SESSION ON OCEAN ENGINEERING

Chairman: Dr. S. Takezawa

Ocean Engineering Committee Memberships: E. Huse (Chairman) – A. Incecik (Secretary) – J.I. Collins – K. Kokkinowrachos (to November 1988) – J. Lundgren – H. Maeda – J.A. Pinkster – G. Poerio – J.V. Römeling.

Discussion on the Report and the Draft Recommendations of the Ocean Engineering Committee (cf. Proceedings, Volume 1, pp. 479–523).

I. DISCUSSIONS

OE–1

J.E.W. WICHERS
Maritime Research Institute Netherlands, The Netherlands

SOME RECOMMENDATIONS TO THE OCEAN ENGINEERING COMMITTEE OF ITTC

After studying the 19th Ocean Engineering Committee report I like to make some recommendations:

1. The committee should pay more attention to wind spectra. For moored structures the effect of wind spectra (wind gusts) on the low frequency surge motions can be of the same order as induced by the wave drift forces in case of higher Beaufort sea states.

2. The various descriptions of wind spectra result in substantial difference of the values. More investigations must be carried out in prototype wind measurements.

3. A principle description of the procedure how to compute the low frequency surge motions of a tanker moored by a simple (horizontal) spring and exposed to irregular head waves, head

current and head wind, to be considered as a basic case, is necessary. The results of computations must be compared with model test results. If the ITTC can achieve a consistent description of this basic case then low frequency statistics and prototype scale effects can be considered more seriously.

4. Standard test procedures have to be developed to establish and to determine the low frequency hydrodynamic (viscous) reaction forces acting on a floating structure (for instance a bow hawser moored tanker) due to the low frequency motions in the horizontal plane (combined surge, sway and yaw).

OE-2

M. ABE
Akishima Laboratory, Mitsui, Japan

DISCUSSION TO THE OCEAN ENGINEERING COMMITTEE REPORT

I congratulate the big works of the Committee, but the O.E.C. is still inside the engineering for off-shore structure.

Recent utilization of the ocean is widely spreading, where the oil production is one of the aims of it. And, we commercial tank people are recently being involved in the wide range of the engineering works relating the ocean, namely, ocean space utilization, ocean-wave and current control, ocean energy absorption, and finally, the environmental assessment of the ocean.

So, I would like to request that the Committee will spread, in future work, the field of survey toward the ocean engineering, but not limited in marine structure engineering, and they will remark this in the Recommendation.

OE-3

P. BOGDANOV, Sv. SPASSOV
Bulgarian Ship Hydrodynamics Centre, Varna, Bulgaria

LOW-FREQUENCY DAMPING CO-EFFICIENTS AND THEIR INFLUENCE ON SEMISUBMERSIBLE MOTION CHARACTERISTICS

1. INTRODUCTION

The aim of this contribution is to present some results of the recent BSHC studies supporting and/or discussing some aspects of the very interesting 19th ITTC OE Committee Report.

2. LOW-FREQUENCY DAMPING

As can be seen from the OE Committee Report the investigations in the field concerned have been very successful in the last three years. Intensive work in this area has been realized in the last 6–7 years also at BSHC, results of which have been reflected in [1], [2], [3], [4], [5], [6], [8], [9], etc.

Systematic investigation of a 6–column twin pontoon semisubmersible platform with wide variation range of 2a/B, Dk/H, B/H, T/H were carried out by Kishev and Spassov as major scientists, implemented a relevant contract for Krylov Shipbuilding Research Institute [2] published in [3], etc.

where, 2a – clearance between pontoons
B – pontoon width,
H – pontoon height,
Dk– column diameter,
T – platform draught.

The added masses and the damping coefficients in the Low–Frequency and Wave Frequency regions were determined by forced oscillation test. The experiments were performed for a single column and part of the pontoon and for the complete platform model. Figs. 1, 2 and 3 show a few examples of the sway damping coefficient. In the low frequency range, where the potential damping is negligible, the damping coefficients obtained by the experiments, are significant. Besides that, it can be seen that the influence of the motion amplitude is noticeable. That allows approximation of the damping coefficient by means of the empirical formulae (see Fig. 3 [1]):

$$B22(x,w) = B22.w + B22.w.x$$

The data processing of the experimental results was performed by the same procedure as described on p.6 in [4]. The comparison between the theoretical results obtained by the use of the discrete vortex method and the experimental data for low frequency damping, was also presented in ITTC'87 [3] (Fig. 1). The agreement between the calculation and the experiments show the applicability of that approach.

