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Stability Characteristics of Catamaran Ship Model Based on the Hull Shape Variation

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ABSTRACT

Small dredger catamaran is a vessel of tin suction is used for tin mining community. Shipbuilding business using a circular catamaran hull have problems such as poor stability resulting in IMO standars of safety operation in the sea. The purpose of this study is to analyze geometry hull of the tin mining equipments to obtain good stability based on minimum criteria of IMO standars. 3 models of small dredger catamaran with geometry hull i.e. circular, rectangular, and oval with variety of configurated catamaran hull ratio length-breath (S/L) on a small dregder catamaran 10 m with scale model 1 : 8 are using in this study. The stability experiment is used a inclining test in basin with refer to ICAS 2004 procedure. Comparasion of ship stability with variety of geometry hull is shown on the graph as a fuction of angle of heel. The result showed that stability of small dredger catamaran using a rectangular geometry hull is better to improve the most corecction for ship stability could achieve 16 – 23 % base on minimum IMO standar.

1. Introduction

One of the intermediate ships that operate mining at the sea is dredger. Manufacturing costs is become a main problem for building a dredger. Dredger is a ship that has special equipment to do the dredging. For Bangka Belitung community islands, small dredger catamaran has been built is used with a economy operationg cost. It has a length of small dredger is 10 meters with circular geometry hull (figure 1). Multi-hull like catamaran hull form is used on the small dredger is more efficeint. Victor Dubrovsky et al [1] Multi-hull vessel of various types have inherently larger deck area, higher safety, and better seaworthiness than conventional monohulls. Their particular area of proliferation is the short sea shipping where they show considerable superiority over competitive designs in attributes such as space availability and seakeeping quality [2]. Throw the analysis of damage stability on typical catamaran that SA criteria application on multi-hulls is not so irrelevant as mentioned in [3] because of large car decks

Figure 1: Small dredger catamaran at Bangka Belitung.

Source: Authors.

A greater variety of possible stability characteristics on small dredger allows us to design vessels suited for specific operatioanl requirement. Recent accidents have pointed out the importance of careful consideration of stability characteristics before small dredger catamaran is put in service.

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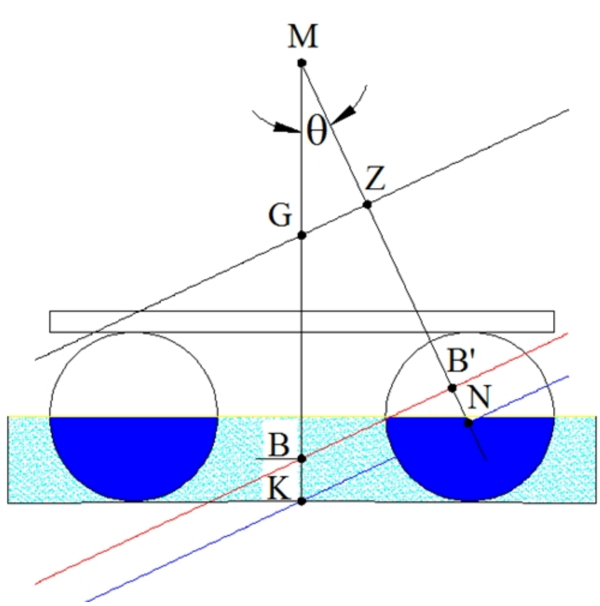
Stability againts capsizing in heavy seas is one of the fundamental requirement in ship design. The main concern with small dredger ship design relates to stability characteristic. It is vital that a rational approch to safety is demonstrated, validated, and adopted. The stability criterion is a requirement for some vessels, notably for all types of ships on domestic voyages. The standars are contained in IMO [4] Resolution A.749 (18); the code on intact stability.

B Deakin et al [5] the method desribed here offers a very simple means of using statical stability to estimate the safety of an intact and damage vessel, while recognising that safety also depends on the size of the vessel in relation to the operasional at the sea. This is the right way to ensure both the survival and a meaningful evolution of small dredger in the future.

The main problem on small dredger catamaran with circular geometry hull has a poor stability resulting in IMO standars of safety operation in the sea. The effort in correcting the ship stability with changes ageometry hull and enlarge the configuration hull to get a lever of stability. The purpose of this study is to analyze geometry hull of the tin mining equipments to obtain good stability based on minimum criteria of IMO standars. 3 models of small dredger catamaran with geometry hull i.e. circular, rectangular, and oval with variety of configurated catamaran hull ratio length-breath (S/L) on a small dregder catamaran 10 m with scale model 1 : 8 are using in this study. The dimension of small dregder catamaran model L = 1250 mm, B = 300 mm and T = 50 mm is used in this research. The stability experiment is used a inclining test in basin with refer to ICAS 2004 procedure. The comparation of stability characteristics using geometry catamaran hull i.e. circular, rectangular, and oval and variety of separation hull are also investigated.

