The influence of spacing between two submerged bodies on wave loads of SWATH

Guoqing Feng[a] , Xueyun Jiang[b] , Huilong Ren[c], Qingyue Zhang[d]

College of ShipBuliding Engineering, Harbin Engineering University, Harbin, 150001, China

[a]771955943@qq.com

Abstract. The determination of the spacing between two submerged bodies is of great significance in preliminary design stage of SWATH. And this paper focus on researching the influence of spacing between two submerged bodies on SWATH wave loads. Wave loads forecast are made for three different loading conditions, which are normal loading, full loading and maximum loading. For each loading condition, no parameter except the spacing of two submerged bodies is changed from the available data of a certain SWATH in practical project to obtain a series of SWATH computation models. By means of 3-D frequency domain, wave load forecast of different computation models is made to obtain the transfer function, long-term and short-term forecast value, then the comparisons between the value of wave load forecast and that of ABS and CCS specifications are done. By comparing the wave load forecast value of different calculation models, the degree and characteristics of impact which the spacing between two submerged bodies has on the wave loads are obtained, thus providing a reference for the preliminary design of SWATH.

Introduction

With the rapid development of SWATH in the field of shipbuilding, the study of SWATH wave loads has gradually developed and deepened in recent years. Currently, researches about SWATH wave loads are mainly focused on the following: the estimation and empirical formulas of design loads, the dangerous working conditions, the hydrodynamic pressure and motion response characteristics. In preliminary design stage of SWATH ship, the determination of spacing between two submerged bodies is very important, which has seldom been studied in the shipbuilding field. Actually, the underwater part of SWATH mainly consists of two submerged bodies and two pillar bodies, which can provide buoyancy for the whole vessel. Based on source-sink distribution theory, two submerged bodies can be regards as two symmetrically arranged ellipsoids. And the presence of one submerged body will act as an additional wall for the other, while solving the velocity potential. Thus, different spacing between two submerged bodies will surely lead to different wave loads.

Therefore, this article focus on researching the influence of spacing between two submerged bodies on SWATH wave loads under three loading conditions. For each loading condition, spacing is the only variable, thus a series computation models with different spacing are obtained. Then COMPASS-WALCS-BASIC software is adopted to do wave loads forecast for those computing models. By comparing the wave load forecast results of different computation models, the influence of spacing between two submerged bodies on SWATH wave loads can be obtained, which can provide a reference for the preliminary design of SWATH ship.

Computation parameters

To compute the sectional wave loads, 21 transverse sections and a longitudinal section are selected. And all the transverse sections distribute along the captain uniformly, while the longitudinal section locates in longitudinal section of the ship.

In regular waves computing, the computed speed is 6kn, and the computed wave interval amounts to 15 °, while 36 frequencies were used (0.2rad/s with steps of 0.05 rad/s up to 2.0 rad/s). Due to space

limitations, only transfer functions of relevant wave loads of partial frequencies under full loading condition are illustrated in Figs .1~4.

Given the results of regular wave calculations, wave loads in irregular waves can be obtained based on relevant mathematical statistics principles. And the wave parameters of short-term forecast are shown in table 1, while NO.34 North Atlantic waves scatter plots recommended by IACS are selected in the long-term forecasts. In the long-term forecasts, the exceedance probability is 10^{-8} and the point spread function is $\frac{2}{\pi}\cos^2\theta$.

Table 1. Wave parameters of short-term forecast

Scale of state of sea	H_S（m）	T_P(s)
4	2.5	6.8
5	4	7.5
6	6	9.6
7	9	11.6

Presentation of the results

Due to space limitations, only transfer functions of relevant wave loads of partial frequencies under full loading condition are illustrated in Figs.3~6. And when the vessel is in full loading condition, the short-term wave loads forecast of different calculation models under different scale of state of sea are illustrated in Figs.5~8.

Then, comparison between the long-term forecast values of WALCS and specification values of CCS and ABS is shown in Table 2.
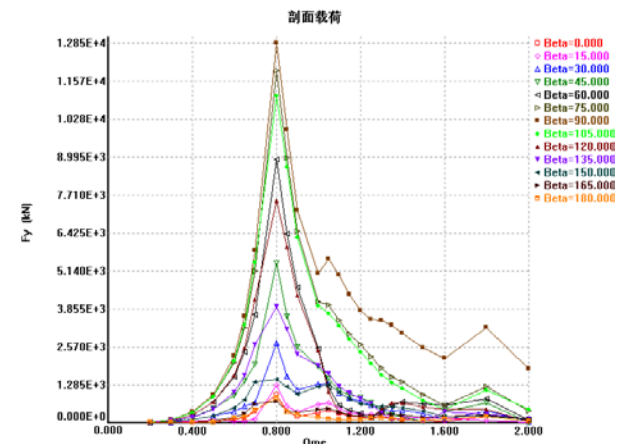

