International Journal of Marine Engineering Innovation and Research, Vol. 8(2), Jun. 2023. 376-390
(pISSN: 2541-5972, eISSN: 2548-1479)

Hydrostatics Curve Approach as a Design Development of Fishing Canoe With Bilge Keel to Improve Rolling Period

Bima Ramadhani[1], Yeddid Yonatan Eka. Darma.[2]*, I.G.N.A Satria Prasetya[3], Mohammad Danil Arifin[4]

(Received: 10 April 2023 / Revised: 10 May 2023 /Accepted: 10 May 2023)

***Abstract*— Canoes are currently starting to be in demand among the public, some of the activities that can be carried out using canoes include fishing, traveling or water sports. Canoes are still in great demand compared to other types of boats, because canoes are very stable in calm water. Its stability is the reason why this type of boat is usually chosen as the type of boat for beginners and family outings. Unfortunately the canoe is less stable in challenging waters. When the weather or waters are calm the canoe is reliable, however when it turns bad with very choppy water and high winds a skilled oarsman is needed to keep the boat afloat. The downside with canoes is having good primary stability but usually poor secondary stability. This means the boat is only stable in still water. If the wind blows hard and creates very choppy water, then the canoe or canoe will lose stability and rolling motion which can cause accidents for its users. Therefore I will try to use a flat bottom canoe design by adding a bilge keel to the hull of the canoe in hopes of adding stability. I tried to compare the stability and roll period of a regular canoe with one that used 1 pair of bilge keels, 6.25 cm wide, 0.8 cm thick and 30 degrees angled. Variations in the length of the bilge keel used include 0.875, 1.05 and 1.225 m. Mounted in the middle of the ship, not too forward or backwards.**

Keywords—Canoe, Bilge Keel, Stability, Rolling Period.

I. INTRODUCTION

Canoes are currently starting to be in demand among the public, some of the activities that can be carried out using canoes include fishing, traveling or water sports. Canoes are still in great demand compared to other types of boats, because canoes are very stable in calm water. Its stability is the reason why this type of boat is usually chosen as the type of boat for beginners and family outings. Unfortunately the canoe is less stable in challenging waters. When the weather or waters are calm the canoe is reliable, however when it turns bad with very choppy water and high winds a skilled oarsman is needed to keep the boat afloat.

The downside with canoes is having good primary stability but usually poor secondary stability. This means the boat is only stable in still water. If the wind blows hard and creates very choppy water, then the canoe or canoe will lose stability and rolling motion which can cause accidents for its users. Stability is also negatively affected in canoes as loads increase.

However, since most beginners and tourists will prefer the calm inland waters, the canoe is by far their best choice of all the small boat designs. For calm rivers, lakes and other calm waters, a canoe is best.

This is why most canoes will only be used on shallow, calm inland lakes and rivers. Because of this stability problem, in order to increase stability and reduce the tossing period during wavy water, I will try to add variations to the bilge keel using canoes from previous research. The main dimensions of this canoe boat are: LOA = 3.5 meters, width = 0.625 meters, draft = 0.2 meters, and height = 0.3 meters and with a flat bottom, and assuming the average passenger weight is 50 kg/person.

A. Canoe

Canoe is a small and narrow boat that is usually propelled by human power. However, there are also those who use the screen. The shape of the canoe is generally sharp at both ends and open at the top. However, this section can be covered. Canoe uses human power, driven by paddles. The number of paddlers depends on the size of the canoe itself (usually two). The paddlers sit facing the direction of the trip. They sit on the support in the body of the boat or kneel directly on the body of the boat.

Bima Ramadhani is with Department of Ship Manufacture Engineering, Politeknik Negeri Banyuwangi, Banyuwangi, 68461, Indonesia. E-mail: bimaramadhani979@gmail.com
Yeddid Yonatan E. D. is with Department of Ship Manufacture Engineering, Politeknik Negeri Banyuwangi, Banyuwangi, 68461, Indonesia. E-mail: yeddidyonatan@poliwangi.ac.id
I.G.N.A. Satria Prasetya is with Department of Ship Manufacture Engineering, Politeknik Negeri Banyuwangi, Banyuwangi, 68461, Indonesia. E-mail: satris88@gmail.com
Mohammad Danil Arifin is with Department of Marine Engineering, Universitas Darma Persada, Jakarta, 13450, Indonesia. E-mail: mohammad danil arifin@ftk.unsada.ac.id

B. Bilge Keel

A bilge keel is a plate/fin on the side of a ship's hull which is usually in the form of a flat bar, V shape and a bulb shape, the material used by the bilge keel must be the same as that used with the ship's hull, the function of the bilge keel is to prevent rolling movement ships that are too extreme at sea and to resist ship rolling to increase ship stability.

C. Hydrostatic

The function of the hydrostatic arch is to determine the properties of the hull submerged in water (the properties of the ship's karene). The most common way to describe hydrostatic arcs is to construct two axes that are perpendicular. The horizontal axis is the ship's baseline, while the vertical axis shows the ship's draft and is used as the starting point for measuring hydrostatic curves.

D. Ship Resistance

Based on the book Principle Of Naval Architecture, a ship's resistance at a certain speed is the amount of force needed to pull the ship in a fluid with the assumption that there is no interference during the pulling process. Meanwhile, the power required to pull it is called Effective power. When pulling the ship, you will feel a force that opposes the pull, this force is called the drag force. The resistance is equal to the component of the fluid force acting parallel to the ship's axis of motion. To get the value and validation of the total resistance (RT) of the boat, we can get it through software analysis (in this design using resistance software) and using the empirical data calculation method (empirical method).

$$RT = CT\ (\tfrac{1}{2}\ \rho\ V2\ S) \qquad (1)$$

E. RAO Analysis With Software

Response Amplitude Operator (RAO) or also known as Transfer Function is a structure response function due to wave loads hitting floating objects at a certain frequency. RAO is referred to as Transfer Function because RAO is a tool for transferring external loads (waves) in the form of responses to a structure.

F. Period of Time

One period of complete roll is the period of time required from when the ship is upright, tilted to the left, then straightened again, continues to tilt to the right, until the ship is upright again.

$$T = (2\ C\ B)/\sqrt{GM} \qquad (2)$$

Where:

T = Roll Period
C = 0.373 + 0.023 (B/D) - 0.043 (L/100)
B = Canoe Width (m)
GM = Metacenter Height (m) obtained from the canoe model

II. METHOD

The method used is to find Kano's primary data from previous journals, add variations in the length of the bilge keel using journals about the bilge keel in previous studies. then correct the main dimensions by comparing the hydrostatic and resistance calculations. Choose hydrostatic based on the characteristic shape of the canoe, where the bow and stern are symmetrical (equal) and choose the smallest resistance, because the driving force is human, where it is assumed that the canoe passengers row at a speed of 2 knots, the canoe with the smallest resistance will have a fast rolling period. therefore, a bilge keel keel will be added to improve the rolling period.

A. Canoe Primary Data

The first step is to find the primary data to be used, while the primary data used is as follows and can be seen in Figure 1 below.

