The Stability Test of Traditional Fishing Boats in East Java, Indonesia based on the International Maritime Organization Standard

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WORD COUNT 3118 TIME SUBMITTED 27-NOV-2020 01:35AM
PAPER ID 65712452

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

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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 of 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 ladd 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).

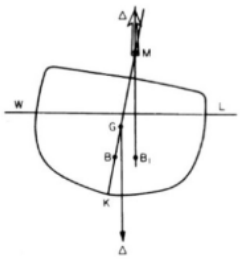

Figure 1. The position points affect the ship stability

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):

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

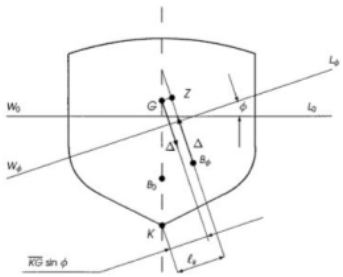

Figure 2. The enforcement moment

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).

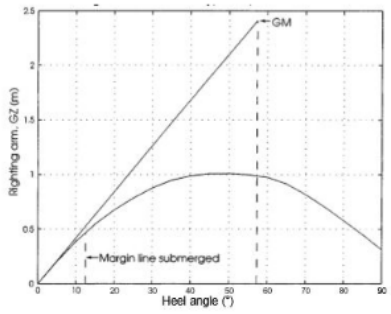

Figure 3. A GZ Curve

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.

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3. Research Methodology

3.1 Research stages

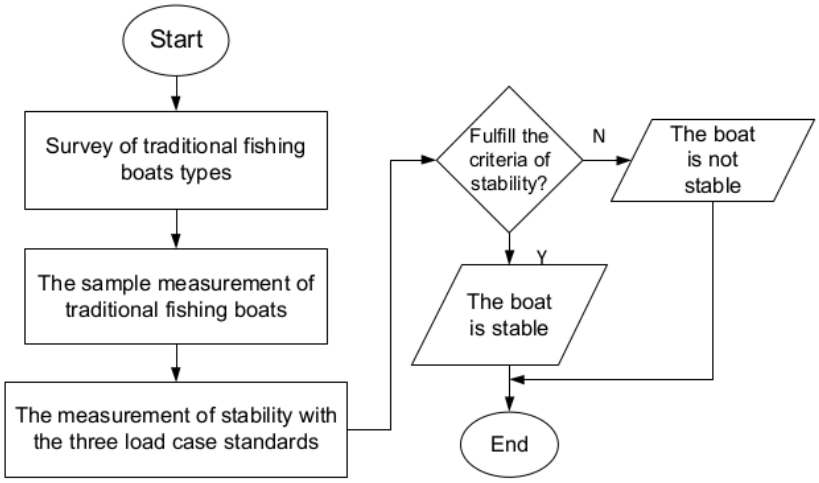

Figure 4. The research stages

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

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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.

