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COMMITTEE II.2
DYNAMIC RESPONSE

COMMITTEE MANDATE

Concern for the dynamic structural response of ship and floating offshore structures as required for safety and serviceability assessments, including habitability. This should include steady state, transient and random responses. Attention shall be given to dynamic responses resulting from environmental, machinery and propeller excitation. Uncertainties associated with modelling should be highlighted.

CONTRIBUTERS

Official Discusser: Suk-Yoon Hong, *Korea*

Floor Discussers: Robert A. Sielski, *USA*

Reply by Committee:

Chairman: D.S. Cho, *Korea*
S. Brizzolara, *USA*
I. Chirica, *Romania*
A. Düster, *Germany*
A. Ergin, *Turkey*
O.A. Hermundstad, *Norway*
M. Holtmann, *Germany*
C. Hung, *China* (*Taiwan*)
A. Ivaldi, *Italy*
C. Ji, *China*
W.H. Joo, *Korea*
B. Leira, *Norway*
S. Malenica, *France*
Y. Ogawa, *Japan*
M.A. Vaz, *Brazil*
A. Vredeveldt, *The Netherlands*
Y. Xiong, *UK*
D. Zhan, *Canada*

CONTENTS

1. DISCUSSION

1.1 Official Discussion by Suk-Yoon Hong

1.1.1 Introduction

It is my great pleasure to have the opportunity to serve as the official discusser of the report of Committee II.2. Here, I would like to congratulate all the committee members for their success in achieving the task assigned to the committee. This report is very well organized showing every contents currently issued, and then I just express some recommendations with relevant questions.

1.1.2 Ship Structures

- Would you explain the reason why you focus on the unconventional ships and large ships? In some aspect, issues on the conventional ships and small ships are noticeable.

– *Environmental-induced vibration*

✓ *Wave-induced vibration*

- This section is considered as the prime important part of the report, and I would like to suggest committee of next period to include the II.2 keywords in the sub-section titles as seen in the 2012 report.
- I recommend committee to focus on the significant progressive results and developments rather than to refer all the current works. Especially in numerical methods part, the representative works are expected to be explained in detail to share more significant achievements.
- In numerical methods part, fully coupled 3D FEM-BEM from Bureau Veritas tool is mentioned. Does 'fully coupled' means the coupling at the governing equations level or tool/module operations level?

✓ *Ice-induced vibration*

- Compared to wave-induced vibration, this area does not grow up to the independent field, and I would like to suggest committee of next period to cover this section within the wave-induced vibration part.

– *Machinery or propeller-induced vibrations*

✓ *Propeller-induced vibration*

- Propeller-induced vibration and propeller radiated noise became important issues nowadays, and profound understanding on the propeller hydrodynamics, ship/propeller vibration, CFD, hydroacoustics and/or acoustic field analysis method are required to solve this matter.
- Remarkable ship propeller noise and propeller-induced structural vibration researches have been progressed covering wide frequency ranges with the structural acoustic coupling analysis tools in link with propeller hydrodynamics, and I would like to introduce Dr. J. D. Kim's Ph.D. thesis (2012) titled 'A study of propeller noise and pressure fluctuation analysis considering scattering effects in time-domain and some applications to ships'.

✓ *Machinery-induced vibration*

- Recently, machinery-induced noise and vibration researches have been progressed covering fluid loading and mounting effects at the wide frequency ranges, and I would like to introduce Dr. J. B. Han's Ph.D thesis(2014) titled 'Extended researches on power flow analysis for predictions of underwater radiated noise generated by machinery vibration of naval ships'.

✓ *Numerical and analytical vibration studies of ship structures*

- I agree that in some aspects it is meaningful to focus on the non-FEM and/or elements based researches. But still FEM based full scale ship vibration analysis is prime interest of many ship noise and vibration engineers. And here, I would like to suggest next committee to cover the diverse full scale ship vibration analyses with any kinds of possible methods.

