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Stability Prediction of a Multi Purpose Vessel

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ABSTRACT

Operational determination requirements for Multi Purpose Vessel Ship need to consider the basic functions carried out, namely to carry out the transportation of equipment and combat logistics from the base to the operating area both in the context of amphibious landings and administration landings. Stability predictions are very important to be carried out at the design stage to determine the static stability conditions of the ship as well as its estimated dynamic stability In addition to the basic functions on board the type of Multi Purpose Vessel (MPV) Ship can be given the following additional functions: Transport troops, logistics and equipment from or ships to landing beaches, and sea transportation assistance, in SAR activities. In this manuscript, the MPV will be analyzed for the stability value. Those stability will be analyzed in order to predict whether the stability value in the MPV for the operational ship is feasible or not. The calculation will take into account the value of KN and also limiting KG value. The result is shown that the overall KN value shows good and normal value for the MPV

KEY WORDS: *Multi purpose vessel, Stability, Limiting KG.*

NOMENCLATURE

LOA	Length over all
LWL	Length Water Line
BM	Bread Moulded
HM	Height Moulded
KM	Keel of Metacentre
KB	Keel of Buoyancy

1.0 PRELIMINARY

Multi Purposes Vessel Ship shape is such that it can be operated in narrow grooves and shallow waters with a sea state no more than Sea State 2 [1-3]. Able to monitor on beaches up to 1: 30 gradient and do not require a special dock. And able to carry out the transfer of personnel, combat vehicle and materials in various forms up to + 250 tons. Has a minimum speed of 12 knots at full load and can reach speeds of up to 18 knots [4-5,7].

- Operational Capability: Able to operate continuously at sea for up to 10 days, or if using economic / roaming speed can travel + 2,880 Nm.
- Economic Facilities : Accommodation of 30 person guards
- Equipped with lifeboats, as a means, to carry out SAR and other activities.[8]

The main size specifications for Multi Purpose Vessel Ship vessels can be seen below,

1. LOA length: 82.8 meters
2. LWL length: 79 meters
3. Bmld Width: 16 Meters
4. Load Tmld: 2.8 Meters
5. Height Hmld: 7.2 Meters
6. Displacement: 2477 Ton
7. Cruise Speed: 12 Knots 8. Max Speed: 18 Knots
9. Cruise Speed: 12 Knots
10. Sea State: 2 (Beaufort Scale)
11. Operating Length: 10 Days
12. Cruise Distance: 2880 NM
13. Number of crew members: 30 people.

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2.0 STABILITY

Stability studies are very important to be carried out at the design stage to determine the static stability conditions of the ship as well as its estimated dynamic stability. Static stability calculation is carried out by rotating the ship transversally (heel) 180 degrees to the starboard in various laden variations and calculating the amount of GZ that occurs [9].

The criteria for assessing the level of performance of the static stability of the vessel are adjusted to the type of vessel according to the world's marine safety organizations such as IMO, SOLAS and so on.

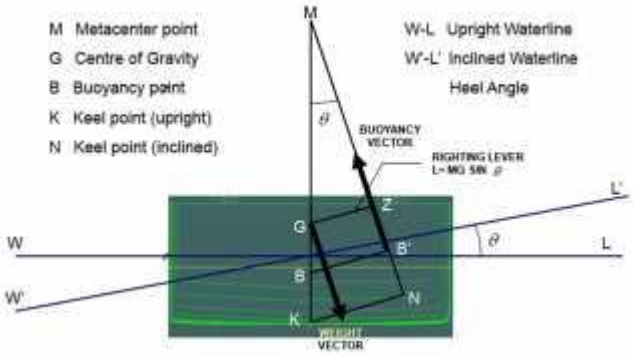

Figure 1: Various schemen on ships

The concept of calculating stability can be seen in the picture above where point M is a metasenteric point that seems to function as a swinging point in a shaky motion of a ship. The position of point M is obtained from the calculation of KM = KB + BM where KB is obtained from the calculation of hydrostatics and BM = l/v. The KM line shows the position of the M point on the condition of the upright vessel and the NM line is the position of the M point in the heel condition.

