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WORD COUNT 3118

TIME SUBMITTED 18-JUL-2020 01:57AM

PAPER ID 61307842

Proceedings of the International Conference on Industrial Engineering and Operations Management, Pilsen, Czech Republic, July 23-26, 2019

The stability test of traditional fishing boats in East Java, Indonesia based on the International Maritime Organization Standard

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Abstract

East Java province is the one of shipbuilding industry cluster in Indonesia. Traditional fishing boats have been widely used by most fishermen in East Java. In this study, we aim to test the stability traditional fishing boats according to the International Maritime Organization (IMO) standard. The results show that there are four types of traditional fishing boats, namely: ijon-ijon, perahu, pursein, and ethek-ethek. The stability test shows that all these types of traditional fishing boats has confirmed to the IMO standard, except the ethek-ethek boat. In order to fulfill the IMO standard, the bilge keel can be used to modify the ethek-ethek boat.

Keywords
Traditional fishing boats, stability test, IMO standard, Indonesia

1. Introduction

Traditional fishing boats or wooden boats have been used widely by fishermen in East Java, Indonesia. Based on the survey, there are 4 types of traditional fishing boats in East Java, namely: ijon-ijon, perahu, purse seine, and ethek-ethek. These boat type names are adopted from the local language. Each boat has difference in the shape of pole, but has the same hull construction. The stability of these boats is necessary since there is a regulation from the International Maritime Organization (IMO) standard.

The study from Rizaldo et al. (2019) showed that roll the in-roll out ferry boat in Indonesia has fulfilled the intact and damage stabilities according to the IMO standard. Paroka (2018) studied the relationship between geometry and roll in-roll out ferry boat characteristics. The analysis revealed that the stability of the ship is linear to the width and ladder ratios. As the ratios are greater, the ship has been more stable. Wongngernyuang and Latorre (1989) studied the development of ship course stability diagrams for deep and shallow water with the influence of trim. Taury and Zakki (2018) discussed normal modes analysis of global vibration on traditional fishing boat with purse seine type in Batang regency, Indonesia. This study is motivated by their initiatives.

In this study, we aim to test the stability of traditional fishing boats with 4 types, namely ijon-ijon, perahu, purse seine, and ethek-ethek. All these vessel types are adopted from local language. We will use the standard of IMO for stability criteria. We use 3 types of load case measurement such as when the ship departs for sailing, the

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ship is sailing, and the ship is returning to the port. It is expected that all the stability tests criteria are fulfilled in these 3 types of load case measurement for each boat.

The remaining papers are organized as follows. Section 2 presents the literature review. Section 3 discusses the research methodology including the research stages and load case design measurement. Section 4 discusses the survey results of traditional fishing boats, the lines plan of sampling measurement, and the stability test of all the sampling. Finally, section 5 presents the conclusions, limitations, and future research directions derived from this paper.

2. Literature Review

2.1 The stability centre of the ship

The stability of the ship is the equilibrium of the ship. When it is floated, it is not tilted left or right. When the ship is lured by waves or wind in the sailing, the ship can re-erect. There are 3 centres of the ship stability, i.e.: the centre of gravity, the centre of buoyancy, and the centre of metacentric. Figure 1 shows the three centres of the ship stability. The centre of gravity, known as the point G of a ship, is the catch point of all forces pressing down on the ship. The location of the point G can be seen by reviewing all the weight divisions on the ship. The more weights placed at the top, the higher the location of the point G. The centre of buoyancy, known as point B of a ship, is the catch point of the resultant forces which press upright from the part of the ship that is immersed in water. The centre of metacentric, also known as point M of a ship, is a false point of the boundary where point G cannot pass over it so that the ship still has positive stability (Biran 2002).

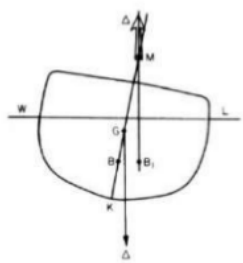

Figure 1. The position points affect the ship stability

2.2 The types of stability

There are three types of stability, namely: positive, neutral, and negative stability. Positive stability is a condition where the G point is above the point M. It means that a ship has a steady stability. When it is shaken, it must have the ability to re-erect. Neutral stability is a state in which the point G coincides with point M. The enforcement moment of ships that has a neutral stability equals to zero. It means that the neutral stability does not have the ability to re-erect when it is shaken. In other words, there is no the successor moment so that the ship stays tilted at the same shaken corner. It happens because there is too much load on the top of the ship. Negative stability is a state in which the G point is above the point M. A ship that has a negative stability does not have the ability to re-erect when it is shaken. Its shaken angle will increase caused the ship to tilt again and may even be reversed (Setiawan 2015).

