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Analysis of Stability, Resistance, and Seakeeping Accord to Dimension and Form of Fishing Vessel 10, 20, 30 GT

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Abstract**—**Fishing vessels used to catch resources from the sea has to pass some of the regulations from International Maritime Organization for sea-worthiness of the vessel especially about stability, resistance to acquire the highest velocity, and the vessel's motion. This research discusses the effect of the vessel's dimension and the hull shape by using the stability standard from IMO.

The result shows that the ratio of the B/T which meets the stability criteria is 2.50 with the ratio of KG/H of the vessel is 0.65, with the assumption that the KG and H of the vessel are more than 0.70. Whereas if the resistance ratio B/T is big, the resistance for the vessel will be relatively smaller. In terms of the vessel motion, a vessel with a V-type hull will better than a U-type hull in seakeeping.

Keywords—Fishing Vessel, Stability, Resistance, Vessel Motion, Hull Type

I. Introduction

Fishing vessels are ships used in fisheries activities that include capture or collection activities of aquatic resources, management of aquatic resources, and use in research work, training and inspection of water resources (Nomura & Yamazaki, 1977). In an effort to preserve fish resources and sustainability of fishing business, Indonesia is committed to implement Code of Conduct for Responsible Fisheries (CCRF).

In the early stages, designing the determination of principal dimension and geometric characteristics related to performance problems (resistance and propulsion) as well as those related to safety issues (stability, strength, and maneuvering) should be predictable. Preliminary predictions can be made based on the ship's ratio (Phoels,1979).

Fishing vessels in Indonesia have different forms. Theoretically, the waters, where the vessel will be operated, and the method of operation of the fishing gear operated by the vessel, really affect the form of the ship's. For example, fishing vessels that operate fishing gear with static operation, are more useful if they have a U-type. This is caused when the ship begins the operation. Ships are more in a state of silence in the middle of the waters. This condition resulted in the influence of external factors. In this case, ocean waves, are very dominating the variety of ships in the sea. Therefore, ships that operate static fishing gear need high stability.

It can be said that the form of hull is one of the technical factors that contribute to the success of the operation of the ships on the sea.

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Table 1. The Main Dimension of Fishing Vessel Sample

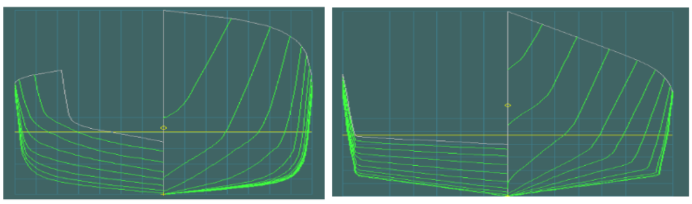
No	Main Dimension	Unit	10 GT	20 GT	30 GT
1	LOA	M	13,5	17	20
2	B	M	2,8	3,6	4,3
3	H	M	1,45	1,9	2
4	T	M	1	1,3	1,35
5	Fb	M	0,45	0,6	0,65
6	Cb U/V	-	0,518/0,428	0,548/0,549	0,61/0,551
7	B/T	-	2,8	2,76	3,18
8	Fb/B	-	0,16	0,16	0,15
9	Crew	People	7	7	12
10	Vs	Knot	9	9	9

In addition to that, some aspects of one important thing that needs to be considered, is about the ability of movement due to sea water waves in the waters traversed. This relates to the motion of the ship which is the response from the outside forces acting on the vessel. Movements caused by outer forces that work, or sea water waves will affect the safety and the comfort of the crew of the fishing vessel itself.

II. Experimental Set Up

This study uses fishing vessel samples that have different hull forms. In order to observe the effects of the ratio between the width and draft to the stability, the draft is varied with a fixed width. Variations of ships are carried out by taking 2 (two) smaller draft designs and bigger draft designs.

The same method is carried out to observe the effect of comparison between freeboard and the width of the ship. At each variation of the ratio, the ship's stability arm is calculated and evaluated by IMO stability criteria (IMO, 2008).



(a) (b)

Figure 1. *Body Plan* 30 GT (a) V- Type (b) U- Type

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The influence of superstructure on the arm of stability is not calculated. Based on the results of stability arm calculations and evaluation results on the IMO stability criteria, changes in characteristics of arm stability as a function of two major size comparisons can be obtained. The effects of the crew moment, the moment of the cycles, and the likelihood of a load shift when a ship with a large angle is calculated into this analysis.

