Journal of Advanced Marine Engineering and Technology, Vol. 46, No. 6, pp. 348~355, 2022
J. Advanced Marine Engineering and Technology (JAMET)
https://doi.org/10.5916/jamet.2022.46.6.348
ISSN 2234-7925 (Print)
ISSN 2765-4796 (Online)
Original Paper

Study on the application of the safety criteria for standard fishing vessels form for coastal fishing vessels

Sung-Uk KIM[1] ・ Intae KIM[2] ・ Gun-Kyung LEE[3] ・ In-Seob KIM[†]

(Received November 1, 2022 ; Revised November 26, 2022 ; Accepted December 15, 2022)

Abstract: With the recent establishment of the Criteria for Standard Fishing Vessels Form with Reinforced Stability and Welfare noticed by the Ministry of Oceans and Fisheries, fishing vessels with a gross tonnage of less than 10 tons can also be approved for stability. The distance between a ship's center of gravity and its metacenter (referred to as GM) and the righting arm at the angle of deck edge immersion (referred to as GZ) are used as primary indicators of fishing vessels stability in the stability approval standard of the Fishing Vessels Act and Criteria for Standard Fishing Vessels Form. In this study, K-SHIP software was used to calculate the stability indicators for 25 fishing vessels with a gross tonnage of less than 10 tons and to examine whether the calculated stability indicators achieved the values required by the Criteria for Standard Fishing Vessels Form and the Fishing Vessels Act's Stability Standard. The GZ requirement of the Criteria for Standard Fishing Vessels Form was always lower than the Fishing Vessels Act, with all 25 fishing vessels meeting the GM and GZ requirements of the Criteria for Standard Fishing Vessels Form, but some failing to meet the criteria of the Fishing Vessels Act.

Keywords: Ship stability, Coastal fishing vessel, Criteria for standard fishing vessels form, Fishing vessels Act, K-SHIP

Nomenclature

A	Projection area of the hull of the upper part of the draft line of the fishing vessel in an upright state
a	Floor area of the fishing passenger loading area
B	Breadth
b	Average moving breadth of fishing passengers at the fishing passenger loading area
D	Depth
H	Vertical distance from the center of the upper part of the draft line to the center of the lower part of the draft line in an upright state in the projection area of the longitudinal section of the hull of the fishing vessel
n	Number of fishing passengers
w	Displacement
T	Draft
α	Coefficients determined by the material
β	Coefficients determined by the ratio of freeboard to hull depth

1. Introduction

According to statistics from the Korea Maritime Safety Tribunal, capsizing accidents that involved fishing vessels with a gross tonnage of less than 10 tons in 2020 (hereafter referred to as "coastal fishing vessels") accounted for approximately 92% of the total capsizing accidents, as shown in **Figure 1** **[1]**. However, not all coastal fishing vessels registered in Korea are listed as stability-approved under the Fishing Vessels Act because the vessel length does not exceed 24 m **[2]**. In this regard, the International Maritime Organization (IMO) approved a provisional guideline for fishing vessels with lengths between 12 and 24 m, and decided to promote the implementation of international safety criteria for fishing vessels with lengths less than 12 m **[3]**.

However, the Ministry of Oceans and Fisheries recently notified the Criteria for Standard Fishing Vessels Form with Reinforced Stability and Welfare (hereafter referred to as the Criteria for Standard Fishing Vessels Form) **[4]**. Therefore, even vessels that are not subject to the Fishing Vessels Act's Stability Standard

† Corresponding Author (ORCID: http://orcid.org/0000-0002-0935-8848): Chief, Smart Safety Research Department, Korea Maritime Transportation Safety Authority, 27, Areumseo-gil, Sejong-si, 30100, Korea, E-mail: cookie@komsa.or.kr, Tel: +82-44-330-2450
1 Senior Surveyor, Smart Safety Research Department, Korea Maritime Transportation Safety Authority, E-mail: sukim0125@komsa.or.kr, Tel: +82-44-330-2350
2 Researcher, Smart Safety Research Department, Korea Maritime Transportation Safety Authority, E-mail: kimit@komsa.or.kr, Tel: +82-44-330-2455
3 Senior Surveyor, Plan Approval Office, Korea Maritime Transportation Safety Authority, E-mail: fio040@komsa.or.kr, Tel: +82-44-330-2281

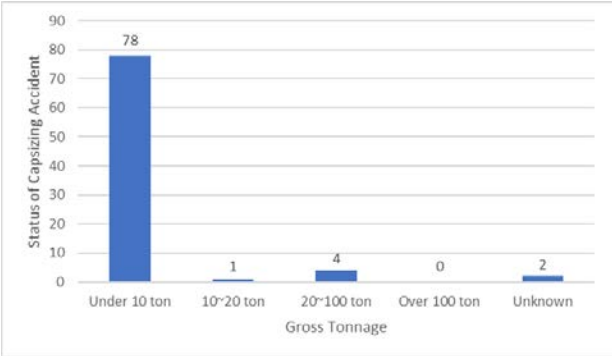


Figure 1: Weights of capsized fishing vessels in 2020 **[1]**

can be approved for the stability based on the Criteria for Standard Fishing Vessels Form **[3]**.