The moment that causes the slope of the ship is x Displacement while the return moment is Buoyancy x. Because the size of the Displacement style = the Buoyancy style, then the large Pure Return Moment which serves to return the ship to an upright position is the difference between the two moments = Displacement x GZ. So the size of the GZ arm is one factor that greatly determines the stability of a ship. The purpose for this research is to find the value of the stability from the MPV itself. These stability value will become an evaluation whether the MPV could be used for the the waterways in Indonesia.

The initial point of M (initial metacentre) can generally be determined through the price of MB which is referred to as the metacentre radius. To find the length of the radius of the initial metacentre (MB) can be used inertia moment formula from the corresponding waterline field, divided by its displacement.

Metacentre radius is divided into:

The radius of the metacentre transversely.

$$M_TB = \frac{IXX}{V} \qquad (1)$$

and the metacentre radius extends (for trim).

$$M_LB = \frac{IYY}{V} \qquad (2)$$

Where;

Ixx = the moment of inertia of the water line to the longitudinal axis of the vessel (XX) through the center of the water line (m^4).

Iyy = moment of inertia of the water line to the transverse axis of the ship (YY) through the center of the water line (m^4).

V = The volume of water transferred to the water line (m^3).

For the purpose of checking the stability of a ship in a simple way, the formula of approach is usually used, even though the results are not so precise

Among other things are the approaches to metacentre radius

$$M_TB = \frac{\propto(\propto+0{,}04)}{12{,}5\delta} \text{ x } \frac{B^2}{d} \quad \text{Pos/dunine} \qquad (3)$$

$$M_TB = \frac{\propto}{d.\delta} \cdot \frac{57\propto - 22}{420} \quad \text{Rauert} \qquad (4)$$

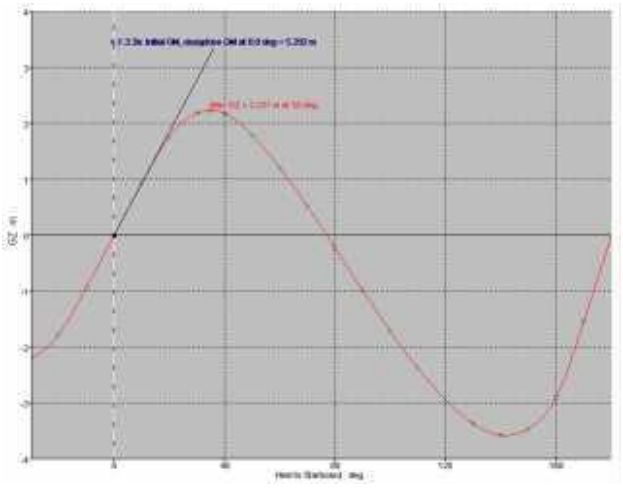

Figure 2: Figure- Multi Purpose Vessel Ship Stability Curve

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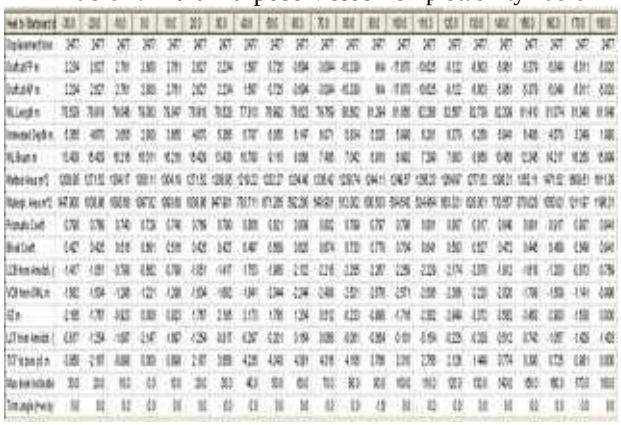
Table 1: Multi Purpose Vessel- Ship Stability Table



The results of the calculation of the static stability of the ship can be seen in Figure 4 above where the initial GZ is 5.292 meters as shown in the tangent to the stability curve at heel 0 degrees. The maximum GZ value of 2,231 meters occurs at the heel angle of about 37 degrees where this value indicates the magnitude of the vessel's greatest moment to return to the upright position.

For heel angles above 40 degrees, the moment's ability to return gradually decreases to reach zero at the heel angle of about 75 degrees where in this position the ship has no ability to return to its upright position and the ship will sink later.