1. Length (LOA) = 3.5 m
2. Width (B) = 0.625 m
3. Height based on the diameter (H) = 0.3 m
4. The vertical distance from the bottom line of the canoe

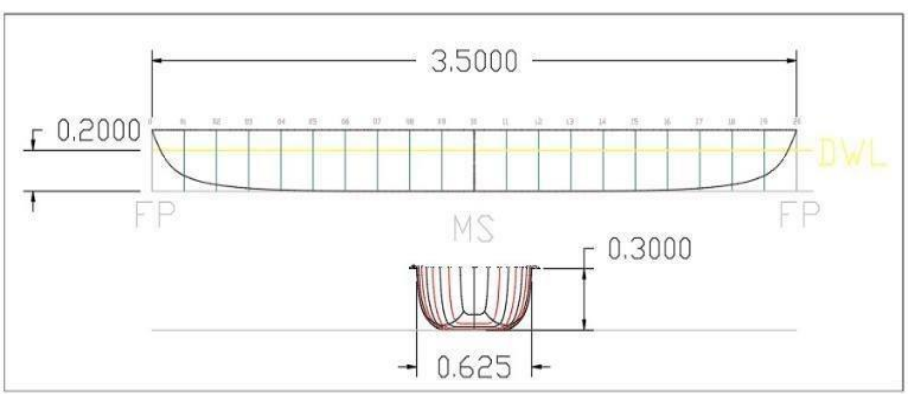


Figure. 1. Primary Data Line Plan [Yeddid Yonatan et al, 2022]

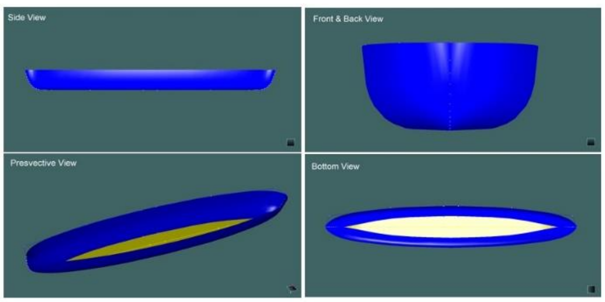
to the waterline (T) = 0.2 m

B. Canoe Major Size Correction

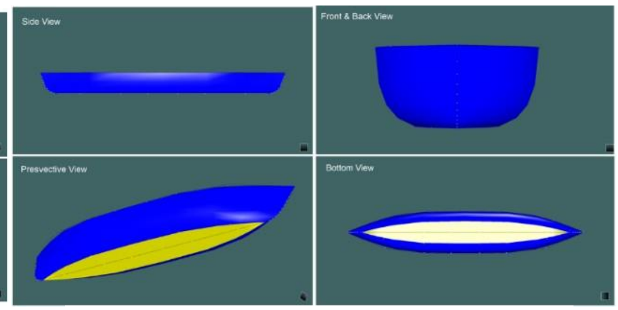
The second step is making a canoe model, then correct the main dimensions by comparing the hydrostatic and resistance calculations. There are 6 models that will be used to find the best size. The model is made with the maxsurf design application, which can be seen in the Figure 2.

seen that canoe models 4, 5 and 6 have graphic lines that match the characteristics of the canoe. which can be compared with canoe models 1, 2 and 3 which have LCF and LCB which are not straight, because the canoe is symmetrical (the bow and stern are the same), so the LCF and LCB must have straight graphics according to their characteristics.

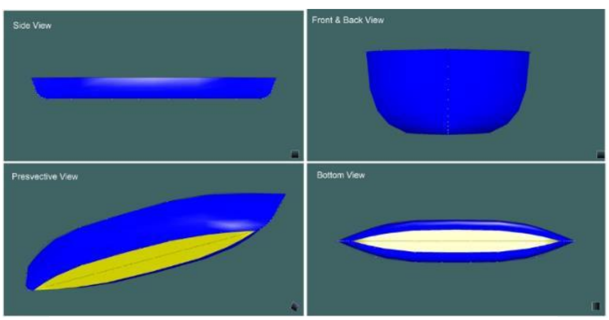
Meanwhile, from the analysis of all the resistance of the canoe model in Figure 3.20, the graph above, it can be seen that the model 4 canoe has the smallest resistance of each canoe model. This small resistance is taken because the driving force is human, where it is assumed that the canoe passengers row at a speed of 2 knots, the canoe with the smallest resistance will have a fast swaying period. Therefore, the model 4 canoe with the smallest resistance will be added to the bilge keel to improve the rolling.



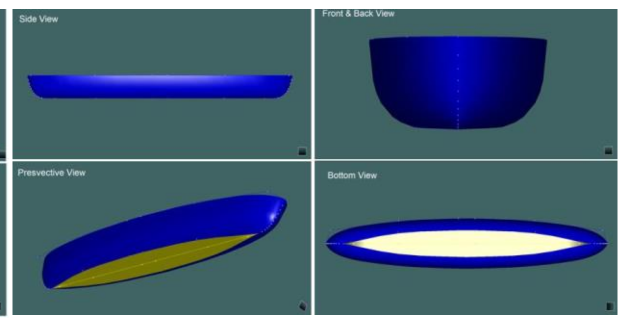
(a) Canoe Model 1



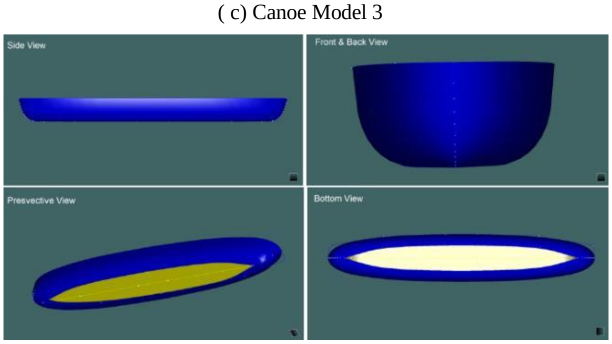
(b) Canoe Model 2



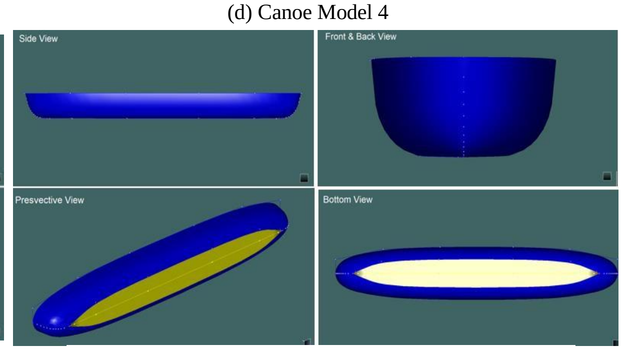
(c) Canoe Model 3



(d) Canoe Model 4



(e) Canoe Model 5



(f) Canoe Model 6

Figure 2 Canoe Model 1 – 6

C. Hydrostatic Analysis

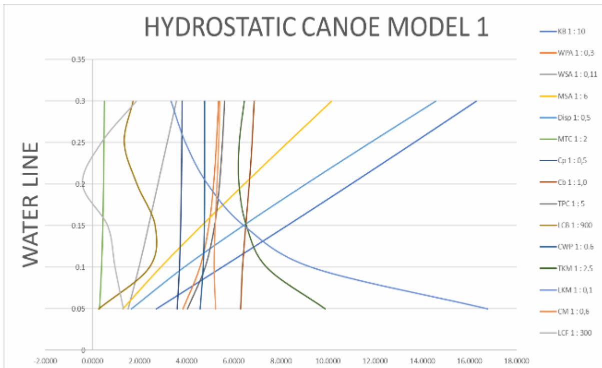
After the correction of the main size of the canoe is complete, the next step is hydrostatic analysis, which can be seen in the Figure 3.

D. Resistance Analysis

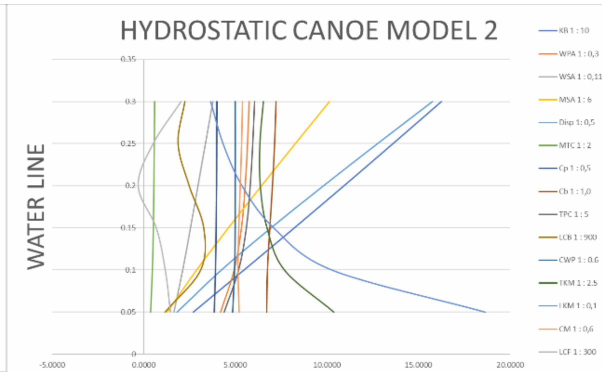
After the hydrostatic analysis is complete, the next step is the resistance analysis using the Holtrop method, which can be seen in the Figure. 4. From the hydrostatic and resistance analysis of each canoe model, it can be

$$RT = CT \times 0,5 \times p \times Vs2 \times S$$

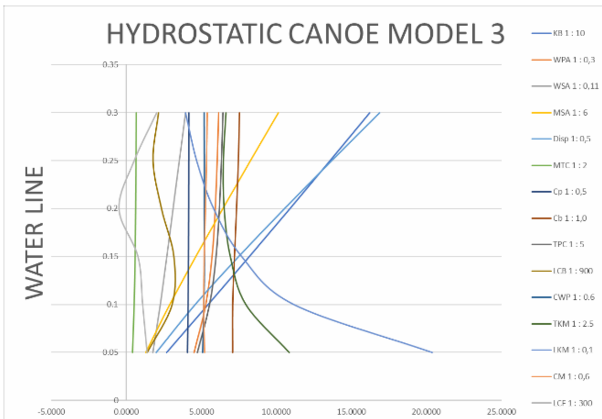
$$RT = 0.043580893 \times 0.5 \times 1.025 \times (1.028888^2) \times$$



