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 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 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 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).

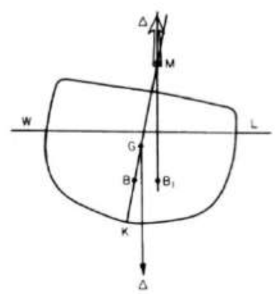


Figure 1. The position points affect the ship stability

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

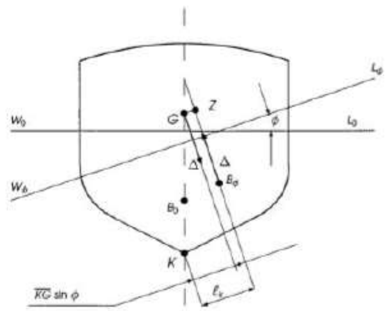


Figure 2. The enforcement moment

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).

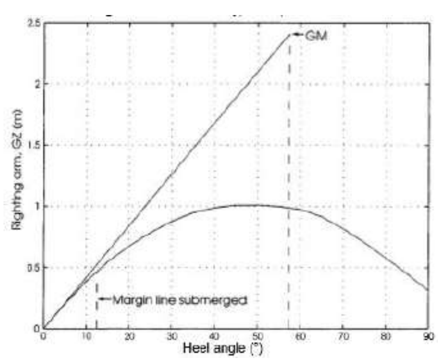


Figure 3. A GZ Curve

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

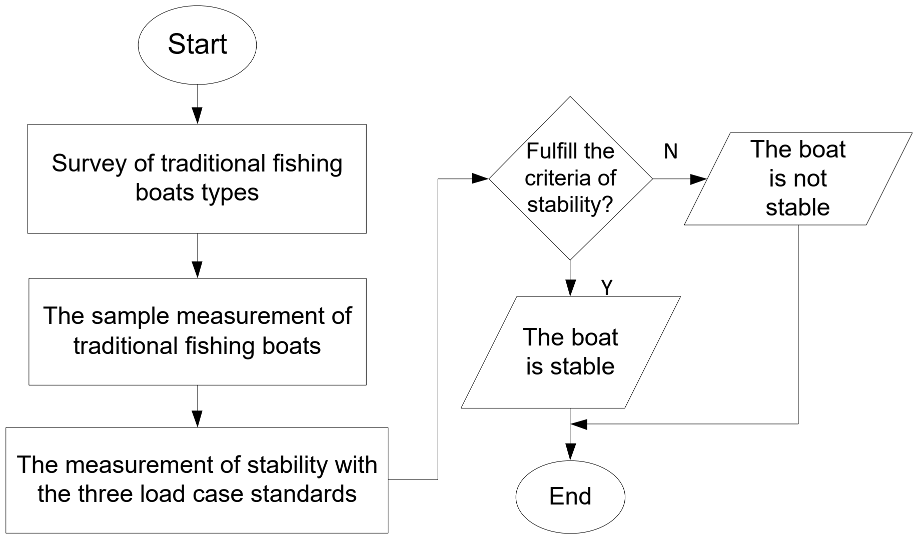


Figure 4. The research stages

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.