III. Results and Discussion

Ratio Width and Draft

The result of the arm stability calculation for the sample vessel at each width and draft ratio is shown in Figure 2 – 4. The result of each arm stability for width/draft ratio is shown in the picture above. The six figures above show that increasing ratio of width and draft and arm stability will be even greater. It is seen from the six figures, that the higher the ratio has, the bigger area of arm stability is, for both a U-type and a V-type.

So the larger the width and the draft ratios are, the greater the stability arm is. This is similar to what is said by Daeng Paroka (2012). He says that if draft is smaller, the angle of the tilt (from the front side until the edge of the deck), that sinks into the water, will also increase. The width of the water line of the vessel will increase with increasing angle to the slope angle where the edge of the deck is immersed in water.

Compared Stability between a U-Type and a V-Type

The ratio used for this type of vessel is at the time of maximum draft design when the ship is sailing. Figure 5 shows that stability with hull of a U-Type is better than hull of a V-Type. Arm Stability for a U-type vessels has a larger area compared to a V-type vessels. This is due to the different shape of the cross section where the shape of the cross section U is wider than the shape of the cross section V. Therefore, the value of BM or radius metacentre at a certain angle becomes greater resulting in the arm stability which becomes greater. The value of the BM is influenced by the moment of greater inertia at a certain angle that causes the BM value to be large.

Influence of Width and Draft Ratio to Resistance

The results of the arm stability calculation for the sample vessel for each width and draft ratio are shown in Figure 2,3,&4. Each figure shows the smallest ratio that has a small resistance. This means that the larger the width and draft ratio are, the less resistance the ship will experience. Therefore, the small resistance of the vessel will make the vessel more efficient in conducting fishing operations.

This is due to the effect of named Wet Surface Area of the ship (Wetted Surface Area) becoming smaller along with the large ratio of width and draft.

If the WSA is small then the ship's resistance will be small, but if the WSA is big then the ship's resistance will get bigger. The size of the WSA is affected by the freeboard from the ship itself. WSA will be small if the freeboard arises large, but if the freeboard arises small then WSA will get bigger. This is also found in the formula developed by Holtrop, where WSA or S affects the value of the total resistance of the vessel itself.

Compared Resistance U-Type and V-Type

Figure 9 shows that the resistance of a U-type's hull is larger than a V-type's. This is due to the difference in cross-sectional shape in which the shape of the U-section is wider than the V-cross section.

Therefore, the value of WSA becomes bigger which resulted in resistance to be even greater. In addition to the WSA factor, the hull of a V-type ship is slimmer than a U-type. That is why a WSA V-type is smaller than a U-type ship. So in the case of resistance, vessels with a V-type is more suitable for catching operations considering this type more efficient than a U-type because it can save the fuel.

Ratio Center of Gravity and High Accord to Stability

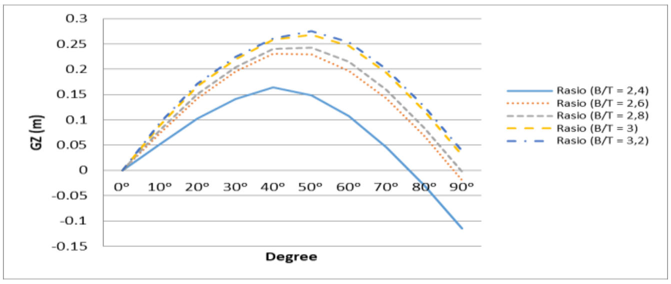
In the above two figures shows that the greater the ratio of the center of gravity and the height of the ship, the smaller the width and the levy ratio and the smaller the ratio of the weight and the height of the vessel, the larger the width and the ship's ratio.

At that time high KG is almost close to the height of the ship. It can be concluded that the more weight of the ship (KG) approaches the height of the ship (H) or when the ratio is 1 or the weight of the vessel exceeds the height of the vessel, the stability of the vessel becomes bad or not good seen from some criteria that do not meet IMO stability standards. This is due to the high weight of the ship that causes the value of GM from the ship decreased.

