ISSN 0554-6397
Konferencijski članak
(*Conference paper*)

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Seaworthiness and Stability Analysis of a Pontoon for Holiday House

Abstract

In this paper, the methodology of seaworthiness and stability analysis of a pontoon for holiday house has described. A 3D model of the pontoon was modelled in the NAPA software to perform hydrostatic analysis. It is necessary to emphasize the fact that hydrostatic analysis has been made for several drafts and trims of pontoons. The hydrostatic analysis yielded data such as displacement, moulded volume, longitudinal centre of buoyancy, the transverse metacentric height, change of displacement, moment to change trim, and more. This part of the analysis also includes the loading scale from which we can see the deadweight at a given draft. Further, it is necessary to make weight study to get moulded displacement for pontoon for a holiday house. The pontoon also includes capacity tanks, so it is necessary to know the accurate dimensions of the tanks and their position for further analysis. It is necessary to know the exact geometry of the tanks because of the free surface effect. When calculating the stability of the pontoon, it is necessary to determine the minimum metacentric height and the maximum distance from the keel to the centre of gravity. Intact stability conditions must be met for GM limit curves and also for KG curves. Intact stability criteria of the pontoon were tested for four loading conditions: lightship, pontoon with 10% consumables without passengers, pontoon with 100% consumables with passengers, pontoon with 50% consumables with passengers. It is important to emphasize that all tasks meet the stability criteria.

Keywords: intact stability, hydrostatic analysis, loading scale, weight study, cross curves

1. Introduction

The topic of this paper is a modelling of a pontoon and calculation of pontoons buoyancy and stability. The methodology of the analysis will also be described. The pontoon is designed for tourist purposes. The purpose is to accommodate guests and it is designed as an accommodation unit, i.e. a holiday home. Floating objects are maritime objects constantly anchored or moored at sea. They are not intended for navigation. The term floating objects also includes pontoons. Their block coefficient must be greater than 0.9. Pontoons have a simple geometric or analytic shape. They have a square shape and can be used for various purposes.

Residential pontoons are designed so that the accommodation unit or a house stands on a pontoon base in accordance with the calculation of the weight and centre of gravity of the pontoon and structure, the buoyancy of the building and the strength of the structure for the given environmental conditions. Figure 1 depicts the proposed holiday house pontoon arrangement while table 1 provides basic particulars.

Table 1. Basic information about the pontoon

Length overall	L_{OA}	18.00 m
Breadth overall	B_{OA}	8.30 m
Length of waterline	L_{WL}	14.15 m
Breadth at waterline	B_{WL}	6.15 m
Depth to freeboard deck	D	1.15 m
Height	H	5.05 m
Draught	T	0.65 m
Deadweight	DWT	19.4 t

Figure 1. Pontoon for holiday house

2. Intact stability

The stability of a ship is the ability to return the ship to its initial position due to the effect of external forces, the displacement of the masses on the ship. It depends on the shape of the hull as well as the distribution of mass on board.

2.1. Stability criteria

According to the rules for statutory certification of seagoing ships of the Croatian Register of Shipping (CRS) from Annex 4, for the stability of floating cranes, pontoons, docks and ships permanently connected to the coast, the stability criteria to be met have been taken into account.

Stability of a pontoon shall be considered sufficient if:

- ◊ The area under the righting lever curves up to the angle of maximum righting lever or the downflooding angle, whichever is less, is not less than 0.08 metre-radians.
- ◊ The range of positive stability levers is at least 20° for pontoons with a length of less than or equal to 100 metres, or 15° for pontoons with a length of more than or equal to 150 metres. The range value for the length intermediate values is calculated by linear interpolation.

The downflooding angle shall be taken as the angle at which an opening through which progressive flooding may take place is immersed.

For pontoons shorter than 24 m in length and intended for navigation in “calm waters”, the Register may allow not to compute the righting lever curve for greater angles if the initial metacentric conditions for all loading conditions has a value of no less than 0.35 m. [2]

2.2. Crowding of passengers

Crowding of passengers is one of the requirements of the register for passenger ships. The angle of static inclination must not be greater than the angle of deck dive or the angle of emerge of the bilge. Furthermore, this angle of inclination must not exceed 10°.

When determining the angle of inclination due to the crowding of passengers on one side, the average weight of passengers is taken to be 75 kilograms. The assumed density of passengers on deck is 4 people per square metre. The centre of gravity of the passenger is calculated 1.0 metres above deck level in case the passenger is standing or 0.3 metres above the passenger seat in case the passenger is sitting. [3]

2.3. Weather criterion

Every ship must have the ability to withstand the effects of bad weather, as well as the effects of strong crosswinds. The same goes for a residential pontoon.

One of the criteria that must be met is that the angle at equilibrium must not exceed 16° or 80% of the value of the deck immersion angle.

Additionally, the minimum height of the freeboard that does not sink due to wind must be greater than or equal to 10 millimetres.

2.4. Openings applied for intact stability calculations

When building a ship, there is a need for caution when positioning the openings. Unprotected openings are leaky and water will penetrate unhindered when the deck floods. The residential pontoon below the main deck contains a freshwater tank, a sewage tank, a fuel oil tank, and a dry space.

