Measurement System for Border Height of the Mass Centre of a Vessel

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ABSTRACT: *This paper provides an algorithm and program module based on the "Method for Calculation of Stability at Moderate and Big Heeling Angle of a Vessel". The program is designed to assist the ship's command staff by significantly simplifying the calculations related to the cargo plane and the vessel's stability. The program is implemented in Matlab.*

Keywords: Static Stability Curve, Dynamic Height Of The Mass Centre, Metacentric Height, Matlab

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1. Introduction

The researches related to the normalization of the stability of a ship meet significant difficulties caused by the ignorance of its hydrodynamic interaction with the water. The empiricalstatistic method widely covers in the introduction of certain norms for stability in the design and exploitation of the vessels. The research of the stability could be most clearly made with graphical interpretation of the so called Static Stability Curve (*SSC*). The direct building of the curve is too hard for the command staff because of the many calculations. Therefore a new method is presented in "Method for calculating the stability at moderate and big heeling angles of a vessel". It simplifies the graphic work on creating SSC and initiating a diagram of the dynamic height of the mass centre (*DHMC*). An algorithm and a program module are created using this method. The program module is realized on Matlab [3].

2. Algorithm

The sequence of the algorithm based on the new method for obtaining the border graphical dependence between the mass centre and the displacement of the ship ∇ is the following:

1. The values $(KN_\theta)_j$ (Figure 1) are determined from the *KN*-curves for each displacement ∇_i from ∇_1= *"empty"* to ∇_n= "*full*" ship in m^3 at intervals of $\delta\nabla = 500m^3$. (Figure 2).