This shows that the value of KG is inversely proportional to the value of GM. If the value of KG is large or high, then the GM value is small or low. So even if the KG value is small or low, the GM value becomes big or high. GM value may change according to KG value. this shows that the value of KG is important in stability.

The maximum width and draft ratio that meets the stability criteria of a ship is also affected by the block coefficient of the vessel. The smaller the block coefficient, the larger the minimum width and levitative ratios required to meet the criteria of IMO stability, especially the slope angle at which the maximum stability arm occurs.

The minimum width and draft ratio that meets the stability criteria is 2.50 with the ratio of center of gravity and ship height equal to 0.65. If the minimum ship weight is 70 percent of the ship's height then the minimum ship width and height ratio should be greater than 2.50



(a)

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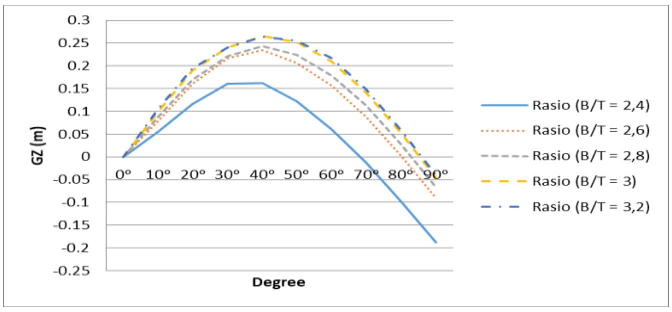
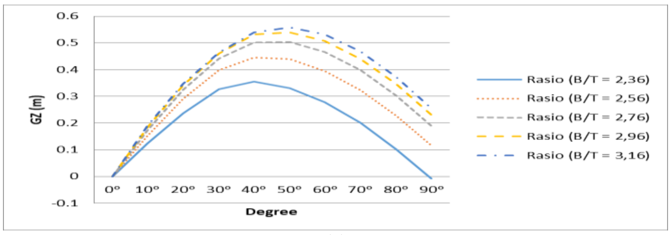


(b)

Figure 2. Arm Stability of 10 GT U (a) and V (b)



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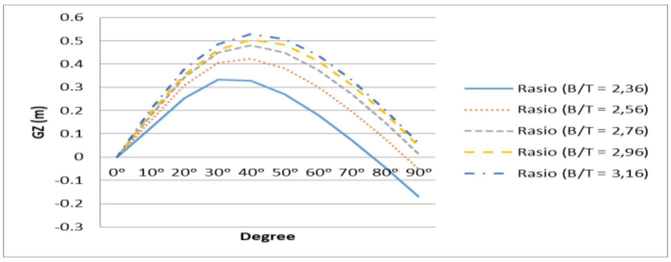
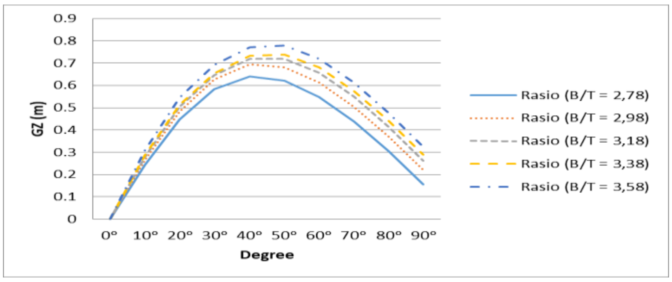


(b)

Figure 3. Arm Stability of 20 GT U (a) and V (b)



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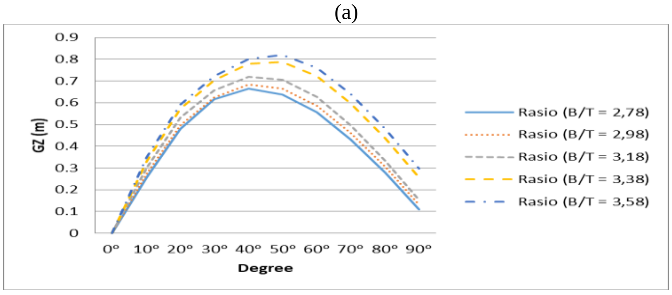
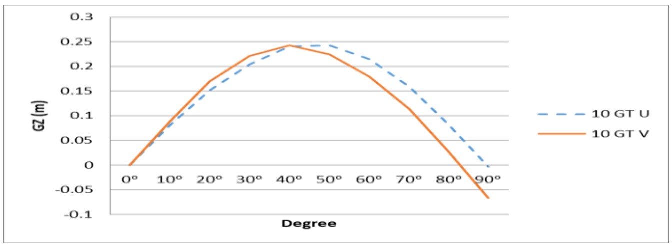