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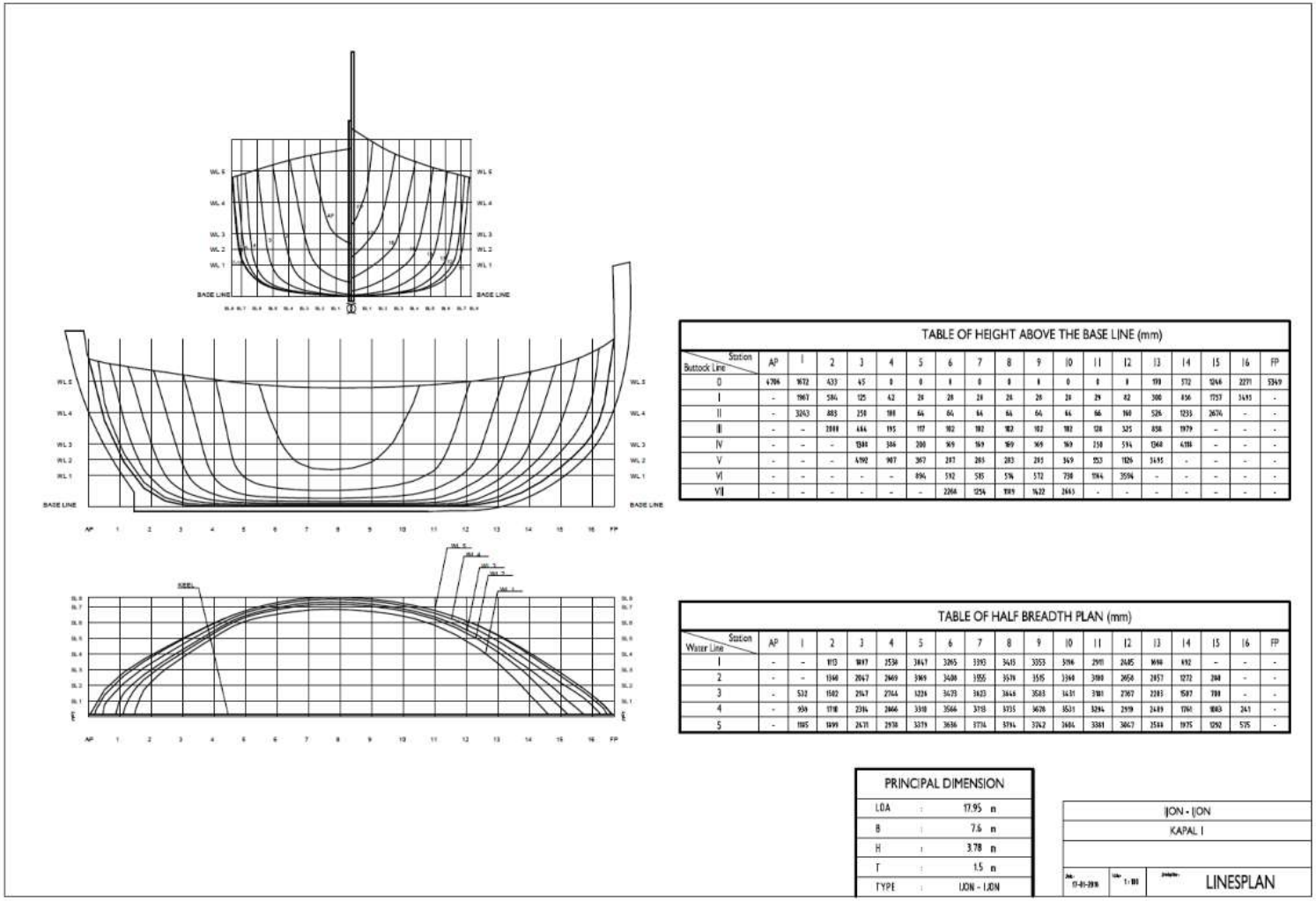

TABLE OF HEIGHT ABOVE THE BASE LINE (mm)

Station / Buttock Line	AP	I	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	FP
0	4706	1672	433	45	0	0	0	0	0	0	0	0	0	198	572	1266	2271	3349
I	-	1967	584	125	42	28	28	28	28	28	28	29	82	300	856	1737	3495	-
II	-	3243	885	258	108	66	66	66	66	66	66	66	160	526	1233	2674	-	-
III	-	-	2088	666	195	117	102	102	102	102	102	128	325	858	1979	-	-	-
IV	-	-	-	1388	386	200	169	169	169	169	169	250	594	1368	4186	-	-	-
V	-	-	-	4192	907	367	287	285	283	285	349	553	1126	3495	-	-	-	-
VI	-	-	-	-	-	896	592	585	596	572	738	1196	3596	-	-	-	-	-
VII	-	-	-	-	-	-	2266	1256	1189	1622	2643	-	-	-	-	-	-	-

TABLE OF HALF BREADTH PLAN (mm)

Station / Water Line	AP	I	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	FP
I	-	-	1113	1817	2538	3147	3265	3393	3415	3553	3596	2911	2485	1698	692	-	-	-
2	-	-	1340	2047	2469	3149	3406	3555	3579	3595	3360	3080	2656	2057	1272	284	-	-
3	-	532	1502	2147	2744	3226	3473	3623	3648	3588	3431	3181	2767	2283	1587	788	-	-
4	-	959	1718	2336	2866	3310	3566	3718	3735	3678	3531	3296	2919	2449	1761	1063	241	-
5	-	1195	1899	2471	2978	3379	3636	3774	3796	3742	3606	3381	3047	2568	1975	1292	575	-