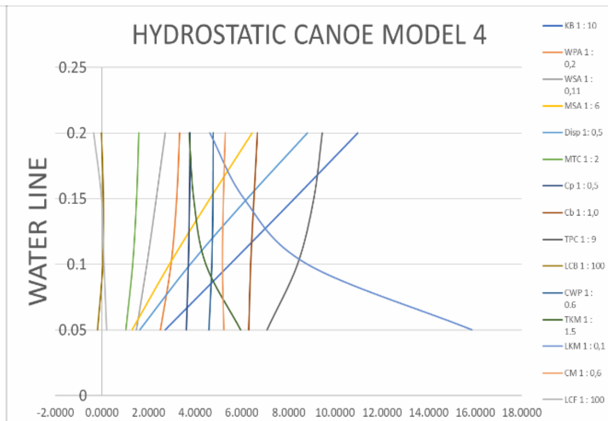
(a) Hydrostatic Canoe Model 1



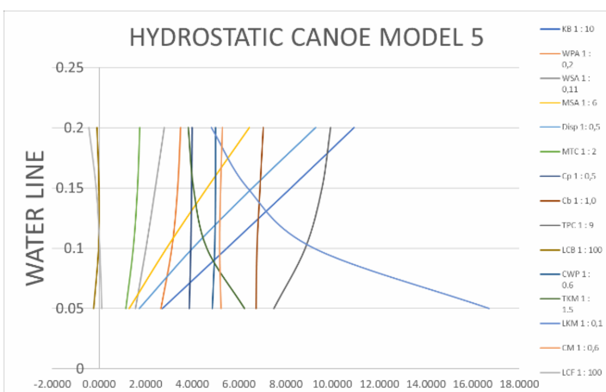
(b) Hydrostatic Canoe Model 2



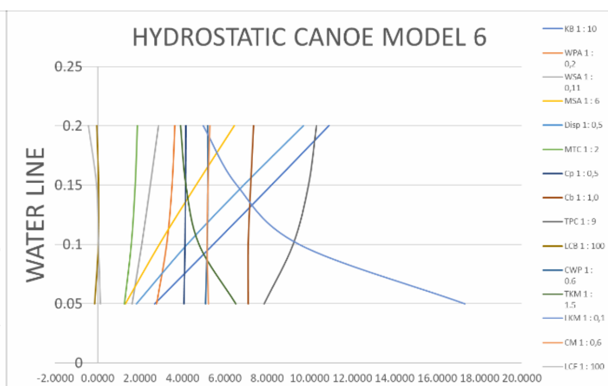
(c) Hydrostatic Canoe Model 3



(d) Hydrostatic Canoe Model 4



(e) Hydrostatic Canoe Model 5



(f) Hydrostatic Canoe Model 6

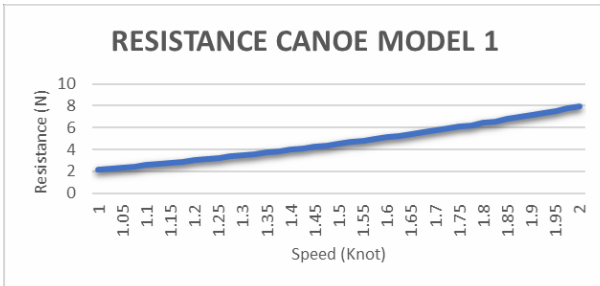
Figure 3 Hydrostatic Analysis Canoe Model 1-6

2.584932
= 0.008067691

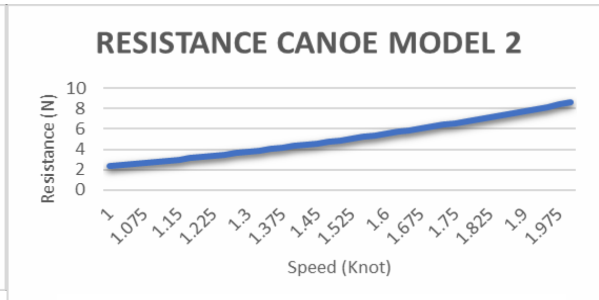
Empirical calculation 0.008067691 and numerical calculation 0.00782 (3.07% of 5% tolerance). Then the canoe model 4 was chosen because it has hydrostatic which is in accordance with the characteristics of the canoe and has the smallest resistance.

E. Determination of the Canoe Model to be Installed with the Bilge Keel

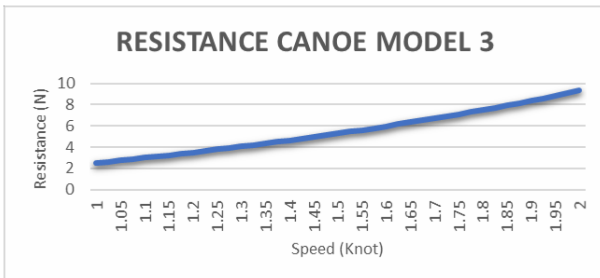
Canoe model 4 was chosen because it has hydrostatic which is in accordance with the characteristics of the canoe and has the smallest resistance.



