of the sea or river flow. For some tourists, enjoying a tour on the Siak river tour is something new, tourists will be presented with a historical city view along the Siak river Riau Province.

A. Fishing Vessel Model

In this research, the model of Tourism Boat uses software maxsurf as for the dimension of Tourism Boat Siak River areas follows LOA (figure 2): 17, Meter Breadth: 4 m Height: 1.65 M draft:1 m, Vessel Speed: 9 Knot (table 1).

Fig. 2. Tourism boat siak indrapura river.

TABLE I. CALCULATION RESISTANCE

Item	Value	Unit	Holtrop
LWL	16,701	M	16,701
Beam	3,8	M	3,8
Draft	1	M	1
Displaced volume	24,887	m^3	24,887
Wetted area	62,113	m^2	62,113
Prismatic coeff. (Cp)	0,577		0,577
Waterpl. area coeff	0,734		0,734
1/2 angle of entrance	14,4	deg.	14,4
LCG from midships	-0,653	M	-0,653
Transom area	0	m^2	0
Transom wl beam	0	M	--
Transom draft	0	M	--
Max sectional area	2,581	m^2	--
Bulb transverse ar	0,012	m^2	0,012
Bulb height fr keel	0	M	0
Draft at FP	1	M	1
Deadrise at50% WL	14,5	deg.	--
Hard chine or Round bilge	Round bilge		--

B. Ship Resistance for Fishing Vessel

The result of this research is based on analysis of maxsurf-hull speed software, it showed that the hull form tourism boat Siak.

TABLE II. TOTAL RESISTANCE FOR MODEL

No	Speed (KN)	Froude No (LWL)	Holtrop Resist (KN)	Holtrop Power (KW)
1	0,00	0	0	--
2	0,38	0,015	0,05	0,002
3	0,75	0,03	0,08	0,014
4	1,13	0,045	0,1	0,045
5	1,50	0,06	0,1	0,103
6	1,88	0,075	0,1	0,194
7	2,25	0,09	0,2	0,327
8	2,63	0,106	0,2	0,509
9	3,00	0,121	0,3	0,746
10	3,38	0,136	0,4	1,047
11	3,75	0,151	0,5	1,418
12	4,13	0,166	0,6	1,871
13	4,50	0,181	0,7	2,419
14	4,88	0,196	0,8	3,081
15	5,25	0,211	0,9	3,884
16	5,63	0,226	1,1	4,863
17	6,00	0,241	1,3	6,057
18	6,38	0,256	1,5	7,558
19	6,75	0,271	1,8	9,475
20	7,13	0,286	2,1	11,783
21	7,50	0,301	2,4	14,339
22	7,88	0,317	2,8	17,144
23	8,25	0,332	3,1	20,448
24	8,63	0,347	3,6	24,673
25	9,00	0,362	4,3	30,346
26	9,38	0,377	5,1	38,08
27	9,75	0,392	6,3	48,509
28	10,13	0,407	7,5	60,359
29	10,50	0,422	8,6	71,563
30	10,88	0,437	9,7	83,468
31	11,25	0,452	10,8	96,081
32	11,63	0,467	11,9	109,407
33	12,00	0,482	13	123,453

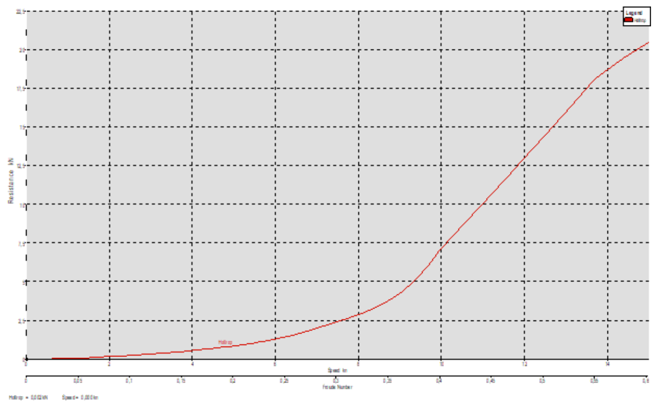

Fig. 3. Total resistance vs speed.

In table II and figure 3, the total resistance of Tourism Boat Siak River for the speed is from 0 knots to 12 knots, the prediction of the resistance value reveals the maxsuft resistance where the sum of the total resistance is 4.3 kN at 9 knots ship speed with power requirements 30,346 KW.

C. Ship Stability

After knowing each high load for each loadcase condition either before the addition of the payload or after the addition of the payload, it can be seen under which conditions the ship is not able to meet IMO criteria. Based on the results of running stability, for each timber ship each vessel almost meets all criteria IMO except ship-1 for criterion 300-400 does not meet IMO criteria. For more details, the output of the IMO requirement results from Maxsurf-hydromax results as shownin table III-VII.