(b)

Figure 4. Arm Stability of 30 GT U (a) and V (b)



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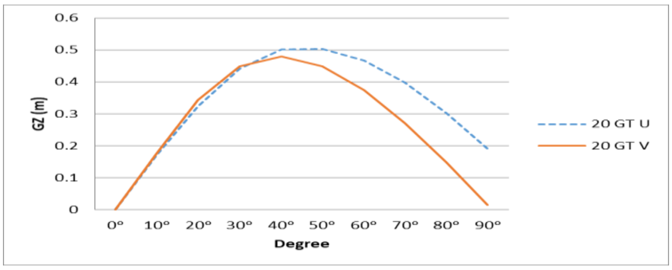

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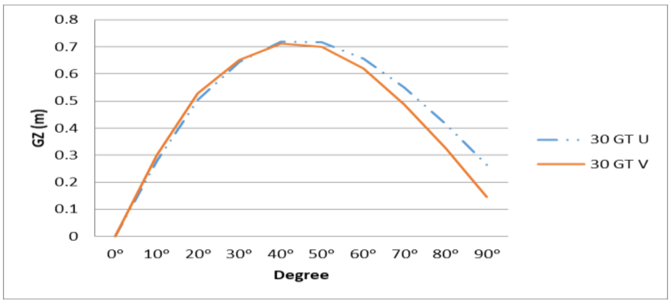
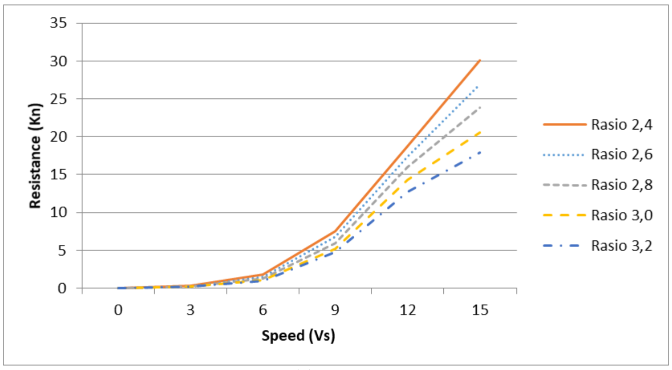
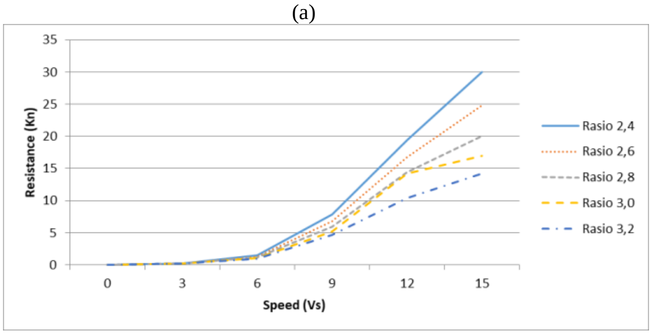


(c)

Figure 5. Compared arm stability of (a)10 GT, (b) 20 GT, (c) 30 GT



(a)



(b)