With the plotting and determination of the positions of the tanks and the associated openings, the analysis begins, in which the point of immersion of the deck and the opening is determined. Flooding angle is the angle of inclination at which the opening or openings in the deck sink and progressive flooding can occur.

The analysis concludes that for a construction draught of 0.65 m, the deck floods at an angle of 12.8 degrees, and the first unprotected opening plunges into the water at 24.5 degrees as seen on figure 2.

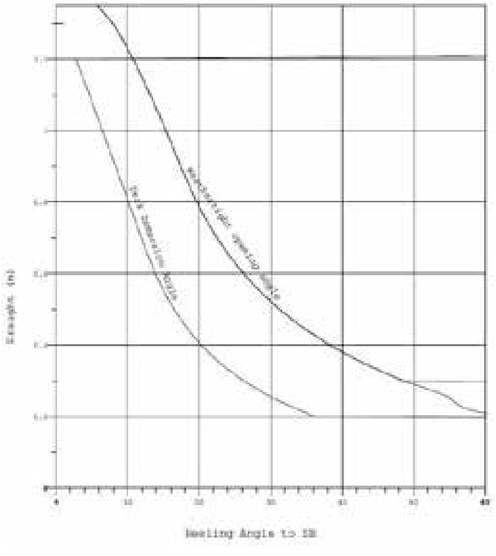


Figure 2. Deck immersion and weathertight opening angle

2.5. Deadweight scale and hydrostatics

The deadweight scale provides a method for estimating the increase in the ship's draught or determining the additional loads, that could be placed on the ship. The main use of the scale is to observe the deadweight at a given draught. In addition to presenting the relationship between draught and deadweight, it shows how the displacement depends on the density of the medium. With the same deadweight, but with a different density of water, the displacement of the ship changes.

By looking at the deadweight scale, we can see that for the project draught of 0.65 metres, the deadweight of the pontoon is 19.4 tons, given that the pontoon is located at the sea, and that it has a displacement of 59 tons.

The hydrostatic data of the residential pontoon are shown for trim values of 0 metres and trim values of -0.2, -0.1, 0.1 and 0.2 metres. The analysis took into account the thickness of the plating, which is 5 millimetres.

The analysis shows that the pontoon for a moulded draught of 0.65 metres has a displacement of 59 tons, immersed volume of 57 cubic metres, the longitudinal centre of buoyancy is 8.50 metres from the aft perpendicular, the transverse metacentric height is 5.15 metres, change of draught is 0.89 tons per centimetre and the moment to change trim is 1.1 tons meter per centimetre.

The pontoon at the trim of -0.2 meters does not have a precisely defined displacement of 59 tons. The interpolation obtained a draught value of 0.6385 metres, an immersed volume of 58.03 metres, the longitudinal centre of buoyancy is 8.86 metres from the aft perpendicular, the transverse metacentric height is 5,11 metres, the change of draught is 0.89 tons per centimetre and the moment to change trim is 1.1 ton metres per centimetre. Hydrostatic data for the trim of -0,2 m is presented in the following figure 3.