In view of this, the purpose of this study is to examine whether fishing vessels belonging to the size of the Criteria for Standard Fishing Vessel Form can satisfy the Criteria for Standard Fishing Vessel Form's stability. In addition, when fishing vessels were subject to the Fishing Vessels Act's Stability Standard, they were reviewed to compare and evaluate the Fishing Vessels Act's Stability Standard and the Criteria for Standard Fishing Vessels Form.

2. Criteria for standard fishing vessels form

The Ministry of Oceans and Fisheries implemented the Criteria for Standard Fishing Vessels Form in 2020 to improve the working conditions of fishermen and enhance the safety of offshore fishing vessels. The main contents of the Criteria for Standard Fishing Vessels Form are listed in **Table 1 [4]**. The standard fishing vessel form considered in this study refers to a fishing vessel based on Article 5 of the Criteria for Standard Fishing Vessels Form; the next-generation safety-welfare standard fishing vessel was not considered.

Table 1: Standard fishing vessel form conditions and benefits

Standard fishing vessel form	
Coastal fishing vessel condition	- Does not exceed the standard length or tonnage permitted for fishing - Satisfies Safety Criteria for Standard Fishing Vessels Form (excluding fishing vessels with gross tonnage below 5 tons)
Offshore fishing vessel condition	- Coastal fishing vessels with a length of less than 24 m: Meet the Standard Fishing Vessel Standards - Coastal fishing vessels with a length of more than 24 m: Satisfy Articles 3-2 (approval and maintenance of stability) and 4 (indication, etc. of a full streamline) of the Fishing Vessels Act
Benefits	- Welfare spaces (seafarers' rooms, sanitation rooms, and residential rooms) are allowed as excluded places up to 45% of the maximum volume according to the tonnage of fishing permits

The minimum distance between the center gravity of a ship and its metacenter (referred to as GM) and righting arm at the angle of deck edge immersion (referred to as GZ) of fishing vessels to satisfy the Safety Criteria for Standard Fishing Vessels Form are expressed by **Equations (1)** and **(2) [5]**, respectively. **Equations (3)** and **(4)** express the minimum GM and GZ, respectively, of the Stability Standard of the Fishing Vessels Act **[6]** for comparison and evaluation.

$$\boldsymbol{GM} \geq \mathbf{0.117}\boldsymbol{B}\left(\frac{\boldsymbol{B}}{\boldsymbol{D}} - \mathbf{2.20}\right) + \left[\mathbf{1.773}\left(\frac{\boldsymbol{T}}{\boldsymbol{D}}\right)^{2} - \mathbf{2.646}\frac{\boldsymbol{T}}{\boldsymbol{D}} + \mathbf{1.016}\right]\boldsymbol{B} \tag{1}$$

$$\boldsymbol{GZ} \geq \frac{\mathbf{2.74}(\boldsymbol{A}\cdot\boldsymbol{H})}{\mathbf{100}\boldsymbol{W}} \tag{2}$$

$$\boldsymbol{GM} \geq \mathbf{0.04B} + \boldsymbol{\alpha}\frac{\mathbf{B}}{\boldsymbol{D}} - \boldsymbol{\beta} \tag{3}$$

$$\boldsymbol{GZ} \geq \frac{\mathbf{2.74}(\boldsymbol{A}\cdot\boldsymbol{H}) + \mathbf{0.214}\Sigma\left(\mathbf{7} - \frac{\boldsymbol{n}}{\boldsymbol{a}}\right)\boldsymbol{n}\cdot\boldsymbol{b}}{\mathbf{100}\boldsymbol{W}} \tag{4}$$

Considering these characteristics, the GM required for the stability standard of the Fishing Vessels Act is applied to fishing vessels with a length of 24 to 40 m in Korea, whereas the GM required for the Safety Standards of Standard Fishing Vessels Form is an IMO regulation used for coastal fishing vessels with a length of less than 12 m.

However, because the size of domestic fishing vessels is smaller than that in foreign countries, IMO regulations were introduced as domestic regulations and applied to fishing vessels under 24 m **[2]**.

In addition, the required GZ of the Stability Standard of the Fishing Vessels Act is divided into a wind pressure moment term ($\frac{\mathbf{2.74}(\boldsymbol{A}\cdot\boldsymbol{H})}{\mathbf{100}\boldsymbol{W}}$) and passenger moment term ($\frac{\mathbf{0.214}\Sigma\left(\mathbf{7}-\frac{\boldsymbol{n}}{\boldsymbol{a}}\right)\boldsymbol{n}\cdot\boldsymbol{b}}{\mathbf{100}\boldsymbol{W}}$), indicating that the required GZ of the Safety Criteria for Standard Fishing Vessels Form is the same as deleting the passenger moment term of the Fishing Vessels Act.