PRINCIPAL DIMENSION		
LOA	:	17.95 m
B	:	7.6 m
H	:	3.78 m
T	:	1.5 m
TYPE	:	IJON - IJON

IJON - IJON
KAPAL I
LINESPLAN

Figure 6. The lines plane of ijon-ijon type

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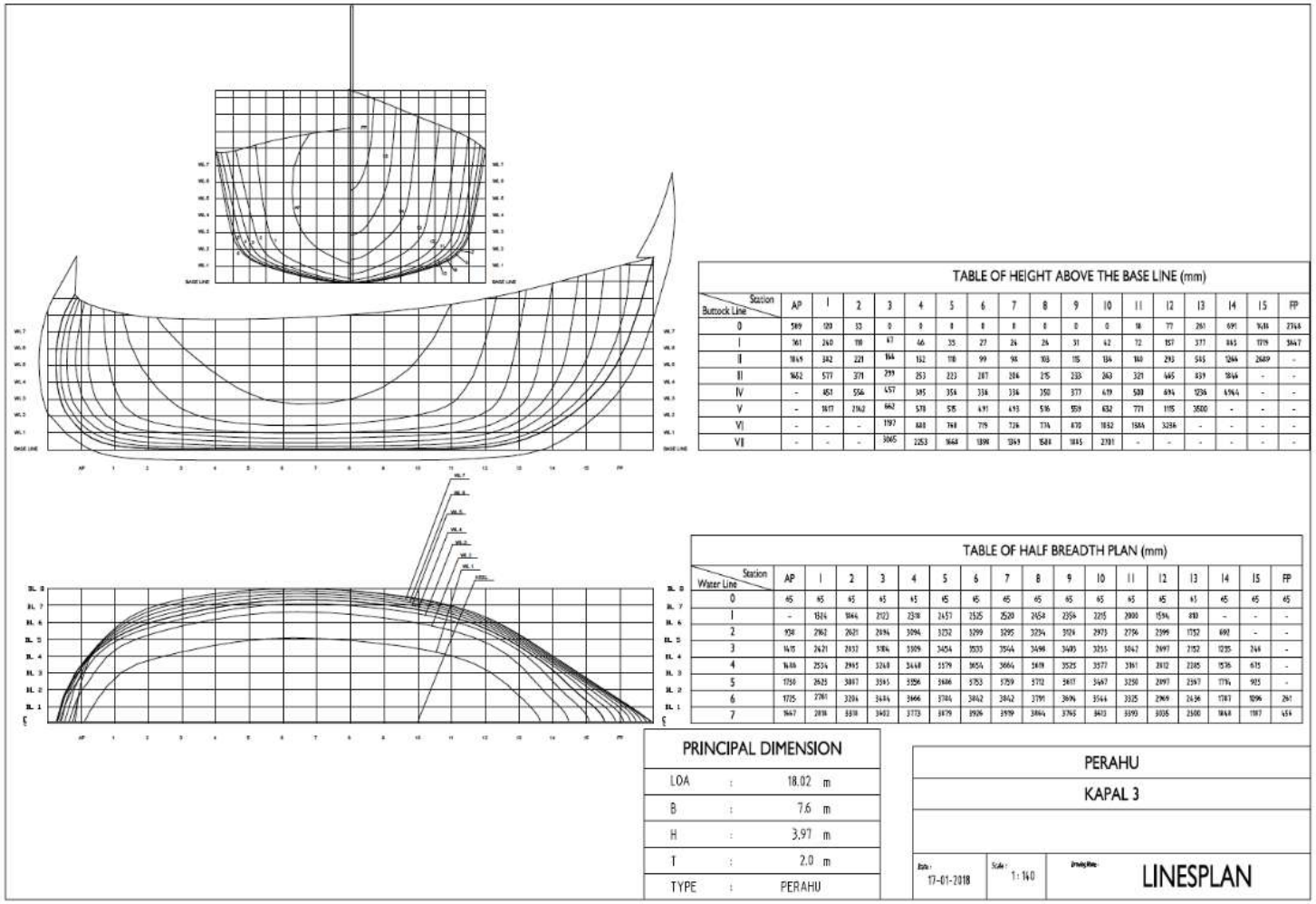