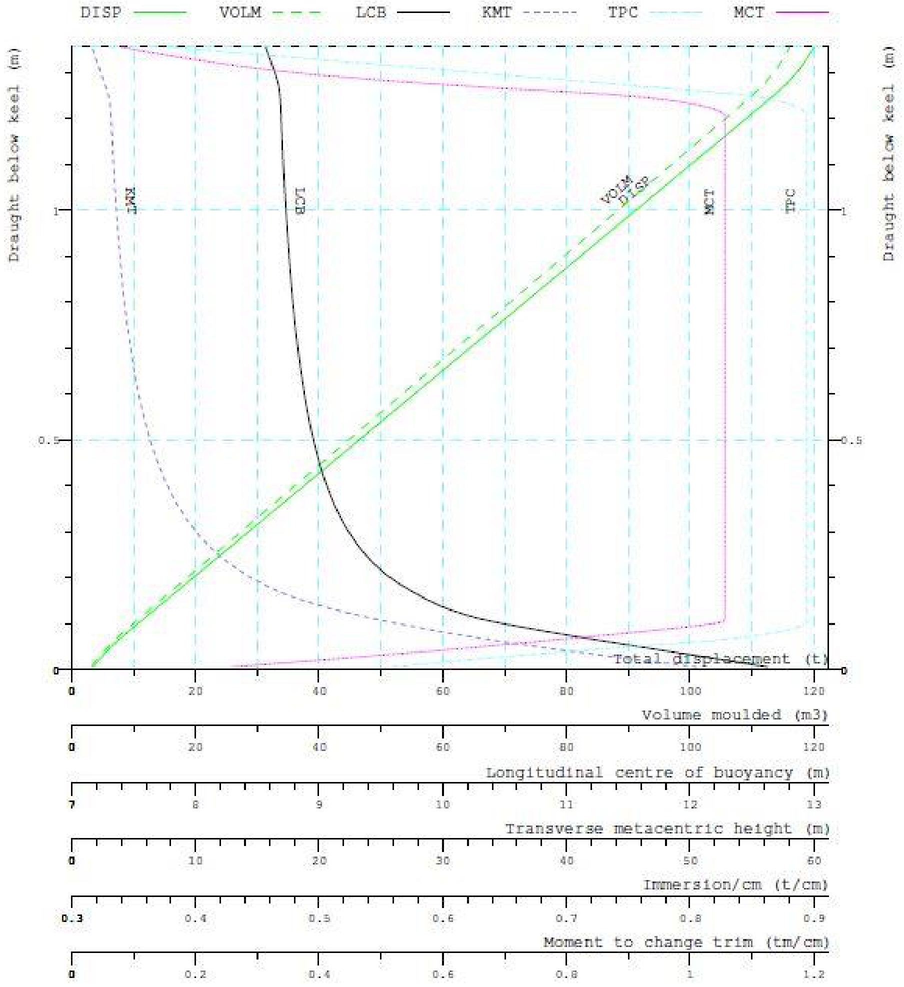


Figure 3. Hydrostatic data for the trim of -0,2 m

The pontoon at the trim of -0.1 metres for an initial displacement of 59 tons and draught of 0.65 m, immersed volume of 58 cubic metres, the longitudinal centre of buoyancy is 8.68 metres from the aft perpendicular, transverse metacentric height is 5.08 metres, the change of draught is 0.89 tons per centimetre and the moment to change trim is 1,1 ton metres per centimetre.

Interpolation showed that the pontoon at the trim of 0.1 metres has a draught of 0.6625 metres, the immersed volume of 57.26 cubic metres, the longitudinal centre of buoyancy is 8.3225 metres from the aft perpendicular, the transverse metacentric height is 5.137 meters, the change of draught is 0.89 tons per centimetre and the moment to change trim is 1.1 ton metres per centimetre.

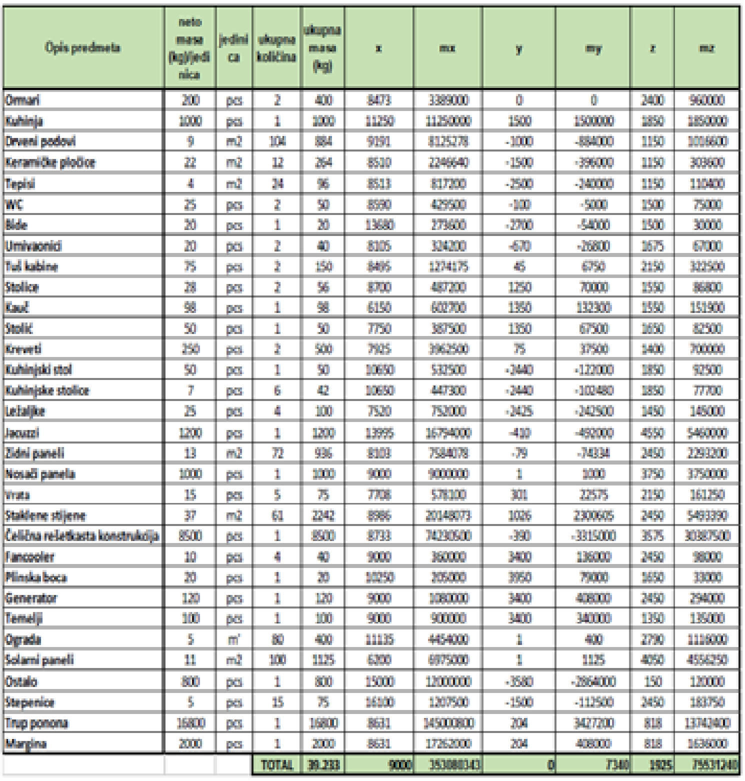
Interpolation for the initial value of displacement of 59 tons at trim of 0.2 meters obtained the value of draught of 0.65 metres, the immersed volume of 57.5 cubic metres, the longitudinal centre of buoyancy is 8.145 metres from the aft perpendicular, the transverse metacentric height of metacentre is 5.13 metres, the change of draught is 0.89 tons per centimetre and the moment to change trim is 1.1 ton metres per centimetre.

2.6. Weight study

A very important step in both the preliminary and the final ship design stage is to asses as accurate as possible approximation of the various weight groups of the ship, and the position of their centroid. When determining the weight study, it is necessary to know the mass of each element that makes up the pontoon and where is located at, particularly the structural steel weight, but the present study takes into account other various weight groups such as for example, kitchen or solar panels on top of the deck.

Also, it is necessary to know the positions of the centre of gravity of individual masses. It is necessary to calculate the individual moments of mass (m_x, m_y, m_z) in order to obtain the centre of gravity of the masses as shown in table 2.