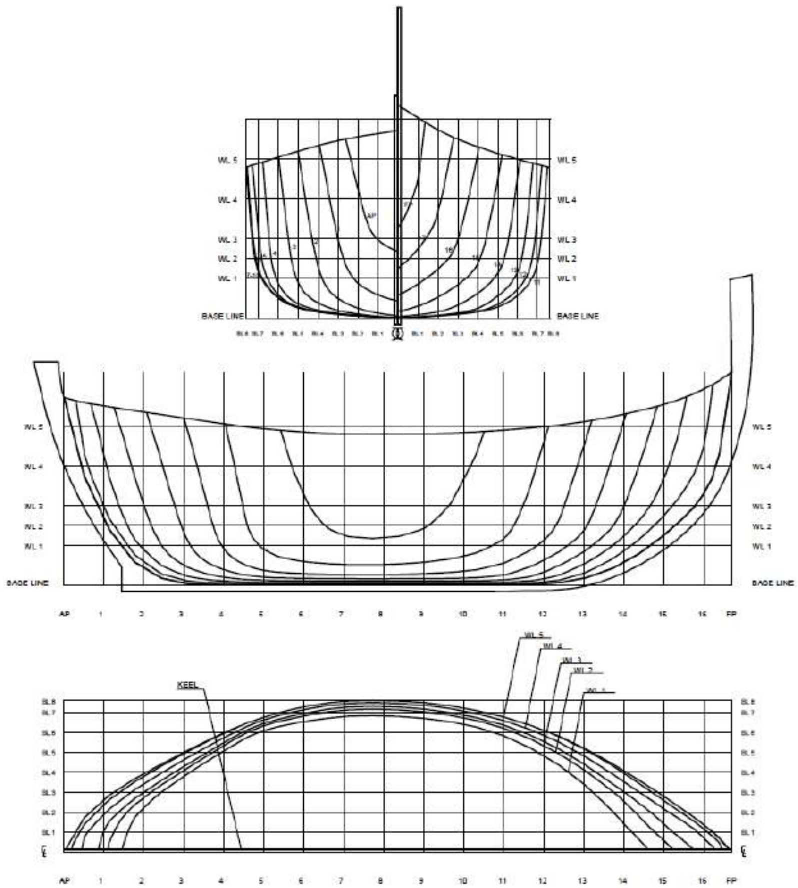


TABLE OF HEIGHT ABOVE THE BASE LINE (mm)

Buttock Line \ Station	AP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	FP
0	4786	1672	433	45	0	0	0	0	0	0	0	0	0	170	572	1244	2271	5347
I	-	1967	584	125	42	28	28	28	28	28	28	29	82	308	856	1737	3493	-
II	-	3243	883	258	190	64	64	64	64	64	64	66	160	524	1233	2674	-	-
III	-	-	2109	484	195	117	102	102	102	102	102	124	325	454	1979	-	-	-
IV	-	-	-	1388	386	300	169	169	169	164	169	254	514	1368	4118	-	-	-
V	-	-	-	4192	907	347	287	283	293	283	349	553	1126	3495	-	-	-	-
VI	-	-	-	-	-	896	592	515	514	572	730	1164	3594	-	-	-	-	-
VII	-	-	-	-	-	-	2164	1254	1189	1422	2663	-	-	-	-	-	-	-

TABLE OF HALF BREADTH PLAN (mm)

Water Line \ Station	AP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	FP
1	-	-	1113	1817	2534	3047	3265	3393	3413	3353	3196	2911	2405	1694	652	-	-	-
2	-	-	1364	2047	2461	3169	3408	3555	3578	3515	3368	3100	2658	2057	1272	280	-	-
3	-	532	1502	2147	2744	3226	3473	3623	3646	3583	3431	3181	2767	2203	1587	700	-	-
4	-	939	1718	2314	2464	3310	3566	3718	3735	3678	3531	3294	2919	2409	1761	1083	241	-
5	-	1165	1891	2471	2974	3319	3634	3774	3794	3742	3684	3381	3047	2588	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
17-01-2018 | 1:100 | LINESPLAN

Figure 6. The lines plane of ijon-ijon type

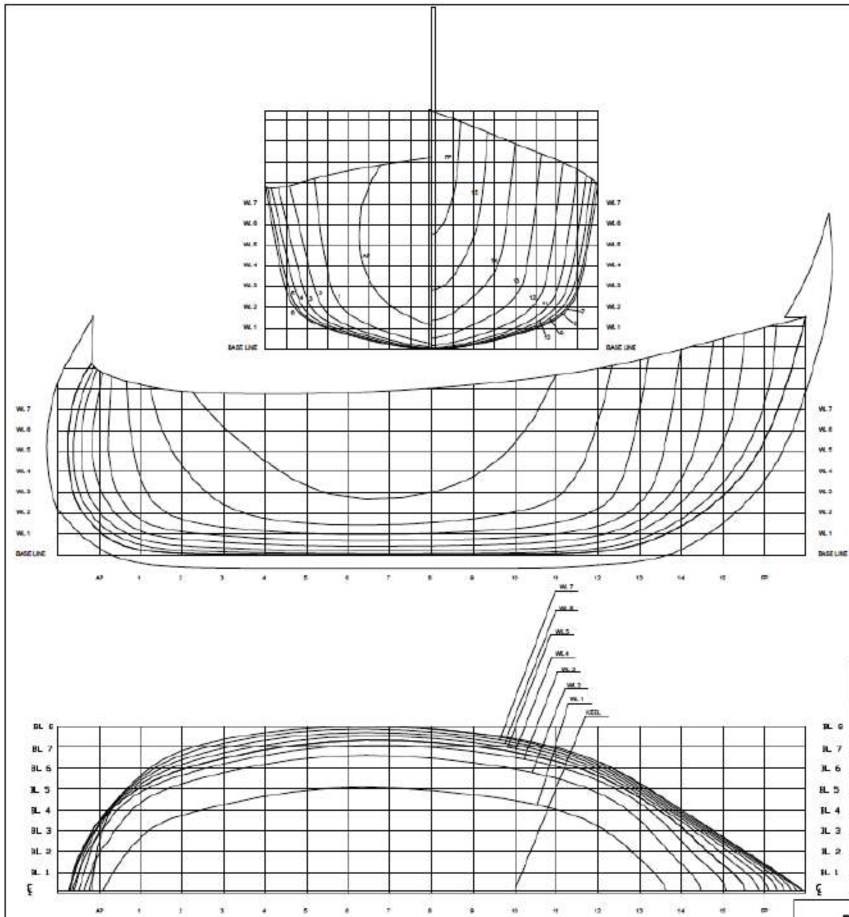


TABLE OF HEIGHT ABOVE THE BASE LINE (mm)