Figure 2: Transverse stabilty on small dredger catamaran.



Source: Authors.

2. Experimental Set-up.

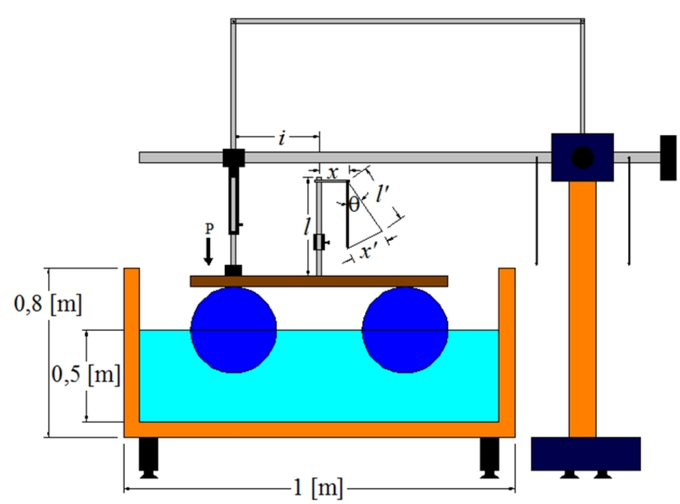
A series of model tests was conducted at the basin. The basin has a length of 5 m and width of 1 m, and the water depth was maintained at a constant depth of 0,5 m. The experiments of inclining test with refer to IACS 2004 procedure and were conducted for angle of heel up to 60.

Table 1: Main characteristics a small dredger catamaran with geometry and separation catamaran hull .

Main Dimensions	Circular			Rectangular			Oval		
	S/L= 0,14	S/L= 0,16	S/L= 0,18	S/L= 0,14	S/L= 0,16	S/L= 0,18	S/L= 0,14	S/L= 0,16	S/L= 0,18
Displacement [ton]	9,27	9,27	9,27	9,27	9,27	9,27	9,27	9,27	9,27
Volume [m^3]	9,05	9,05	9,05	9,05	9,05	9,05	9,05	9,05	9,05
Length waterlinel [m]	10	10	10	10	10	10	10	10	10
B overall [m]	2,2	2,4	2,6	2,2	2,4	2,6	2,4	2,6	2,8
H [m]	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9
T [m]	0,4	0,4	0,4	0,39	0,39	0,39	0,39	0,39	0,39
Water plane area [m^2]	23,99	23,99	23,99	23,83	23,83	23,83	23,9	23,9	23,9
Cp	0,94	0,94	0,94	0,96	0,96	0,96	0,96	0,96	0,96
Cb	0,94	0,94	0,94	0,96	0,96	0,96	0,96	0,96	0,96
Cm	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99

Source: Authors.

Figure 3: Experimental set-up.

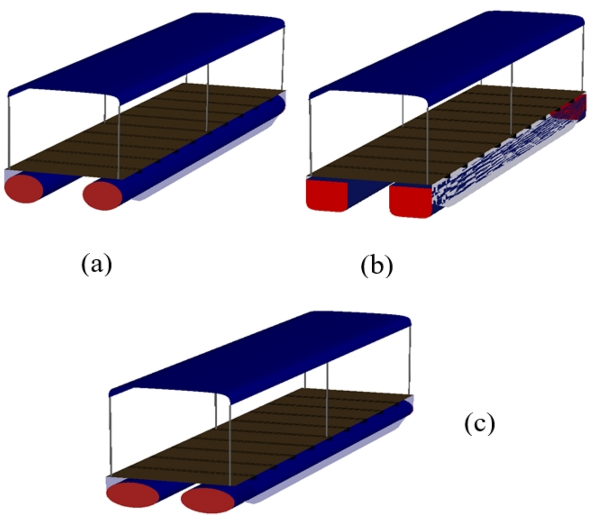


Source: Authors.