Table 2. Weight study of the pontoon



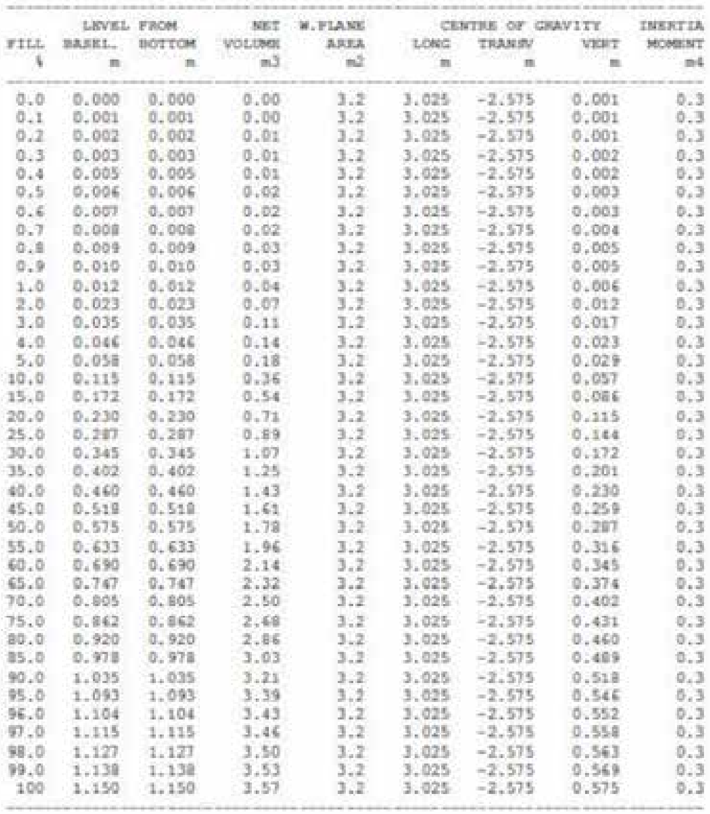
Opis predmeta	neto masa (kg)/jedinica	jedinica	ukupna količina	ukupna masa (kg)	x	mx	y	my	z	mz
Ormari	200	pcs	2	400	8473	3389000	0	0	2400	960000
Kuhinja	1000	pcs	1	1000	11250	11250000	1500	1500000	1850	1850000
Drveni podovi	9	m2	104	884	9191	8125278	-1000	-884000	1150	1016600
Keramičke pločice	22	m2	12	264	8510	2246640	-1500	-396000	1150	303600
Tepisi	4	m2	24	96	8513	817200	-2500	-240000	1150	110400
WC	25	pcs	2	50	8590	429500	-100	-5000	1500	75000
Bide	20	pcs	1	20	13680	273600	-2700	-54000	1500	30000
Umivaonici	20	pcs	2	40	8105	324200	-670	-26800	1675	67000
Tuš kabine	75	pcs	2	150	8495	1274175	45	6750	2150	322500
Stolice	28	pcs	2	56	8700	487200	1250	70000	1550	86800
Kauč	98	pcs	1	98	6150	602700	1350	132300	1550	151900
Stolić	50	pcs	1	50	7750	387500	1350	67500	1650	82500
Kreveti	250	pcs	2	500	7925	3962500	75	37500	1400	700000
Kuhinjski stol	50	pcs	1	50	10650	532500	-2440	-122000	1850	92500
Kuhinjske stolice	7	pcs	6	42	10650	447300	-2440	-102480	1850	77700
Ležaljke	25	pcs	4	100	7520	752000	-2425	-242500	1450	145000
Jacuzzi	1200	pcs	1	1200	13995	16794000	-410	-492000	4550	5460000
Zidni paneli	13	m2	72	936	8103	7584078	-79	-74334	2450	2293200
Nosači panela	1000	pcs	1	1000	9000	9000000	1	1000	3750	3750000
Vrata	15	pcs	5	75	7708	578100	301	22575	2150	161250
Staklene stijene	37	m2	61	2242	8986	20148073	1026	2300605	2450	5493390
Čelična rešetkasta konstrukcija	8500	pcs	1	8500	8733	74230500	-390	-3315000	3575	30387500
Fancooler	10	pcs	4	40	9000	360000	3400	136000	2450	98000
Plinska boca	20	pcs	1	20	10250	205000	3950	79000	1650	33000
Generator	120	pcs	1	120	9000	1080000	3400	408000	2450	294000
Temelji	100	pcs	1	100	9000	900000	3400	340000	1350	135000
Ograda	5	m'	80	400	11135	4454000	1	400	2790	1116000
Solarni paneli	11	m2	100	1125	6200	6975000	1	1125	4050	4556250
Ostalo	800	pcs	1	800	15000	12000000	-3580	-2864000	150	120000
Stepenice	5	pcs	15	75	16100	1207500	-1500	-112500	2450	183750
Trup ponona	16800	pcs	1	16800	8631	145000800	204	3427200	818	13742400
Margina	2000	pcs	1	2000	8631	17262000	204	408000	818	1636000
			TOTAL	39.233	9000	353080343	0	7340	1925	75531240

The total mass of the pontoon is 39233 kg, and the centre of gravity of the system has coordinates x = 9000 mm, y = 0 mm and z = 1925 mm.