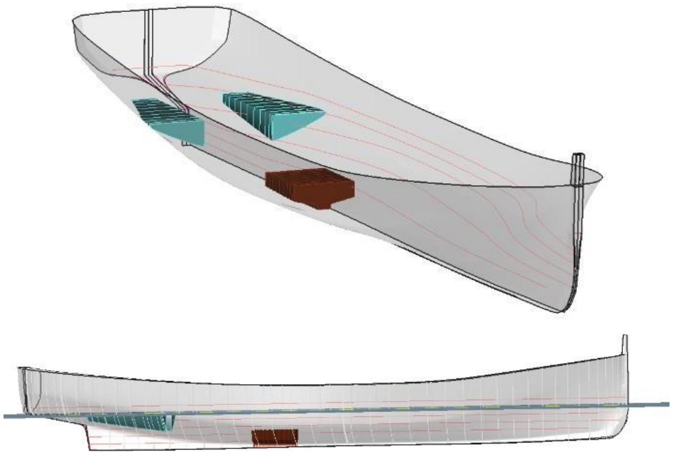

Fig. 4. Model maxsuft stability.

Stability calculations are performed by using Maxsurf Stability (figure 4). Stability calculations are calculated in the condition of the ship with various loading conditions. Some of the conditions taken into account in the analysis are as follows:

- Analyzed with 100% full load cese load with initial passengers or a full load of 10 people with an assumed weight of 75 kg each.
- Analyzed with full load cese load with initial passengers or a full load of 15 people with an assumed weight of 75 kg each.
- Analyzed with 100% full load cese load with initial passengers or a full load of 20 people with an assumed weight of 75kg each.
- Analyzed to see the maximum passenger load that can beloaded when the ship is operated.

The following is a graph of the analysis of the Siak River Tourism Boat using 10 passengers in Full Load conditions (figure 5).

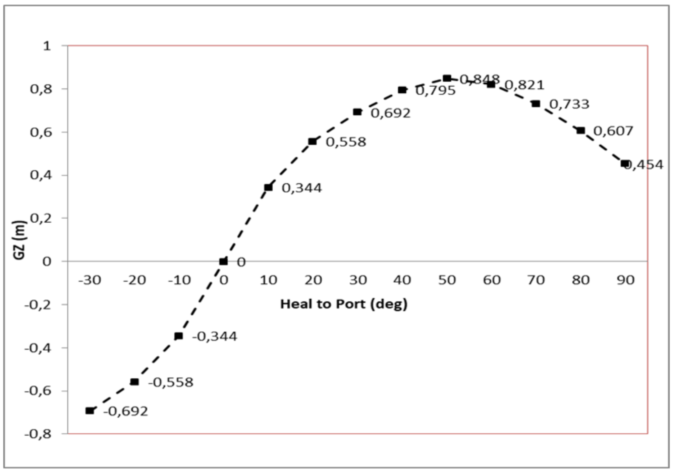

Fig. 5. Curve stability 10 Passenger.

TABLE III. TABLE EVALUATION OF STABILITY FOR 10 PASSENGER

Criteria	Value	Units	Actual	Status
2.3.3.1: Weather criterion				Pass
Angle of steady heel shall not be greater than (<=)	16	Deg	0,9	Pass
Angle of steady heel / deck edge immersion angle shall not be greater than (<=)	80	%	3,86	Pass
Area 1/Area2 shall not be less than (>=)	100	%	245,29	Pass
2.3.3.2: Area 0 to 30 or GZmax	3,1513	m.deg	8,3706	Pass
2.3.3.3: Area 30 to 40	1,7189	m.deg	4,7273	Pass
2.3.3.4: Max GZ at 30 or greater	0,2	m	0,476	Pass
2.3.3.5: Angle of Maximum GZ	15	deg	35,5	Pass
2.3.3.6: Initil GMt	0,15	m	1,276	Pass

The following is a graph of the analysis of the Siak River Tourism Boat using 15 passengers in Full Load conditions (figure 6).

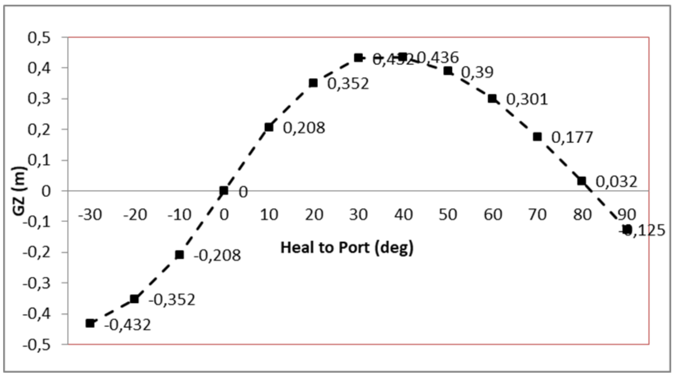

Fig. 6. Curve stability 15 Passengger.

