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COMPARATIVE STUDY OF ESTIMATED DRAFT AND RIGHTING ARM STABILITY FOR TRADITIONAL FISHING VESSEL UNDER LOADING

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ABSTRACT

The designed hull form of the ship may influence the stability of the ship floating in the water. The existing equipment may affect the operational performance of the ship in which the height of the draft of the ship controls the floating ability and comfortable stability. The purpose of this research was to obtain the stability data from the traditional fishing boat models with various standard sizes according to the ratio of width/draft (D /B). An optimal design output was computed to meet the various criteria required for the design using computational software. The resulting comparison of trim (TF or TA) showed that the movement of the point of gravity is relatively small. This indicates that the influence of ship movement and external forces either from sea waves or wind has a high enough on changes in the center of gravity. Therefore, the effect of using the (D/B) value ratio greatly determines the comfort and stability of the ship when operating to the fishing ground.

Keywords: fishing vessel, design, comparative, stability, traditional fishing.

INTRODUCTION

Each traditional fishing ship has a distinctive appearance of hull indicating the area of origin of shipping. The form of the hull ship is mainly considered as a part that relates to the existing ship design [1]. Especially in the Tambak Lorok area, Semarang, many traditional ships have been fabricated according to the hull design criteria for ship stability and capability. These criteria are commonly adopted in the hull design [2]. Several studies reported the comparative results of the estimated draft values of vessels in terms of the type of fishing boat according to its different fishing gear [3], [4].

Figure-1. Traditional fishing vessel.

Furthermore, the existing types of equipment can affect the operational performance of the ship so that the height of the draft of the ship must be adjusted for the ability of the ship to float and comfortable stability [5]-[7].

At present, traditional fishing vessels play an important role in the fishing industry including fishing, transporting, and storing fish [8], [9]. Increased shipping activity in the sea has also an impact on an increasing number of incidents. The high case of maritime accidents in Indonesia at that time should be the concern of all parties, not only the ship-owner but also Governments, relevant agencies, and communities to be more active in providing information [10].

Further analysis of fishing vessel accidents with Bayesian network and Chi-square methods, provided a relationship for each variable influencing accident of fishing vessels. In this way, the occurrence of accidents under various conditions could be predicted [11]. Correspondingly a significant relationship could be observed between the characteristics of the accident with the length of the ship, the age of the ship, and the performance of safety equipment on the ship's passengers [12].

The previous research in the Northern South China Sea area reported on the combined samples of four drift experiments for a new type of 20 m length fishing vessel. Results showed that a downward trend as the wind speed increased at 10 m- wind speed distribution, which provided an effect of resistance to the movement of the ship [13]. Accordingly, the coefficient change along with the wind speed should be considered in the calculation of the drift simulation in future studies [14].

Significantly, the size of the ship's shipping line can affect the rate of expansion of the ship, particularly ships with large cargo hold capacities. Ships may experience shallow water effects such as the bottom effect grounding, which affects the maneuverability and stability of the ship. Furthermore, the muddy layer effects on Ship's resistance and squat showed can be investigated by the Volume of Fluid (VoF) method through simulating the multiphase flow form for various variables. From several parameters of the bottom conditions of the waters, a resistance value could be varied depending on the depth of the submerged part of the hull. This investigation also can be completed by the performance analysis in the CFD method to simulate the movement of the ship resistance [15].

In contrast, the comparative methods for modeling ship hull roughness stability, and specific roughness function by selecting a suitable hull model for

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the CFD setting require more detailed surface characteristics such as hydrodynamic characterization of the hull lining and expected wastage [16]. Correspondingly, a comparison can be made for the ship design according to the size ratio D / B ratio, which relates to the stability performance of the ship.

Also, efforts have been made to prevent accidents on fishing vessels by preparing an ideal design ratio for varying main ship sizes. The previous research reported for designing small fishing vessels according to cargo conditions, the approximate height of the vessel and also the “displacement” of the ship's load on various types of fishing vessels. Here, comparative results on similar to gill nets, long liners, jigging in the South Korean sea under various conditions could be could be presented into one curve [17].