According to the general stability criteria as listed in Table 2 above, the position of the maximum stability arm has been fulfilled. The magnitude of the area under the stability arm curve above shows the amount of energy that the Multi Purpose Vessel Ship has the potential to return to its upright position when there is an external force that makes it shaky.

Thus the size of the area under the curve also requires the minimum criteria for the assessment as shown in the table above. For an area between 0-30 degrees of heel angle and 30-40 degrees, Multi Purpose Vessel ships have proven to be fulfilling, so that in general the stability level of Multi Purpose Vessel ships can be said to be quite good.

3.0 KN VALUES

One other factor that determines the level of stability of a ship is the value of KN = as shown in Figure 2 above, and is the arm of the return moment of the Buoyancy style when the ship is tilted

The process of calculating the arm size is the same as the arm of GZ above by dividing the vessel into 10 parts and tilting the ship from 0 to 180 degrees and calculating the value of KN and displacement in each of these loaded.

Table 2: Multi Purpose Vessel Ship Stability Criteria

Code	Criteria	Value	Units	Actual	Status
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	75.9	deg		
	shall not be less than (>=)	3.151	m.deg	38.429	Pass
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	75.9	deg		
	shall not be less than (>=)	1.719	m.deg	22.138	Pass
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		
	angle of max. GZ	36.0	deg	36.0	
	shall not be less than (>=)	0.200	m	2.231	Pass
	Intermediate values				
	angle at which the GZ occurs		deg	36.0	
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	36.0	Pass
4.1 Cargo ships carrying timber deck cargoes	4.1.3.1: Area 0 to 40				Pass

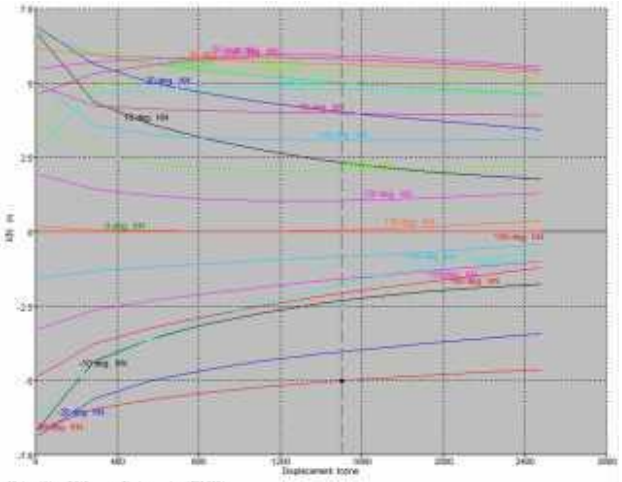


Figure 3: Figure Multi Purpose Vessel- Ship KN Value Curve

The overall value of KN Multi Purpose Vessel Ship for various displacement conditions can be seen in the picture above and almost all of them show positive values which

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generally increase from a slope of 0 degrees to 80 degrees to then decrease to a 180 degree slope in the form of a line with zero values

The positive value of the KN value is very important because it shows good potential as the main factor of the return moment.

Charts for heel angles 140 - 180 degrees begin to show negative values for all displacement values or all loaded values as shown in Figure 2 above. Considering the value of KM = KB + BM and the value of KB is always positive because its position is always above the keel line, the value of KN negative can be ascertained due to the value of BM = ;/v which is negative or the position of the metasenter point M falls below point B or falls in the portside section ship (see Figure 2 above).

The position of M points like this can be caused by the lower the water-laden, the rate of decline in the value of V (volume displacement) is much slower than the rate of decline in value I (Moment of Lineage area) or due to the BM value that remains large at low load so that point M is no longer located on the centerline of the ship, but moves on the portside side so that KN = is negative because it is on the opposite side of the position, which causes the twisting moment to strengthen and enlarge the shaky angle of the ship.

The value of KN when the displacement is equal to zero indicates that the value of KN is not certain considering KN = KB + BM and KN =. On zero laden the value of KB = 0 and the value of V = 0. Because the value of BM = I / v then the value of BM becomes uncertain and the Maxsurf program changes it to ZERO value

4.0 LIMITING KG

Another factor that is very important to predict the level of stability of the ship is the value of KG because the value is a deduction from the value to obtain the value of the stability arm of GZ =. According to Figure 3 above, the value of KM can also be expressed as KM = KG + GM and because GM values must be positive (point M must be above point G) then the vertical position of point G must be limited to not exceeding the vertical position of point M.

