A Study on the damage stability requirements for Ro-Ro passenger ships

Yoshitaka Ogawa,
National Maritime Research Institute, Japan.

Shingen Takeda,
Mitsubishi Heavy Industries, Ltd.

ABSTRACT

With regard to the middle and the small size Ro-PAX ferry, the safety levels of the SOLAS 2009 and the SOLAS 1990 regulations in association with the Stockholm Agreement (SA) was examined. Firstly, calculation of the required GM by applying SOLAS 2009 and SOLAS 1990 with SA was carried out. It is clarified that the required GM of the present calculated ship in SOLAS2009 is larger than, or at least equivalent to, in SOLAS90 with SA. It is also clarified that we should take such difference of philosophy into account in the further consideration of the safety levels of the SOLAS 2009. Secondly, model tests were conducted with the middle-size Ro-PAX ferry. It is rational to compare safety level of the SOLAS 2009 with that of the SOLAS 90 with SA adjusted by model tests.

KEYWORDS

Damage Stability; Ro-PAX ferry; SOLAS 2009; Stockholm Agreement.

INTRODUCTION

With regard to the damage stability requirements of the SOLAS 2009 amendments on RO-PAX ships, the IMO had started comprehensive examination on whether or not the safety levels of the SOLAS 2009 and the SOLAS 1990 (SOLAS90) regulations in association with the Stockholm Agreement (SA) are generally equivalent.

It is believed that the examination should be based on comprehensive research work. Based on this background, intentional studies have been conducted (e.g. EUROYARDS Stability Group, 2009). As a preliminary result, it is confirmed that, in terms of large Ro-PAX ferries, safety level of the SOLAS 2009 is more stringent than that of SOLAS90 with SA because the philosophy of each regulation is different, particularly the difference of the definition of damage extent and the increase of required index in the SOLAS2009 (EUROYARDS Stability Group, 2009).

In the meanwhile, it is considered that there are some points for further examination. One is the further comparison of the safety levels between the SOLAS 2009 and the SOLAS90 with SA

particularly in terms of the middle and the small size Ro-PAX ferry.

Another is the comparison of safety level between numeric standards and model tests adjustment in SA. It is considered that accumulated water on deck stipulated in SA may be overestimated in numeric standards and therefore it may often need to be adjusted by a model test to satisfy SA.

Based on this background, firstly, calculation of the required GM by applying SOLAS 2009 and SOLAS 90+SA was carried out. With regard to the subjected Ro-PAX ferries, it is clarified that the required GM of the present calculated ship in SOLAS2009 is larger than, or at least equivalent to, in SOLAS90 with SA. It is also found that such difference can be attributed to the difference of philosophies between SOLAS 2009 and SOLAS 90, in particular to the difference of definition of damage extent and required index in SOLAS2009.

Secondly, model tests were conducted with the middle-size Ro-PAX ferry. It is clarified that there are a certain difference between the safety levels of SOLAS 90 with SA obtained by the numerical standards and that obtained by model tests because accumulated water on deck stipulated in SA is overestimated in the numeric standards.

CALCULATION OF THE REQUIRED GM BY APPLYING SOLAS2009 AND SOLAS90+SA

The Subject Ships

For the comparison of required safety level by applying SOLAS2009 and SOLAS90+SA, two model ships of RO-PAX ferry were prepared based on typical existing ones complying with damage stability requirements of the SOLAS2009. One of them is middle-size Ro-PAX ferry. Principle particular is shown in Table 1. The subdivision of this Ro-PAX ferry is shown in Figure 1. Another one is small-size Ro-PAX ferry. Principle particulars and the subdivision of this ship are shown in Table 2 and Figure 2, respectively.

Within the framework of the SOLAS2009, RO-PAX ferry with long lower hold (LLH) especially that fitted with B/10 longitudinal bulkheads can be considered. It was found that we couldn't find such ferries within the Japanese Ro-PAX ferries. However, it is considered that the safety level examined by means of the present two ferries could describe the average safety level of the middle-size and the small-size RO-PAX ferry.