The purpose of this research was to obtain the comparative stability data from the development of traditional fishing boat models with various standard sizes according to the ratio D / B ratio. The method was designed to produce an optimal design output and meet the various criteria required by the data of the comparative method, and the design and calculation of criteria using computational software.

MATERIAL AND METHOD

Theoretical Basis

The ship model examined in this study was a traditional fishing boat type, in which the comparative method focussed on its main size of vessels transporting commonly in many shallow sea areas. This type of ship was here considered the most economical for daily operations, in particular a monohull shape and slimmer one. However, the design comparison considered the type of fishing gear in the traditional fishing boat. The more fishing ground coverage area of the planned traditional fishing boat provided the more logistics that can be carried. This condition affects the ratio of the main size of the ship, especially on the width (B) and draft (D) of the ship (Table-1).

Table-1. Main size ship design.

Dimension	Value
Lwl	12.58 m
B	3.02 m
T	1.7 m
Wetted Area	184.358 m^2
Displacement	35,05 ton
Volume (displaced)	34.20 m^3
CB	0.53
L/B	4.16
B/T	1.77

From the ship size data, the ratio of the main size of the ship could be computed. Furthermore, this data was modeled into a traditional ship design by variations in the draft size section. Therefore, each model describes the different D / B ratio (Figure-2).

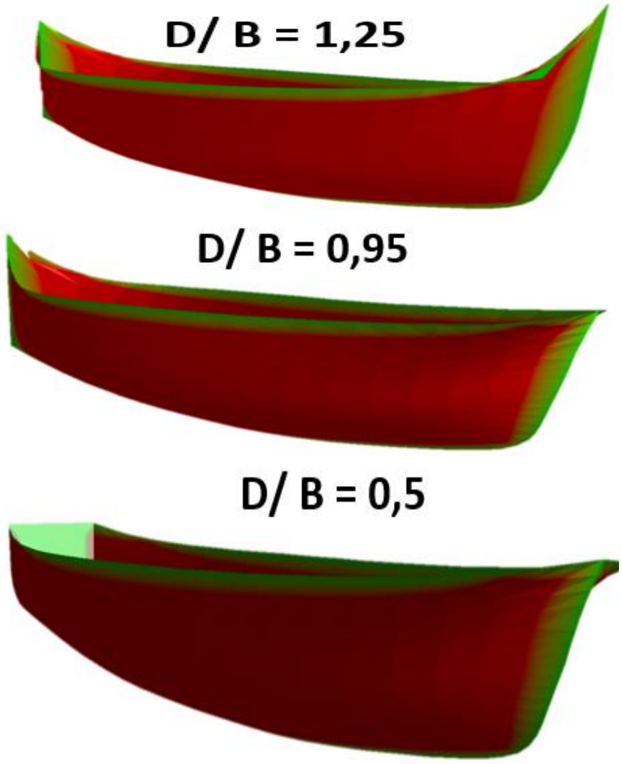

Figure-2. Representative traditional fishing vessel.

Specifically, ship sstability is a point of equilibrium, that the location of the point of gravity and Metacentra must be determined for the representation of the construction design of a ship. Here there is an approach for determining the location of the GM point as a representation of the initial condition of the ship or after being affected by sea waves[18]–[20]. The equation can be presented as follows:

$$GM = w\,.MB\sin x + w.(KB - KG)\,sin\,x \quad (1)$$

Where GM presents the distance from the point of Gravity to Metacentre; the value of w represents the weight of the ship; the value of MB is the distance from Metacentre to Buoyancy; the value of KB is the distance from Keel to Buoyancy; the value of KG is the distance from Keel to Gravity, and sin (x) is the angle formed from the tilt of the ship. Moreover, the value of w and the location of the ship's centre of gravity (LCG) was first determined so that the ship's stability was calculated according to its tilt angle and the made comparison [17]. The calculation of the value of w can be written in equation 2.