TABLE OF HEIGHT ABOVE THE BASE LINE (mm)

Station / Buttock Line	AP	I	2	3	4	5	6	7	8	9	10	11	12	13	14	15	FP
0	589	109	33	0	0	0	0	0	0	0	0	18	77	261	691	1631	2744
I	761	240	118	67	46	35	27	24	24	31	42	72	157	377	865	1779	3447
II	1069	342	221	164	132	110	99	98	103	115	134	160	293	545	1244	2689	-
III	1452	577	371	299	253	223	207	204	215	233	263	321	445	839	1846	-	-
IV	-	851	556	457	385	354	336	334	350	377	419	500	694	1236	6944	-	-
V	-	1617	1142	862	578	515	491	493	516	559	632	771	1115	3500	-	-	-
VI	-	-	-	1197	888	768	719	726	774	870	1062	1584	3286	-	-	-	-
VII	-	-	-	3065	2253	1668	1398	1369	1568	1845	2701	-	-	-	-	-	-

TABLE OF HALF BREADTH PLAN (mm)

Station / Water Line	AP	I	2	3	4	5	6	7	8	9	10	11	12	13	14	15	FP
0	65	65	65	65	65	65	65	65	65	65	65	65	65	61	65	65	65
I	-	1564	1944	2122	2318	2457	2525	2520	2458	2356	2215	2000	1594	810	-	-	-
2	938	2162	2621	2896	3094	3252	3299	3295	3234	3124	2973	2756	2399	1752	690	-	-
3	1415	2621	2832	3084	3309	3454	3533	3544	3498	3405	3255	3042	2697	2152	1235	244	-
4	1686	2534	2965	3268	3448	3579	3654	3664	3618	3525	3377	3161	2812	2285	1536	615	-
5	1750	2625	3007	3345	3556	3686	3753	3759	3712	3617	3467	3250	2897	2367	1776	925	-
6	1725	2701	3204	3484	3666	3784	3842	3842	3791	3694	3544	3325	2969	2436	1787	1096	261
7	1667	2816	3318	3402	3773	3879	3926	3919	3864	3765	3613	3393	3035	2500	1868	1187	454