2.7. Tank capacity

For further analysis of tanks loading, data on the location of tanks on the pontoon, their volume, mass and moments of inertia are required. The analysis of the weight study of tank consumables was performed on the principle of analysis of the weight study of mass, but it was supplemented by the moment of inertia for the calculation of the moment of free surfaces. The tanks considered are water tank, sewage tank or optional fuel tank. Table 3. shows capacity plan of the sewage tank with its net volume, eater plane area, longitudinal, transverse and vertical center of gravity and moments of inertia.

Table 3. Capacity plan of the sewage tank



	LEVEL FROM		NET	W.PLANE	CENTRE OF GRAVITY			INERTIA
FILL	BASEL.	BOTTOM	VOLUME	AREA	LONG	TRANSV	VERT	MOMENT
%	m	m	m3	m2	m	m	m	m4
0.0	0.000	0.000	0.00	3.2	3.025	-2.575	0.001	0.3
0.1	0.001	0.001	0.00	3.2	3.025	-2.575	0.001	0.3
0.2	0.002	0.002	0.01	3.2	3.025	-2.575	0.001	0.3
0.3	0.003	0.003	0.01	3.2	3.025	-2.575	0.002	0.3
0.4	0.005	0.005	0.01	3.2	3.025	-2.575	0.002	0.3
0.5	0.006	0.006	0.02	3.2	3.025	-2.575	0.003	0.3
0.6	0.007	0.007	0.02	3.2	3.025	-2.575	0.003	0.3
0.7	0.008	0.008	0.02	3.2	3.025	-2.575	0.004	0.3
0.8	0.009	0.009	0.03	3.2	3.025	-2.575	0.005	0.3
0.9	0.010	0.010	0.03	3.2	3.025	-2.575	0.005	0.3
1.0	0.012	0.012	0.04	3.2	3.025	-2.575	0.006	0.3
2.0	0.023	0.023	0.07	3.2	3.025	-2.575	0.012	0.3
3.0	0.035	0.035	0.11	3.2	3.025	-2.575	0.017	0.3
4.0	0.046	0.046	0.14	3.2	3.025	-2.575	0.023	0.3
5.0	0.058	0.058	0.18	3.2	3.025	-2.575	0.029	0.3
10.0	0.115	0.115	0.36	3.2	3.025	-2.575	0.057	0.3
15.0	0.172	0.172	0.54	3.2	3.025	-2.575	0.086	0.3
20.0	0.230	0.230	0.71	3.2	3.025	-2.575	0.115	0.3
25.0	0.287	0.287	0.89	3.2	3.025	-2.575	0.144	0.3
30.0	0.345	0.345	1.07	3.2	3.025	-2.575	0.172	0.3
35.0	0.402	0.402	1.25	3.2	3.025	-2.575	0.201	0.3
40.0	0.460	0.460	1.43	3.2	3.025	-2.575	0.230	0.3
45.0	0.518	0.518	1.61	3.2	3.025	-2.575	0.259	0.3
50.0	0.575	0.575	1.78	3.2	3.025	-2.575	0.287	0.3
55.0	0.633	0.633	1.96	3.2	3.025	-2.575	0.316	0.3
60.0	0.690	0.690	2.14	3.2	3.025	-2.575	0.345	0.3
65.0	0.747	0.747	2.32	3.2	3.025	-2.575	0.374	0.3
70.0	0.805	0.805	2.50	3.2	3.025	-2.575	0.402	0.3
75.0	0.862	0.862	2.68	3.2	3.025	-2.575	0.431	0.3
80.0	0.920	0.920	2.86	3.2	3.025	-2.575	0.460	0.3
85.0	0.978	0.978	3.03	3.2	3.025	-2.575	0.489	0.3
90.0	1.035	1.035	3.21	3.2	3.025	-2.575	0.518	0.3
95.0	1.093	1.093	3.39	3.2	3.025	-2.575	0.546	0.3
96.0	1.104	1.104	3.43	3.2	3.025	-2.575	0.552	0.3
97.0	1.115	1.115	3.46	3.2	3.025	-2.575	0.558	0.3
98.0	1.127	1.127	3.50	3.2	3.025	-2.575	0.563	0.3
99.0	1.138	1.138	3.53	3.2	3.025	-2.575	0.569	0.3
100	1.150	1.150	3.57	3.2	3.025	-2.575	0.575	0.3

2.8. Free surfaces

The level of liquid or bulk that can be moved is called the free surface. Any weight on the ship whether added to the ship during boarding, unloading or just moving around the ship causes the moving the centre of gravity of the ship's system. When tilting, the slope of the liquid surface in the tank or the level of bulk cargo in the warehouse changes and their centre of gravity changes in the direction of the ship's tilt, which creates a moment of free surface acting in the direction of the ship's tilt and the ship's centre of gravity shifts systematically.

It is important to emphasize that due to the influence of free surface there is a loss of the actual metacentric height and a decrease in the lever of stability in relation to the initial state. The loss occurs regardless of where the liquid on board is.