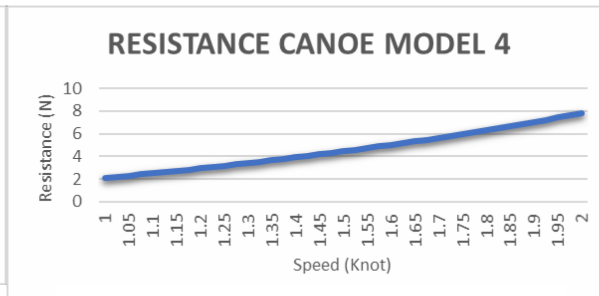
(a) Resistance Canoe Model 1



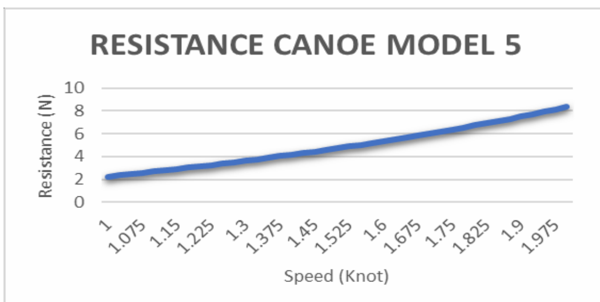
(b) Resistance Canoe Model 2



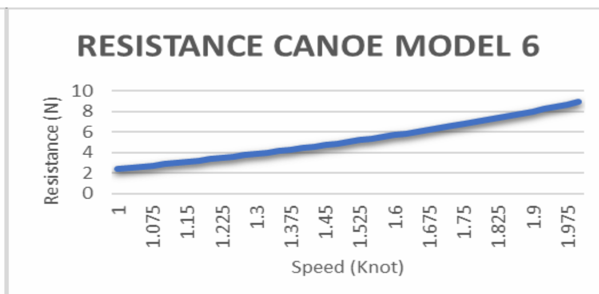
(c) Resistance Canoe Model 3



(d) Resistance Canoe Model 4



(e) Resistance Canoe Model 5



(f) Resistance Canoe Model 6

Figure 4 Resistance Analysis Canoe Model 1-6

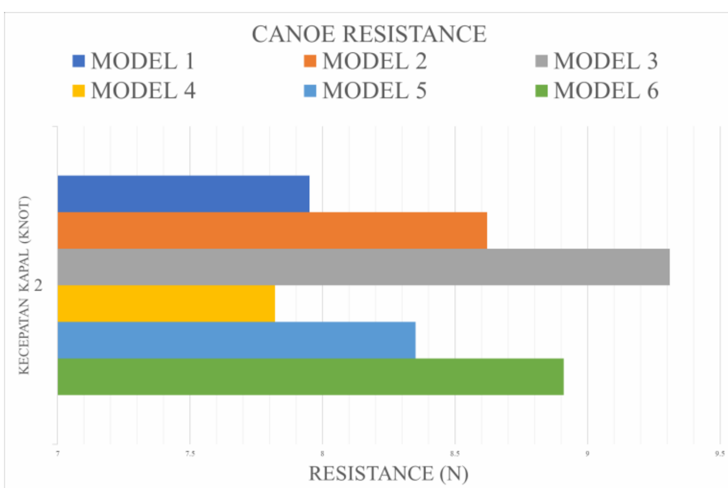


Figure. 5. Graphical Analysis of All the Resistance of the Canoe Model

TABLE 1.
CANOE MODEL 4

Model 4		
LOA	3,5	m
B	0,625	m
H	0,3	m
T	0,2	m
VS	1 s/d 2	Knot

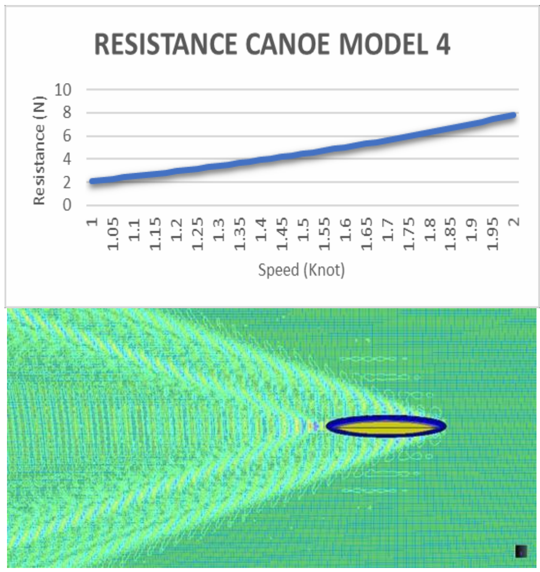


Figure. 6. Resistance Analysis Canoe Model 4

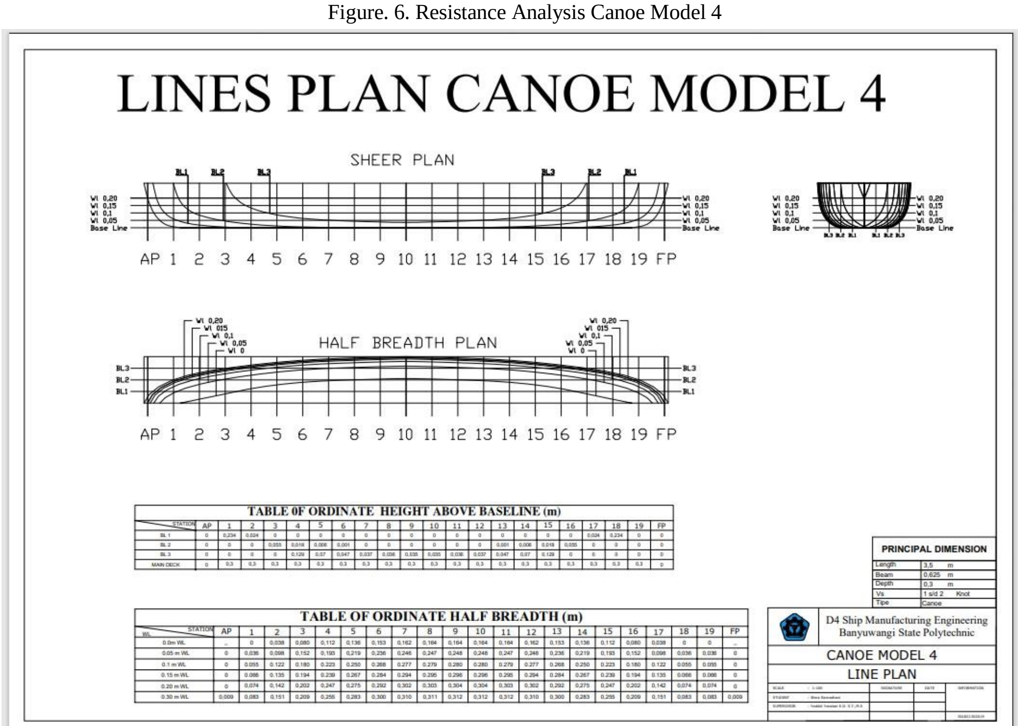


Figure. 7. Lines Plan Canoe Model 4

International Journal of Marine Engineering Innovation and Research, Vol. 8(2), Jun. 2023. 376-390
(pISSN: 2541-5972, eISSN: 2548-1479)

F. General Plan of Canoe Model 4

TABLE 2.
DATA CANOE MODEL4

Type	**Mono Hull**	
Boat Type	Canoe	
LOA	3.5	m
LWL	3.451	m
B	0.625	m
H	0.3	m
T	0.2	m
Vs	2	knot
Cb	0.666	
Cm	0.87	
Cp	0.625	
Displacement	1.76	ton
Route	Bangsring Waters Area	
Sailing Radius	0.5	mile
Sailing Radius (Full)	1	mile
Sailing Length	0.010416667	day
Sailing Length	0.25	o'clock
	15	minute

TABLE 3.
PASSENGER ORDER

Passenger Order			
No	Information	Amount	Heavy
1	Passenger 1	1	50 kg
2	Passenger 2	1	50 kg
Total		2	

TABLE 4.
MODEL 4 CANOE WEIGHT

Wr	(0,5 -1,5)% . Disp 0.0264	ton

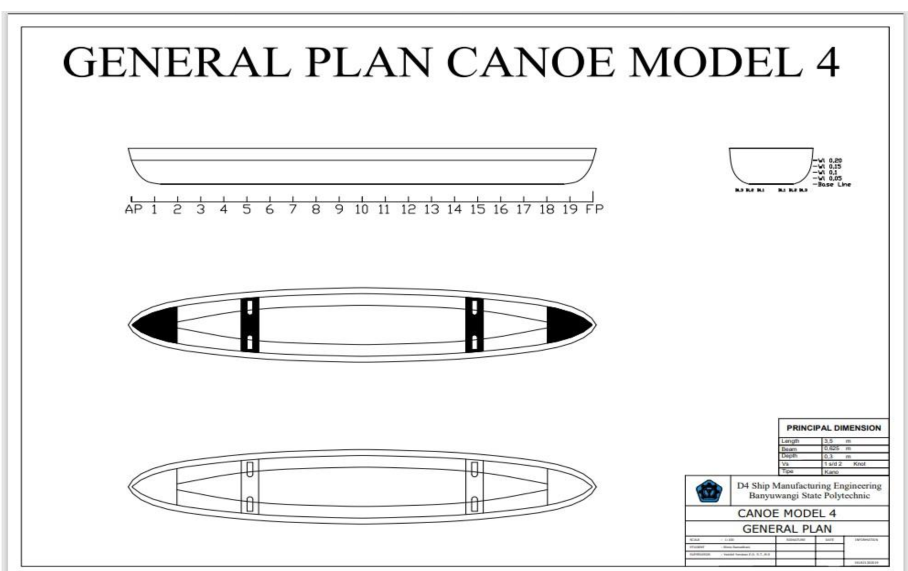


Figure. 8. Canoe General Plan CAD Model 4

G. Canoe Model 4 Curve Sectional Area

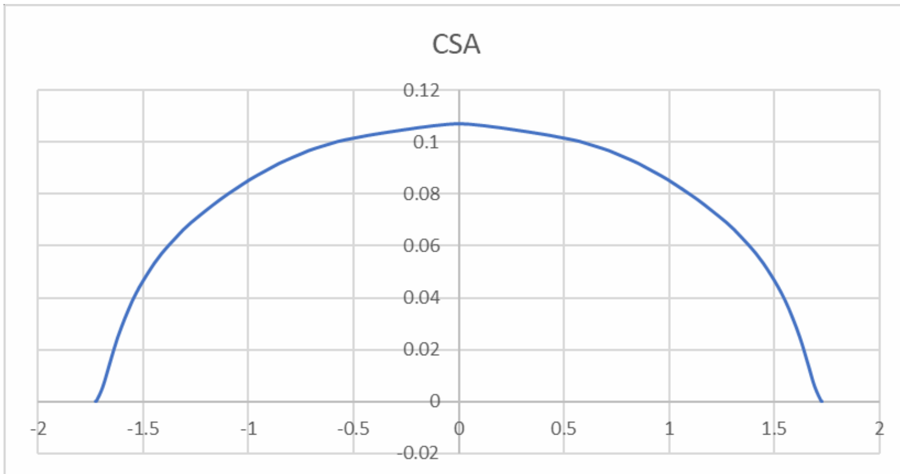


Figure. 9. Graphical CSA Canoe Model 4

H. Dimensions of the Bilge Keel Canoe

Determination of the dimensions of the bilge keel kano with reference to the journals, while the determination is as follows:

1. Bilge Keel Length Determination

Based on the information in the journal Analysis of the Effect of the Number of Bilge Keels on Rolling Movement on Patrol Boat 14, it is known that the variation is between 25% - 50%, then the value is determined as follows and can be seen in Figure 10.

1. Variation 1 (25 % LOA), 25% x 3.5 = 0.875 m
2. Variation 2 (30 % LOA), 30% x 3.5 = 1.05 m
3. Variation 3 (35 % LOA), 35% x 3.5 = 1.225 m

2. Determination of Bilge Keel Width and Thickness

Based on information from the journal Analysis of the Effect of the Number of Bilge Keels on Rolling Movement on Patrol Boat 14, it is known that the width of the bilge keel is 10% of the width of the canoe, as can be seen in Figure 11. The thickness used is 0.8 cm. B/L (keel) from reference 0.3/3.2 (9.38%), then the thickness value of the bilge keel is determined as follows: (B x 10%) = 0.625 x 10%, 0.0625 (62.5 cm)

3. Determination of the Bilge Keel Angle

Based on the information in the journal Stability of Canoes Made from Used Paint Buckets with Bilge Keels at Angles of 30 and 45 Degrees, in this journal there are 2 variations of the Bilge Keel angle and an angle of 30 degrees has the best stability. Therefore, this study will take an angle of 30 degrees.

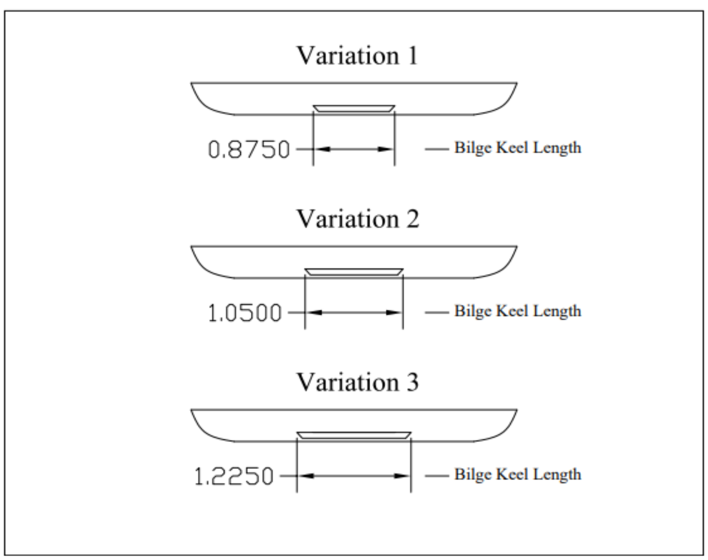


Figure. 10. Bilge Keel Length Variations

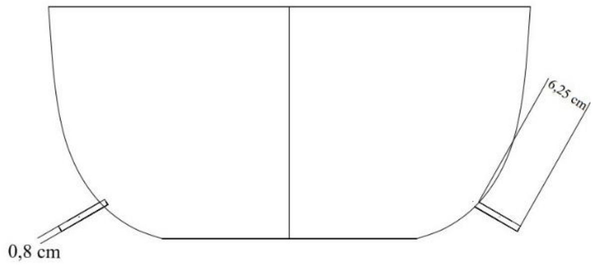


Figure. 11. Bilge Keel Width and Thickness

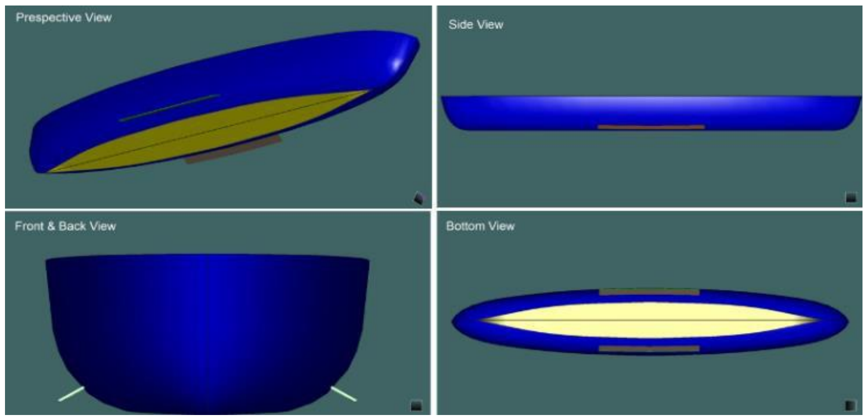


Figure. 12. Variation 1 Bilge Keel Length 0.875 m

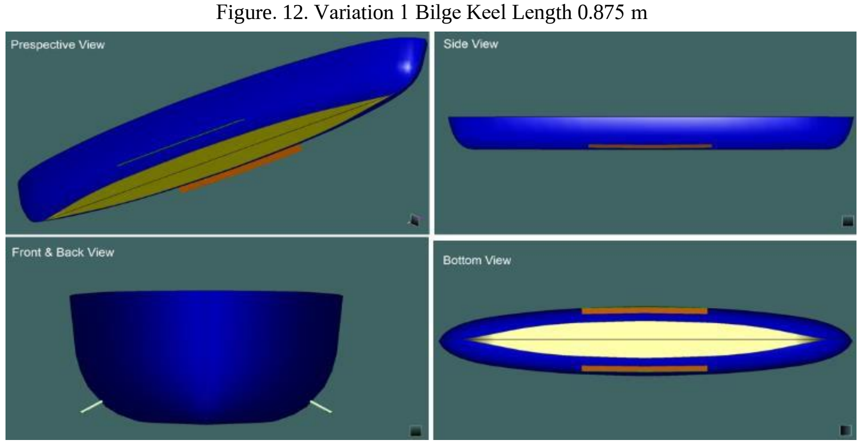


Figure. 13. Variation 2 Bilge Keel Length 1.05 m

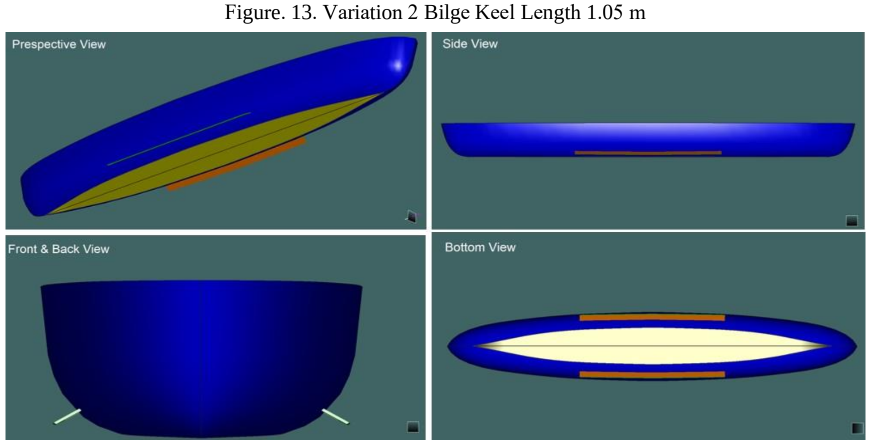


Figure. 14. Variation 3 Bilge Keel Length 1.225 m

4. Final Results for Each Bilge Keel Variation

The following are the results of several variations of the bilge keel.