Calculation of the required GM of middle-size Ro-PAX ferry

Table 3 shows the calculated required GM, which indicates that, in the Partial and Light Service cases, the required GM is larger in the SOLAS2009 than in the SOLAS 90 with SA. Table 3 also shows that, in the case of the deepest subdivision, the required GM in the SOLAS2009 is almost the same as that in the SOLAS90 with SA. Thus, it is clarified that the required GM of the present calculated ship in SOLAS2009 is larger than, or at least equivalent to, in SOLAS90 with SA. Findings drawn from the calculation are similar with that drawn from the study by the EMSA (EUROYARDS Stability Group, 2009).

Table 1: Principle particulars of a middle-size RO-PAX ferry

Subdivision length (Ls) (m)	199.2
Breadth(B) (m)	27.0
Number of persons on board (persons)	850

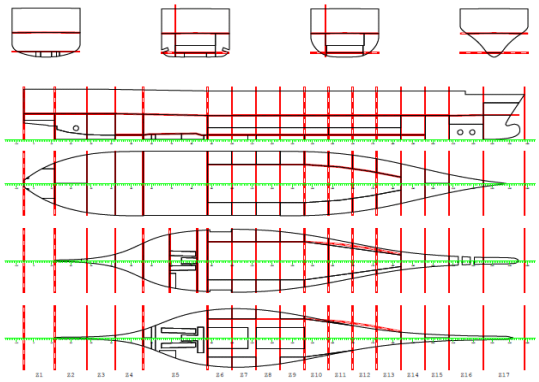


Fig. 1: The Subdivision of middle-size Ro-PAX ferry.

Table 2: Principle particulars of the small-size RO-PAX ferry

Subdivision length (Ls) (m)	100.0
Breadth(B) (m)	17.8
Number of persons on board (persons)	218

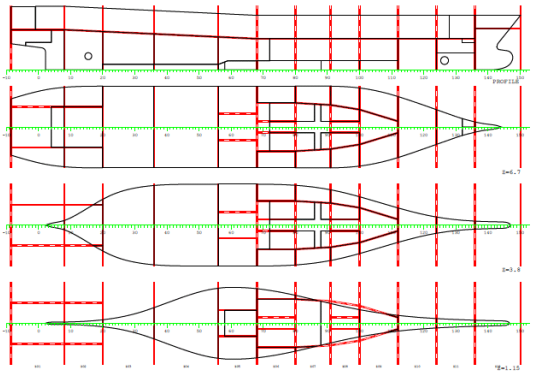


Fig. 2: The Subdivision of small-size Ro-PAX ferry.

Such difference of the required GM can be attributed to the difference of the philosophy of each regulation, in particular to the definition of damage extent. As the number of passenger increases, the required Index in the SOLAS2009 increases and the required GM of every loading condition increases. For the compliance with such a severe required index, flooding of more than two compartments is required to be taken into account in the SOLAS2009. On the other hand, in the SOLAS90, although the number of passengers has impact on the subdivision coefficient (Cs) which defines the number of damage compartment, most of the damage case results in two compartment damage. This implies that it becomes relatively easy for larger ship to comply with SOLAS90. Consequently, the number of passenger has little effect on the required GM in the SOLAS90.

Because of such difference in philosophy of both regulations, it is clarified that safety level of the SOLAS2009 of a relatively large ship becomes higher than that of the SOLAS90 with SA.

Table 3: Required GM of the middle-size RO-PAX ferry for SOLAS2009, SOLAS90 and SOLAS90+S.A.

	Light service dl	Partial dp	Deepest ds
Draught (m)	5.7	6.4	6.9
Required GM (m)			
CASE1 SOLAS2009	2.5	1.3	1.73
CASE2 SOLAS90	1.4	1.19	1.33
CASE3 SOLAS90+SA	1.44	1.25	1.65

Calculation of the required GM of small-size Ro-PAX

The required GM of small-size Ro-PAX is also calculated. In this calculation, the required GM is calculated based on the SOLAS2009 Reg.7 (Probabilistic requirement) and Reg.8 (minor side damage requirement), separately. To examine the effect of accumulated water based on SA, assumed wave height and derived accumulated water are varied in this calculation. Figure 3 shows the calculated required GM, which indicates that, in all loading case, the required GM in the SOLAS2009 is almost the same as that in the SOLAS90 with SA, which corresponds to the case of 4m significant wave height in Fig.3, because the requirement in regulation 8 in SOLAS2009, minor damage requirement, is similar to that in SOLAS90. It is found that minor damage requirement is dominant to the small-size Ro-PAX. It is clarified that the required GM of the present calculated small-size Ro-PAX ferry in SOLAS2009 is almost same as in SOLAS90 with SA.