2.3 The enforcement moment

The enforcement moment described in Figure 2 is the moment returns the ship to its upright position after the ship has tilted. It is because the outside forces are no longer working. The value of the moment of enforcement is directly proportional to the value of the GZ line. Therefore, the value of GZ can be used to measure the value of the ship stability. The calculation of the GZ value is as follows (Biran 2002):

Sin φ = GZ/GM
GZ = GM x sinus φ
The enforcement moment = W x GZ

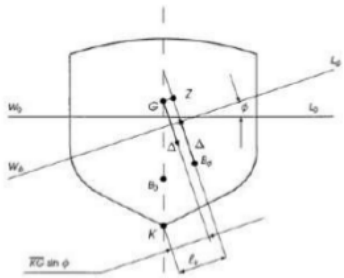

Figure 2. The enforcement moment

2.4 A GZ curve

The return arm plot, GZ, is a shaken function of 0, at the constant V value. Figure 3 is used to evaluate the stability of the ship under certain loading conditions (Santoso et al. 2016).

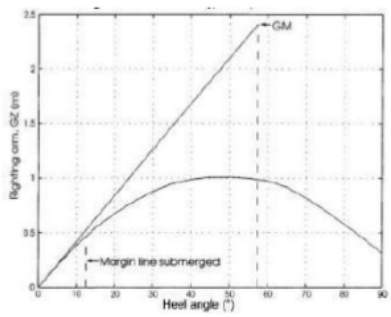

Figure 3. A GZ Curve

2.5 Criteria according to the International Maritime Organization (IMO)

A ship can be classified as having a good stability if it meets the requirements of a class. One example of an organization that publishes provisions on ship stability is the International Maritime Organization (IMO). IMO mentioned that the ship has a good value of stability if it meets the following (Resolution 1993):

a. The area under the GZ curve from 0 ° to 30 ° should not be less than 0.055 meters radians. Moreover, the area under the GZ curve to a slope of 40 °should not be less than 0.099 m-radians.
b. The area under the GZ curve between the angles of 30 ° and 40 ° cannot be less than 0.03 meters radians.

3. Research Methodology

3.1 Research stages

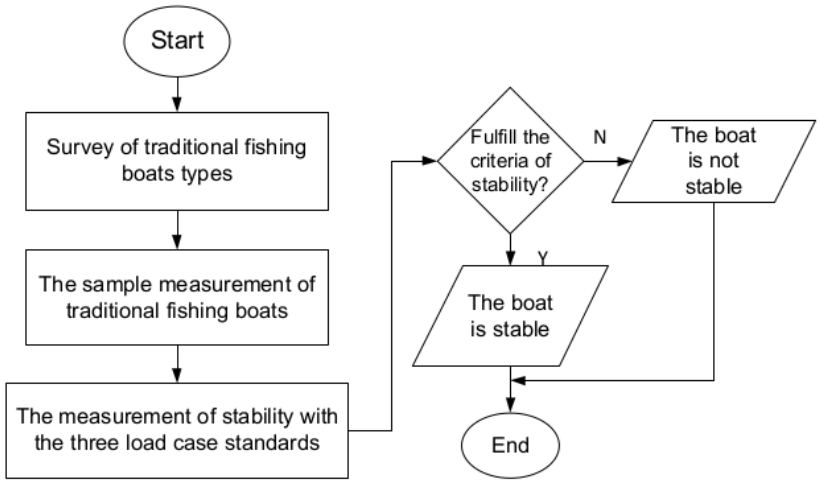

Figure 4. The research stages

Figure 4 shows the research stages in this study. Firstly, we did the survey of traditional fishing boats types. We found that there were 4 types of fishing boats, namely: ijon-ijon, perahu, purseine, and ethek-ethek. Secondly, we did the sampling of each types of boat. We chose the up straight boat located on the land to be measured accurately. Furthermore, we did test the stability measurement of traditional fishing boats using 3 criteria as described in Section 2.5. If the results fulfil all the criteria based on IMO standard, the boat is stable. Otherwise, the boat is not stable. Thus, the process will end.