$$w = w_0 + \alpha(w_1 + w_2 + w_3) + \beta w_4 + \gamma w_5 \quad (2)$$

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Then the total LCG value can be determined using equation 2 correlating with the center of gravity distance [17]. This value could be formed in Equation 3 as follows:

$$LCG = [w_0.LCG_0 + \alpha(w_1.LCG_1 + w_2.LCG_2 + w_3.LCG_3) + \beta w_4.LCG_4 + \gamma w_5.LCG_5]/\,W \quad (3)$$

Furthermore, Buoyancy is one of the components influencing the position of the stability of a ship. So that the determination of the draft of the bow (TF) and the draft of the stern (TA) yields the condition of the ship experiencing a keel or trim event. These conditions can be calculated according to Equation 5.

$$Trim = TA - TF \quad (4)$$

Trim conditions can be computed from the difference between the stern draft and the bow draft, as presented in Equation 4.

$$TF'/\,TA' = Lb\,.\frac{w\,.l}{W_s\,.M_{lc}} \quad (5)$$

Where *Lb* is the distance to the buoyancy points formed; w is the weight of the ship; *Ws* is the displacement weight; and *Wlc* is the total weight after load has simulated displacement. Then this displacement value could be used to determine per draft condition so that the ship's ability to return to certain load conditions for GZ (Righting Levers) could be obtained with the angle of slope agreed upon in the IMO regulations, as presented in Equation 6.

$$GZ = MG \sin x \quad (6)$$

The resulting data from Equation 6 can be compared and presented so that the ability of the righting arm of the ship can be formed in certain conditions.

Research Methodology

In this method, the estimated stability and draft ship were computed by comparing traditional fishing boat models. Calculations of Equations 1 and 2 were helped using computer software to determine the ship's gravity point. The resulting data were subsequently used for calculations of Equations 5 and 6, and the obtained data were presented in graphical form to facilitate the analysis process.

Further parameters were examined in the calculation including the size of the ship's shape and the angle of the ship. In this case, the angle was presumably formed from 10^0 to 90^0. This angle represents every process of fishing activity by traditional fishermen, where the largest angle of 90^0 was considered to have a critical point in the ship's ability to return to its original position.

After forming a graph, an analysis and comparison of each model were then carried out according to the main size criteria of the ship, namely the comparison of the D/B value. The resulting value was compiled for subsequent analysis. Each graph was formed for representation of each of the main sizes of the ship, on which a diagnosis that describes the capabilities of the vessels could be available in shallow water areas. The research methodology is presented in Figure-3.

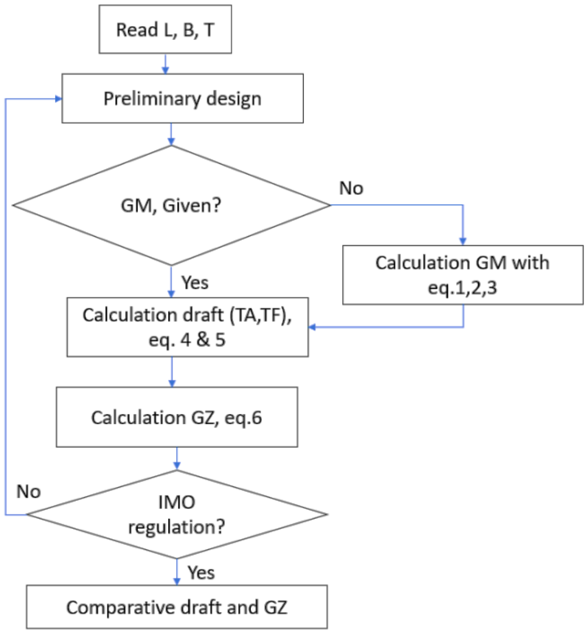

Figure-3. Method flow.