TABLE IV. TABLE EVALUATION OF STABILITY FOR 15 PASSENGER

Criteria	Value	Units	Actual	Status
2.3.3.1: Weather criterion				Pass
Angle of steady heel shall not be greater than (<=)	16	deg	0,9	Pass
Angle of steady heel / Deck edge immersion angle shall not be greater than (<=)	80	%	3,86	Pass
Area1 / Area2 shall not be less than (>=)	100	%	245,29	Pass
2.3.3.2: Area 0 to 30 or GZmax	3,1513	m.deg	8,3706	Pass
2.3.3.3: Area 30 to 40	1,7189	m.deg	4,7273	Pass
2.3.3.4: Max GZ at 30 or greater	0,2	m	0,476	Pass
2.3.3.5: Angle of maximum GZ	15	deg	35,5	Pass
2.3.3.6: Initial GMt	0,15	m	1,276	Pass

The following is a graph of the analysis of the Siak River Tourism Boat using 20 passengers in Full Load conditions (figure 7).

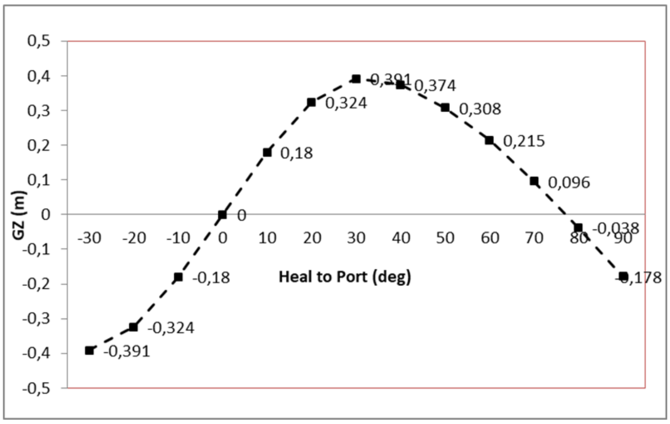

Fig. 7. Curve stability 20 passengger.

TABLE V. TABLE EVALUATION OF STABILITY FOR 20 PASSENGER

Criteria	Value	Units	Actual	Status
2.3.3.1: Weather criterion				Pass
Angle of steady heel shall not be greater than (<=)	16	Deg	0,8	Pass
Angle of steady heel / deck edge immersion angle shall not be greater than (<=)	80	%	3,8	Pass
Area 1/Area2 shall not be less than (>=)	100	%	246,67	Pass
2.3.3.2: Area 0 to 30 or GZmax	3,1513	m.deg	7,4002	Pass
2.3.3.3: Area 30 to 40	1,7189	m.deg	4,0631	Pass
2.3.3.4: Max GZ at 30 or greater	0,2	m	0,411	Pass
2.3.3.5: Angle of Maximum GZ	15	deg	32,7	Pass
2.3.3.6: Initil GMt	0,15	m	1,076	Pass

The following is a graph of the analysis of the Siak River Tourism Boat using 25 passengers in Full Load conditions (figure 8).

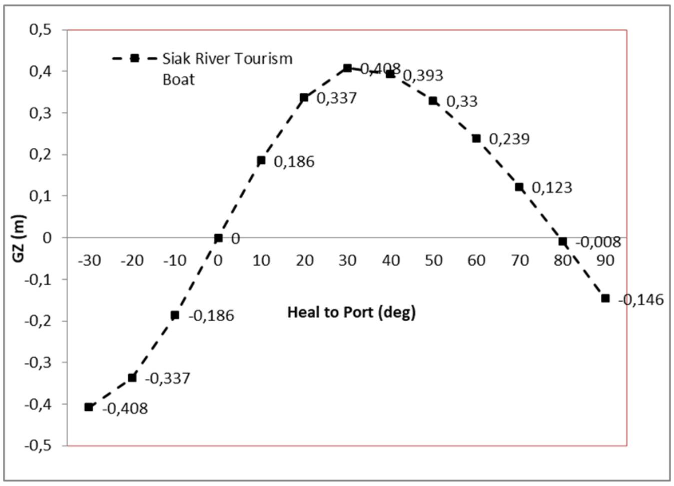

Fig. 8. Curve stability 25 passengger.