3. Calculation and evaluation of stability

3.1 Stability calculation targets and conditions

In this study, the target for calculating stability was 25 coastal fishing vessels belonging to the Safety Criteria for Standard Fishing Vessels Form, and their principal dimensions for light ship conditions are listed in **Table 2**.

Table 2: Principal dimensions of target fishing vessels

No.	GT (ton)	LBP (m)	B (m)	D (m)	T (m)	Box Keel (m)
1	1.99	8.00	2.46	0.70	0.34	0.28
2	2.89	8.27	3.36	0.73	0.47	0.23
3	3.00	9.60	3.42	0.62	0.20	0.00
4	3.00	9.50	2.86	0.86	0.41	0.36
5	3.29	9.30	3.00	0.67	0.23	0.00
6	3.66	9.00	3.31	0.80	0.39	0.37
7	4.99	12.70	3.57	0.82	0.43	0.48
8	4.99	11.70	3.54	0.80	0.40	0.69
9	4.99	11.70	3.54	0.80	0.42	0.68
10	4.99	12.90	3.57	0.82	0.45	0.49
11	5.54	12.80	3.68	0.77	0.42	0.55
12	6.67	15.50	4.84	0.75	0.22	0.57
13	7.31	14.01	3.84	1.05	0.55	0.29
14	7.93	12.70	4.00	1.27	0.87	0.00
15	7.93	16.00	4.20	0.85	0.33	0.52
16	7.93	12.65	3.80	1.20	0.66	0.30
17	7.93	13.20	3.90	1.22	0.53	0.53
18	7.93	15.24	4.50	0.86	0.34	0.63
19	9.77	18.15	4.40	0.70	0.26	0.70
20	9.77	17.05	4.84	0.96	0.36	0.40
21	9.77	14.10	4.20	1.18	0.66	0.32
22	9.77	14.92	3.95	1.20	0.73	0.37
23	9.77	14.20	4.33	1.20	0.61	0.47
24	9.77	16.20	4.50	0.95	0.49	0.57
25	9.77	15.14	4.30	1.10	0.52	0.48

In addition, K-SHIP software, developed by the Korea Maritime Transportation Safety Authority and used to approve ship drawings, was used to calculate their stability. The calculated results were evaluated using the Criteria for Standard Fishing Vessels Form and the Fishing Vessels Act.

As listed in **Table 3**, the loading conditions used in the stability calculation are the standard loading conditions for fishing vessels.

Table 3: Loading conditions of fishing vessel

Loading conditions	Loading standard
Lightship condition	State in which the weight of the statutory fastener and spare parts are added to the hull and engine
Full load departure condition	State in which ice, fishing gear, crew and crew's belongings, engine spares, warehouse load, and extra water are loaded in light condition, and fuel, fresh water, food, etc., are loaded.
Fishing ground departure condition	State in which fishes are fully loaded and consumables such as fuel, fresh water, and foodstuffs are consumed by 75% from the full load departure condition.
Full load arrival condition	Consumption of 90% of consumables, such as fuel, freshwater from fishing ground departure condition
Partial load arrival condition	State in which 20% of the full catch is loaded and 90% of consumables, such as fuel, freshwater, and food, are consumed

3.2 Stability calculation S/W and reliability review

In this study, the stability of the fishing vessel was calculated using K-SHIP, a ship stability calculation software developed by the Korea Maritime Transportation Safety Authority. In addition, before calculating the stability of fishing vessels, we compared the results of Bentley's Maxsurf v.23 and K-SHIP software, which are frequently used to calculate the stability of small- and medium-sized ships, to examine the accuracy and reliability of the K-SHIP software.

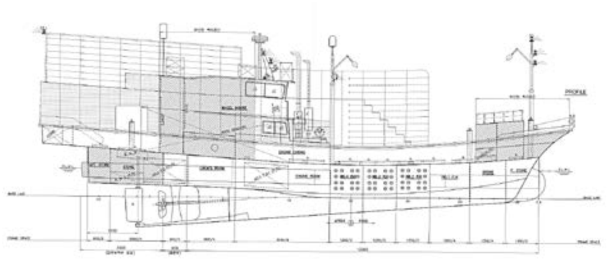


Figure 2: Profile of the fishing vessel

Table 4: Principal dimensions of the fishing vessel

Principal dimension	Value
Length Between Perpendicular	14.100 m
Breadth, molded	3.900 m
Depth, molded	1.220 m
Draft (at full Load Fish GR)	0.971 m
Box of Keel	0.559 m
Displacement (at full Load Fish GR)	48.976 ton

The ship used to review the reliability of the software was an 8.55-ton fishing vessel. The basic specifications and profile are shown in **Table 4** and **Figure 2**.