3.2 Load case measurement

Load case measurement is the planning of weight distribution of various conditions of the sailing ship. The load case measurement is divided into 3 types, namely: the ship departs for sailing (empty cargo), the ship is sailing (50% load), and the ship is returning to the port (100% load). The Maxsurf software is used to calculate the ship stability.

Table 1. Load case measurement

Item	Load case 1	Load Case 2	Load Case 3
Load weight	0%	50%	100%
Fuel weight	100%	50%	20%
Logistics weight	100%	50%	20%
Ice blocks weight	100%	50%	20%
Fresh water weight	100%	50%	20%

Load case 1 is the distribution of the ship load when the ship departs for sailing. In the load case 1, we assumed that each of fuel, logistics, ice blocks and fresh water weight is 100%. Meanwhile, the load weight of fish is 0%. Load case 2 is the distribution of ship loads when the ship is sailing and has got fish. In the load case 2, we assumed

that each of the load of fish, fuel, logistics, ice blocks and fresh water weight is 50%. Load case 3 is the distribution of ship loads when the ship sails back to the port. In the load case 3, we assumed that each of the fuel, logistics, ice blocks and fresh water weight is 20%. Meanwhile, the load weight of fish is 100%.

4. Result and Discussions

4.1 The types of traditional fishing boat

Figure 5a: Perahu boat

Figure 5b: Purse seine boat

Figure 5c: Ijon-ijon boat

Figure 5d: Ethek-ethek boat

Figure 5a-5d show the traditional fishing boats at the front and the back sides in four types, namely perahu, purse seine, ijon-ijon, and ethek-ethek. All those types of vessel have U shape hull construction. The difference is on the shape of pole. Ijon-ijon, purse seine, and ethek-ethek do not have a taper pole. Meanwhile, perahu has a high taper pole (Praharsi et al. 2018).

4.2 The measurement result of traditional fishing boats

Figures 6-9 show the lines plan of ijon-ijon, perahu, purse seine, and ethek-ethek traditional fishing boats, respectively. The measurements of lines plan are processed to measuring the stability test in Table 2.