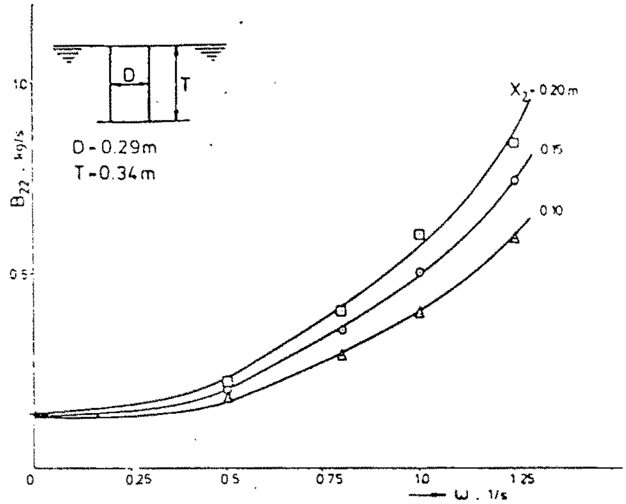

Fig. 1. Damping Coefficient of Circular Cylinder in Different Amplitudes of Horizontal Motion

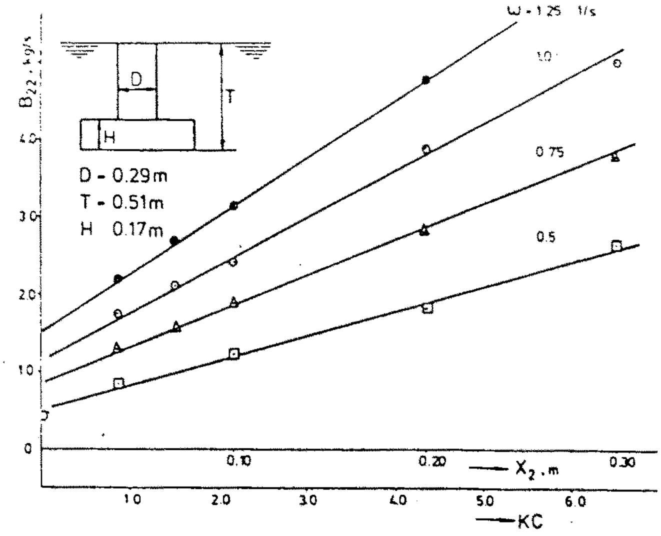

Fig. 2. Frequency Influence and Sway Motion Amplitude on Damping Coefficients of a "Pontoon–Column" Element

Following p.11.2 [6] we can agree with the conclusion there that the damping coefficients obtained from the model tests were much higher than those obtained from the calculations of the potential damping based on the source-sink technique in case of surge and sway mode.

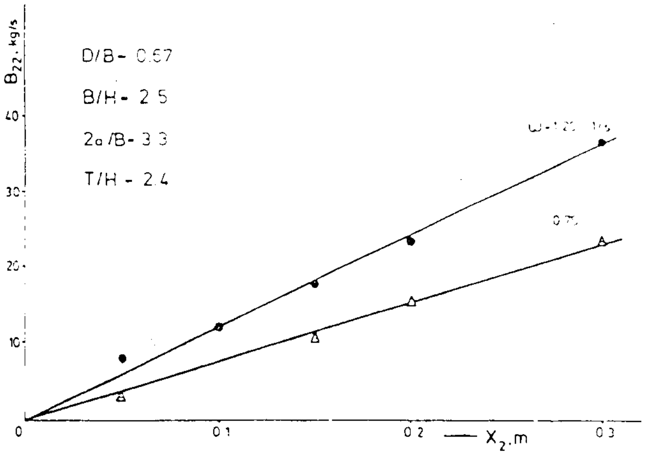

Fig. 3. Amplitude Influence of Sway Motion on Damping Coefficient of Semi-submersible Platforms

The coupling coefficients -Fig. 4- of semisubmersibles (surge-pitch and sway-roll) were also determined in the same series of experimental tests [3], [4]. The comparisons between theoretical and experimental results showed that more accurate prediction is needed. Probably, this can be also one of the reasons for the poor correlation between the motion predictions by computer programs developed by different institutions (p.11 [6]).