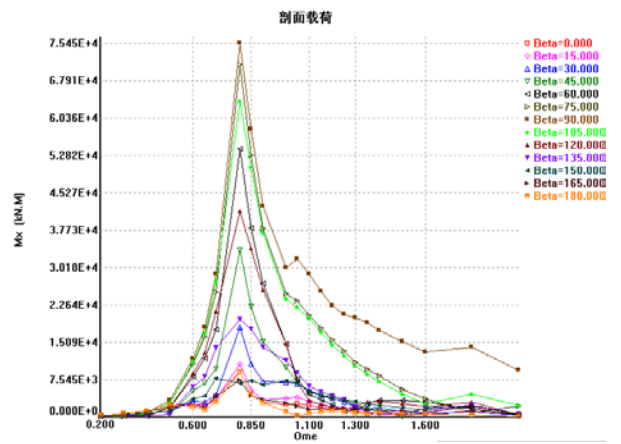Fig.1 Transfer function of horizontal split force

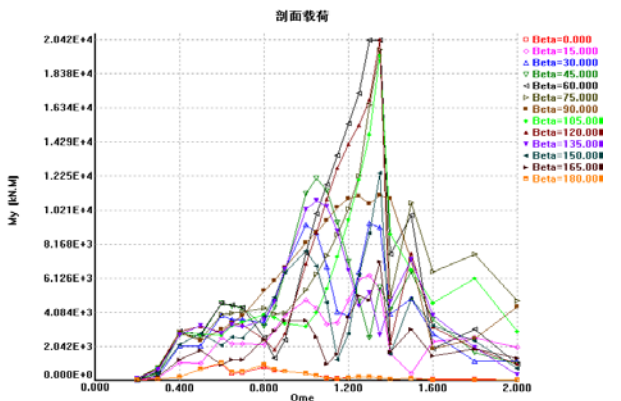Fig.2 Transfer function of transverse bending moment

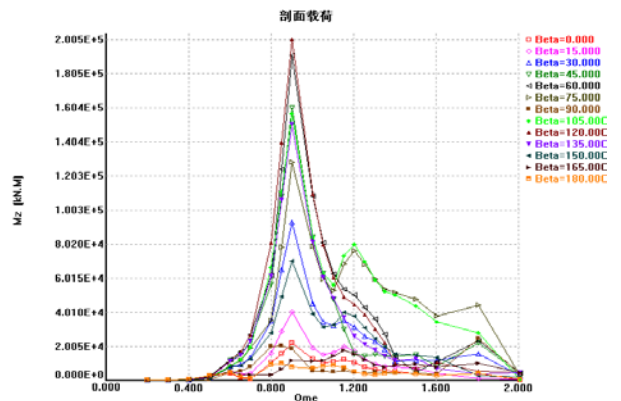Fig.3 Transfer function of sync pitch torsional moment

Fig.4 Ttransfer function of horizontal torsional moment

Table 2. Long-term forecast values and specification values of CCS and ABS

Wave loads	Compare form	Wave loads value	Ratio
horizontal split force	WALCS/CCS	4.7×10^4 /5.2×10^4	89.0%
	WALCS /ABS	4.7×10^4/5.4×10^4	87.0%
transverse bending moment	WALCS /CCS	4.7×10^5/$\times10^5$	89.0%
	WALCS /ABS	4.7×10^5/5.4×10^5	87.0%
sync pitch torsional moment	WALCS /CCS	5.5×10^4/5.4×10^4	101.8%
	WALCS /ABS	-	-
horizontal torsional moment	WALCS /CCS	5.6×10^5/4.5×10^5	124.0%
	WALCS /ABS	5.6×10^5/5.9×10^5	94.0%

According to Table 2, the wave loads forecast valus of WALCS are very close to the computed results of CCS 《Guidelines of Small Water plane Area Twin Hull Craft》(2005) and ABS 《Guide for Building and Classing SWATH vessels》（1999）, thus verifying the correctness of the computation result by WALCS.

Figs. 9~12 show the short-term wave loads forecast of each computation model under three different loading conditions.
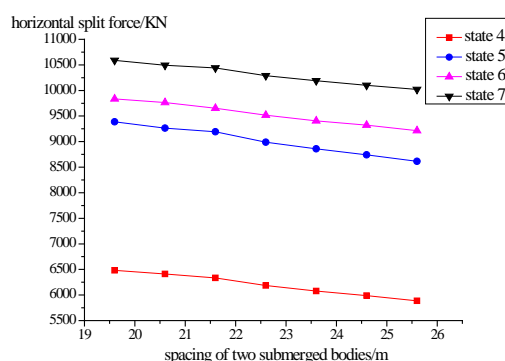

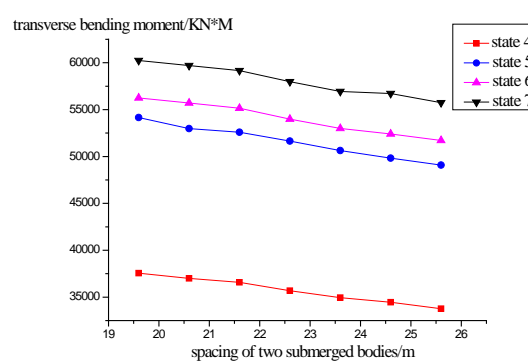Fig.5 Short-term value of horizontal split force