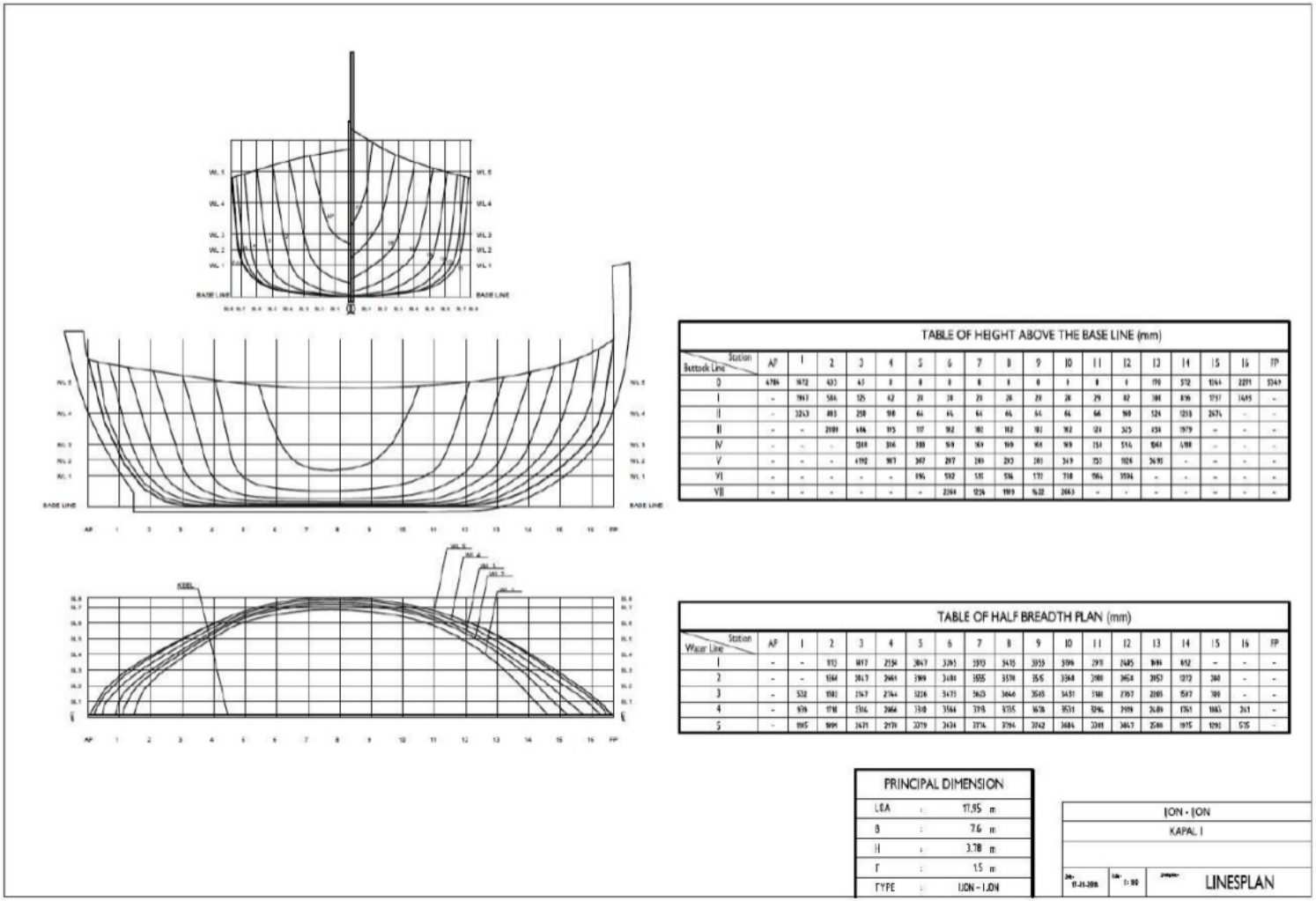

Figure 6. The lines plane of ijon-ijon type

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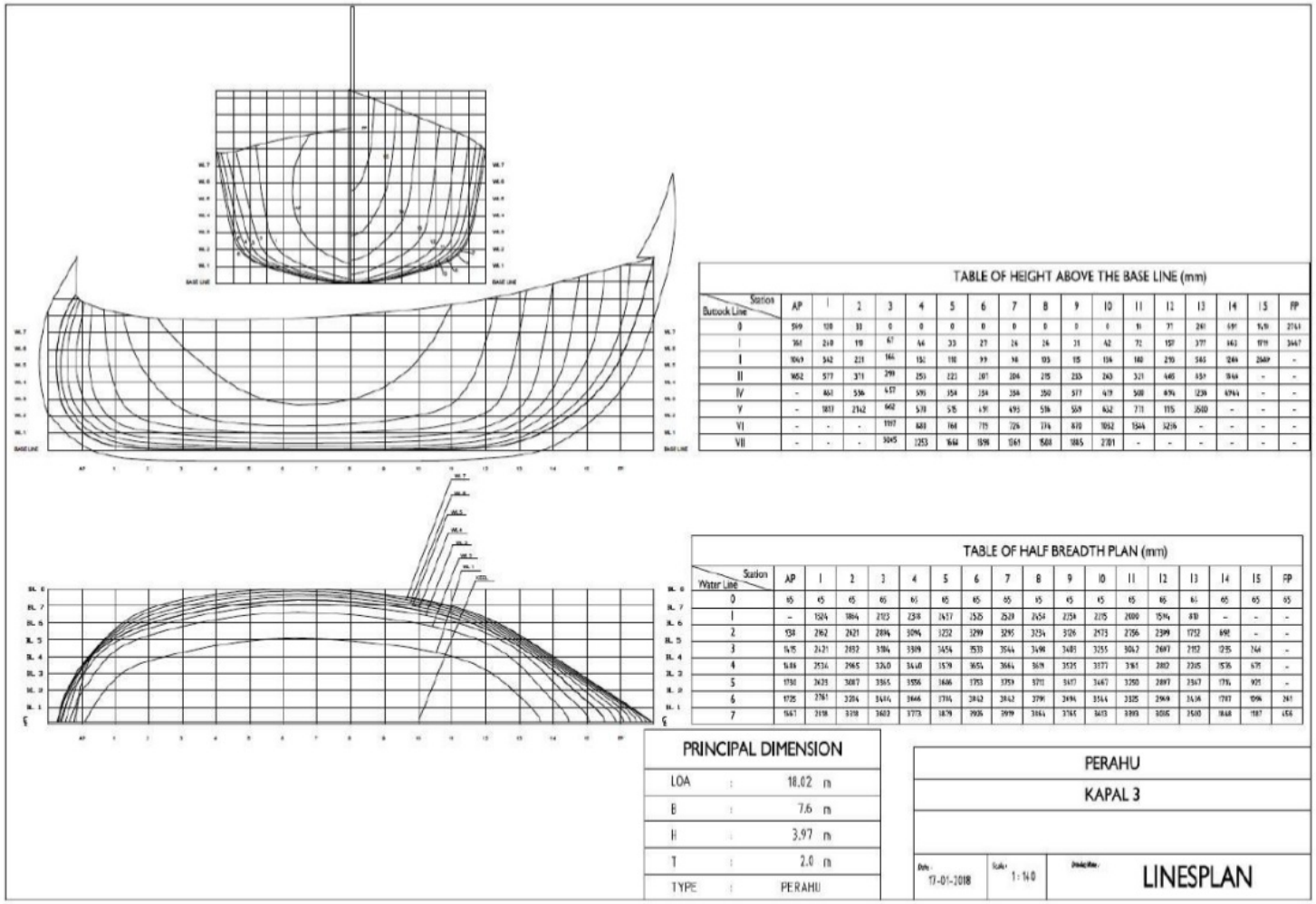