Figure 6. Resistance Vs Speed Curve on 10 GT (a) U Type and (b) V Type

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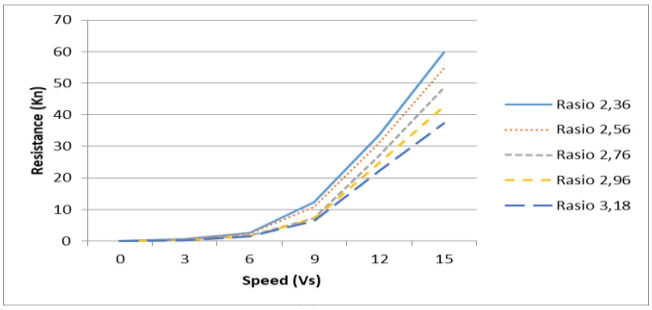
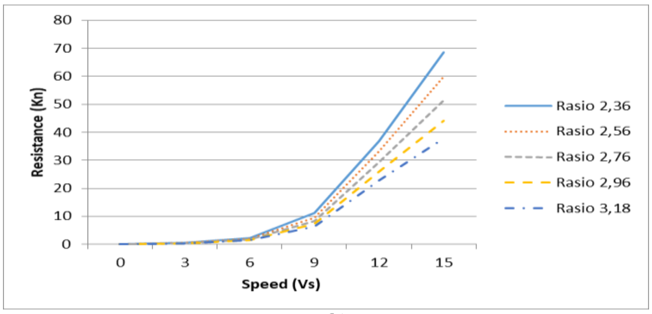
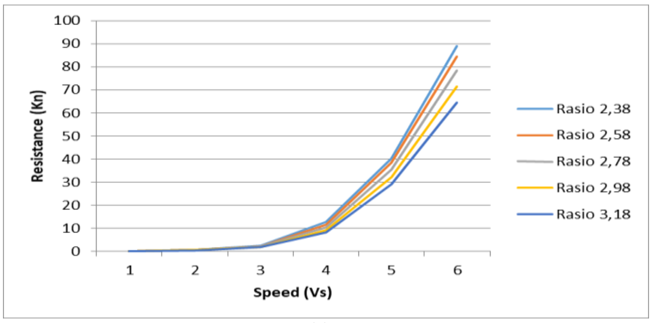


(a)

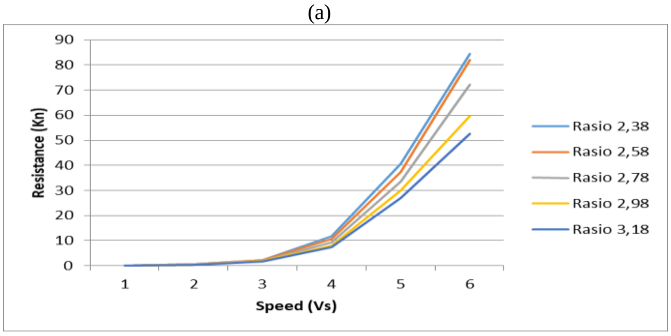


(b)

Figure 7. Resistance Vs Speed Curve on 20 GT (a) U Type and (b) V Type

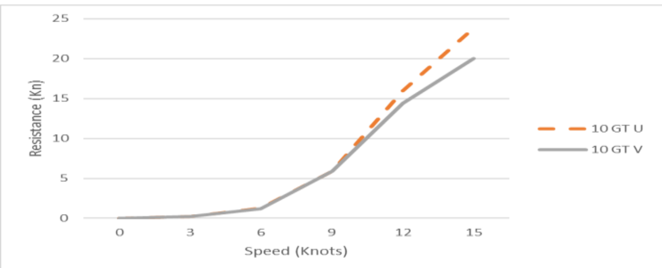


(a)

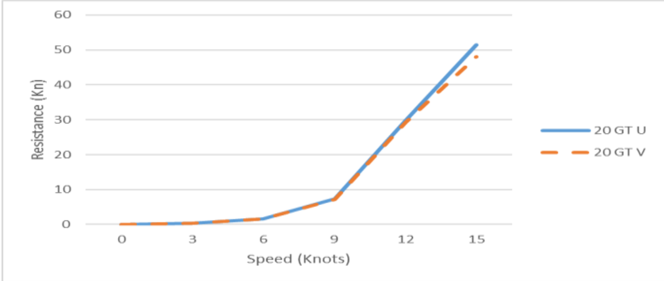


(b)

Figure 8. Resistance Vs Speed Curve on 30 GT (a) U Type and (b) V Type



(a)