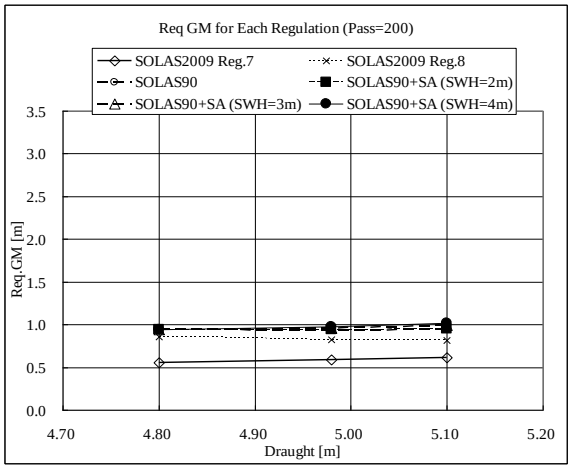


Fig. 3: Required GM of the small-size RO-PAX ferry for SOLAS2009, SOLAS90 and SOLAS90+S.A. (N=200).

Furthermore, the effect of number of persons on board on the required GM is examined. Figure 4 shows the required GM under the assumption of increase of number of persons on board. It is found that, in the case of the deepest subdivision, the required GM in the SOLAS90 with SA is significantly larger than that in SOLAS2009. The assumed damage extent in SOLAS90 and SOLAS2009 reg.8 increases due to the increase of number of person on board (more or less than 400 persons). It is found that such an increase has effect on the required GM in the SOLAS90 with SA. It is clarified that we should take such difference of philosophy into account in the further consideration of the safety levels of the SOLAS 2009.

Particularly, it should be considered that operational factor such as the number of persons on board has much relation with the safety level of small-size Ro-PAX ferry.

CONSIDERATION OF ACTUAL SAFETY LEVEL ENSURED BY THE STOCKHOLM AGREEMENT

Comparison of Safety level between Numeric Standards and Model Tests Adjustment

It is considered that accumulated water on deck stipulated in SA may be overestimated in numeric standards. Consequently, it may often need to be adjusted by a model test to satisfy SA. This means that there may be a certain difference between the safety levels of SOLAS90 with SA obtained by the numerical standards and that obtained by model tests.

Therefore, model test was conducted to investigate the difference of required GM between SOLAS90+SA in numeric standards and that adjusted by model test and to find out whether the ship designed according to SOLAS 2009 would survive in model tests carried out according to the guidelines in the Annex of the Stockholm Agreement or according to the Directive 2003/25/EC, as amended. Therefore, model tests were carried out with various loading conditions (GM=1.0, 1.2 and 1.4m)

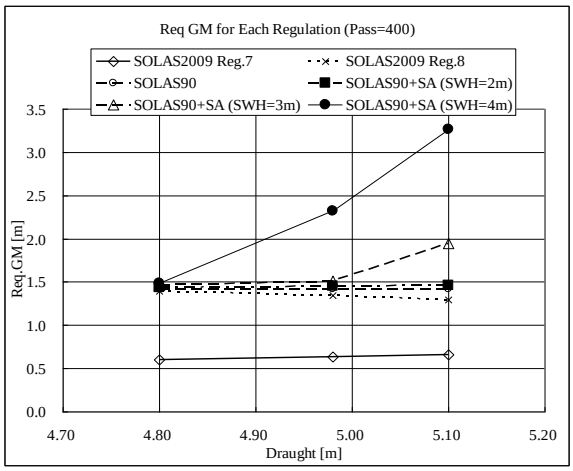


Fig. 4: Required GM the small-size RO-PAX ferry for SOLAS2009, SOLAS90 and SOLAS90+S.A. (N=400).