Figure 7. The lines plane of perahu type

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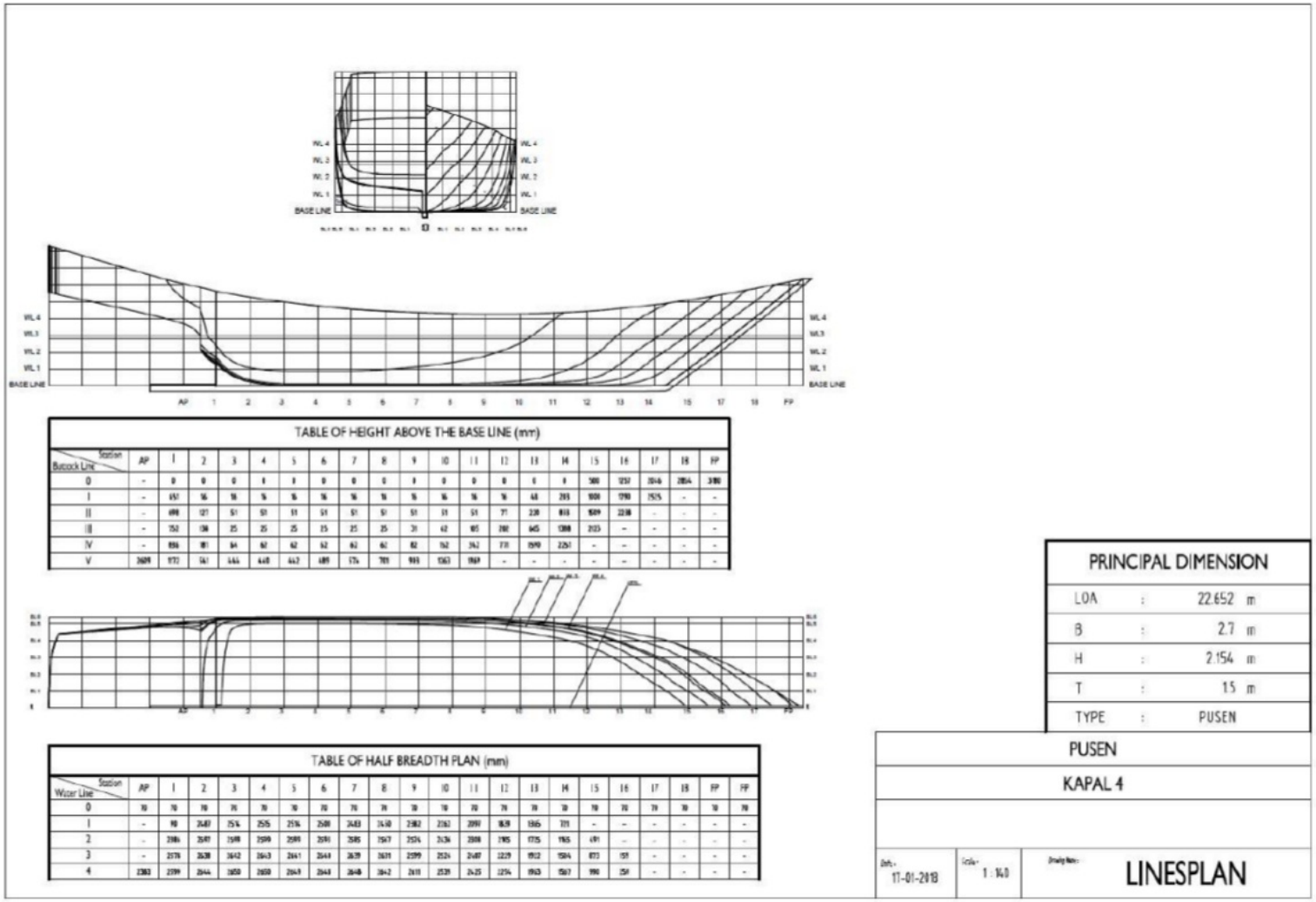