RESULTS AND DISCUSSIONS

In designing a fishing vessel for the Tambak Lorok sea area, a comparison vessel model with the same type of hull and hull shape was performed. The comparison vessel technical data were obtained from the literature. The main size of various vessel models was examined in determining the main size of the designed vessel. Accordingly, several comparisons of the main size of the ship were presented in the form of curves, while a comparison of the D / B values was made according to the size that was mostly obtained in the field, as shown in Figure-4.

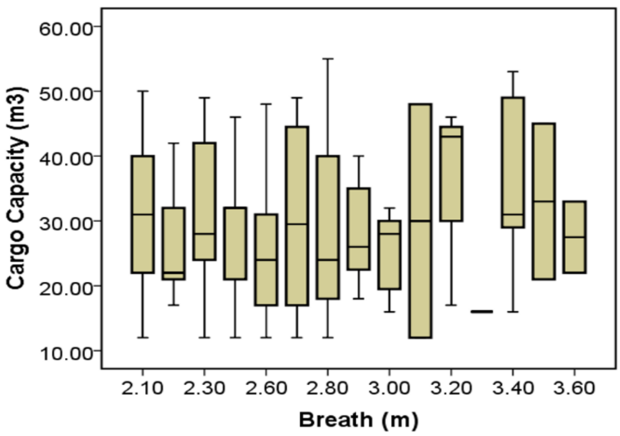

Figure-4. Distribution of the size of the ship's breath and cargo capacity.

From the main model of the D / B comparison ship, a calculation simulation was carried out using a mathematical formula of Equation 1 provides a comparison between the GM calculation results and the degree of rolling on a ship under full load (Figure-5).

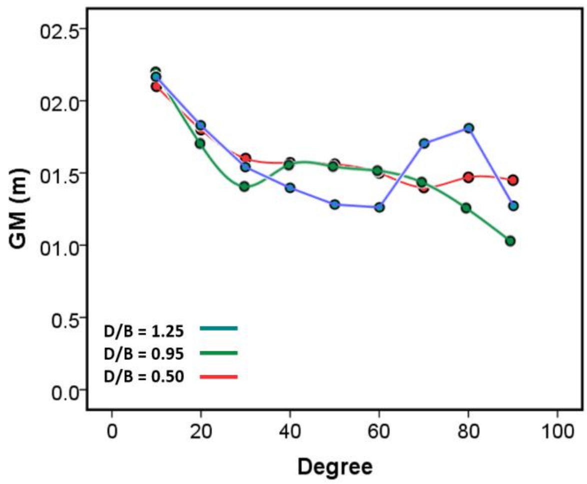

Figure-5. GM in full load condition.

It shows that the higher the draft of the ship made the location of the point of gravity at the angle of slope almost towards the maximum. If compared to the full charge position, the same part of the shift could be observed in the point of gravity. At GM's distance value of above 1 meter to 2.5 meters, there is still a limiting condition for the movement of the ship while rolling. Figure-6 presents the comparison of the cargo ship for empty load or lightweight.

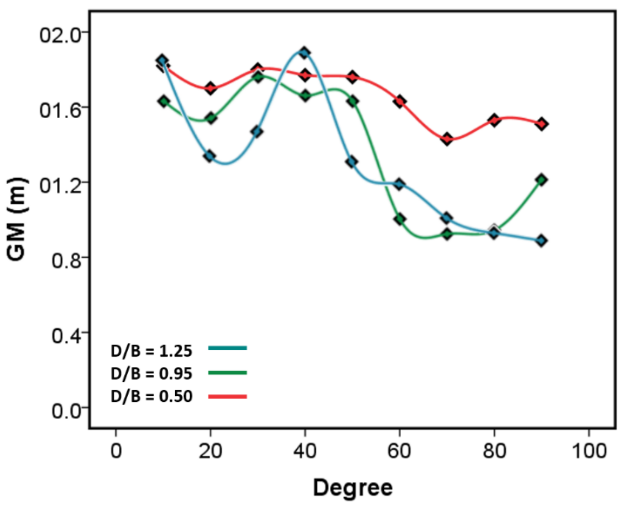

Figure-6. GM in lightweight condition.