In K-SHIP and Maxsurf, the fishing vessel was modeled and used for calculations, as shown in **Figures 3** and **4**, respectively.

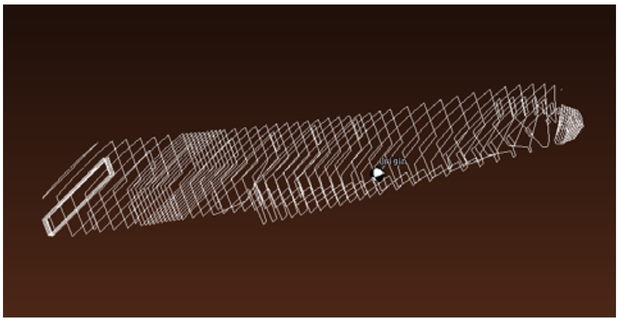


Figure 3: Fishing vessel model of K-SHIP

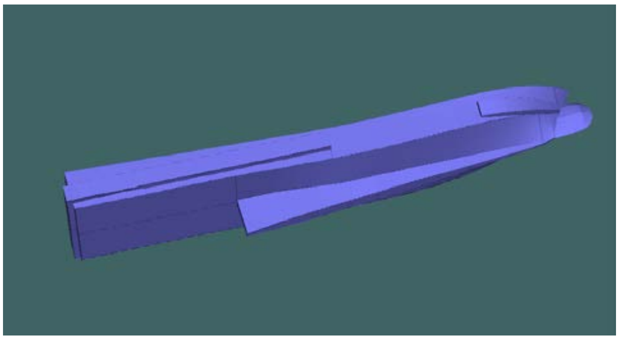


Figure 4: Fishing vessel model of Maxsurf

Table 5 shows the stability calculation results for the light ship condition of the K-SHIP and Maxsurf software using the same longitudinal center of gravity (LCG), center of gravity height (KG), and draft.

Table 5: Comparison of principal dimension calculation results

Item	K-SHIP	Maxsurf	Difference
KM (m)	3.669	3.672	0.08%
GM (m)	2.264	2.269	0.22%
Displacement (ton)	26.24	26.24	0%

As listed in **Table 5**, it was confirmed that the K-SHIP and Maxsurf software showed similar stability calculation results, and the difference rates of K-SHIP and Maxsurf satisfied the criteria of IACS URL5**[7]**.

3.3 Stability calculation and evaluation results

The stability index of coastal fishing vessels was calculated using K-SHIP, and the stability of the target fishing vessels was evaluated using the criteria for GM and GZ. **Figure 5** shows the displacement of each fishing vessel based on the loading conditions.

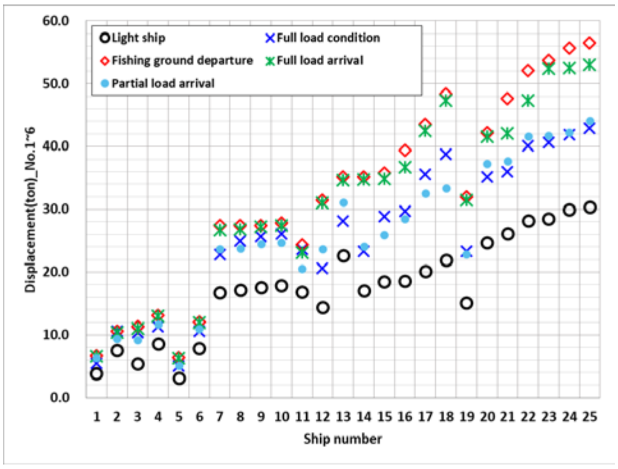


Figure 5: Displacement of target fishing vessels

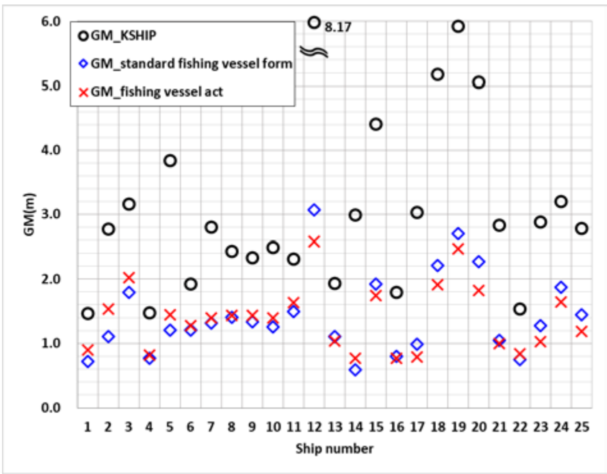
3.3.1 Comparison of GM calculation results

Figure 6 shows the calculation results of the GM of 25 fishing vessels using the K-SHIP and the required GM of the Criteria for Standard Fishing Vessels Form and the Fishing Vessels Act. A comparison was performed for the light ship condition and other loading conditions.