Figure 8. The lines plane of purse Seine type

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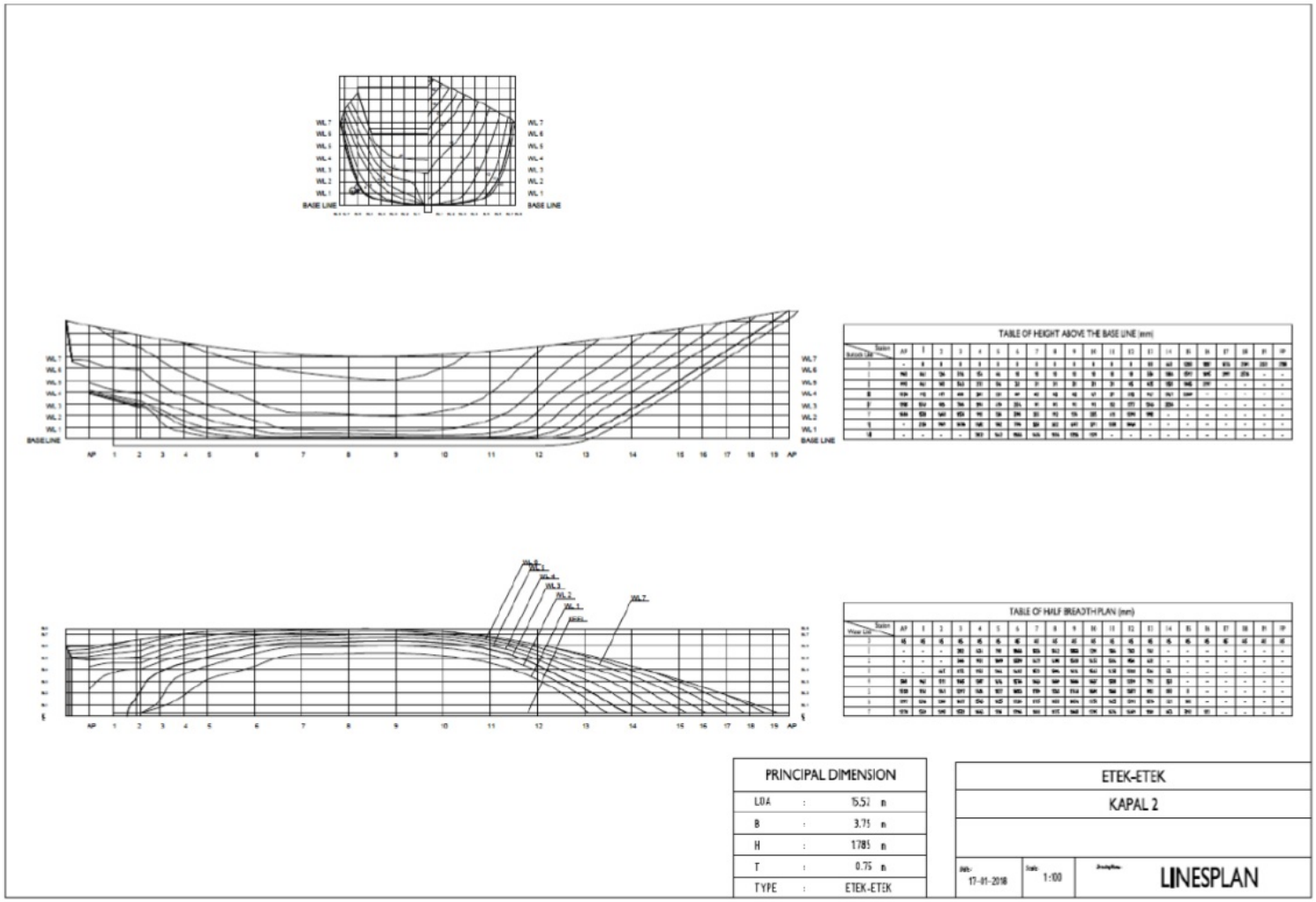