Figure 3. This set-up consists of small dredger catamaran models, inclining test equipment, and plumbine. The comparison of stability using all of geometry catamaran hull i.e. circular, rectangular, and oval is analiyzed. Hyrostatic information will give the displacement and MK for the small dredger catamaran as inclined. The difference KM and obtained GM then

the GK for the small dredger catamaran as inclined. During the inclining test, plumbine is located on center of gravity (COG) at the midships of small dredger catamaran model. As knownn weight 25 – 100% loaded is the shifted transversely across the upper deck. This cause ship model to list and plumbine to move accross the batten. The deflection is measured. The deflextion is defined (x) and length of plumbine is defined (l). The model is pulled by the one of inclining test equipmemt variation (P) with the distance of P is (i) are used to GM calculations. A mean deflection is then used in the GM calculation. The model test is conducted in order to have metacentric values of the ship model (GM) at various angle of heel conditions (degree).

Figure 4: Design model of Small dredger catamaran (a) circular (b) rectangular, and (c) oval geometry hull with Maxsurf Software Realease 12.02.



Source: Authors.

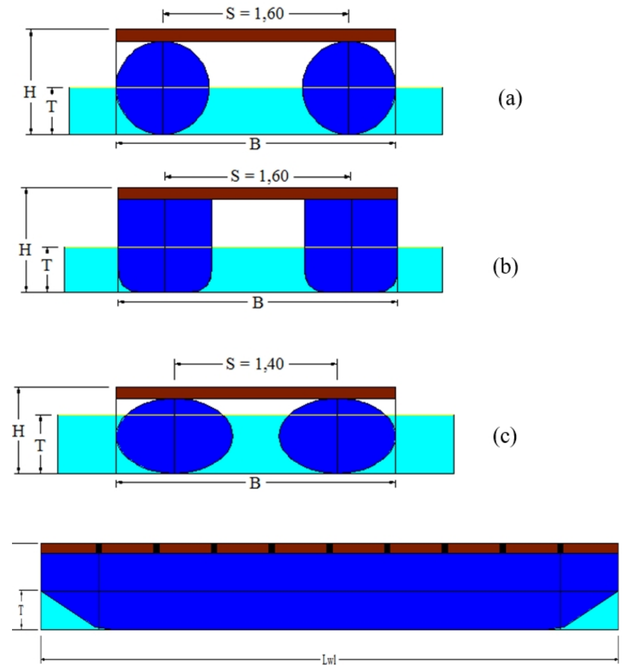
Figure 4 & 5. shows the design model of small dredger catamaran with geometry and distance of separation (S/L) catamaran hull variation using maxsurf sofware realease 12.02. The configuration of geometry model are used displacement catamaran type (Δ) with symentrical hull. The geometry hull analysis with the influence of geometry hull i.e. circular (ϕ = 800 mm), rectangular (B = 800 mm), and oval (ϕ_1 = 1000 mm and ϕ_2 = 640 mm). Another analysis are used variations of separation catamaran hull (S/L) i.e. 0.07, 0.08, and 0.09 were investigated and compared regarding the stability characteriscstics. Main characteristics a small dredger catamaran with geometry and separation catamaran hull in the following table 1.

3. Test Analyzes.

Small dredger catamaran in a stable condition if able to return to its original posisition when subjected to the slope. To calculate a distance between the bottom ship with a transverse field is used metacentric point. The formula as follows :

$$KM = GM + KG \quad (1)$$

Figure 5: Lines plan of small dredger catamaran with (a) circular (b) rectangular, and (c) oval geometry hull.



Source: Authors.

KM is distance from keel to metracentric point, GM is distance from center of gravity to metracentric point and KG is keel to center of gravity point for depends on loading characteristics of the ship.

The distance calculations a transverse field for the ship as inclined using a formula as follows :

$$KM \sin\theta = GM \sin\theta + KG \sin\theta \quad (2)$$

KM sin θ is distance from keel to metracentric point for the ship as inclined (θ), GM sin θ is distance from center of gravity to metracentric point for the ship as inclined (θ) and KG sin θ is keel to center of gravity point for depends on loading characteristics of the ship as inclined (θ).

While the stability characteristics can be determined by the following formulas The value of righting level comply with a base on minimum IMO standars :

$$GZ = KN - GK \sin\theta \quad (3)$$

The GZ lever can teh be expressed in terms of metacentric point, i.e. GZ = GM sin θ. KN = KM sin θ is see cross curve information will give the displacement of the ship.

From the experimental in basin results, for the models the metracentric point have been calculated as :

$$GM = \frac{P \times i}{\tan\ \theta \times \Delta} \quad (4)$$

where P is pulled by the one of inclining test equipmemt variation, (i) is the distance of P and Δ is displacement of ship model.