III. Results and Discussion

A. RAO Maxsurf Roll Analysis Results for Each Bilge Keel Length Variation

belongs to a bilge keel length of 1.05 m with a value of 6.359461 rad/m. It can be seen in the graph above that the rolling RAO value in the direction of the wave arrival is 315°, the canoe without a bilge keel has the largest value, namely 4.710533 rad/m, while the smallest value is owned by a bilge keel with a length of 1.225 m with a value of 4.613671 rad/m.

TABLE 5.
RAO VALUE of ROLLING CANOE at 180° WAVE DIRECTION

RAO Value of Rolling Canoe at 180° Wave Direction	
No Keels (rad/m)	0
Keel 0,875 m (rad/m)	0
Keel 1,05 m (rad/m)	0
Keel 1,225 m (rad/m)	0

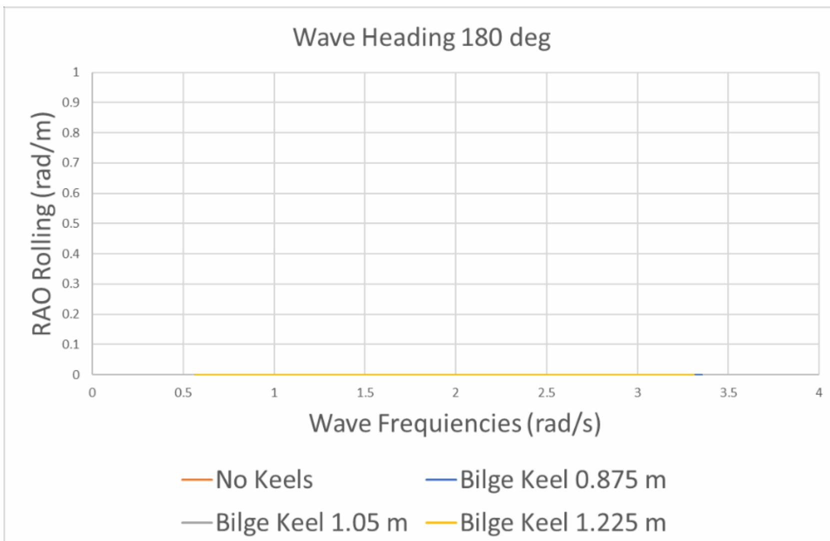


Figure. 15. 180° Wave Direction Analysis Graphic

Analyze each bilge keel length variation. The results of the analysis for each bilge keel model are in the form. Of data tables and graphs. The following are the results of Roll RAO analysis of canoes without bilge keel and each model of variation in bilge keel length. The results of RAO roll analysis can be seen in Tables 5, 6, 7, 8 and Figures 11, 12, 13, and 14. In the 180° wave direction, all model variations have an RAO value of 0 rad/m because the rolling motion itself is a rotational motion on the x-axis, so for wave impacts from the front or 180° it does not affect the canoe's rolling motion. It can be seen in the graph above that the RAO rolling value in the direction of the wave arrival is 225°, the canoe with a bilge keel length of 0.875 m has the largest value of 4.680962 rad/m while the smallest value belongs to a bilge keel length of 1.05 m with a value of 4.496818 rad/m. It can be seen in the graph above that the RAO rolling value in the direction of the wave arrival is 270°, the canoe with a bilge keel length of 0.875 m has the largest value of 6.61988 rad/m while the smallest value

From the results of all RAO roll analysis for each bilge keel model in Tables 9, 10 and Figure 19 above, it can be concluded that a bilge keel with a length of 1.05 m has the lowest average roll value of several variations in bilge keel length, the comparison between the bilge keel and length of 1.05 m to a canoe without a bilge keel has a percentage value of RAO rolling reduction of 33%. Where the addition of a bilge keel with a length of 1.05 m can improve the swaying period 33% better. RAO is a transfer function used to determine the effect of sea conditions on ship movements. If the RAO value is low, so is the maneuverability, and vice versa if the RAO analysis value is high, the ship's maneuverability is also high.

B. Roll Period Calculation

After the Maxsurf Roll RAO analysis, then calculate the roll period for each bilge keel length variation. The calculation of the roll period is used to determine how

TABLE 6.
RAO VALUE of ROLLING CANOE at 225° WAVE DIRECTION

RAO Value of Rolling Canoe at 225° Wave Direction	
No Keels (rad/m)	4.603833
Keel 0,875 m (rad/m)	4.680962
Keel 1,05 m (rad/m)	4.496818
Keel 1,225 m (rad/m)	4.525405

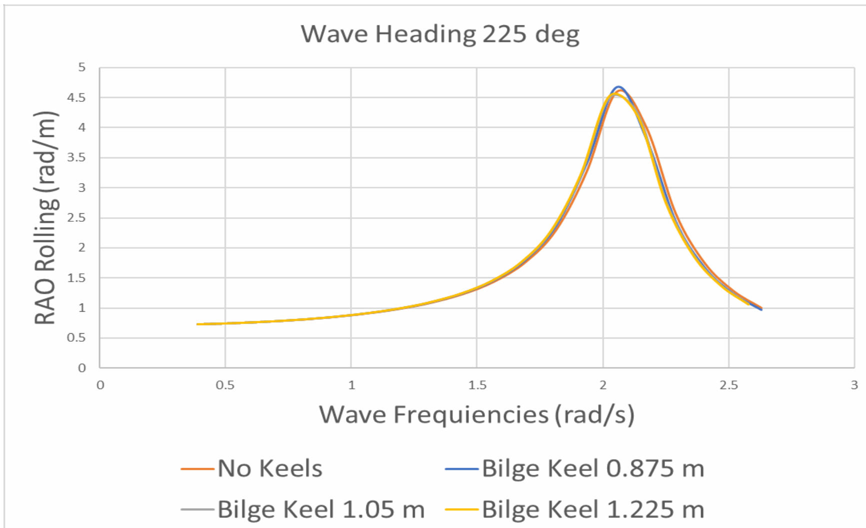


Figure. 16. 225° Wave Direction Analysis Graphic

long it takes for the canoe to return to its previous position after experiencing a rolling motion. This calculation is based on Code On Intact Stability Resolution A749 (18) by the International Maritime Organization (IMO).The calculate on results can be seen below.

$$T = (2\,C\,B)/\sqrt{GM} \quad (2)$$

Where:

T = Roll Period
C = 0.373 + 0.023 (B/D) - 0.043 (L/100)
C = 0.373 + 0.023 (0.625/0.3) - 0.043(3.451/100) C = 0.419432737
B = Canoe Width (m)
GM = Metacenter Height (m) obtained from the canoe model

After calculating the completion, it can be seen in Table Table above that the addition of a bilge keel to a canoe can improve the rocking period by 1.03%. It is known that the longer the rolling period(s), the better the rolling. It can be concluded that the canoe with the addition of a 1.05 m bilge keel has a lower rolling RAO value and has a longer rolling period compared to the canoe without the bilge keel. Therefore the canoe model with a bilge keel of 1.04 m will be taken for GZ calculations.

C. GZ Calculations

GZ is the enforcement arm for the ship to return to its original position which is illustrated by the displacement of point G when the balance changes to point G' after experiencing an oscillation. The distance between G to G' is GZ. The displacement of this point in each condition will produce a different stability curve appearance. The data can be seen in Table 11, 12 and Figure 21. (Medium precision, 65 sections, Trimming on, Skin thickness not applied). Long. Datums: MS; vert. datums: Baselines. Analysis tolerance – ideal (worst case): Disp. %: 0.01000(0.100); Trim % (LCG-TCG): 0.01000(0.100); Heel % (LCG-TCG): 0.01000(0.100)

The GZ analysis results on a model 4 canoe with the addition of a 1.05 m bilge keel, the GZ graph shows that the canoe has good stability, filled with 2 passengers weighing around 50 kg each, GZ is the enforcement arm for the ship to return to its original position which is illustrated by the displacement of point G when the balance changes to point G' after experiencing rocking. The distance between G to G' is GZ. The displacement of this point in each condition will produce a different stability curve display. The line graph in red shows the limit of the roll of the canoe which is almost close to 0.25 m while the draft of the canoe is only 0.2 m. and the graphic line in gray shows the roll of the canoe which only reaches a value of 0.16 m, not reaching the water draft.