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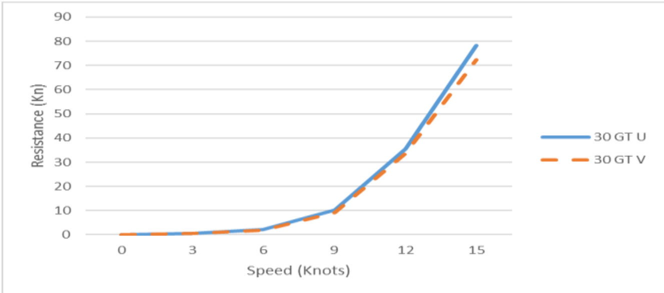
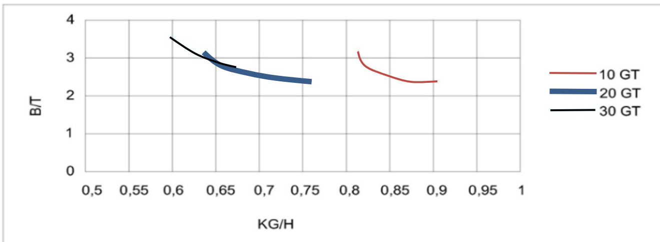
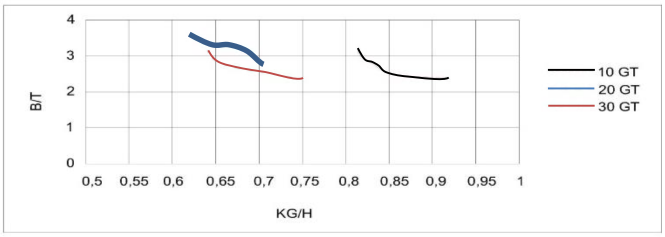


(c)

Figure 9. Compared Resistance Ships (a) 10 GT, (b) 20 GT, (c) 30 GT



(a)



(b)

Figure 10. Ratio KG/H (a) U Type and (b) V Type

Seakeeping Analysis

The table below shows the performance on the 10, 20, 30 GT type U and type V.

Table.2 *Seakeeping* on 10 GT (U) for *Following Seas*

a	b	c	d	e	f
0,5	0,031 & 0,032	0	0,68	0	Pass
1	0,061 & 0,063	0	1,39	0	Pass
1,5	0,092 & 0,095	0	2,05	0	Pass
2	0,122 & 0,127	0	2,73	0	Pass
2,5	0,153 & 0,159	0	3,41	0	Fail
3	0,184 & 0,19	0	4,09	0	Fail

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Table.3 *Seakeeping* on 10 GT (U) for *Beam Seas*

a	b	c	d	e	f
0,5	0,155 & 0,112	0,107 & 0,07	0,28	1,53	Pass
1	0,311 & 0,224	0,215 & 0,14	0,56	3,05	Pass
1,5	0,466 & 0,335	0,322 & 0,21	0,84	4,58	Pass
2	0,622 & 0,447	0,429 & 0,28	1,13	6,11	Fail
2,5	0,777 & 0,599	0,536 & 0,35	1,41	7,64	Fail
3	0,932 & 0,671	0,644 & 0,42	1,69	9,16	Fail

Table.4 *Seakeeping* on 10 GT (U) for *Head Seas*

a	b	c	d	e	f
0,5	0,276 & 0,471	0	0,55	0	Pass
1	0,553 & 0,942	0	1,10	0	Pass
1,5	0,829 & 1,412	0	1,65	0	Pass
2	1,105 & 1,882	0	2,20	0	Pass
2,5	1,381 & 2,354	0	2,76	0	Fail
3	1,658 & 2,825	0	3,31	0	Fail

Table.5 *Seakeeping* on 10 GT (V) for *Following Seas*

a	b	c	d	e	f
0,5	0,031 & 0,034	0	0,70	0	Pass
1	0,062 & 0,069	0	1,41	0	Pass
1,5	0,094 & 0,103	0	2,11	0	Pass
2	0,125 & 0,137	0	2,82	0	Pass
2,5	0,156 & 0,172	0	3,52	0	Fail
3	0,187 & 0,206	0	4,23	0	Fail

Table.6 *Seakeeping* on 10 GT (V) for *Beam Seas*

a	b	c	d	e	f
0,5	0,151 & 0,131	0,109	0,30	1,61	Pass
1	0,302 & 0,263	0,218	0,60	3,21	Pass
1,5	0,453 & 0,394	0,327	0,90	4,82	Pass
2	0,604 & 0,525	0,436	0,12	6,42	Fail
2,5	0,755 & 0,657	0,545	0,15	8,03	Fail
3	0,906 & 0,788	0,654	0,15	9,64	Fail