2.9. KN Cross curves

Cross curves represent the distance between the points K and N at a given draught and the heel of the ship. Cross curves are used to determine the stability lever of the ship. Figure 4 depicts the KN curves with respect to drought,

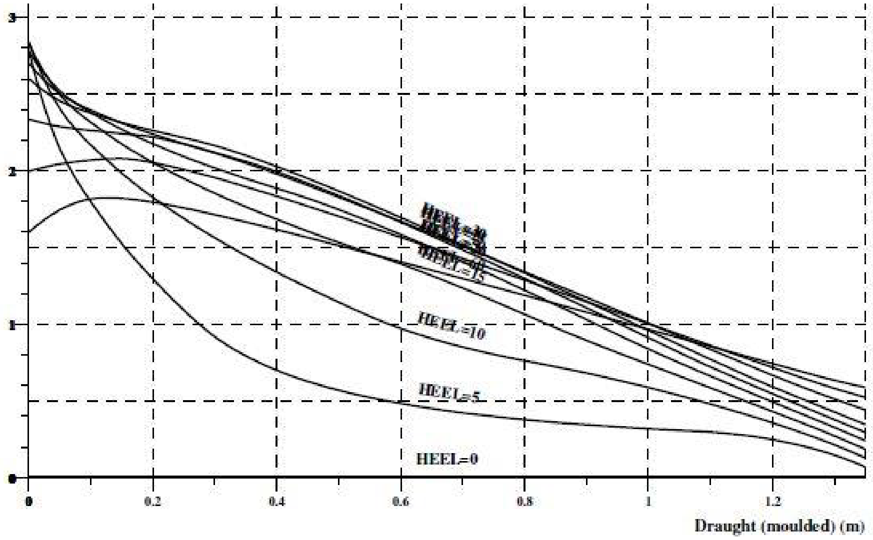


Figure 4. Pontoon KN curves

2.10. GM Limit curves

The GM limit curves show the values of the minimum metacentric height curves for a draught of 0 meters up to a moulded draught of 0.65 metres. This curve separates the area where the metacentric heights did not meet the stability criteria (restricted area) and the area of allowed metacentric heights. It should also be noted that GM limit curves are constructed without the influence of free surfaces of liquids in tanks so that to obtain accurate results one should calculate the actual metacentric height corrected for the influence of free surfaces and check whether the value obtained is greater or less than the minimum metacentric height GM.

In addition to the GM limit curves, the curves of the maximum height of the centre of gravity KG are made in the same way. They also show two areas of allowable and impermissible values according to stability criteria. They are also shown as functions of the centre of gravity of the system and the draught for a particular trim.

The determination criteria DCRI for the minimum and maximum metacentric height for the trim of 0.2 m is given in the following figure 5,

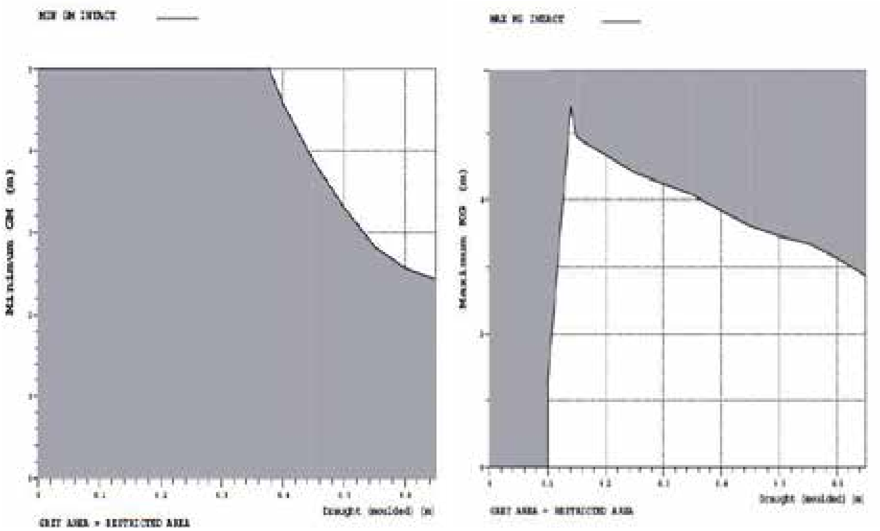


Figure 5. Minimum and maximum metacentric heights for the trim of 0.2 m

2.11. Loading conditions

A pontoon stability check will be shown for four cargo loading cases. In these cases, the percentage of tanks filled with consumables and the combination with or without the crowding of passengers on the side of the pontoon will differ. In addition, the pontoon will be exposed to a wind gust of 170 km/h.

Cases in which the criteria of stability, crowding of passengers on the side, strong wind and minimal freeboard will be examined are the case of a lightship, the case of a pontoon whose freshwater, fuel oil and sewage tank capacities are filled with 10% consumables, the case of pontoons whose tanks are filled 50% consumables and passengers are on the side of the pontoon and the case when the tanks are completely full and the passengers are piling up on the side of the deck.

2.11.1. Lightship

In the first case of the stability test, the lightship was tested, i.e. the case of pontoons of empty tanks and without passengers. In this case, there is no influence of free surfaces and the value of the corrected distance from the keel to the centre of gravity KGcorr and the corrected metacentric height GMcorr is their actual value. Intact stability criteria is provided in table 2 as well as on figure 2.