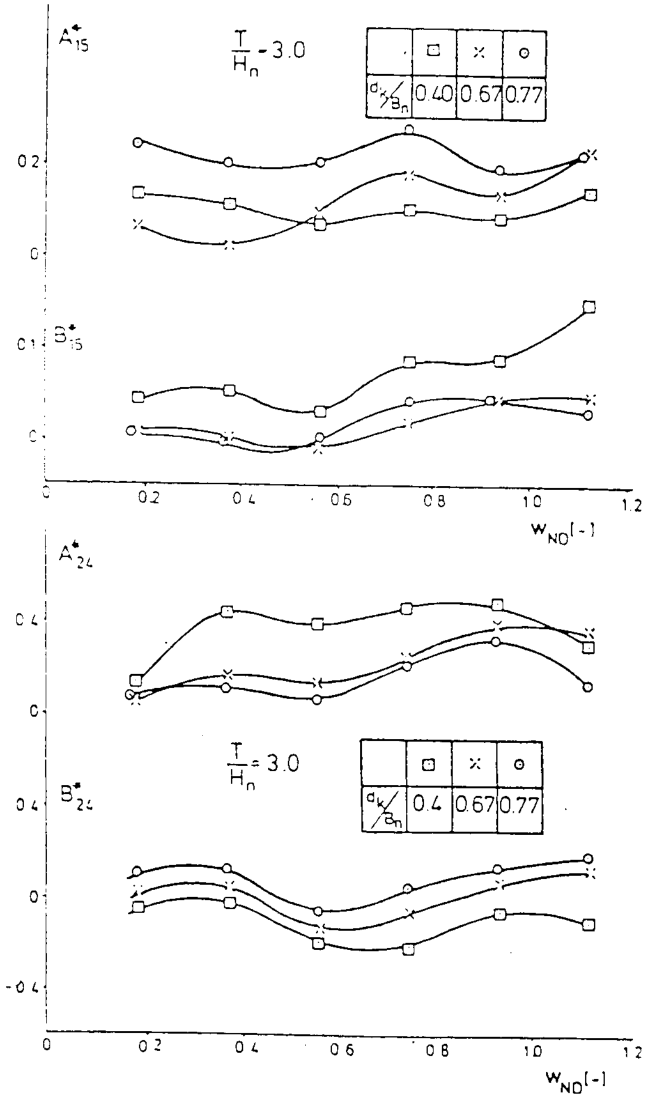

Fig. 4. Parametric Investigation of Coupling Coefficients of Semisubmersibles

3. MOTION CHARACTERISTICS

The next step, following the previous conclusions, is of course the calculations of horizontal motions. Fig. 2 [3] shows the sway motion characteristics for model scale. BSHC results were slightly different in the larger wave periods (model scale). Now we are happy that Dr. Lundgren results shows the same tendency (for full scale probably) and now the Committee reply will encourage that.

The results for time simulation in regular waves for low frequency motion are presented on Figs. 5 and 6. Fig. 5 shows the sway motion with potential damping (B22~0), with viscous damping (B22=12kg/s) and their accelerations are shown. The reduction of the motion amplitude is about 15/20%. The conclusions made by Huse in "Influence of Mooring Line Damping upon Rig Motions" and Huse and Matsumoto [7.1], [7.2], [7.5] considered drag and friction damping of the main structure, including the effects of appendages, roughness, marine growth, etc. (OTC, 5204), to be one of the most important contribution, which decreases the surge and sway amplitude of displacement. Of course, the problem of the percentage of motion reduction is still open for discussion, but the results of the above mentioned authors show similar percentage to that obtained by different "completely independent" institutions.