It shows that varying GM conditions could be observed when the rolling angle reached above 20 degrees. Correspondingly the significant effect of the ship's operational related to the higher draft ratios. Conversely, conditions of slope angles above 60 degrees tend to decrease, indicating that the location of the point of gravity is quite stable and no significant changes. With the condition of the ship's full load, for comparison with this condition, the GM distance value ranges from 0.8 meters to 2 meters, indicating that there is still a limiting condition for the ship's movement during rolling. Figure-7 shows the condition of the ship to the fishing ground as compared to several models of D/B.

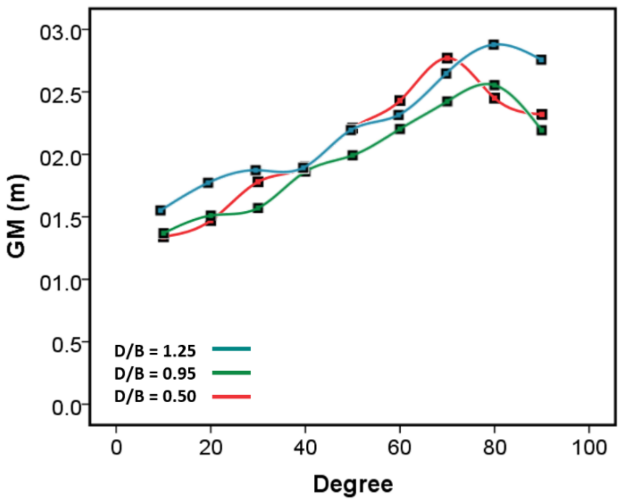

Figure-7. GM in fishing ground condition.

Correspondingly an increase in GM has resulted from the change in the location of the point of gravity along with its distance. The increasing GM trend is shown after the ship had experienced a rolling movement above 20 degrees to its peak at a rolling angle of 80 degrees. Apparently, each ship's draft changes resulting in the trend of GM increases. This condition indicates the external force and the activity of changing the movement, which also affects the stability of the ship, especially when the vessel is loaded and active in the fishing process. GM's distance value looks quite increasing, ranging from 1.2 meters to almost 3 meters, quite risky for the movement of the ship when rolling considering the maximum ship draft is not up to 3 meters.

An interactive estimation procedure from the comparison between the stern ship draft (TA) and the bow ship draft (TF) with the location of the point of gravity is presented in Figure-8. It presents an agreement between the position and condition of the ship. When the trim is in the full load condition, the movement of the gravity influenced the formation of the point load. Consequently, the trend of value in this distribution curve provided the smallest point of gravity displacement when the ship floated a bow trim as deep as 0.4 meters. An increase in changes in the value of gravity could be observed when the condition of the ship was fully loaded for the trim ranging from 0.1 to 0.4 meters.

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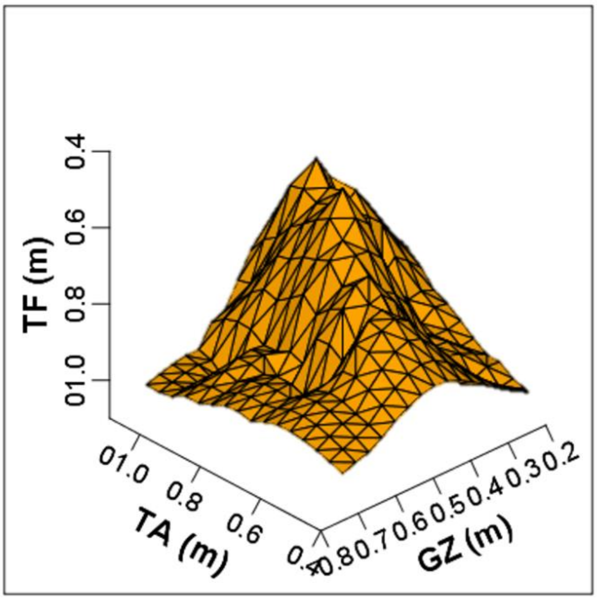

Figure-8. Distribution GZ according to TA and TF in full load condition.