Table.7 *Seakeeping* on 10 GT (V) for *Head Seas*

a	b	c	d	e	f
0,5	0,265 & 0,521	0	0,58	0	Pass
1	0,529 & 1,041	0	1,16	0	Pass
1,5	0,794 & 1,562	0	1,74	0	Pass
2	1,058 & 2,082	0	2,32	0	Pass
2,5	1,323 & 2,603	0	2,89	0	Fail
3	1,587 & 3,124	0	3,47	0	Fail

Table.8 *Seakeeping* on 20 GT (U) for *Following Seas*

a	b	c	d	e	f
0,5	0,037 & 0,019	0	0,64	0	Pass
1	0,074 & 0,039	0	0,128	0	Pass
1,5	0,112 & 0,058	0	0,192	0	Pass
2	0,149 & 0,078	0	0,256	0	Pass
2,5	0,186 & 0,097	0	3,2	0	Fail
3	0,223 & 0,117	0	0,385	0	Fail

Table.9 *Seakeeping* on 20 GT (U) for *Beam Seas*

a	b	c	d	e	f
0,5	0,163 & 0,099	0,257 & 0,21	0,28	1,67	Pass
1	0,326 & 0,198	0,514 & 0,42	0,57	3,34	Pass
1,5	0,488 & 0,298	0,771 & 0,63	0,85	5,01	Pass
2	0,651 & 0,397	1,028 & 0,840	1,14	6,68	Fail
2,5	0,814 & 0,496	1,285 & 1,050	1,42	8,35	Fail
3	0,977 & 0,595	1,541 & 1,259	1,71	10,02	Fail

Table.10 *Seakeeping* on 20 GT (U) for *Head Seas*

a	b	c	d	e	f
0,5	0,276 & 0,410	0	0,52	0	Pass
1	0,553 & 0,82	0	1,04	0	Pass
1,5	0,828 & 1,23	0	1,56	0	Pass
2	1,106 & 1,640	0	2,08	0	Pass
2,5	1,382 & 2,050	0	2,60	0	Pass
3	1,659 & 2,460	0	3,12	0	Fail

Table.11 *Seakeeping* on 20 GT (V) for *Following Seas*

a	b	c	d	e	f
0,5	0,039 & 0,041	0	0,66	0	Pass
1	0,078 & 0,082	0	1,32	0	Pass
1,5	0,117 & 0,123	0	1,98	0	Pass
2	0,155 & 0,164	0	2,64	0	Pass
2,5	0,194 & 0,205	0	3,3	0	Fail
3	0,233 & 0,246	0	3,96	0	Fail

Table.12 *Seakeeping* on 20 GT (V) for *Beam Seas*

a	b	c	d	e	f
0,5	0,152 & 0,107	0,301 & 0,246	0,29	1,68	Pass
1	0,305 & 0,214	0,601 & 0,492	0,59	3,36	Pass
1,5	0,457 & 0,322	0,902 & 0,738	0,88	5,04	Pass
2	0,610 & 0,429	1,203 & 0,984	1,18	6,72	Fail
2,5	0,762 & 0,536	1,504 & 1,229	1,47	8,4	Fail
3	0,915 & 0,643	1,804 & 1,475	1,76	10,08	Fail

Table.13 *Seakeeping* on 20 GT (V) for *Head Seas*

a	b	c	d	e	f
0,5	0,251 & 0,437	0	0,52	0	Pass
1	0,502 & 0,874	0	1,04	0	Pass
1,5	0,753 & 1,311	0	1,56	0	Pass
2	1,004 & 1,748	0	2,08	0	Pass
2,5	1,255 & 2,185	0	2,60	0	Pass
3	1,506 & 2,622	0	3,12	0	Fail

Table.14 *Seakeeping* on 30 GT (U) for *Following Seas*

a	b	c	d	e	F
0,5	0,032 & 0,032	0	0,6	0	Pass
1	0,063 & 0,064	0	1,19	0	Pass
1,5	0,095 & 0,096	0	1,79	0	Pass
2	0,127 & 0,128	0	2,39	0	Pass
2,5	0,159 & 0,160	0	2,99	0	Pass
3	0,190 & 0,192	0	3,58	0	Fail