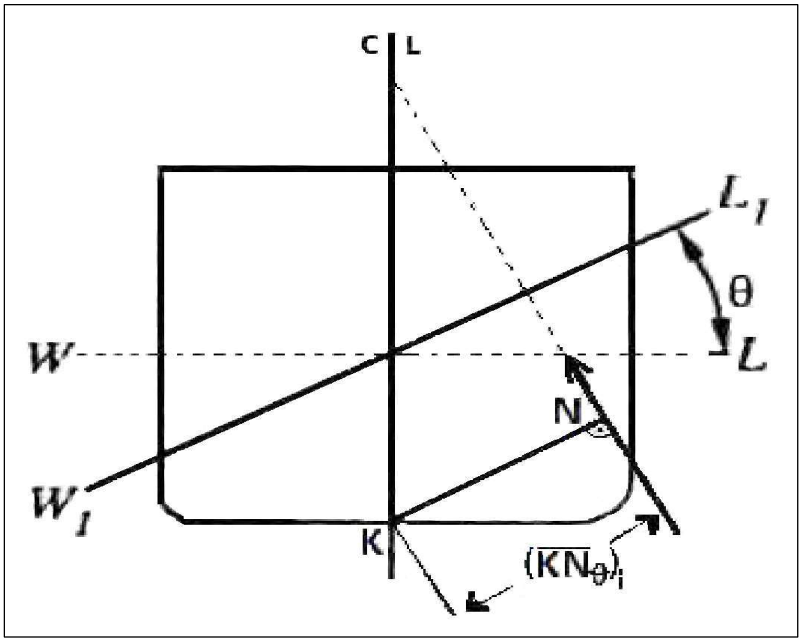

Figure 1. Arm of the form

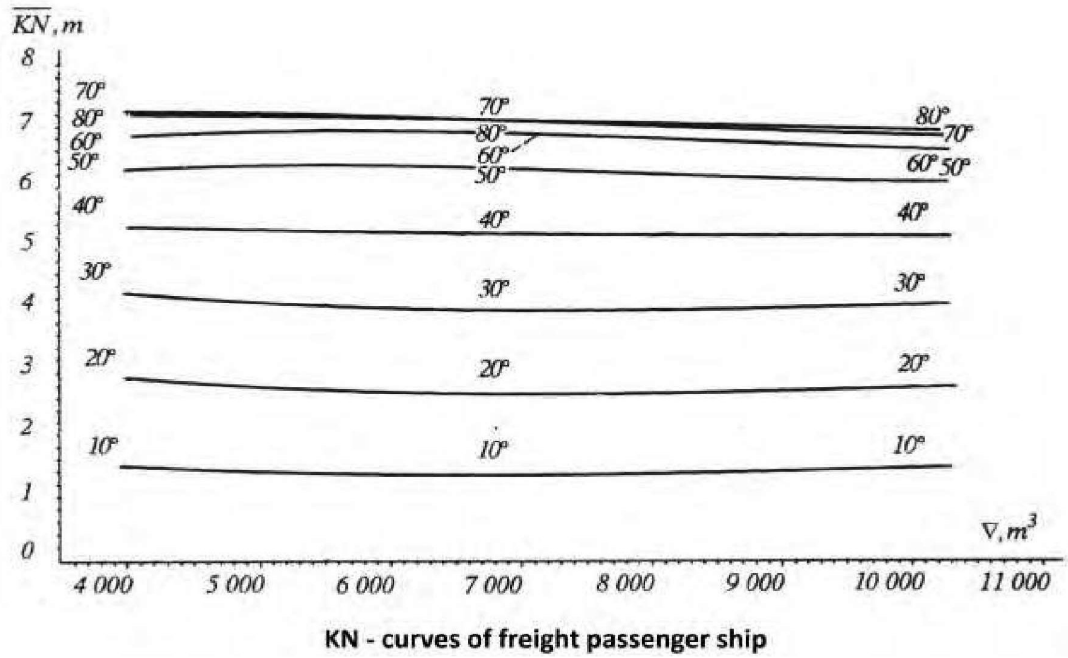

Figure 2. KN-curves of freight passenger ship [1]

2. For each ∇_i are taken heights of the mass centre $\overline{KG_j}$ in realistic exploitation borders for the height of the mass centre G throughout $0.1m$.

3. The arm of the height $(l_G)_\theta$ is calculated for each $\overline{KG_j}$, heeling angle θ and ∇_i by the formula [1,3]

$$\left[(l_G)_\theta\right]_j = \overline{KG_j} \sin\theta, \tag{1}$$

where θ is from 10^0 to 40^0 throughout 10^0. [3] (Figuer 3)

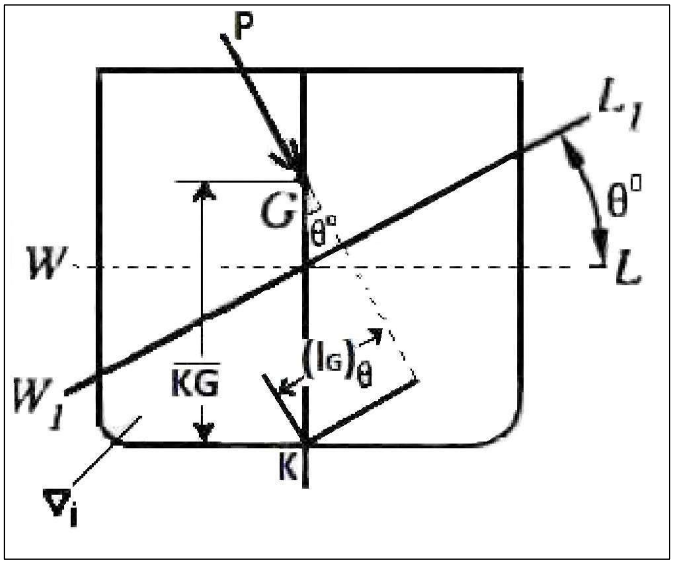

Figure 3. Arm of the height

4. The arm of the righting moment $\left(\overline{GZ}\right)_{i,j}$, is evaluated for each ∇_i and each 10^0, 20^0, 30^0, 40^0. (Figure 4) [2]