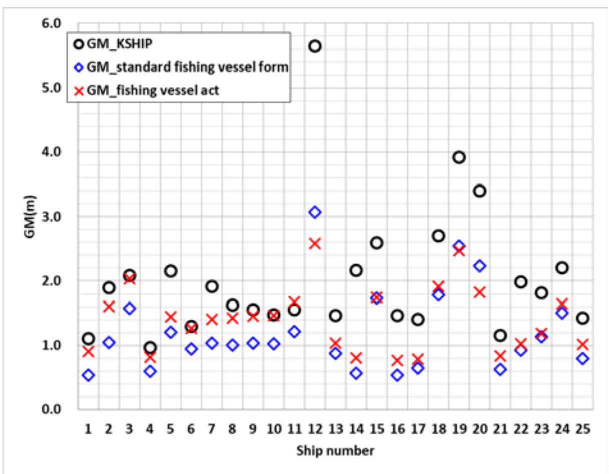
First, when comparing the GM of the target fishing vessels by the loading conditions, the smallest value was found under the fishing ground departure condition. The displacement of the fishing ground departure condition was the largest among the standard loading conditions, and the value of the metacentric radius (BM) decreased, owing to which GM was judged to be small.

In addition, most of the required GM values of the Safety Criteria for Standard Fishing Vessels Form had the largest value under light ship conditions; however, some fishing vessels had higher required GM values under full load departure conditions and fishing ground departure conditions, such as No. 16. Meanwhile, the required GM of the Fishing Vessels Act had the highest required value under the fishing ground departure condition, because the freeboard decreased as the displacement of the fishing vessel increased, that is, as **β** in **Equation (3)** decreased, the required GM value increased.

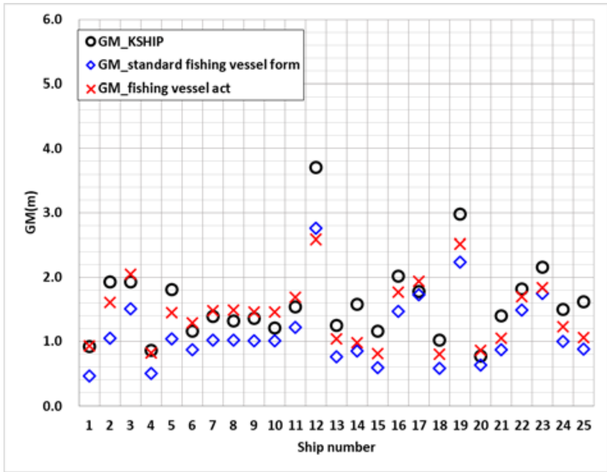
In addition, when comparing the required GM of Criteria for Standard Fishing Vessels Form and the Fishing Vessels Act, most of the Fishing Vessels Act requirements showed a larger GM; however, in some fishing vessels, the GM of the Criteria for Standard Fishing Vessels Form was larger than the Fishing Vessels Act. When comparing the Criteria for Standard Fishing Vessels Form and the Fishing Vessels Act, the reason why the GM required by the Criteria for Standard Fishing Vessels Form for a specific vessel is large is because it is influenced by the constant coefficient used in the Fishing Vessels Act. In the case of coefficient β used in the Fishing Vessels Act, a fixed value is used without considering the size of the hull as a value determined using the ratio of the freeboard to the hull depth. The reverse phenomenon was observed when the Fishing Vessels Act, which is applied to relatively large fishing vessels over 24 m, was applied to relatively small fishing vessels.