TABLE VI. TABLE EVALUATION OF STABILITY FOR 25 PASSENGER

Criteria	Value	Units	Actual	Status
2.3.3.1: Weather criterion				Pass
Angle of steady heel shall not be greater than (<=)	16	Deg	0,8	Pass
Angle of steady heel / deck edge immersion angle shall not be greater than (<=)	80	%	3,68	Pass
Area 1/Area2 shall not be less than (>=)	100	%	248,37	Pass
2.3.3.2: Area 0 to 30 or GZmax	3,1513	m.deg	6,4002	Pass
2.3.3.3: Area 30 to 40	1,7189	m.deg	4,0631	Pass
2.3.3.4: Max GZ at 30 or greater	0,2	m	0,191	Fail
2.3.3.5: Angle of Maximum GZ	15	deg	32,7	Pass
2.3.3.6: Initil GMt	0,15	m	0.906	Pass

The following is a summary table 6 of the stability value of loading conditions with a load of 10 passengers, 15 passengers, 20 passengers and 25 passengers with a load of 75 kg each passenger.

TABLE VII. TABLE RECAPITULATION OF STABILITY FOR 10,15,20 AND 25 PASSENGER

Criteria	Value	Units	10	15	20	25
2.3.3.1: Weather criterion						
Angle of steady heel shall not be greater than (<=)	16	Deg	1,1	0,9	0,8	0,7
Angle of steady heel / deck edge immersion angle shall not be greater than (<=)	80	%	4,04	3,86	3,8	3,68
Area 1/Area2 shall not be less than (>=)	100	%	240,92	245,29	246,67	248,37
2.3.3.2: Area 0 to 30 or GZmax	3,1513	m.deg	9,6168	8,3706	7,4002	6,4268
2.3.3.3: Area 30 to 40	1,7189	m.deg	5,5482	4,7273	4,0631	4,0631
2.3.3.4: Max GZ at 30 or greater	0,2	m	0,57	0,476	0,191	0,191
2.3.3.5: Angle of Maximum GZ	15	deg	41,8	35,5	32,7	32,7
2.3.3.6: Initil GMt	0,15	m	1,566	1,276	1,076	0,906
Status			Pass	Pass	Pass	Fail

Results of table 7 shows a recapitulation of the stability value of loading conditions with a load of 10 people, 15 people, 20 people and 25 people with a load of 75 kg each passenger. The results of the analysis listed on the ship show failures in the load of 25 passengers, namely in the criteria IMO 3.1.2.2: Max GZ at 30 or greater (GZ arm length of area 30 or more) which shows 0.191 m results. This value does not meet the criteria, namely that it cannot be less than or equal to 0.2 m.

The addition of weight and passengers on the ship has an effect on the point of gravity (point G). Afriantoni et al., [2] it is said that point G is the catch point of all the forces pressing down on the ship. The location of point G is known by observing the distribution of weight on the ship, the more weight is placed at the top, the higher the location of point G. Thus the load, the point will be higher which results in a smaller GM value. Because GZ is a function of GM, GM can be used as a measure of initial stability. If the GM of a ship has a large value, the value of GZ will be large so that the enforcer will also be large, and the GM value of a small ship will be small, so that the time of the enforcer will be small [1]. The results of the calculation of the stability of the ship show that in the condition the ship is loaded with the number of passenger weights, the smaller the MG value which makes the GZ value smaller so that the enforcer is getting smaller. It can be seen in the table that in criteria 3.1.2.1: Area 0 to 30. The area under the GZ curve on a load of 10 people is 9,6168 m.deg. on a passenger load of 15 people is worth 8.3706 m.deg. on a passenger load of 20 people the GZ curve is worth 7.42002 m.deg. while for 25 passengers the value of the GZ curve is 6.4286 m.deg. This shows that the condition of the ship being loaded with a higher number of passenger weight results in a smaller MG value which makes the GZ value smaller.

IV. Conclusion

The main purpose of this research is to determine the condition of the ship's stability when loading passengers exceed the load capacity, and to determine the maximum number of passengers allowed for the Siak River Tourism Boat when loading passengers exceed the load capacity. From the results of the research that has been done, it is concluded that:

- The results of the calculation of resistance for the Siak River Tourism Boat at a speed of 9 knots of 4.3 kN, with a power requirement of 30.346 KW.
- The results of the calculation of the Stability of the Siak River Tourism Boat show that the ship has good stability and meets the standard requirements of the IMO code on Intact stability A.749 (18), Ch. 3 - design criteria applicable to all ships for a maximum passenger load of 20 people with weight passenger 75 kg

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