PRINCIPAL DIMENSION

LOA	:	18.02 m
B	:	7.6 m
H	:	3.97 m
T	:	2.0 m
TYPE	:	PERAHU

PERAHU

KAPAL 3

Date : 17-01-2018 | Scale : 1 : 140 | Drawing Name : LINESPLAN

Figure 7. The lines plane of perahu type

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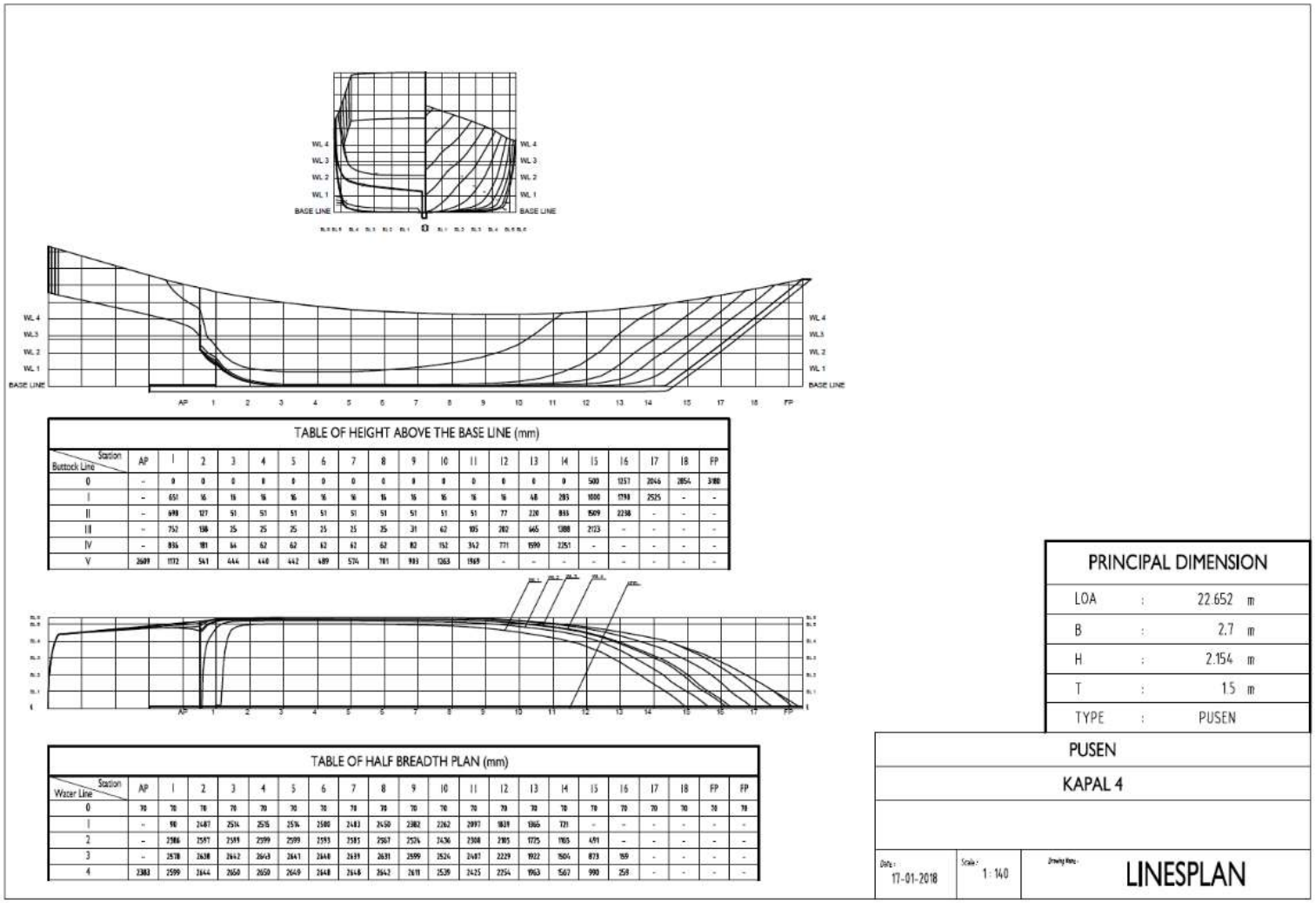

TABLE OF HEIGHT ABOVE THE BASE LINE (mm)

Buttock Line \ Station	AP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	FP
0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	1257	2046	2854	3188
I	-	651	16	16	16	16	16	16	16	16	16	16	16	48	293	1000	1798	2525	-	-
II	-	698	127	51	51	51	51	51	51	51	51	51	77	220	865	1509	2238	-	-	-
III	-	752	136	25	25	25	25	25	25	31	62	105	202	665	1388	2123	-	-	-	-
IV	-	886	181	64	62	62	62	62	62	82	152	362	771	1590	2251	-	-	-	-	-
V	2609	1172	561	444	448	442	689	574	781	993	1263	1969	-	-	-	-	-	-	-	-

TABLE OF HALF BREADTH PLAN (mm)

Wacer Line \ Station	AP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	FP	FP
0	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
1	-	98	2487	2514	2515	2514	2500	2483	2450	2382	2262	2097	1839	1366	721	-	-	-	-	-	-
2	-	2586	2597	2599	2599	2599	2593	2585	2567	2524	2436	2308	2105	1725	1105	491	-	-	-	-	-
3	-	2578	2638	2642	2643	2641	2640	2639	2631	2599	2526	2407	2229	1922	1504	873	159	-	-	-	-
4	2383	2599	2644	2650	2650	2649	2648	2648	2642	2611	2539	2425	2254	1963	1567	990	258	-	-	-	-