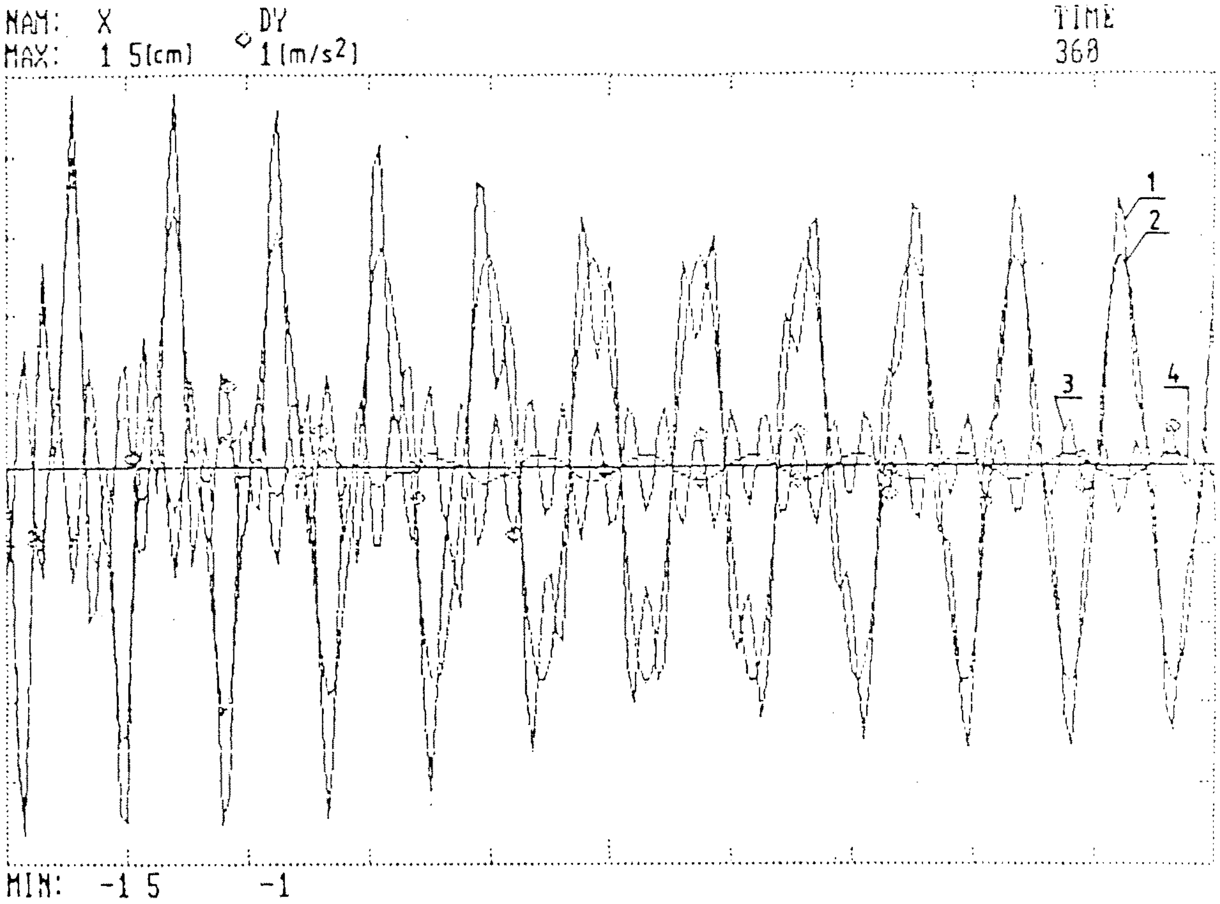

Fig. 5. Time Trace of Sway Motion Simulation at Model Scale

1 – Theoretical prediction of sway motion without LF damping

2 – Theoretical prediction of sway motion with LF damping

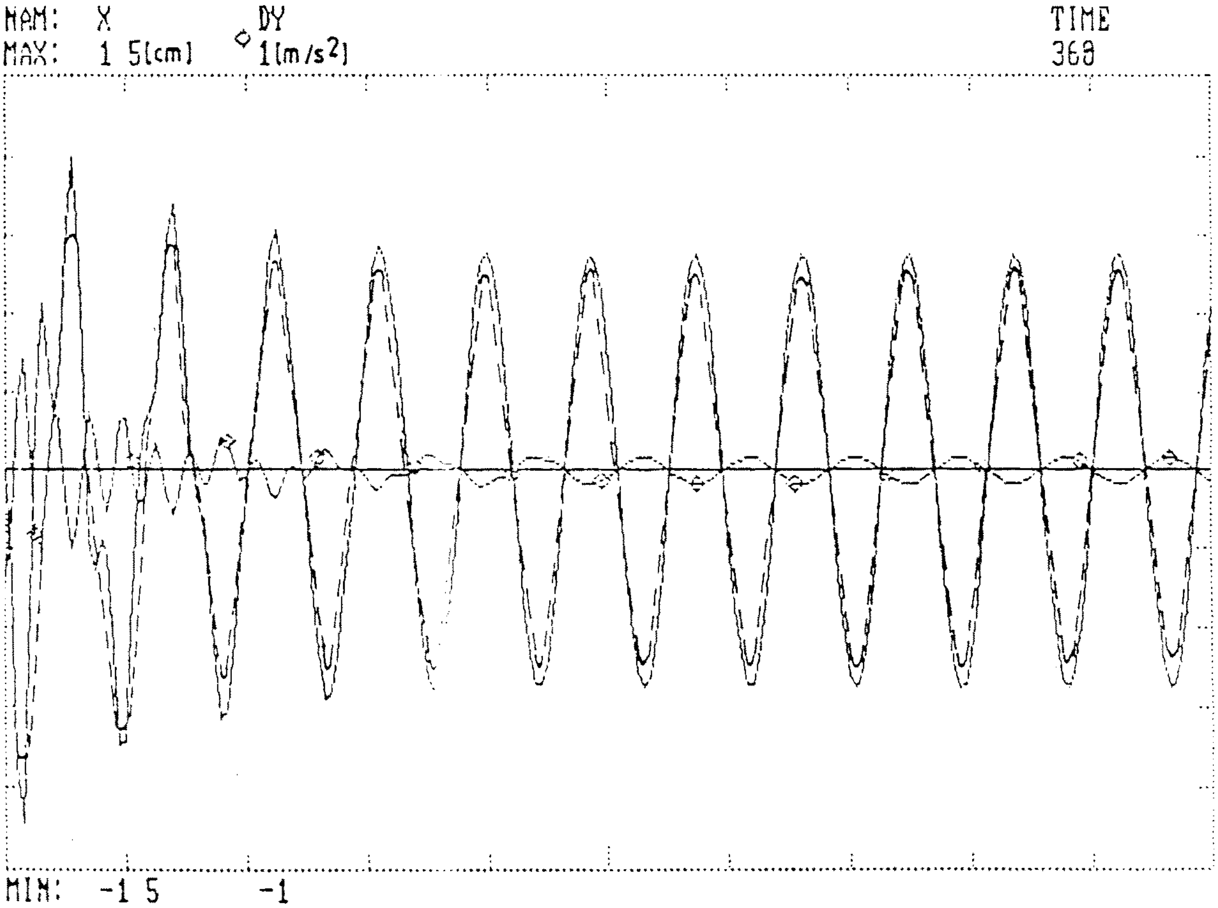

Fig. 6. Time Trace of Sway Motion Simulations at Model Scale

______ theoretical prediction included LF damping

------ experimental results (model scale)

The comparisons on Fig. 6 show that there is good agreement between the theoretical and experimental sway motion results with low frequency damping and that the reduction of sway motion corresponds to the experimental results.

This is a simple example, of course, compared to the motions simulation of a moored ship in irregular waves, for example. However, the influence of the different parameters can easily be seen here.

This is one way to check the influence of the different contributions not only of LF damping but also to make a list of the possible parameters for particular cases shorter. Otherwise, we shall come to the surprising results: to improve the mathematical model and to get good agreement between theory and experiment, nevertheless that some models are very simple and others are too complicated.

4. DISCUSSIONS

First of all we highly appreciate the Report of the 19th ITTC OE Committee. We would like to make special reference of p.7, which contains the main subject of the contribution discussed and particularly p.9. If the Committee does not object, we would kindly ask to make some remarks:

4.1 The main part of the discussion takes the single point mooring vessels and semisumbersibles. The jacket and especially jack-up platforms are almost not the subject to comment. Some new ideas of jack-up platforms used in deeper waters give the advantage of hydrodynamics problems.