Inclining change of ship model test are define as

$$\tan\theta = \frac{x}{l} \tag{5}$$

The correction of ship stability with geometry hull modification as :

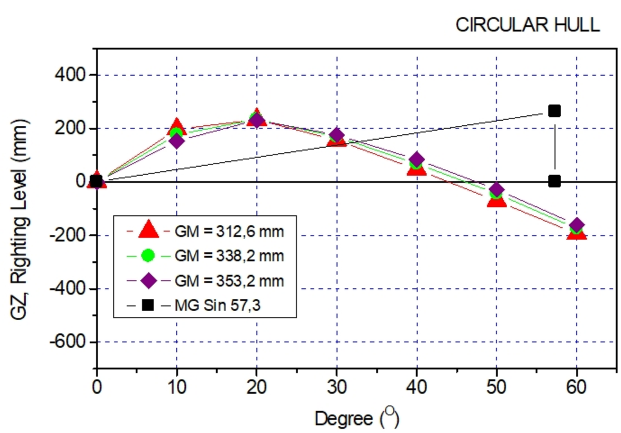
$$SR(\%) = \left|\frac{GZ - GZ_o}{GZ_o}\right| x100\% \tag{6}$$

GZ_O is righting level before geometry hull modification

4. Results and Discussion.

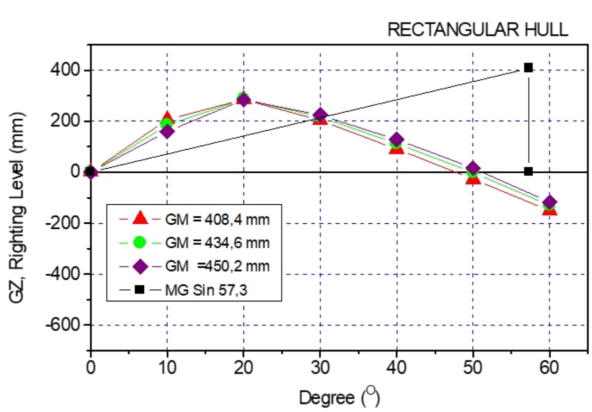
A comparison of the geometry catamaran hull applied for the small dredger catamaran ship model was made to evaluate the stability characteristics as shown in Figure 6-11.

Figure 6: The righting level of small dredger catamaran with circular geometry catamaran hull.



Source: Authors.

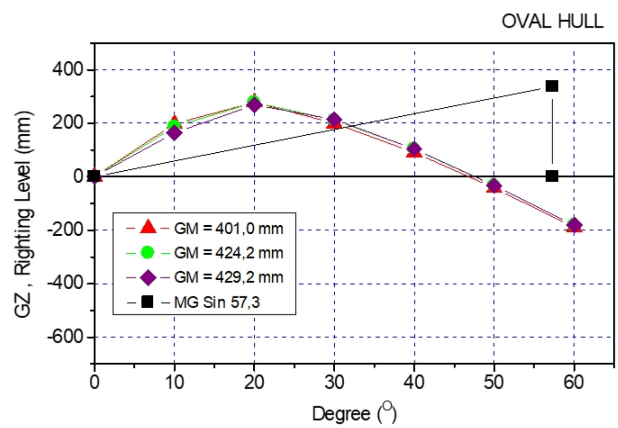
Figure 7: The righting level of small dredger catamaran with rectangular geometry catamaran hull.



Source: Authors.

Figure 6, 7, & 8 show the relationship between angle of hell and righting level (GZ) on the different metacentric GM conditions for small dredger with geometry catamaran hull variation. It appears that for the small dredger catamaran ship model by using geometry hull variations at a variety of loading conditions. When the angle of heel futher increased, values of GZ are smaller. Increasing of loading condition, have a value of GM is relatively higher. It can be said of the effects seen where the ship model become more stable up to lose bouyancy. It happens in each geometry catamran hull model. The distance above the base line of the point where the vertical line and the tangent intersect is the GM and it?s indicates the righting level at 1 radians or $\theta = 57.3$.

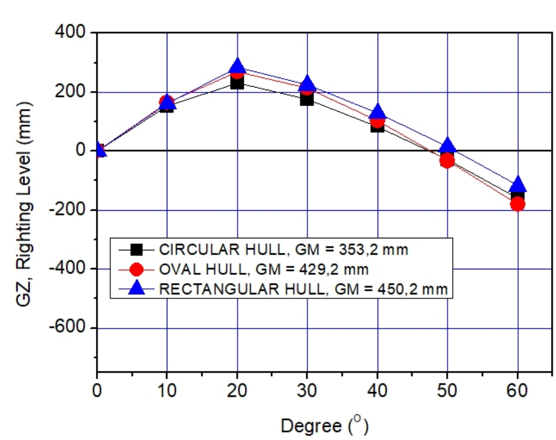
Figure 8: The righting level of Small dredger catamaran with oval geometry catamaran hull.