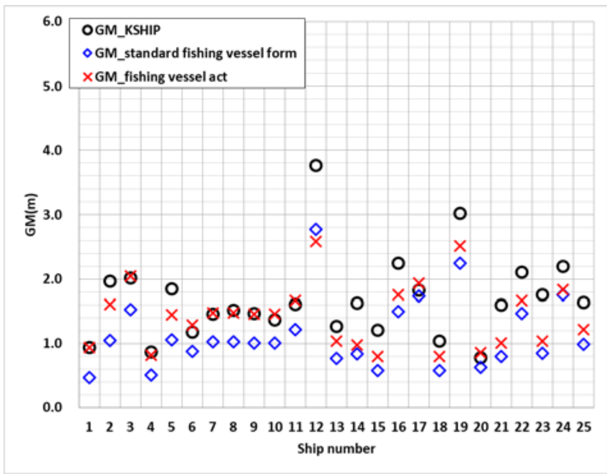
(1) Lightship condition



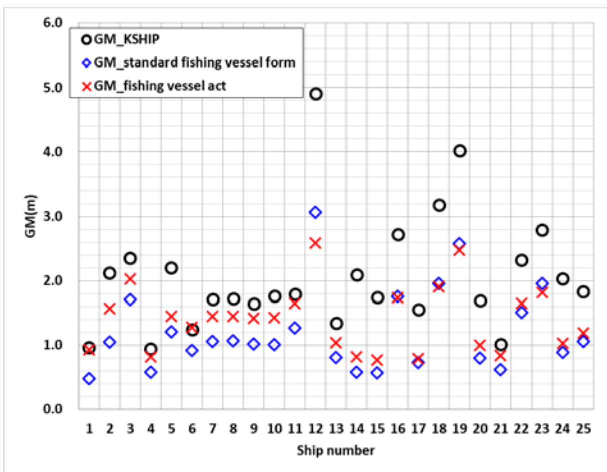
(2) Full-load departure conditions



(3) Fishing ground departure conditions



(4) Full load arrival conditions



(5) Partial load arrival conditions

Figure 6: Comparison of GM results

In addition, although the GM values of the target fishing vessels met the Criteria for Standard Fishing Vessels Form, some fishing vessels did not satisfy the stability criteria of the Fishing Vessel Act under standard loading conditions other than light ship conditions. Although there are differences based on the hull form, ships with L/B less than 2.9 among ship lengths less than 10 m, L/B less than 3.6 among ship lengths less than 14 m did not satisfy the provisions of the Fishing Vessel Act.

The results of estimating the cause of some fishing vessel failures that satisfy the GM standard of the Fishing Vessel Act are as follows. First, according to a study by Lee *et al.* **[8]**, in the case of fishing vessels, as shown in **Figure 7**, the shorter the length of the fishing vessels, the smaller the breadth compared to the length. This is because, as the size of a small fishing vessel is limited, the width is relatively increased to have a large initial restoring force. According to **Equation (3)**, to derive the required GM of the Fishing Vessels Act, the required GM increases in proportion to the width; accordingly, the required GM increases in relatively small fishing vessels. The Fishing Vessels Act is applied to fishing vessels with a length above 24 m. Thus, in the case of fishing vessels below 24 m, it is believed that fishing vessels that do not meet the GM criteria have occurred because of the above reasons.

In addition, it was observed that GM reduced owing to the shallower depth as the width increased to satisfy the gross tonnage standard.

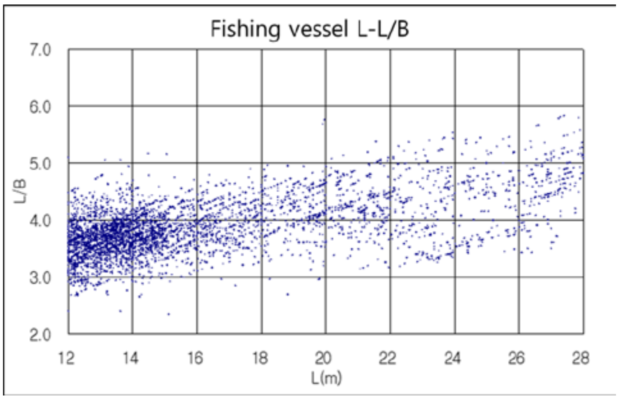
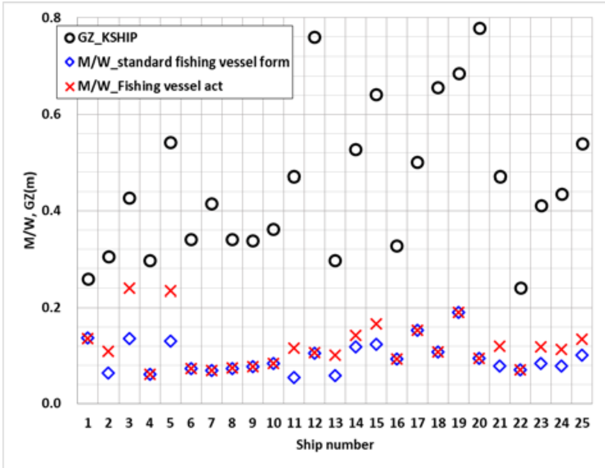


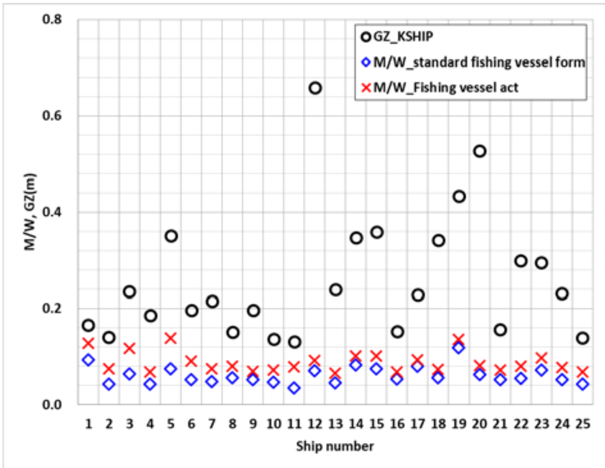
Figure 7: Comparison of fishing vessel L-L/B