4.2 The multibody systems (ship-ship, platform-ship, etc.) are included as discussions neither in OE Committee Report, nor in the Seakeeping Committee Report. The problems are strongly non-linear and nonstationary and they can find their relevant place in the future work in the field of:

- flexible lines (chains, ropes between bodies and other connection);
- coupled motion of multi-mass system;
- interference effects, accelerations and their influence on the work of the staff, etc.

4.3 Sometimes it is easy to find the author of relevant paragraphs, following the references given. There is no Easteuropean reference and particularly BSHC works quotes in the 19th ITTC OE Report. Maybe future participation in any of the annual sessions of BSHC Seminar (considering the experience of other ITTC Committees) will allow improvement of the collaboration between OE Committee and BSHC.

<u>References</u>

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[6] Report of the Ocean Engineering Committee, 19th ITTC, Madrid, 1990.

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OE-4

S. OHMATS
Ship Research Institute, Japan

FULL SCALE MEASUREMENTS OF OFF-SHORE STRUCTURES

In the draft recommendations for future work of the Ocean Engineering Committee, the needs of available full-scale measurement data is emphasized at item 1 for Low frequency responses as well as at item 5 for activities on short-crested seas.

The Ship Research Institute has performed the full scale measurement of a floating structure as shown in Fig. 1, for four years long (9/1986 - 7/1990) at the offshore of the coast of the Japan Sea where a severe sea state be expected always in the winter season. The short-crested waves have been measured as shown in Fig. 2.