PRINCIPAL DIMENSION		
LOA	:	22.652 m
B	:	2.7 m
H	:	2.154 m
T	:	1.5 m
TYPE	:	PUSEN

PUSEN

KAPAL 4

Date : 17-01-2018 | Scale : 1 : 14.0 | Drawing Name : LINESPLAN

Figure 8. The lines plane of purse Seine type

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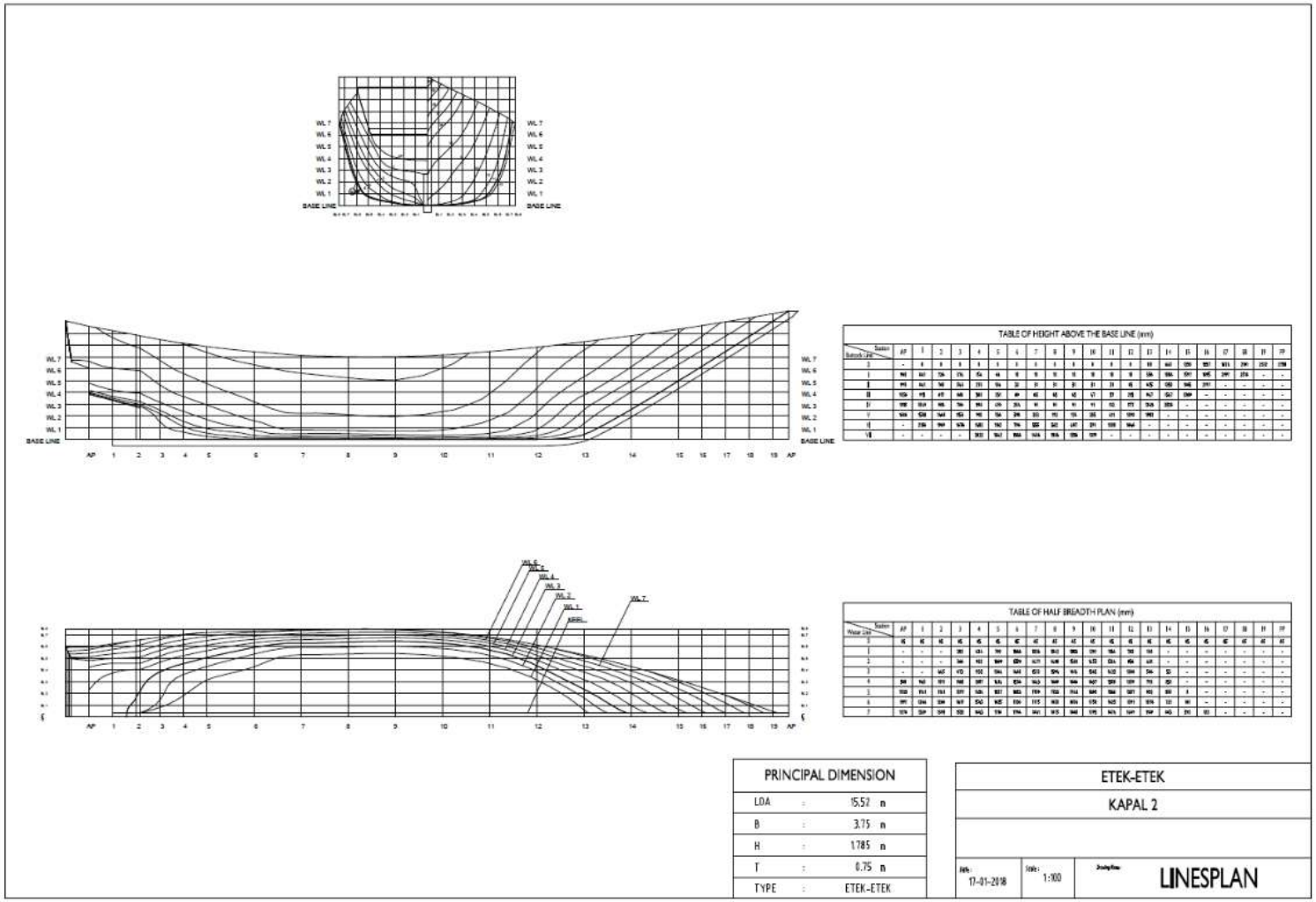

Figure 9. The lines plane of ethek-ethek type

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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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