Buttock Line \ Station	AP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	FP
0	569	120	33	0	0	0	0	0	0	0	0	11	71	261	691	1418	2744
I	761	240	110	67	46	33	27	24	26	31	42	72	157	377	863	1711	3447
I	1049	342	221	166	131	110	99	98	103	115	136	140	293	585	1264	2689	-
II	1652	577	311	299	253	223	207	206	215	233	263	321	465	839	1846	-	-
IV	-	861	536	457	595	354	334	336	350	377	419	500	694	1236	4964	-	-
V	-	1817	2142	662	578	515	491	493	516	559	632	711	1115	3500	-	-	-
VI	-	-	-	1197	881	761	719	726	774	870	1052	1344	3236	-	-	-	-
VII	-	-	-	3045	2253	1664	1898	1861	1508	1885	2701	-	-	-	-	-	-

TABLE OF HALF BREADTH PLAN (mm)

Water Line \ Station	AP	1	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	65	65	65	65
1	-	1324	1864	2123	2318	2457	2525	2521	2454	2354	2215	2000	1594	810	-	-	-
2	938	2162	2621	2894	3094	3232	3299	3295	3234	3126	2173	2756	2399	1752	692	-	-
3	1415	2421	2832	3104	3309	3454	3533	3544	3498	3403	3255	3042	2697	2152	1235	244	-
4	1486	2534	2965	3260	3440	3579	3654	3664	3619	3525	3377	3161	2812	2245	1576	675	-
5	1730	2623	3087	3365	3556	3686	3753	3759	3711	3417	3467	3250	2897	2347	1714	925	-
6	1725	2761	3204	3444	3666	3784	3842	3842	3791	3694	3544	3325	2969	2436	1787	1096	261
7	1667	2818	3318	3602	3773	3879	3926	3919	3864	3765	3613	3393	3035	2500	1848	1187	456

PRINCIPAL DIMENSION

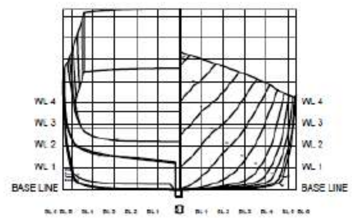
LOA	:	18.02 m
B	:	7.6 m
H	:	3.97 m
T	:	2.0 m
TYPE	:	PERAHU

PERAHU

KAPAL 3

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

Figure 7. The lines plane of perahu type



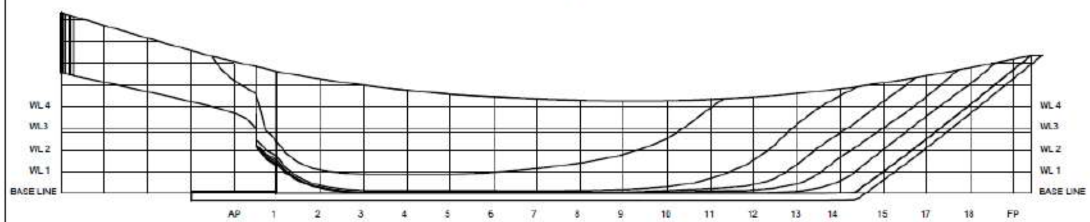


TABLE OF HEIGHT ABOVE THE BASE LINE (mm)

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	3180
I	-	651	16	16	16	16	16	16	16	16	16	16	16	48	283	1000	1790	2525	-	-
II	-	698	127	51	51	51	51	51	51	51	51	51	77	220	833	1509	2238	-	-	-
III	-	752	138	25	25	25	25	25	25	31	62	105	202	665	1388	2123	-	-	-	-
IV	-	856	181	64	62	62	62	62	62	82	152	342	771	1590	2251	-	-	-	-	-
V	2609	1172	561	444	440	442	489	574	701	903	1263	1969	-	-	-	-	-	-	-	-

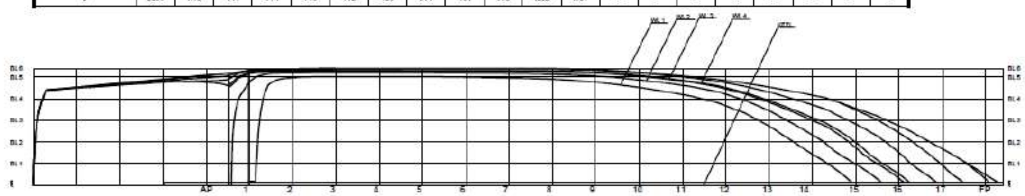


TABLE OF HALF BREADTH PLAN (mm)