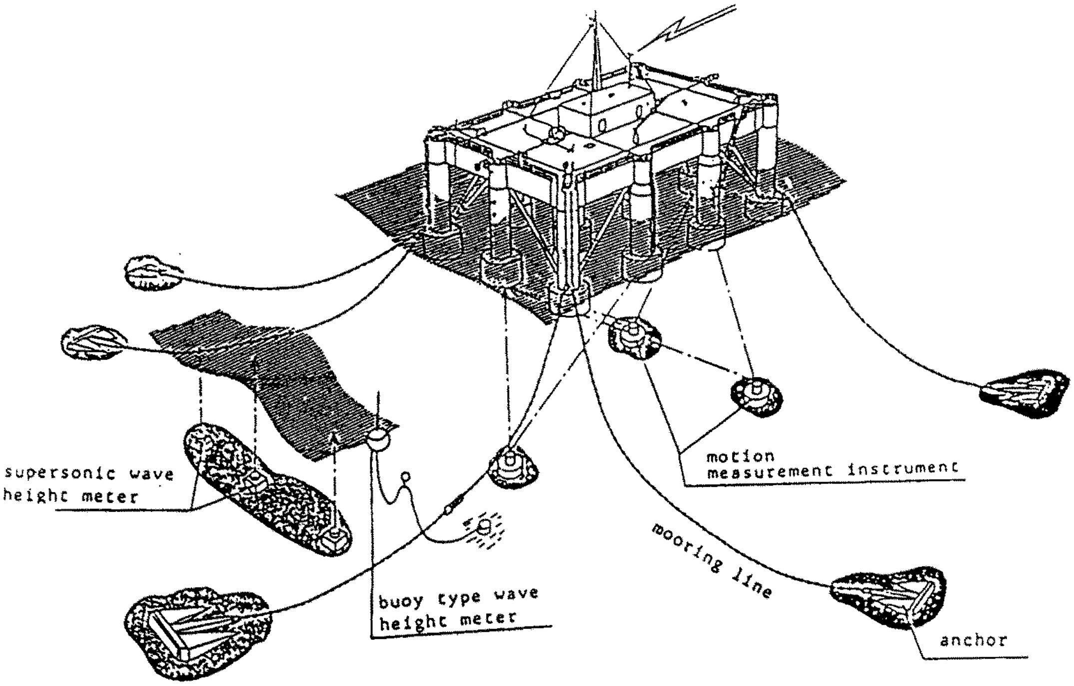

Fig. 1. Concept of the test structure

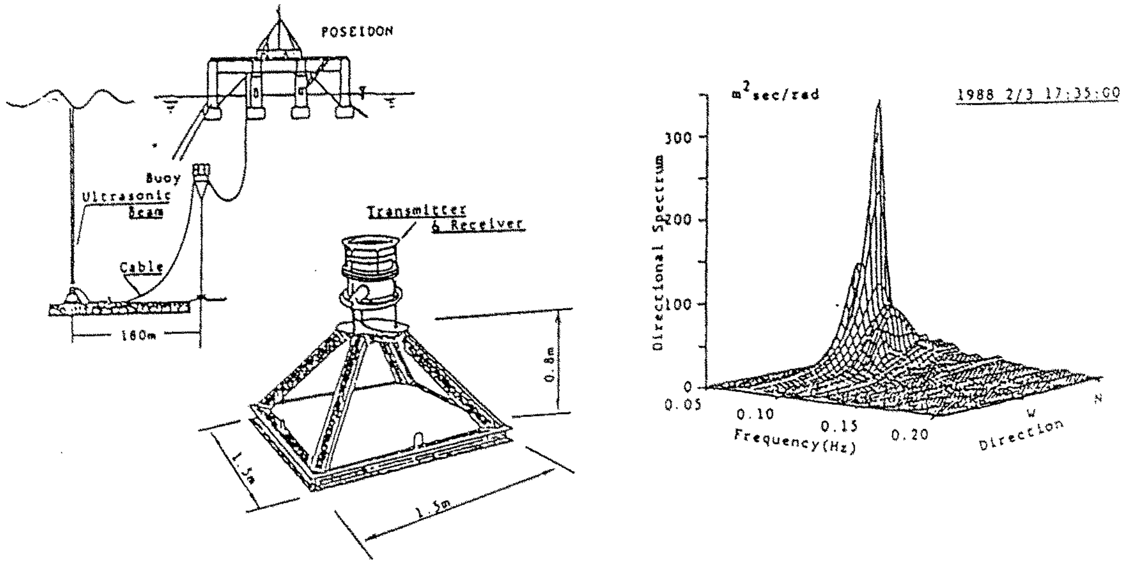

Fig. 2.

We would be able to contribute to the next ITTC by submitting the full-scale measurements data of:

a) directional wave data and its effects on the behaviours of the structure,
b) wave-current interaction,
c) model/full-scale correlation of the low frequency motions,
d) model/full-scale correlation of the damping of the low frequency motion,
e) contribution of wind force on the low frequency motion,
f) hydrodynamic forces acting on the vertical cylinders,
g) mooring forces.

It will be expected that the Committee would recommend the Conference to stimulate the contribution of member organizations to publishing such full-scale measurements results.