TABLE 7.
RAO VALUE of ROLLING CANOE at 270° WAVE DIRECTION

RAO Value of Rolling Canoe at 270° Wave Direction	
No Keels (rad/m)	6.510803
Keel 0,875 m (rad/m)	6.619880
Keel 1,05 m (rad/m)	6.359461
Keel 1,225 m (rad/m)	6.399889

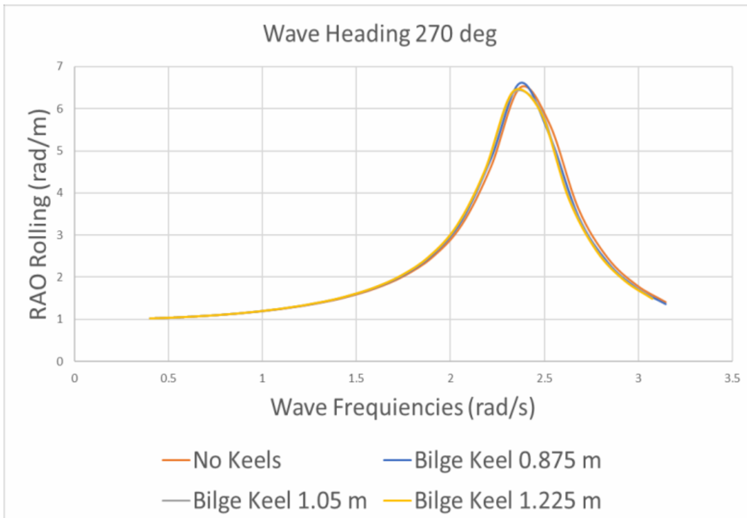


Figure. 17. 270° Wave Direction Analysis Graphic

TABLE 8.
RAO VALUE of ROLLING CANOE at 315° WAVE DIRECTION

RAO Value of Rolling Canoe at 315° Wave Direction	
No Keels (rad/m)	4.710533
Keel 0,875 m (rad/m)	4.655362
Keel 1,05 m (rad/m)	4.635145
Keel 1,225 m (rad/m)	4.613671

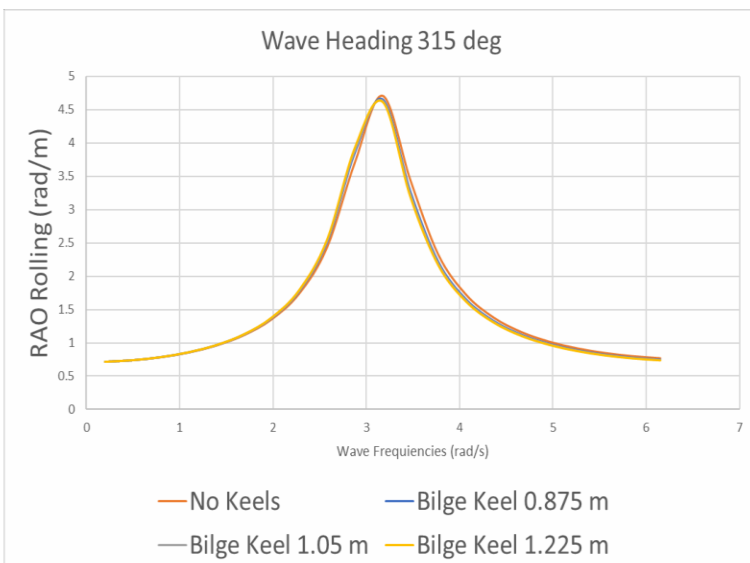


Figure. 18. 315° Wave Direction Analysis Graphic

TABLE 9.
HIGHEST VALUE DATA for EACH BILGE KEEL LENGTH VARIATION

Bilge Keel	**Highest Value Data for Each Bilge Keel Length Variation**			
	180°	**225°**	**270°**	**315°**
0	0	4.603833	6.510803	4.710533
0.875 m	0	4.680962	6.61988	4.655362
1.05 m	0	4.496818	6.359461	4.635145
1.225 m	0	4.525405	6.399889	4.613671

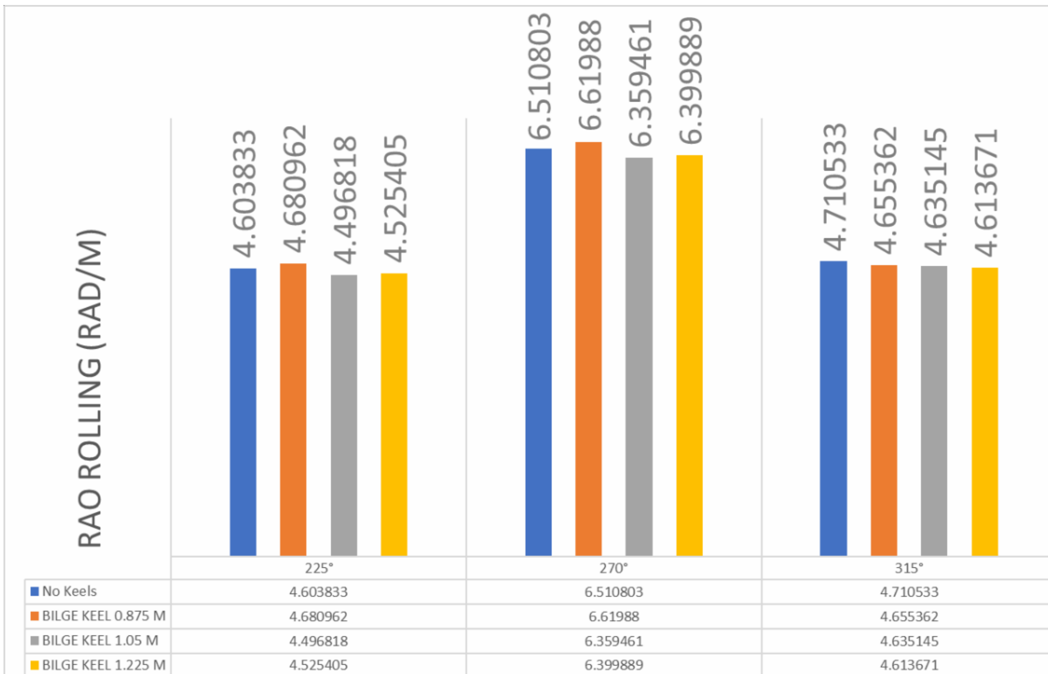


Figure. 19. Graph of Highest Value Data for Each Bilge Keel Length Variation

TABLE 10.
PERCENTAGE of IMPAIRMENT VALUE of RAO ROLLING BILGE KEEL WITH a LENGTH of 1.05 m AGAINTS CANOE WITHOUT BILGE KEEL

Bilge Keel	Angle of Arrival of Waves			
	180°	225°	270°	315°
No Keels	0	4.603833	6.510803	4.710533
1.05 m	0	4.496818	6.359461	4.635145
Percentage of RAO reduction in value of rolling bilge keel with a length of 1.05 m to canoes without bilge keel				33%

TABLE 11.
CALCULATION of ROLLING PERIOD 1 EACH BILGE KEEL LENGTH VARIATION

Canoe	GM (m)	T = (2 C B)/ $\sqrt{GM}$	Period (s)
No Bilge Keels	0,049	T = (2 x 0.419 x 0.625)/ √0,049	2.366061
Length 0.875 m	0,048	T = (2 x 0.419 x 0.625)/ √0,048	2.390581
Length 1,05 m	0,048	T = (2 x 0.419 x 0.625)/ √0,048	2.390581
Length 1,225 m	0,048	T = (2 x 0.419 x 0.625)/ √0,048	2.390581