– *Noise*

- I think this section shows well balanced contents and format. And I would like to ask committee to cover the flow-induced noise including turbulent boundary layer (TBL) effects. Together with the propeller and machinery, air/water flow plays an important part of the generated noise. Especially in the high speed vessels, noise due to the turbulent flow could be even dominant. I would like to introduce Dr. S. Ianniello's work at INSEAN titled 'Ship underwater noise assessment by the acoustic analogy. Part I: nonlinear analysis of a marine propeller, Part II: hydroacoustic analysis of a ship scale model and Part III: measurements versus numerical predictions on a full-scale ship'. To adequately cover the turbulent boundary layer (TBL) effects, the TBL spectrum model and their vibro-acoustic responses are to be formulated considering time cost, and I expect next committee will cover these issues.

✓ *Interior noise*

- As committee mentioned, the interior noise is maybe the oldest fields of applications. But, the shipbuilding industries have still made the particular efforts on this issue. Considering interior noise, I have the design-oriented keywords such as HVAC design, ship silencer/muffler design, floating floor design and noise reduction panel design and design criteria. I would like to suggest committee to dwell on the design-oriented work too. And I think some of the topics covered in Committee II.2 could be surveyed from the design-oriented practical point of view rather than the basic approaches.

✓ *Air radiated noise*

- In this young field, the report is well oriented, and we could expect more advanced work during the next period.

✓ *Underwater radiated noise*

- Underwater radiated noise has been always the main issues in naval ship research and design fields, and it is true that very limited publications are available. But, considering its importance, skipping is not recommendable. I would like to suggest committee to consult on the technical comments and reports available by the communications with Specialist Committee V.5.
- In numerical methods part, CFD-based hydroacoustic approaches are understood as remarkable method nowadays, and the survey on this field is expected to the next committee. And fully coupled FE/BE analysis of a submarine is mentioned in this part. Can you clarify the 'fully coupled FE/BE analyses and is it to the submarine full model?

1.2 Floor and Written Discussions

1.2.1 Robert A. Sielski

The committee has reviewed many reports on means of computing the whipping response at the hall girder to slam loads. Could the committee pleased comment on the relative ability for these methods to compute the phase relationship between the maximum whipping response to maximum wave-induced hull girder bending?

2. REPLY BY COMMITTEE

2.1 Reply to the Official Discusser Prof. Suk-Yoon Hong

2.1.1 Introduction

The Committee thanks Prof. Hong for his generous appraisal of our report and his dedication for official discussion, which complements and amplifies many aspects of our report. Prof. Hong has given not only three explicit questions but also several recommendations. We have attempted to organize our responses to those questions and recommendations according to the heading structure given in the official discussion.

2.1.2 Ship Structures

Prof. Hong asked the reason why the Committee focus on the unconventional ships and large ships because issues on the conventional ships and small ships are noticeable in some aspects. During the literature survey and development of our report, this Committee did not limit kinds of ships. From the results, this Committee only found a great portion of researches during the last three years was focused on the unconventional ships and large ships. Advances on dynamic responses of the conventional ships and small ships were also introduced but it took small portions of our report.

– *Environmental-induced vibration*

✓ *Wave-induced vibration*

The Committee expects the recommendation on the keywords will be discussed in the Committee of next period.

Prof. Hong noted that the Committee focuses on the significant progressive results and developments to share more significant achievements, especially in numerical methods. Actually it is not easy to balance the reviews on a number of literatures and detail descriptions on more significant achievements within a limited page budget of ISSC report. Springing and whipping have been a hot issue during last decade and the significant achievements during recent 3 years were explosively published, of which different numerical methods for hydroelasticity analysis have different merits and demerits. Moreover, more practical or preciser analysis and their validations still need more work, especially in whipping analysis. From the above reasons, the committee focused on the introduction of abundant but selected research results on wave-induced vibration.

In numerical methods part, Prof. Hong asked whether a fully coupled 3D FEM-BEM from Bureau Veritas tool means the coupling at the governing equations level or tool/module operations level. Indeed, the fully coupled 3D FEM-BEM model uses the coupling at the governing equation level, within the framework of the modal approach. The method allows for consistent transfer of the structural deformations to hydrodynamic model and, at the same time, for consistent transfer of the hydrodynamic pressures to structural model, at each time step.