OE-5

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PROCEDURE FOR ANALYSIS OF REGULAR WAVE TESTS OF FLOATING STRUCTURES

1. INTRODUCTION

The aim of this contribution is to comment problems related to the procedure for analysis of regular wave tests of floating structures, reflected in item 6.3 of the very interesting 19th ITTC Committee Report. At that, as well as in the discussion of the Draft Recommentations to the Conference regarding model testing of floating production system with flexible risers, mooring lines and/or Dynamics Positioning Systems (DPS) consideration is taken of the future activity of the Committee.

2. RECOMMENDED ANALYSIS PROCEDURE FOR REGULAR WAVE TESTS OF FLOATING STRUCTURES

BSHC participation in the processing of the exemplary regular wave records has allowed us to get acquainted with the results obtained also by other Institutes, participating in the data processing during the performance of wave tests of floating structures.

The observed significant differences of the data obtained for the amplitudes and phases has stimulated us to look for new nonconventional methods of test result processing of floating structures in regular waves.

The essence of the conventional method, as is shown in the Ocean Engineering Committee Report, is contained in the determination of the main parameters of the investigated processes. Moreover, the following is typical to be noted:

(i) the frequency is determined by the number of signal intersection with the zero level for a prescribed time interval;

(ii) the amplitude is evaluated by the maximum and minimum values;

(iii) standard Fourier analysis is used to determine amplitudes, phases and frequencies.

In the Ocean Engineering Committee Report relevant recommendations are given to increase the accuracy of the test data processing, namely: choice of the number of periods for analysis in a relevant way, choice of initial and final point of the record, filtration and elimination of the trend, etc.

Considering the large discrepancies of the results of the processing are due to the shortcomings of the applied conventional methods and algorithms for processing, as well as on the basis of the experience gained at BSHC in the processing of series test results of floating structures in regular waves, while executing a contract order for Krylov Ship Research Institute [1], at BSHC a new method nonconventional method has been developed for processing of periodic signals. This method was successfully applied also in the data processing of regular wave tests of floating structures (determination of amplitude–frequency characteristics, drift forces, etc.). Presuming that this method would be of interest to the ITTC, in parallel its more detailed description has been proposed for the Group Discussion to Session 3 – Seakeeping and Ocean Engineering. Here the method, which is based on the algorithmic variant of the Fast Fourier Transformation (FFT) is characterized in principle. Due to the FFT integral qualities the method developed allows increase of the accuracy, attainment of higher sensitivity threshold and easiness in the data processing of regular wave tests of floating structures than it is possible in the application of the conventional methods.

This method does not require preliminary filtration and trend elimination. The trend, frequency, amplitude and phase of the relevant harmonic components of the processing signal are obtained by the following formulae:

$$A_o = F(o)/N \tag{1}$$

$$A_m = \frac{2\pi\alpha_m |F_m(l)|}{N \sin(\pi\alpha_m)|} \tag{2}$$

$$\psi_m = \phi_m(l) - \pi\alpha_m + \pi/2 \tag{3}$$

$$A_m = \frac{2\pi(1-\alpha_m)|F_m(l+1)|}{N|\sin\pi(1-\alpha_m)|} \quad (4)$$

$$\psi_m = \phi_m(l+1)-\pi(\alpha_m-1)+\pi/2 \quad (5)$$

$$\omega_m = 2\pi f_m=(l+\alpha_m)2\pi/N\delta t \quad (6)$$

$$\alpha_m = p_m/(1+p_m) \quad (7)$$

$$p_m = |F_m(l+1)| \ / \ |F_m(l)| \quad (8)$$

where:

A_o – Constant component of the processed signal;

ω_m – Angular velocity of the m–th harmonic component;

A_m – Amplitude of the m–th harmonic component;

Ψ_m – Phase of the m–th harmonic component;

$F_m(l)$ – Maximum value of l–th component of the amplitude–frequency characteristics of the periodic signal, corresponding to the m–th harmonic, obtained by FFT;

$\Phi_m(l)$ – Value of the l–th component of the phase–frequency characteristics of the periodic signal;

N – Number of the records in the processed time series;

δt – Period of discretization – sec.;

l – Integer equal to the number of the component of the amplitude–frequency characteristics of the periodic signal, obtained by FFT.

At present the evaluation of the accuracy of BSHC method discussed here has been made with the help of test examples. It would be useful to apply this method for data processing of regular wave tests of floating structures according to the information of the 18th ITTC OEC Programme. In this way comparative evaluation of the different methods could be made and BSHC would take up to this task if it is included in the future activity of the Committee. The practical benefit of BSHC method based on the application of FFT is significant because the same software could be used also in the data processing of irregular wave tests.