Overview of Model Tests

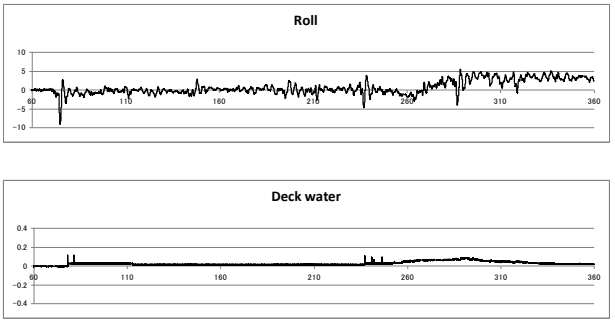
Model tests were conducted with the middle-size Ro-PAX ferry, which is mentioned above section, in accordance with "Revised Model Test Method Under Resolution 14 of the 1995 SOLAS Conference" (MSC.141(76)). The width of the damage openings and all conditions of experiments are determined based on this guideline.

The tests were carried out in the towing tank in National Maritime Research Institute of Japan. About 5 m long model, which corresponds to a model scale of 1:40, was used. Damaged compartments and ro-ro spaces are modelled with the correct surface and volume permeability ensuring that floodwater mass and mass distribution are correctly represented. Ventilating and cross-flooding arrangements are constructed to represent the real situation of the subject Ro-PAX ferry.

The irregular beam seas were generated with the JONSWAP spectrum. The 200 m long test basin provided sufficiently long measurement duration practically free of wave reflection. Ship motion including roll, incident wave and water height on Ro-Ro deck were measured by means of gyro and wave proves.

Results of Model Test

Figure 5 shows the example of time histories of roll motion, water height on Ro-Ro deck and incident waves. In the case of GM=1.2m, it is clarified that the present Ro-PAX ferry did not capsize in different ten 30 minutes realisations although water piled up on Ro-Ro deck and induced the certain heel to lee side. In the meanwhile, in the case of GM=1.0m, ship capsized because GM after damaged became almost zero. Therefore, it is clarified that the required GM exists between 1.0m and 1.2m.



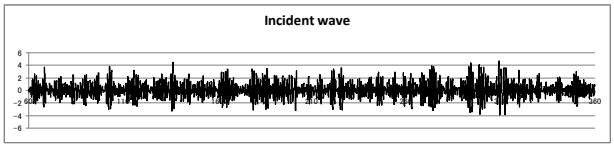


Fig. 5: Sample of time history of roll motion, water height on RoRo deck and incident wave (GM:1.2m, Significant wave height :4m).

The result shows that the required GM exists between 1.0m and 1.2m, which demonstrates that the required GM based on the numeric standards in SA as described in Table 3 (1.65) is larger than the required GM revealed by the model test. Therefore, because the accumulated water on deck stipulated in SA is overestimated in numeric standards, it is clarified that there is a certain difference between the required GM based on the numeric standards and that based on the model test.

Therefore, it should be considered preferable to compare safety levels of the SOLAS2009 with that of the SOLAS90 with SA using model test adjustment.

Table 4: Comparison of Required GM based on the numeric standards in SA with the required GM revealed by the model test.

	Numeric standards	Model test
GM (m)	1.65	1.0<GM<1.2

CONCLUSIONS

As a result of the present study, the following conclusions are obtained;

1. With regard to the subjected Ro-PAX ferries, the required GM in the SOLAS2009 is larger than, or at least equivalent to, in the SOLAS 90 with SA in all the loading cases defined in the SOLAS2009. Such difference can be attributed to the difference of philosophies between SOLAS2009 and SOLAS90, in particular to the difference of definition of damage extent. Therefore, it is important that we should take such difference of philosophy into account in the further consideration of the safety levels of the SOLAS2009.

2. It is clarified that there are certain differences between the safety levels the of SOLAS90 with SA obtained by numerical standards and that obtained by the model tests because accumulated water on deck stipulated in SA is overestimated in numeric standards. It is same findings of the study conducted by the EMSA/HSVA. Hence, it is rational to compare safety levels of the SOLAS2009 with those of the SOLAS90 with SA adjusted by model tests.

ACKNOWLEDMENTS

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