Table 4. Intact stability criteria for the lightship condition

Stability criteria	**Required**	**Attained unit**	**Status**
GM > 0,35	0.350 m	5.500 m	OK
Minimum range of stability > 20°	20.000°	57.573°	OK
Area under *GZmax* > 0,092 mrad	0.092 mrad	0.245 mrad	OK
Residual freeboard > 0,010 m	0.010 m	0.714 m	OK
Maximum heel caused by crowding of passengers < 10°	10.000°	0.826°	OK
Heeling angle due to wind < 16° or < 80% of the angle at which the deck dives	12.356°	1.296°	OK

In addition to the stability criteria, the value of the stability margin is also checked. Stability margin is the value when the corrected distance from the keel to the centre of gravity KGcorr is subtracted from a maximum distance from the keel to the centre of gravity KGmax, i.e. when the value of the minimum metacentric height GMmin is subtracted from the corrected metacentric height GMcorr. The margin value must be greater than or equal to zero and the difference between the two operations must be equal.

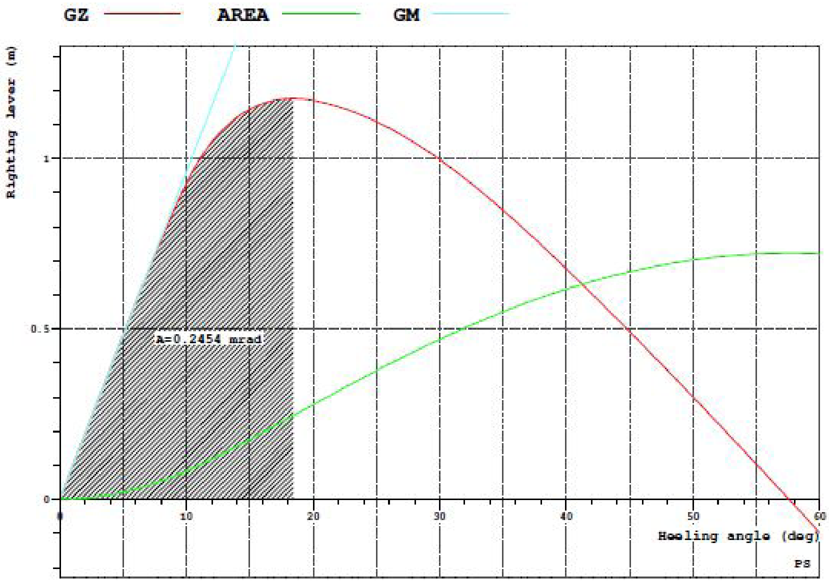


Figure 6. Intact stability criteria for the lightship condition.

2.11.2. Pontoon with 10% consumables without passengers

Another case of stability testing relates to a pontoon whose water, fuel oil and sewage tanks contain 10% liquid. This means that in this case, a moment will occur due to the influence of free surfaces.

In the diagram of the stability lever, in addition to the values of the stability lever GZ and the metacentric height GM, the values at which the openings on the deck are immersed in water and progressive flooding occur are shown. It can be seen that the opening of the freshwater tank (FW) and the opening of the empty space (BAR) is immersed in water at 33.7°. It can also be seen that the fuel oil tank opening (FO) is immersed at 38.9° and the sewage tank opening (SEW) at 41.6° as given in table 3.

Table 5. Intact stability criteria for the pontoon with 10% consumables without passengers

Stability criteria	**Required**	**Attained unit**	**Status**
GM > 0,35	0.350 m	5.150 m	OK
Minimum range of stability > 20°	20.000°	33.403°	OK
Area under *GZmax* > 0,092 mrad	0.092 mrad	0.236 mrad	OK
Residual freeboard > 0,010 m	0.010 m	0.691 m	OK
Maximum heel caused by crowding of passengers < 10°	10.000°	1.092°	OK
Heeling angle due to wind < 16° or < 80% of the angle at which the deck dives	12.356°	1.562°	OK

Due to the influence of the moment of free surfaces, the centre of gravity of the pontoon KG increases and the metacentric height GM decreases. During the analysis, the free surface correction is subtracted or added from the actual value of KG and GM. In further analysis, the value of the corrected distance from the keel to the centre of gravity of the pontoon KGcorr and corrected metacentric height GMcorr is taken instead of the initial value of KG and GM.

2.11.3. Pontoon with 100% consumables with passengers on the deck

The third case of loading the pontoon with cargo describes the case when the pontoon tanks are 100% full and the passengers are on the side of the pontoon as seen on figure 7.

In this case, as in the case of a lightship, there will be no impact of free surfaces, but due to the accumulation of passengers on the side of the deck, a moment is created that affects stability and the criterion of crowding of passengers on the side should be met.

The crowding of passengers is calculated by moving ten passengers weighing 75 kilograms from the middle of the pontoon to the very edge of the pontoon.