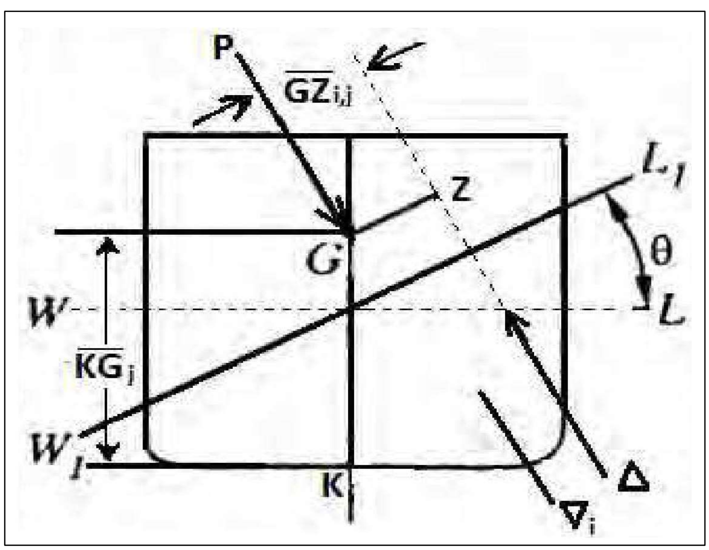

Figure 4. Arm of the righting moment

5. The height of the transverse metacentre $\overline{KM_i}$ is determined depending on the kind of the vessel. (Figure 5).