Limiting KG is intended as a maximum limit of KG distance so that the distance KG does not exceed the vertical position of point M which can cause negative moments so that the ship does not have a positive return moment. This condition study is very important at the ship design stage so that in the design process it must be endeavored so that the vertical position of point G does not exceed the value obtained from the calculation of the Limiting KG.

Table 3: Table Limiting KG Multi Purpose Vessel Ship

	Displacement tonne	LCG m	Limit KG m	Criterion	Name
1	2477	38.889	8.462	A.749(18) Ch3 - Design criteri	3.1.2.1: Area 30 to 40
2	2213	39.033	8.613	A.749(18) Ch3 - Design criteri	3.1.2.1: Area 30 to 40
3	1949	39.159	8.732	A.749(18) Ch3 - Design criteri	3.1.2.3: Angle of maxim
4	1685	39.280	8.455	A.749(18) Ch3 - Design criteri	3.1.2.3: Angle of maxim
5	1421	39.398	8.022	A.749(18) Ch3 - Design criteri	3.1.2.3: Angle of maxim
6	1158	39.512	7.413	A.749(18) Ch3 - Design criteri	3.1.2.3: Angle of maxim
7	892.3	39.625	6.337	A.749(18) Ch3 - Design criteri	3.1.2.3: Angle of maxim
8	626.2	39.755	5.502	A.749(18) Ch3 - Design criteri	3.1.2.3: Angle of maxim
9	364.1	39.955	4.228	A.749(18) Ch3 - Design criteri	3.1.2.3: Angle of maxim
10	100.0	40.593	1.097	A.749(18) Ch3 - Design criteri	3.1.2.3: Angle of maxim

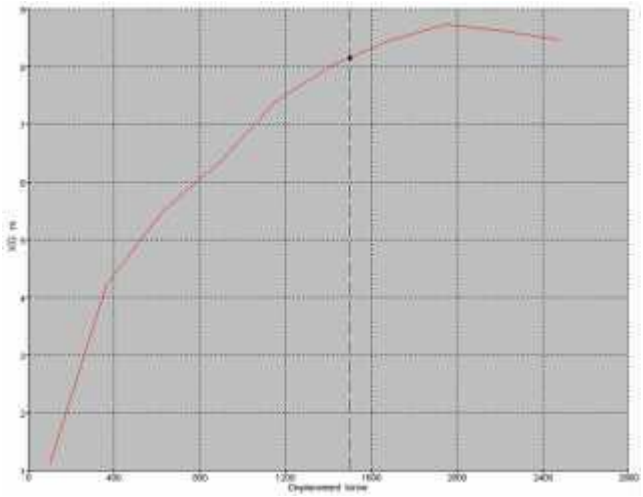

Figure 4: Picture of Limiting KG Multi Purpose Vessel Ship

The Multi Purpose Vessel Ship is a ship with a specific medium to heavy load, so that the vertical position of point G is around KG = 0.7 H = 4.9 Meters. The difference and the innovation that separates between this ship and other ship lies within this limiting KG calculation process.

The limiting KG calculation process is also the same as the above process, which is by dividing the Multi Purpose Vessel Ship laden into 10 parts and calculating the displacement and minimum vertical position from point M, which is also the maximum position from point G, and plots it into a graph as in Figure 3 above.

The result of Multi Purpose Vessel Ship limiting KG calculation as shown in the figure above shows that the larger the ship displacement, or the higher the ship loaded, the limiting KG value will increase and the displacement = 1900 Ton then the maximum KG value will be around 8.75 meters so the KGmax value / H = 1.21, where this high value is unlikely to occur in the type of Multi Purpose Vessel Ship vessel with a moderate to heavy load weight.

By seeing the results of the Multi Purpose Vessel Ship ship limiting KG calculation as in the picture above which has a value above the 5,292 meter KG value for various ship laden conditions and displacement, it can be concluded that the Multi Purpose Vessel Ship ship design has a good limiting KG value unless the ship displacement is below 600 Tons

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5.0 CONCLUSION

Although there are several conditions of the KN value that are negative, but because this value occurs at a very high tilt angle (140-180 degrees), where this condition is not possible in real Multi Purpose Vessel Ship, it can generally be concluded that the overall KN value shows good and normal value occur in almost all ships in general.

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