TABLE 12.
LOADCASE PARAMETER INPUT DATA

NO	Item Name	Quantity	Unite Mass tonne	Total Mass tonne
1	Passenger 1	1	0.05	0.05
2	Passenger 2	1	0.05	0.05
3	Total Loadcase			0.1
4	FS correction			
5	VCG fluid			

TABLE 13.
DATA INPUT ROOM DEFINITON

NO.	Name	Type
1	Passenger 1	Compartment
2	Passenger 2	Compartment

Intact Perm. %	Damaged Perm. %	Spesific Gravity
100	100	
100	100	

Fluid type	Boundary Surface	Aft m	Fore m
	none	0.85	1
	none	-1	-0.85

F. Port m	F. Stbd m	F.Top m	F. Bott m
-0.4	0.315	0.25	0.15
-0.315	0.4	0.25	0.15

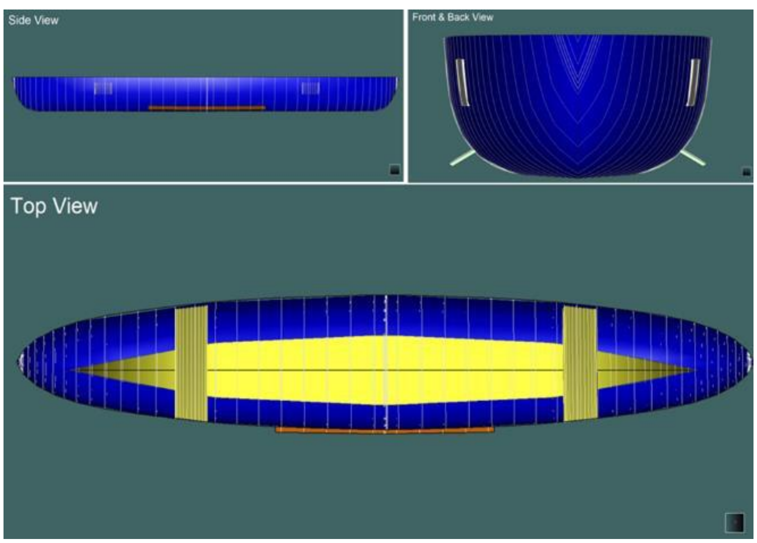


Figure. 20. Placement of Passenger Position, Loadcase Parameters and Room Definition [Author, 2023]

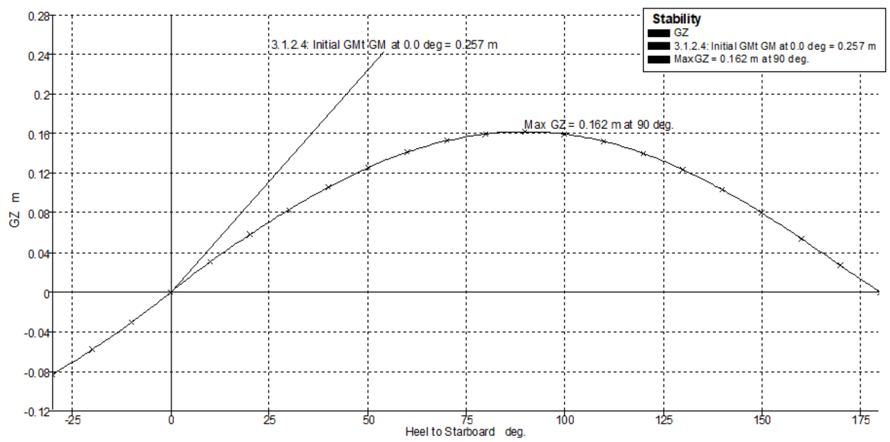


Figure. 21. Graph of GZ Analysis Results Model 4 Bilge Keel Length 1.05 m [Author, 2023]

IV. CONCLUSION

Based on the results of the analysis and discussion of the topic the author did with the title "Canoe Design with a Capacity of Two Passengers With the Addition of a Bilge Keel to Improve the Owing Period", the following conclusions can be drawn.

1. Because there are very few references to installing bilge keels on small boats, especially canoes. The author concludes to take reference from small and medium sized ships by comparing the percentage of the length of the ship and the width of the ship. So that you will find dimensions of 1.05 m long, 6.25 cm wide and 0.8 cm thick which are considered suitable for installation in canoes.
2. From the results of the analysis, it is known that for a canoe with LOA data of 3.5 m, B 0.625 m, H 0.3 m and T 0.2 m if it is planted with a bilge keel it can improve the stability of the canoe by 1.03% better .
3. After analyzing several variations in the length of the bilge keel, the bilge keel with a length of 1.05 cm with a width of 6.25 cm and a thickness of 0.8 cm can improve the stability of the canoe.

ACKNOWLEDGEMENTS

Thank you to the supervising lecturers who have provided understanding and direction so that this research journal can be completed properly. and Banyuwangi State Polytechnic for the room or lab facilities provided for the work on this research journal.

REFERENCES

[1] Ahmad Indra, Perhitungan Hidrostatik Pada Desain Kapal, *Perhitungan Hidrostatik Pada Desain Kapal*https://air.eng.ui.ac. id. 20 19

[2] Akbar Bagus Dermawan. (2022). Analysis The Effect of Outrigger (Cadik) Variations on Motion Response of Fishing Boat Using CFD Method. Politeknik Negeri Banyuwangi

[3] Ari Widyatmoko. (2021). Analisis Pengaruh Jumlah Bilge Keel terhadap Gerakan Rolling pada Kapal Patroli 14 m. Fakultas Teknik, Universitas Diponegoro.

[4] Ayioris IL, Marinaio, Standargm dan Rolling Periodsetiap Deck Officer Khususnya Kelas 3 Ke Atas Pasti, *Standargm dan Rolling Periodsetiap Deck Officer Khususnya Kelas 3 Ke Atas Pasti* 2020

[5] Department of Naval, *Jurnal: Analisa Pengaruh Bilge Keel Tipe Bulb Terhadap Lambung V Dan U Pada Kapal Patroli Dengan Menggunakan Metode ComPutational Fluid Dynamic (CFD),* 2019

[6] Derret, D.R. (1990). Ship Stability for Masters and Mates. Fourth Edition, Revised, B-H Newnes.

[7] Flatbottomboatworld, How a Flat Bottom Canoe Differs From Other Canoe Designs, *How A Flat Bottom Canoe Differs From Other Canoe Designs* https://www-flatbottom boatworld-com.translate.goog/how-a-flat-bottom-canoe-differs-from-other-canoe-de signs/?2022

[8] [IMO] International Maritime Organization. (1955). Code on Intact Stability For All Type of ship Covered by IMO Instruments Re solution A. 749 (18)

[9] Imran Ahmad, Analisis Kekuatan Sruktur Haluan Kapal Survei Seismik Geomarin IV Terhadap Beban Slamming Dan Greenwater. Institut Teknologi Sepuluh Nopember, 2016

[10] Muhammad Agam Thahir, Stabilitas Sampan Terbuat Dari Ember Cat Bekas Dengan Bilge Keel Pada Sudut 30 dan 45 Derajat. Fakultas Perikanan dan Ilmu Kelautan, Institut Pertanian Bogor, 2013

[11] Muhammad Anjas. (2020) Pengaruh Variasi Sudut Bilge Keel Terhadap Stabilitas Gerak Oleng Kapal Ikan Berdasarkan Pengujian Model (Studi Kasus Kapal Kayu Pinisi) Teknik Perkapalan Fakult as Teknik Universitas Hasanuddin.

[12] Yeddid Yonatan Eka Darma, Hery Inprasetyobudi, Rochmad Eko Prasetyaning Utomo. (2022). Jurnal: Aplikasi Integrated Engineer ing dalam Pembuatan Perahu Berbahan Kayu Strip dengan FRP Coating guna Meningkatkan Animo Masyarakat terhadap Wahana Air di Wisata Rumah Apung Bangsring, Politeknik Negeri Banyuwangi.