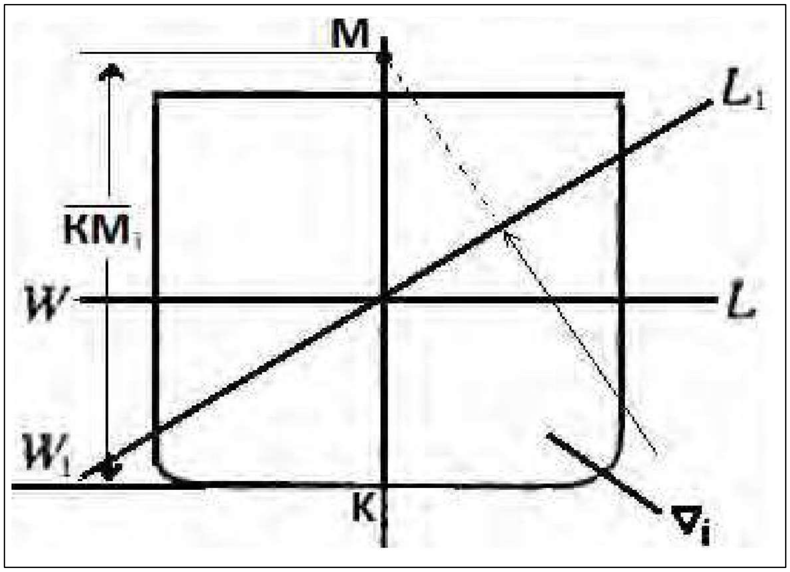

Figure 5. Initial transverse metacentre

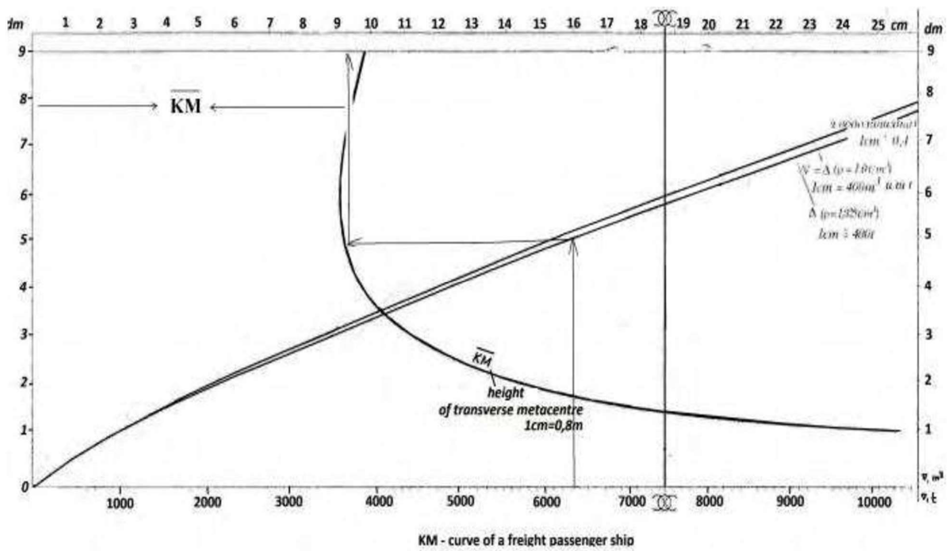

Figure 6. Determining the height of the transverse metacentre [1]

6. The transverse metacentric heights $\overline{G_j M_i}$ are determined as

$$\overline{G_j M_i} = \left(\overline{KM}\right)_i - \overline{KG_j} \tag{2}$$

for each ∇_i.

7. The Static Stability Curve (*SSC*)

$$\left(\overline{GZ}\right)_{i,j} = f(\theta) \,. \tag{3}$$

For each ∇_i are built j in number diagrams respectively for each $l_{j,i}$, i.e. same $\overline{KN}$ for each angle θ_i[2].

To form the initial area from 0^0–10^0 is necessary to lay vertically the initial metacentric height $\overline{G_j M_i}$ at $1 rad = 57.3^0$. The vertex $\overline{G_j M_i}$ is connected to the origin of the coordinate system. At this area the curve must be tangent of the connection between the vertex and the origin. (Figure 7).

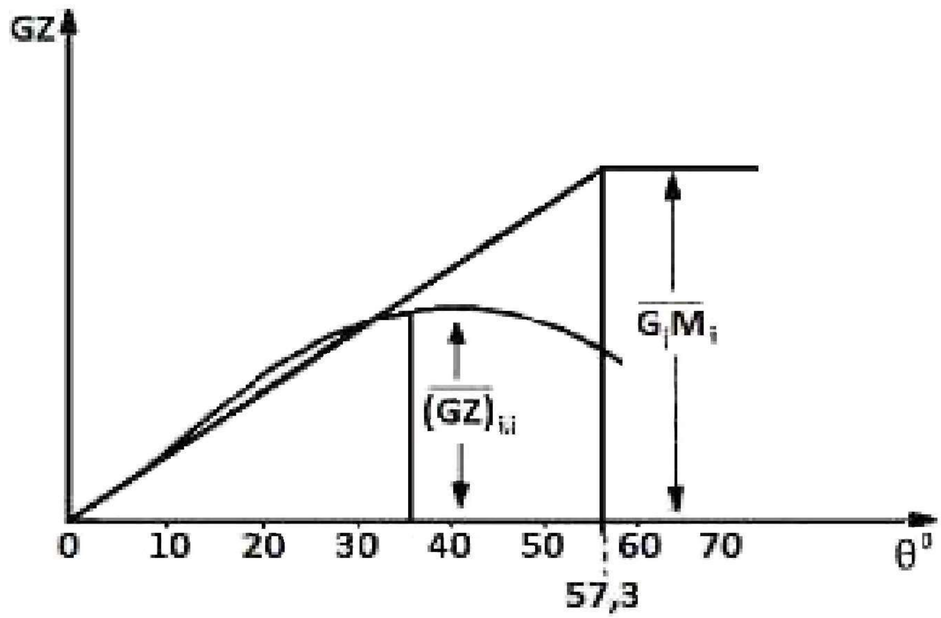

Figure 7. Static Stability Curve

8. Next step is to calculate the areas $S_{0^0-30^0}$, $S_{0^0-40^0}$ and $S_{30^0-40^0}$ and compare them with the ones equired in IMO. If the three areas are the same as the required or one of them is the same and the others are bigger $\overline{KG_j}$ is considered as a solution.[6]

9. The obtained $\overline{KG_j}$ responds to a specific displacement ∇_i. The graph of $\overline{KG_j} = f(\nabla_i)$ is built for the whole diapason $\nabla_i \div \nabla_n$.