3.3.2 Comparison of GZ calculation results

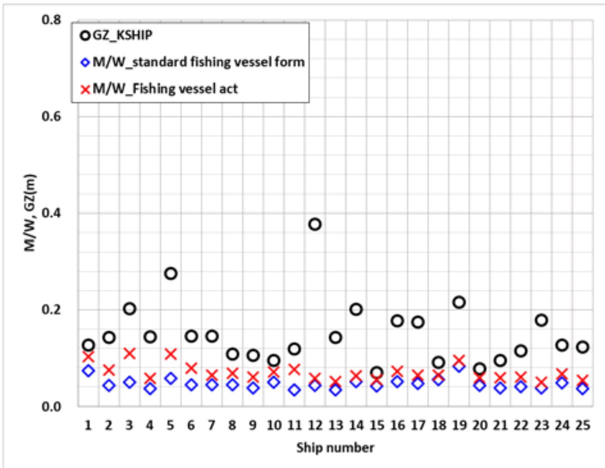
Figure 8 shows the results of calculating the GZ of the target fishing vessels using K-SHIP and comparing the GZ required by the Criteria for Standard Fishing Vessels Form and the Fishing Vessels Act for the light ship and four standard loading conditions. The number of fishing passengers used to calculate the GZ required by the stability standard of the Fishing Vessel Act was calculated based on the maximum number of passengers onboard when the ship was used as a fishing vessel. It was observed that the GZ value of the target fishing vessels satisfied both the fishing vessel act and Criteria for Standard Fishing Vessels Form, regardless of loading conditions.



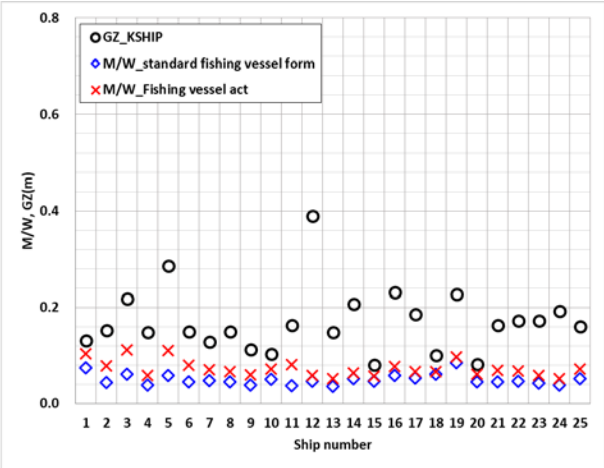
(1) Lightship condition



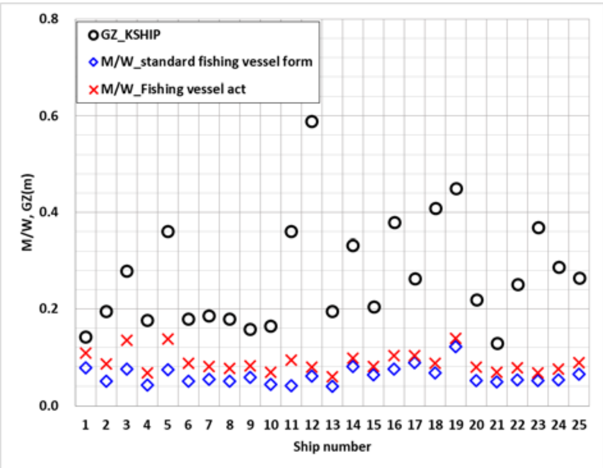
(2) Full load departure condition



(3) Fishing ground departure condition



(4) Full load arrival conditions



(5) Partial load arrival conditions

Figure 8: Comparison of GZ

Furthermore, because there was no passenger moment under lightship conditions, the required GZ values of the Criteria for Standard Fishing Vessel Form and the Fishing Vessel Act were calculated equally. Except for lightship conditions, it was confirmed that the required GZ value of the Fishing Vessel Act was larger than the required GZ value of the Criteria for Standard Fishing Vessel Form.

In addition, it was confirmed that the required GZ value of the Criteria for Standard Fishing Vessels Form had the largest value under the lightship condition with the smallest displacement, according to **Equation (2)**. In addition, the GZ value of the target fishing vessels had the smallest value in the fishing ground departure condition, which was judged for the same reason that the GM of the target fishing vessels had the smallest value in the fishing ground departure condition (GZ=GMsinθ).