Source: Authors.

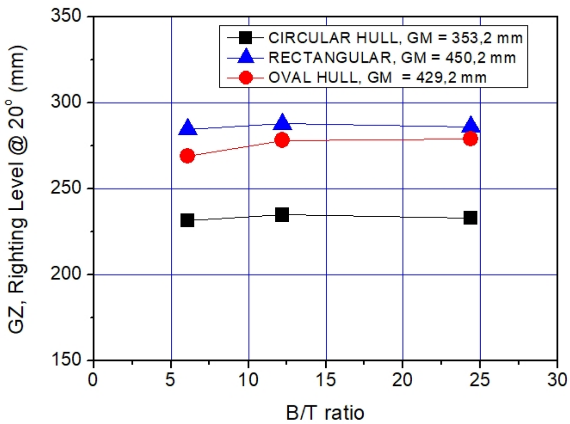
Figure 9 shows the comparation of geometry catamaran hull as function of full loaded condition. The horizontal axis is angle of heel in terms of the angle of heeled ship model. The ship model with catamaran hull will be varied for 3 variation of geometry hull. It appears that for the ship model by rectangular geometry catamaran hull, have a value of righting level is relatively higher when compared with oval and circular geometry catamaran hull. It can be said of the effects seen where rectangular geometry catamran hull become more stable and have the best performance with others.

Figure 9: The righting level of small dredger catamaran with geometry catamaran hull variation by 100% loaded.



Source: Authors.

Figure 10: Variation of righting level when heeled at 20º, with beam/draft ratio.

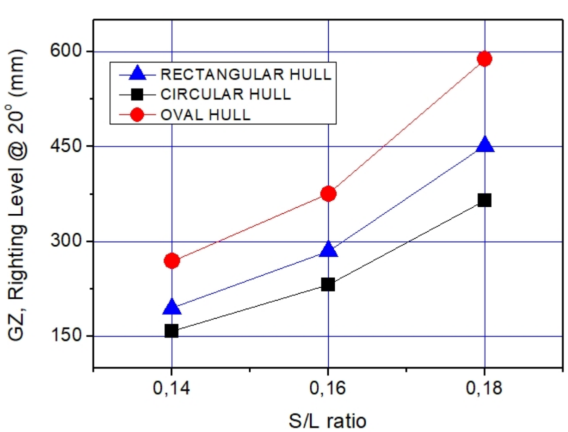


Source: Authors.

Figure 10 shows the relationship between righting level with variation of loading condition and beam/draft ratio. For the purposes of stability assesssment, however, it is the righting level about centre of bouyancy (COB) that generates the righting moment. For a monohull the difference is negligible, but for a catamaran the centre of bouyancy moves significantly towards the leeward side, and the increase in effective level must be taken into account. The stabiltiy characteristics for rectangular slightly higher than oval and circular geometry catamaran hull. It is indicated that rectangular is the best geometry catamaran hull to increase the stability characteristic that occured. The correction of ship stability using a equation (6) can be gained for this study is up to 23% for rectangular and for oval geometry catamaran hull is up to 16%.

This presents the data for 20 degrees of heel.

Figure 11: Variation of righting level when heeled at 20º, with separation hull ratio.



Source: Authors.

Figure 11 shows the variety of separation hull (S/L) are used on geometry catamaran hull i.e. rectangular, oval, and circular catamran hull. This presents the data for 20 degrees of heel. It appears that increasing of separation hull futher increased, have a value of righting lever GZ is relatively higher. It can be said that for the ship model by oval geometry catamaran hull, have a value of righting level GZ is relatively higher on increasing of separation hull are compared with rectangular and circular geometry catamaran hull. This occurs by addition of width with effect ϕ_1 = 1000 mm and ϕ_2 = 640 mm on oval geometry catamaran hull. The correction of ship stability using a equation (6) can be gained for this study is up to 70% for oval and for rectangular geometry catamaran hull is up to 24%. Increasing of separation hull so it can be increased the righting level will increase the ship stability.

Conclusions.

Considering of the experimental model test results to evaluate stability characteristics on small dredger catamaran using variety of geometry and separation catamaran hull. The following conclusions can be stated that variety of geometry catamaran hull and variety of separation hull can change significantly and are found to be positive influences on the ship stability charactristics. The test results found that the correction of ship stability using a variety of geometry changes can be achieved up to 23 % on rectangular catamran hull. Thus, using a variety of separation hull changes can be achieved up to 60 %. Using a rectangular geometry of catamaran hull is the best geometry to get correction of ship stability.

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