The area over the graph is impermissible for the cargo height[1, 4].

3. Program Module Based on the Algorithm

For the calculations in this report are used values from the Naval Academy's traning ship's documents.

The displacements ∇_i are from ∇_1=4000$_m{}^3$ to ∇_n= 10000$_m{}^3$ at intervals of $\delta\nabla$=500$_m{}^3$.[6]

The heights of the mass centre $\overline{KG_j}$ from $\overline{KG_1}$ = *6m* to $\overline{KG_m}$= 9*m* at intervals of 0.1*m*.[6]

The heights of the transverse metacentre are taken from the $\overline{KM}$-curve of a freight passenger ship for each displacement ∇_i [6].

The program is created following the steps shown in the flowchart. (Figure 8).

Finally an acceptable zone for dynamic stability is determined. (Figure 9).

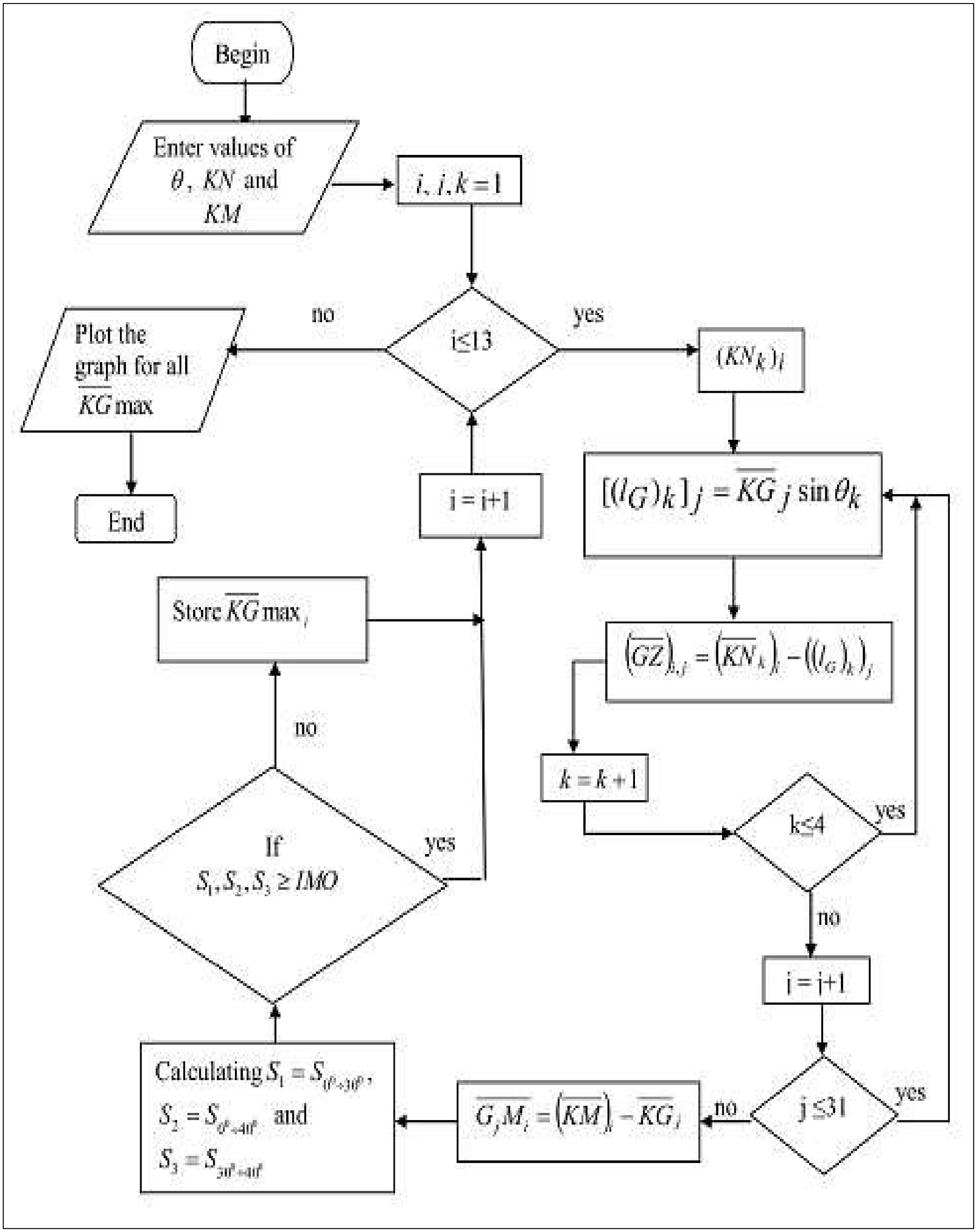

Figure 8. Flowchart of the algorithm

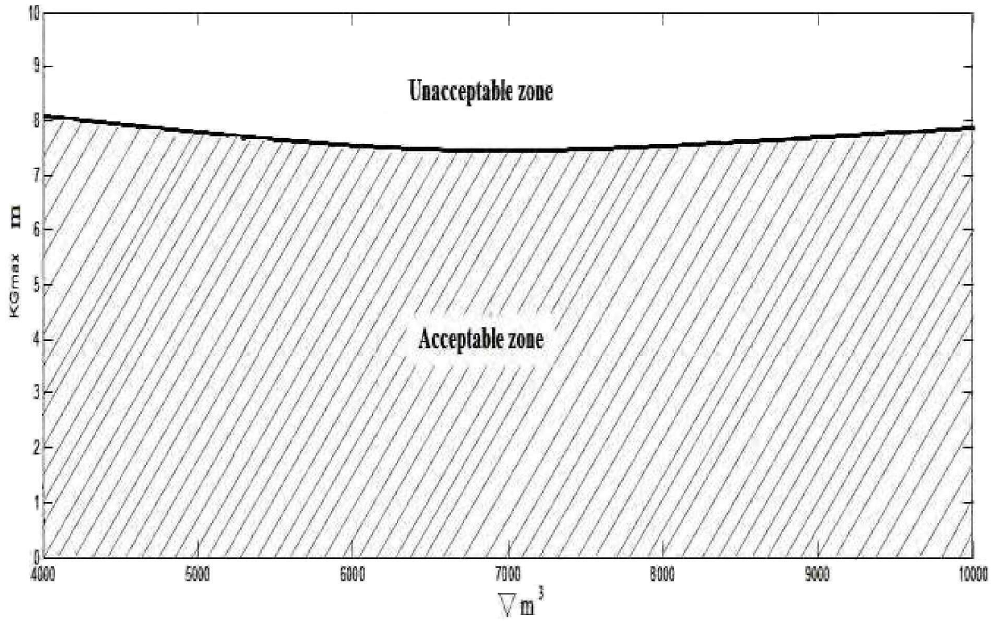

Figure 9. Diagram of the dynamic height of the mass centre

4. Conclusions

1) Simplifies the evaluation of the stability at moderate and big heeling angles of the ship.

2) The program module can be applied to all kinds of ships, for which is necessary to build SSC.

3) The graph of the DHMC could be introduced in the ship's documents as reliable evaluation of stability.

References

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[6] Rezolution A 749 (18) of IMO-requirements for SSC.