Conversely, in the lightweight condition, the ship could be subjected to higher rolling or stability from external forces. Accordingly, the possibility of trim according to the readings of the ship's draft on the bow and stern is presented in Figure 9. Draft changes up to a range above 0.4 meters corresponding to the combined changes in the point of gravity, depicting relatively the same as full load conditions. The characteristic of the change obviously related to the depth of the draft.

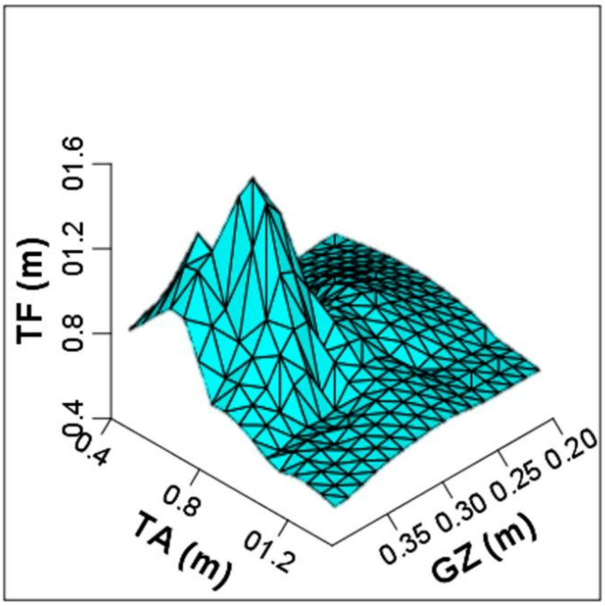

Figure-9. Distribution GZ according to TA and TF in the lightweight condition.

This condition is different when the ship is in operation to the fishing ground (Figure-10). In its operational state, the variations in the trim formed to give a relatively close shift in the point of gravity in the ranges from 0.2 meters to 0.35 meters. The results of the grouping of trim that occur in the condition of the main trim (TF) show that the movement of the point of gravity is not yet the highest. This gives an indication that the influence of ship movement and external forces, whether from sea waves or wind, has a high enough effect on changes in the point of gravity so that the effect of using the D / B value ratio greatly determines the comfort and stability of the ship when operating to the fishing ground.

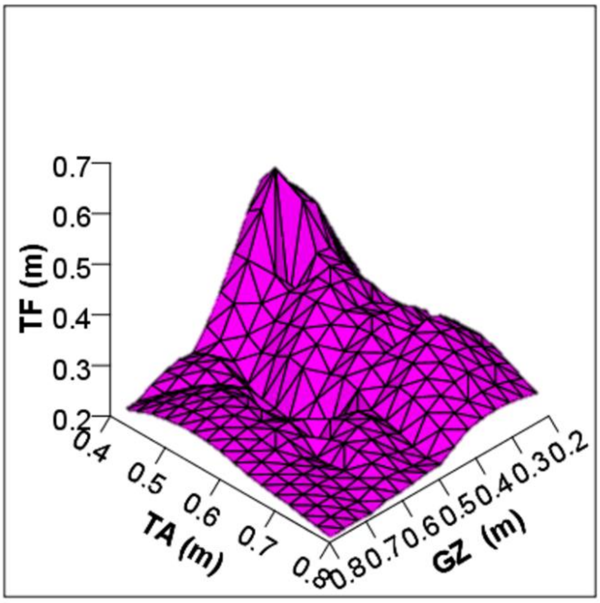

Figure-10. Distribution GZ according to TA and TF in fishing ground condition.