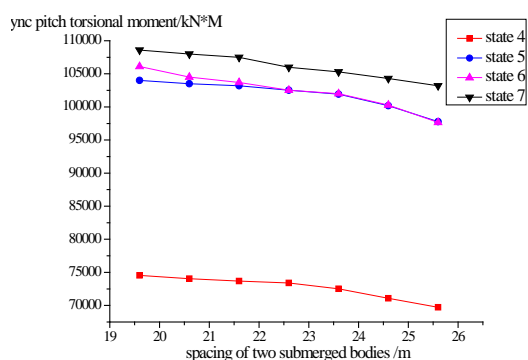Fig.6 Short-term value of transverse bending moment

Fig.7 Short-term value of sync pitch torsional moment
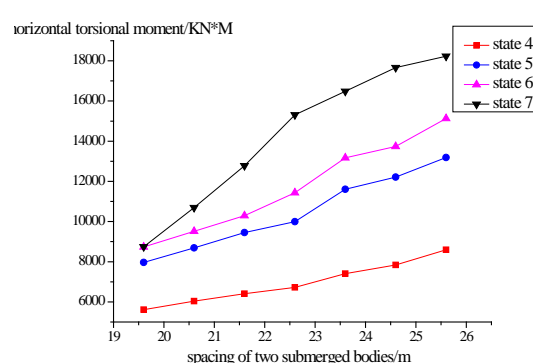

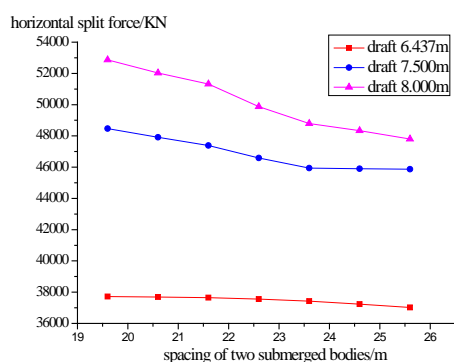Fig.8 Short-term value of horizontal torsional moment

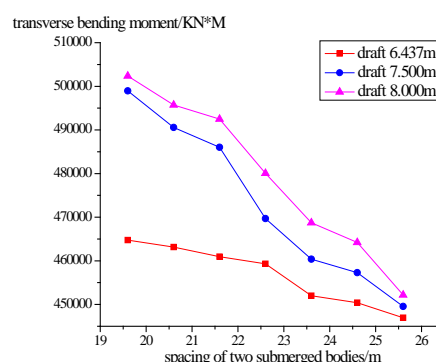Fig.9 long-term value of horizontal split force

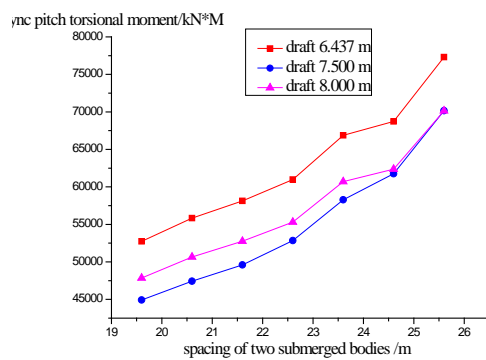Fig.10 long-term value of transverse bending

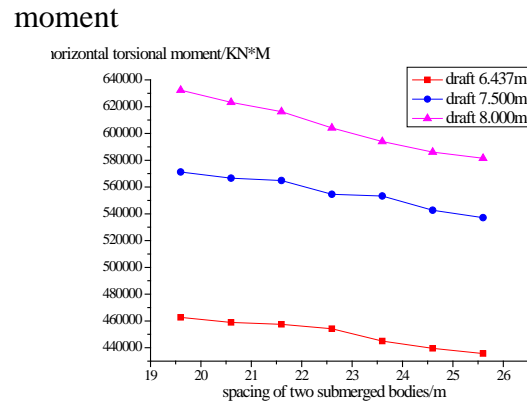Fig.11 long-term value of sync pitch torsional moment

Fig.12 long-term value of horizontal torsional moment

Conclusions

Based on the short-term and long-term wave loads forecast of different computation models, the following conclusions can be drawn:

(1) From the results of short-term and long-term wave loads forecast, it can be clearly concluded that the spacing between two submerged bodies has small effect on the horizontal split force, transverse bending moment, horizontal torsional moment and longitudinal bending moment, which verifies the rationality that CCS and ABS didn't take the spacing as an impact factor in the wave load estimation formula. Though, those wave loads share a common variation: they would increase when the spacing between two submerged bodies decrease, which is very useful for the preliminary design of SWATH.

(2)Different from above wave loads mentioned in(1), the spacing has relatively large impact on the sync pitch torsional moment, and the bigger the spacing is, the bigger the moment will be.

(3)When comparing the short-term and long-term wave loads forecast of the same model under different loading conditions, it can be additionally concluded that the bigger the draft is, the bigger all the wave loads will be. However, the specific influence that the draft has on wave loads may need further research.

Acknowledgements

References

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