Figure 9. The lines plane of ethek-ethek type

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4.3 The measurement result of stability test

Table 2. The measurement results of stability test

The boat types / Tilted angle	Ijon-Ijon			Perahu			Purseine			Ethek-Ethek		
	Load case 1	Load case 2	Load case 3	Load case 1	Load case 2	Load case 3	Load case 1	Load case 2	Load case 3	Load case 1	Load case 2	Load case 3
0°-30°	0.291	0.272	0.236	0.267	0.259	0.244	0.304	0.303	0.290	0.059	0.068	0.054
0°-40°	0.456	0.439	0.390	0.437	0.428	0.410	0.488	0.484	0.468	0.106	0.116	0.086
30°-40°	0.165	0.166	0.153	0.169	0.168	0.165	0.184	0.180	0.177	0.046	0.047	0.032
Results	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	FAIL

The ijon-ijon, perahu and purseine boat types passed the stability test for load case 1, 2, and 3. All the criteria fulfilled the IMO standard, such as: 1) the tilted angle at 0°-30° is not less than 0.055, 2) the tilted angle at 0°-40° is not less than 0.099, and 3) the tilted angle at 30°-40° is not less than 0.03. Meanwhile, the ethek-ethek boat types did not pass the stability test in load case 3. Ethek-ethek fails the stability test because the area under the GZ curve from 0 ° to 30 ° is less than 0.055 meters radian. Moreover, the area under the GZ curve to a slope of 40 ° is also less than 0.099 m-radians.

5. Conclusion

The survey has found that there are 4 types of traditional fishing boats in East Java, Indonesia, namely ijon-ijon, perahu, purse seine and ethek-ethek. All those vessel types are adopted from the local language. Furthermore, the stability test of vessel types is based on the IMO standard. We use three kinds of load measurement for testing such as the ship departs for sailing (empty cargo), the ship is sailing (50% load), and the ship is returning to the port (100% load). The Maxsurf software is used to calculate the ship stability. The results showed that ijon-ijon, perahu, purse seine fulfilled the IMO standard criteria of stability. Meanwhile, ethek-ethek failed the stability test. The future research is designing the bilge keel to modify the ethek-ethek boat in order to fulfil the IMO standard.

6. Acknowledgements

This research was supported by Directorate General of Research and Development, Ministry of Research, Technology, and Higher Education, Indonesia under grant Basic Research in 2019, No. 1616.10/PL19/LT/2019.

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8. Biographies

Yugowati Praharsi is an Assistant Professor at Shipbuilding Institute of Polytechnic Surabaya, East Java, Indonesia. She earned B.Sc. in Mathematics from Satya Wacana Christian University, Indonesia; M.Sc in Electronic Engineering and Ph.D in Industrial and System Engineering from Chung Yuan Christian University, Taiwan. She has published national and international journals and conference papers. Her research interests are in the field of operation research, production system, quality management, and supply chain management.

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