Water 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	-	90	2487	2514	2515	2514	2500	2483	2450	2382	2261	2097	1839	1365	721	-	-	-	-	-	-
2	-	2386	2597	2599	2599	2599	2593	2585	2567	2524	2434	2308	2105	1725	1165	491	-	-	-	-	-
3	-	2578	2638	2642	2643	2641	2644	2639	2631	2599	2524	2407	2229	1922	1504	873	159	-	-	-	-
4	2383	2599	2644	2650	2650	2649	2648	2648	2642	2611	2535	2425	2254	1963	1567	990	154	-	-	-	-

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

PUSEN

KAPAL 4

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

Figure 8. The lines plane of purse Seine type

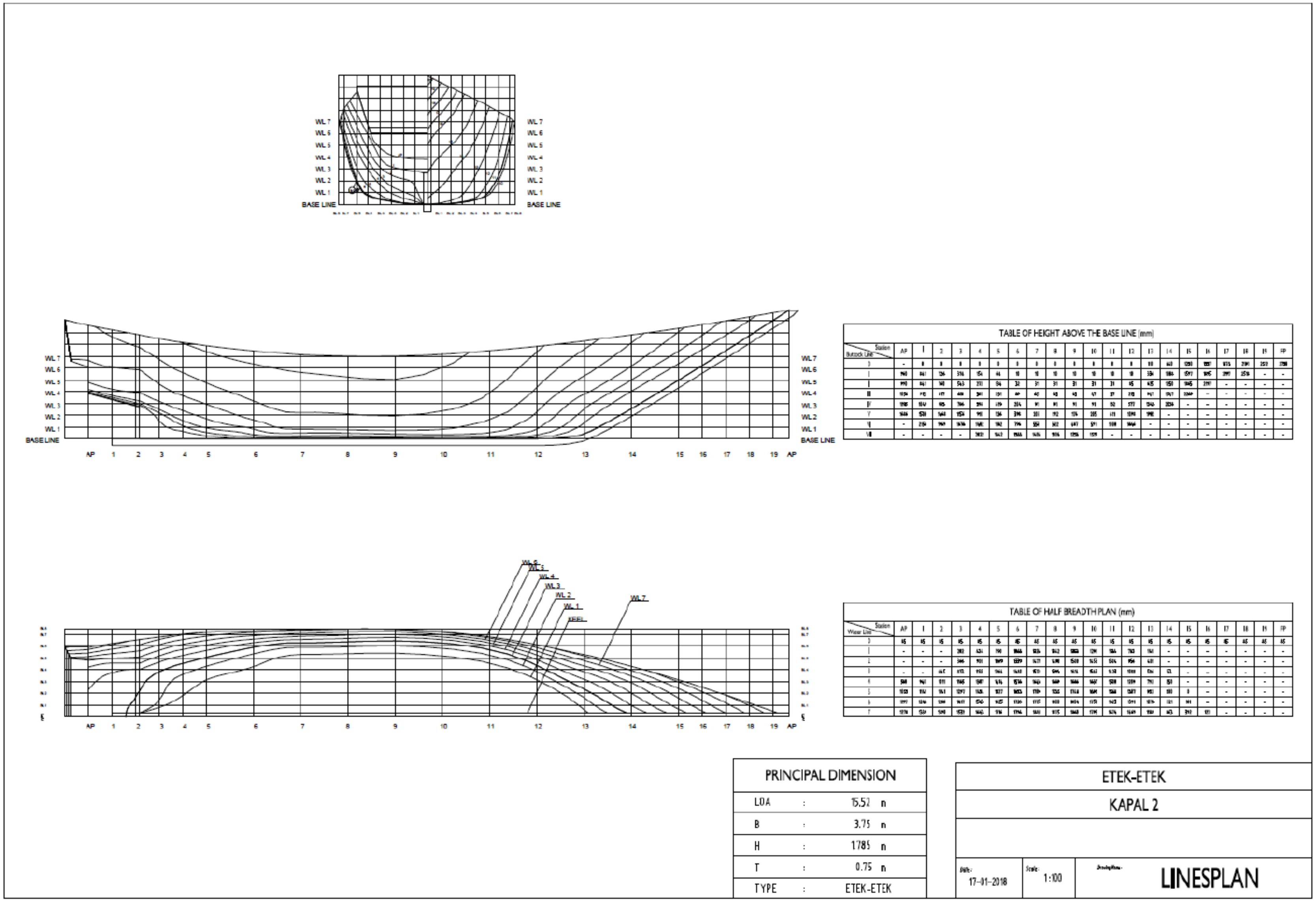


Figure 9. The lines plane of ethek-ethek type

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

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8. Biographies

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