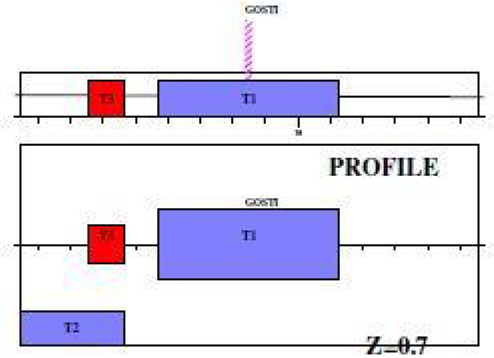


Figure 7. Schematics of the pontoon with 100% consumables with passengers on the deck

It can be seen that the sewage tank opening (SEW) is immersed in water at 23.5°, the fuel oil tank opening (FO) at 23.7°, the freshwater tank opening (FW) and the empty space opening (BAR) are immersed in water at 24.5° shown in table 4.

Table 6. Intact stability criteria for the pontoon with 100% consumables with passengers on the deck

Stability criteria	**Required**	**Attained unit**	**Status**
$GM > 0,35$	0.350 m	3.68 m	OK
Minimum range of stability > 20°	20.000°	21.007°	OK
Area under *GZmax* > 0,092 mrad	0.092 mrad	0.146 mrad	OK
Residual freeboard > 0,010 m	0.010 m	0.447 m	OK
Maximum heel caused by crowding of passengers < 10°	10.000°	3.287°	OK
Heeling angle due to wind < 16° or < 80% of the angle at which the deck dives	12.356°	6.667°	OK

2.11.4. Pontoon with 50% consumables with passengers on the deck

In the latter case, there is a test of the stability of the pontoon with 50% of the consumables in its tanks and the passengers on the pontoon. In this case, there will be two problems, namely the moment due to the influence of free surfaces and the moment due to the crowding of passengers on the side of the pontoon.

From the stability lever diagram, it can be seen that the unprotected openings of the freshwater tank (FW) and the empty space opening (BAR) are immersed in water at 28.7°. The fuel oil tank orifice (FO) is immersed at 30.2° and the sewage tank (SEW) is immersed in the sea at 30.9° presented in table 5.

Table 7. Intact stability criteria for the pontoon with 50% consumables with passengers on the deck

Stability criteria	**Required**	**Attained unit**	**Status**
GM > 0,35	0.350 m	4.310 m	OK
Minimum range of stability > 20°	20.000°	27.424°	OK
Area under *GZmax* > 0,092 mrad	0.092 mrad	0.201 mrad	OK
Residual freeboard > 0,010 m	0.010 m	0.600 m	OK
Maximum heel caused by crowding of passengers < 10°	10.000°	2.085°	OK
Heeling angle due to wind < 16° or < 80% of the angle at which the deck dives	12.356°	2.519°	OK

3. Conclusion and comments

In this paper, a residential pontoon is modelled. On the mathematical model of the pontoon, a stability calculation was performed for four loading conditions. The first state is a lightship, the second is a state without passengers when the tanks are 10% full. The third state is at 100% filled tanks with passengers on deck. The fourth and final state of loading is when the tanks are filled with 50% and when the passengers are on the side, more precisely on the edge of the deck.

It is important to note that for these loading conditions, factors such as the impact of free surfaces, crowding of passengers on the side and side wind gusts must be taken into account. The terms listed in the calculation represent variables that can negatively affect the results when calculating pontoon stability.

As an example, we can cite the problem closely related to free surfaces that directly affect the reduction of GM metacentric height and the centre of gravity KG of the pontoon system. As a result, the GZ stability lever decreases. For all loading conditions, the metacentric height was higher than the given criterion (GM> 0.35 m) and we can conclude that the criterion was met.

The range of positive stability levers must be greater than 20°. It is important to know that during the progressive flooding of tanks through the tank openings, the stability diagram is interrupted. The smallest dive angle of the tank opening was obtained for the case of “100% consumables with passengers on deck” where the opening of the sewage tank (SEW) was immersed in water at 23.5°. From this, it can be concluded that the criteria are met in this part of the analysis.

The area bounded by the stability lever curve and the vertical descending from the highest point of the curve (GZmax) to the abscissa must be greater than 0.092 metre-radians. The above criterion is also met for all loading conditions.

Considering that in the worst case the minimum height of the overhang is 0.447 m, and the prescribed criterion is 0.01 m, we can conclude that the results in this part of the analysis are very conservative.

The slope caused by a wind speed of 170 km/h was in all cases less than the initial condition prescribing a slope of less than 16° or 80% of the value of the deck dive angle.

The slope criterion caused by the crowding of passengers is not specified in individual loading conditions but as a criterion that is then tested for all loading conditions. Theoretically, this could be avoided by making two groups of loading, with and without passengers. In other words, this criterion, like other moments, does not change the displacement, deadweight, draught, trim, heel and more. It depends on the number of passengers on board and their hypothetical shift. It tests what would happen if a passenger (in this case 10) moved from the symmetrical plane CL to the side. In case there are no passengers, it can be easily ignored, which is the case in two loading states (lightship and pontoon with 10% consumables without passengers).

All stability criteria are met for all loading conditions.

As these type of objects get more popular and a nice alternative for living quarters or a great way to get a family, group of friends, or work retreat out on the water, a following figure 3 presents an idea of the possible resort of such floating houses.

Figure 3. Floating houses resort

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