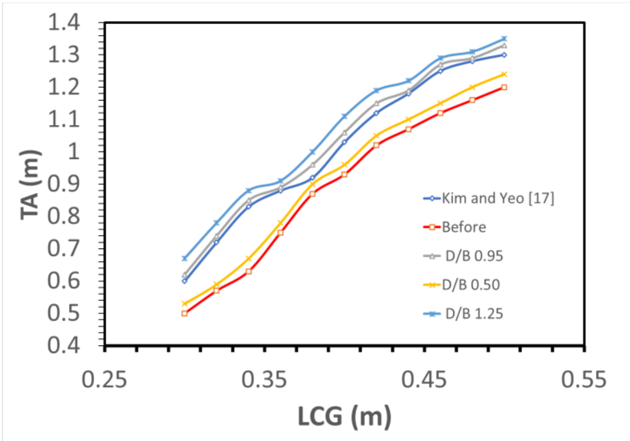

Figure-11. Comparison of after draft conditions to LCG in each ship design.

This comparison graph shows the location of the center of gravity from a range of 0.3 to 0.5 meters which shifts to the front or back of the midship, see Figure-11. Showing the characteristics of each ship model, the previous research model has a relatively small bow draft value, so that ship's movement can be depicted on a certain LCG, the depth of submerged draft is almost constant. When viewed from the shallow water ship model, it must have similarities, however, ships in the northern coastal waters of Java have a difference of 10-20% below that of South Korean regional vessels. Meanwhile, when compared with the D / B 1.25 ratio, it shows an increase in the value of the stern draft ship at the same LCG, this indicates an increase in the movement of the ship's trim draft. This can be due to the influence of shape fishing gear and the ship's hull design construction which is different in shape so that there are frequent trim conditions.

Figure-12 shows, the characteristics of each ship model, the previous research model has a relatively small stern draft value into it so that the movement of the ship can be described in a certain LCG, the depth of the submerged draft has an increased condition, namely in the LCG area 0, 35 -0, 4 meters. The trim condition at the stern indicates that there is optimal engine load performance, or the condition of the ship when it is heading to the fishing ground, this is indicated by the lifting of the bow and then stern that is submerged deeper. However, there is an 8-19% difference between local vessels and designs from South Korean shallow waters. When compared with the comparison design between the D / B 0.5 model then D / B 0.95 and D / B 1.25 shows that the increase in stern draft value of the ship is influenced by the same LCG position. The deeper immersed stern representation of the ship draft shows good performance and speed of the ship.

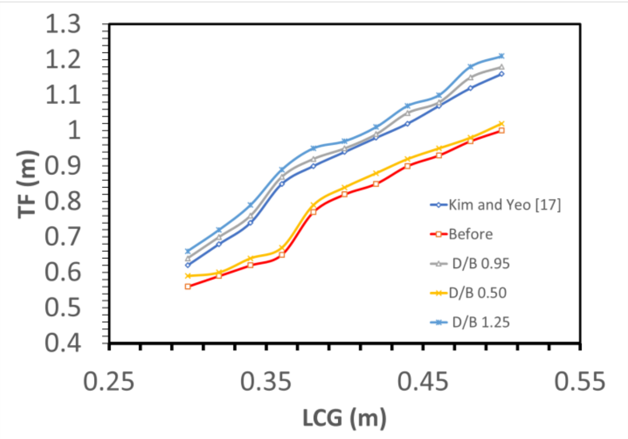

Figure-12. Comparison of fore draft conditions to LCG in each ship design.

CONCLUSIONS

The calculation of stability on a ship is very dependent on conditions and the location of the equilibrium point that occurs. The mathematical approach shows the ship model with the comparison of the D / B ratio showing an ideal form of representation from the Tambak Lorok area sea. The comparison of results shows that each D / B ratio was established to have the trend and character of each hull shape. The comparison also shows the stability of a ship that was affected by external forces and the components of the goods or the weight carried by ship. Apart from rolling ship motion, this can be used as a reference to determine righting arm trend (the ability of ship to return to its original position).

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