For some ships (such as ships No.6 and 20 on fishing ground departure conditions), the GZ value was calculated to be larger than for other ships. This is attributed to the larger GM calculation results than those of other ships.

4. Conclusion

Since the Ministry of Oceans and Fisheries has notified the Criteria for Standard Fishing Vessels Form, we examined whether coastal fishing vessels that are not included in the Fishing Vessels Act's stability approval list meet the Criteria for Standard Fishing Vessels Form.

The following conclusions were obtained by randomly selecting 25 coastal fishing vessels and calculating GM and GZ related to ship overturning using the K-SHIP software developed by the Korea Maritime Transportation Safety Authority.

In the case of GZ, the Criteria for Standard Fishing Vessels Form was always smaller than that of fishing vessels that act as a stability standard. In the case of GM, depending on the size of the fishing vessels, there were cases where the Criteria for Standard Fishing Vessels Form had a larger value than the Fishing Vessel Act's Stability Standard. It was confirmed that all the target fishing vessels met the Criteria for Standard Fishing Vessel Form. When the Fishing Vessels Act was used for coastal fishing vessels, there were limited requirements for some ships.

In Korea, there are approximately 65,700 registered fishing vessels, with coastal fishing vessels accounting for approximately 94%, which is very high. Therefore, it is difficult to say that the 25 ships covered in this study represent the characteristics of all coastal fishing vessels. However, 25 fishing vessels are composed of small fishing boats with a gross tonnage ranging from 1.99 to 9.77 tons that represent coastal fishing vessels; therefore, it can be said that it is suitable as basic data to understand the characteristics of each tonnage class of coastal fishing vessels.

In addition, it is significant in that stability calculations were performed for coastal fishing vessels registered without stability calculation and approval. The values required by the Criteria for Standard Fishing Vessels Form and the Fishing Vessel Act were also compared.

The criteria for evaluating the safety of fishing vessels are largely based on their stability and seakeeping performance. However, in this study, only stability criteria were considered as safety evaluation criteria for coastal fishing vessels. Therefore, follow-up studies considering stability and seakeeping performance are required in the future.

Although smaller-tonnage vessels have more accidents than large vessels, current safety-related studies and criteria of domestic fishing vessels are insufficient when compared to those for large fishing vessels. Therefore, safety-related research of small vessels is expected to be more active reducing domestic marine accidents.

Acknowledgement

This research was supported for regional disaster safety problem-solving technology development of the Ministry of the Interior and Safety (MOIS, KOREA) “Development of real-time detection system to respond to sinking/disaster accidents of small ships (fishing boats/fishing vessels)” (Project No.:20015029).

Author Contributions

Conceptualization, S. -U. KIM and I. KIM; Methodology, S. -U. KIM and I. KIM; Software, S. -U. KIM and G. -K. Lee; Validation, S. -U. KIM; Formal Analysis, S. -U. KIM and I. KIM; Investigation, S. -U. KIM and I. KIM; Resources, G. -K. Lee; Data Curation, I. KIM; Writing—Original Draft Preparation, I. KIM; Writing—Review & Editing, S. -U. KIM and I. KIM, I. -S. KIM; Visualization, I. KIM; Supervision, S. -U. KIM and I. -S. KIM; Project Administration, S. -U. KIM and I. -S. KIM; Funding Acquisition, S. -U. KIM.

References

[1] Statistics of Marine Accidents, https://www.kmst.go.kr/web/stcAnnualReport.do?menuIdx=126, Accessed August 5, 2022.

[2] K. W. Kim and H. J. Lee, A study on advanced fishing vessels to secure crew welfare space, R&D report, Korea Ship Safety Technology Authority, 2012 (in Korean).

[3] S. Y. Kwon and H. J. Lee, “A Study on the Stability Criteria of Small Vessels,” Journal of the Society of Naval Architects of Korea vol. 44, no. 3, pp. 285-295, 2007 (in Korean).

[4] Ministry of Oceans and Fisheries of Republic of Korea, Criteria for Standard Fishing Vessel Form with Reinforced Safety and Welfare, Ministry of Oceans and Fisheries Notice, 2020-237, December 2020.

[5] Ministry of Oceans and Fisheries of Republic of Korea, Criteria for Standard Fishing Vessel Form with Reinforced Safety and Welfare, Ministry of Oceans and Fisheries Notice, 2022-46, April 2022.

[6] Fishing vessel stability and load line standards, https://law.go.kr/LSW/flDownload.do?flSeq=42931579, Accessed September 15, 2022.

[7] Computer Software for Onboard Stability Calculations, https://iacs.org.uk/download/10872.

[8] H. J. Lee, S. Y. Kwon, K. S. Choi, B. J. Kang, C. J. Lee, A study on stability criteria for small fishing vessels and cargo ships (ship length 12m or more and less than 24m), R&D report, Ship Inspection Technology Association, 2006 (in Korean).