Table.15 *Seakeeping* on 30 GT (U) for *Beam Seas*

a	b	c	d	e	F
0,5	0,151 & 0,091	0,325	0,29	1,66	Pass
1	0,302 & 0,183	0,649	0,57	3,33	Pass
1,5	0,452 & 0,274	0,974	0,86	4,99	Pass
2	0,603 & 0,366	1,298	1,14	6,66	Fail
2,5	0,754 & 0,457	1,623	1,43	8,32	Fail
3	0,905 & 0,549	1,947	1,72	9,98	Fail

Table.16 *Seakeeping* on 30 GT (U) for *Head Seas*

a	b	c	d	e	f
0,5	0,234 & 0,375	0	1,48	0	Pass
1	0,468 & 0,749	0	0,95	0	Pass
1,5	0,703 & 1,124	0	1,43	0	Pass
2	0,937 & 1,5	0	1,9	0	Pass
2,5	1,171 & 1,873	0	2,38	0	Pass
3	1,405 & 2,248	0	2,86	0	Fail

Table.17 *Seakeeping* on 30 GT (V) for *Following Seas*

a	b	c	d	e	f
0,5	0,033 & 0,034	0	0,68	0	Pass
1	0,067 & 0,068	0	1,27	0	Pass
1,5	0,100 & 0,101	0	1,9	0	Pass
2	0,133 & 0,135	0	2,54	0	Pass
2,5	0,167 & 0,169	0	3,17	0	Fail
3	0,2 & 0,203	0	3,51	0	Fail

Table.18 *Seakeeping* on 30 GT (V) for *Beam Seas*

a	b	c	d	e	f
0,5	0,155 & 0,129	0,271 & 0,339	0,33	1,68	Pass
1	0,311 & 0,166	0,542 & 0,678	0,66	3,35	Pass
1,5	0,466 & 0,386	0,813 & 1,071	0,99	5,03	Pass
2	0,621 & 0,514	1,084 & 1,356	1,32	6,71	Fail
2,5	0,776 & 0,643	1,355 & 1,695	1,65	8,38	Fail
3	0,932 & 0,772	1,626 & 2,034	1,98	10,06	Fail

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Table.19 *Seakeeping* on 30 GT (V) for *Head Seas*

a	b	c	d	e	f
0,5	0,211 & 0,412	0	0,52	0	Pass
1	0,422 & 0,824	0	1,04	0	Pass
1,5	0,634 & 1,236	0	1,56	0	Pass
2	0,845 & 1,649	0	2,08	0	Pass
2,5	1,056 & 2,061	0	2,60	0	Fail
3	1,267 & 2,473	0	3,12	0	Fail

Information :
a : Wave Height (m)
b : RMS of Vertical Acceleration (at Working Deck AP & FP)
c : RMS of Lateral Acceleration (at Working Deck Ap & FP)
d : RMS of Pitch ; e : RMS of Roll and f : Status

As seen in the table above, pass means to meet the standard seakeeping and fail means not. This standard is according to Tello (2009). From 10 to 30 GT, both a U-type and a V-type average are able to operate well at 1.5 M wave height. In terms of stability, a U-type is better than a V-type seen from the table that RMS pitch and rolling a U-type meet the requirement from Tello (2009). But in term of ship motion or ship manuvering, a V-type is better than a U-type seen from the number of the table above. RMS pitch and roll a V-type are bigger than a U-type, which means a V-type has a big rolling period. In term of stability and comfort, a U-type is better than a V-type because of the small rolling period, but for ship motion, it is not good. In term of ship manuvering or ship motion, a V-type is better than U-type, but it is not good at stability and comfort.

IV. Conclusion

1. The greater the width and draft ratio of the vessel, the better the stability of the vessel because the maximum weight point that meets the criteria of IMO stability also becomes greater. The larger draft vessels will have better stability for the same width and draft ratios. The minimum width and draft ratio for fishing vessels is recommended not less than 2.50.
2. A U-type hull stability is better than a V-type.
3. The greater the ratio of B / T vessels, the smaller the resistance experienced by the ship. But, it happens only if the draft is used as the ratio modifier. Volume displacement also affects the resistance experienced by the ship because the smaller the volume the smaller the resistance and otherwise.
4. Hull resistance with a V-type is smaller than U-type.
5. Seakeeping vessels with V-type hulls are better than U-type hulls when being operated at the same wave height.
6. If we want to ship with good stability, choose a U-type but if want to ship with good manuver choose a V-type.

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