✓ *Ice-induced vibration*

In principle, the suggestion to cover the section on ice-induced vibration (IIV) within the wave-induced vibration part will be discussed in the Committee of next period. Actually, reviewed literatures on IIV of ship structures in our report are only five but those for wave-induced vibration are 124. But, in case of offshore structures, 37 literatures on IIV were reviewed. It would be results of industrial efforts to develop oil and gas fields in arctic regions. This Committee considers it is better to IIV separately because ice-structure-fluid interactions are quite different from fluid-structure interactions of wave-induced vibration. Additionally, the Committee expects researches on IIV of ship structures will be increased for trans-arctic shipping.

– *Machinery or propeller-induced vibrations*

Prof. Hong introduced two additional literatures (Kim 2012, Han 2014) which were Ph.D. theses and might contain cutting edge research results on the topics. It is regrettable for this Committee not to

review those literatures which could not be found through Google searching. The Committee of next period may review themselves or relevant literatures to be published by the authors.

- ✓ *Numerical and analytical vibration studies of ship structures*

  This committee agrees to cover the diverse full scale ship vibration analyses with any kinds of possible methods including FEM based full scale ship vibration analysis. Such full scale simulations are today state of the art in the maritime industry. Maybe that is the reason why less research is conducted in this field. At least our literature review and the few papers found suggest this. Nevertheless, we see that full scale ship vibration analysis still requires more works to enhance its prediction accuracy and/or to reduce its cost. This Committee also hopes the next committee will be able to find more open-accessible research results on them.

– *Noise*

Prof. Hong recommended that next Committee to cover the flow-induced noise including Turbulent Boundary Layer (TBL) effects and introduced three additional literatures (Ianniello et al. 2013, 2014a, 2014b) because noise due to the turbulent flow could be even dominant in high speed vessels. This committee agrees with him and also recommends the next committee will treat the topic.

- ✓ *Interior noise*

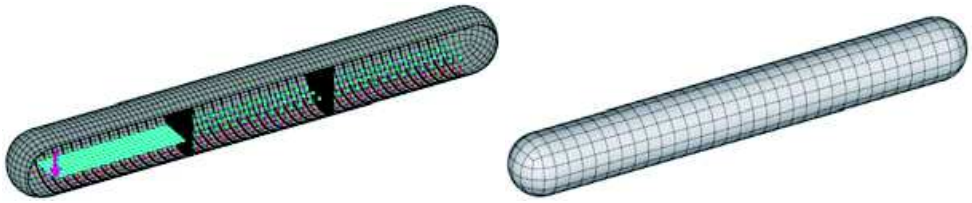
  This committee agrees with him and recommends the next Committee will widen topics on the design-oriented works related to interior noise such as HVAC systems.

- ✓ *Air radiated noise*

  Not only Prof. Hong but also this Committee expects more advanced work during the next period in this field.

- ✓ *Underwater radiated noise*

  Prof. Hong asked that the clarification of 'fully coupled FE/BE analysis' adopted and its numerical model to be analysed by Peter et al. (2014). The authors utilized a simple submarine pressure hull consisted of a cylinder of 45 m length and 6.5 m diameter with hemispherical caps (displacement 1,637 tonnes) whose numerical models are illustrated in the following figure. They solved a fully coupled FE/BE problem in governing equation level by applying a Krylov based model order reduction technique only to the structural part, to consider BE matrices depending on frequency. The analysis results were only introduced up to 100 Hz.



(a) FE model (4,992 elements, 89,496 DOF) (b) BE model (576 elements, 2,304 DOF)

Figure from Peter et al. (2014).

2.2 Reply to Floor and Written Discussion

2.2.1 Reply to Robert A. Sielski

The correct phasing in between the wave induced bending moment and the maximum whipping response is an important issue in the determination of the consistent time history of the total response. Within the approach, which is commonly adopted in the numerical models of whipping, the phasing directly depends on the proper identification of the slamming event. The identification of the slamming event is relatively simple because the seakeeping code directly gives the relative position of the part of the ship which is exposed to the slamming (bow, stern) with respect to the instantaneous wave surface, so that the slamming occurrence can be properly identified. In that respect, the evaluation of the correct phasing represents smaller problem than the amplitude of the local slamming loading which is much harder to evaluate.

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