3. MODEL TESTING OF FLEXIBLE RISERS, MOORING LINES AND DYNAMIC POSITIONING SYSTEMS (DPS)

In the Draft Recommendations for future work of the Ocean Engineering Committee it has been proposed that model testing of future floating systems should include flexible risers, mooring lines and/or DPS systems as critical items to be investigated by the tests. BSHC supports this proposal because the experience has shown us that in the synthesis of DPS with the employment of the modern theory of automated control and Kalman's filtration, the basic problem seems to be the mathematical models of the floating structures and the excitation effects (wave forces of first and second order, wind and current generated forces). The occurrence of this problem is explained by the fact that in the synthesis of DPS the models of the floating structures and the excitation forces should be represented, as is shown in a number of papers [3], [4], [5], in state space form. That is why we think it would be expedient if OEC could organize the development of mathematical models of floating unit and multiconnected systems for exploration and adoption of the ocean resources, suitable for the requirements of the DPS synthesis, as well as the development of methods for obtaining of their coefficients.

4. CONCLUDING REMARKS

By way of concluding and expressing again our appreciations to OEC for the efforts made in the preparation of the very useful report, so much needed and submitted to the 19th ITTC, we would like to note BSHC readiness for cooperation in the execution of OEC Programme. In particular, BSHC contribution could be on the problems treated in 1.1.2 and 3 above regarding the improvement of the procedure in the data processing and the performance of relevant model tests.

References

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[4] Creation of Dynamic Positioning System (DPS) Specialized Floating Structures (Laboratory Sample), BSHC, Internal Report N^ KP 88–05–46/3, 1989 (in Bulgarian).

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OE–6

G.E. HEARN

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LOW FREQUENCY DAMPING CALCULATIONS AND ITS INFLUENCE ON TIME DOMAIN SIMULATIONS

My comment relates to section 7.3 and the reported opinion (page 493) concerning the influence of low frequency damping, upon the statistical properties of low frequency motions and associated line tensions of a moored structure subject to random wave excitation. It is difficult to accept the statement that "time domain simulations were only moderately influenced by the choice of method for wave damping calculations", as a correct interpretation of the information presented in references 7.13 to 7.16. I will give my reasons for challenging the veracity of the quoted statement.

The scaling of the resulting statistics, reported in reference 7.15, for the FG based low frequency damping of reference 7.12 is 10 times larger than that used to scale the experimental measurements of Wichers and our ARG based predictions. Furthermore, in reference 7.15 the conclusions of our reported research clearly stated that the FG based low frequency damping produces motion and mooring line statistics much more extreme that the statistics associated with the total exclusion of low frequency damping effects!. In another paper I argued that if the FG method were appropriate then the FG low frequency damping coefficient could be weighted by forward speed, over an appropriately low forward speed range, and produce reasonably correct estimates of added resistance. This is failed to do [1]. Also, in reference 7.12 the FG based low frequency damping coefficients were compared with our earlier 2D predictions rather than the available 3D results which indicate "a significant improvement of accuracy" over our 2D predictions.

My conclusion was then, and remains to be, that the FG method provides inaccurate and misleading quadratic transfer functions for the low frequency damping and the ARG method is more appropriate for both ships and certain offshore structures. For semisubmersibles both methods may be inadequate, especially for the deep floater of the Norske Hydro Workshop (3).

References

[1] Hearn and Tong, ISP 1988.

[2] Hearn and Tong, OTC 1986.

[3] Norske Hydro Workshop on Floating Production Systems. Dec. 1989. Hearn and Lau contribution.

OE-7

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NOTES FOR ITTC CONFERENCE

I have two comments on Recommendations for future work:

The first concerns the synthesis of waves for model testing. There continues to be considerable controversy over the deterministic versus the probabilistic method. The former is concerned with matching the energy spectrum over a finite time. The short term statistics of the resulting wave train resulting from this technique normally do not show good agreement with the target values. Some researchers in the area argue that this procedure does not yield an authentic representation of a wave spectrum while others suggest that for long wave records it does. The probabilistic method is concerned with matching the statistics of the wave spectrum. The normal procedure here is white noise filtering using the target spectrum. This method does provide better agreement with the short term statistics but must represent rather long wave trains, in the order of 2-4 full scale hours, to get reasonable agreement with the energy spectrum. It may be recommended that a model test program be conducted to investigate the effects of the two methods on a model.

The second item is concerned with determining the heave added mass and damping coefficients of tension leg platforms in calm water and waves. It has been shown that added mass and damping coefficients determined from experiments are lower than those predicted by theory. Interest in tension leg platforms is expected to increase significantly as offshore operations move into deeper water. One of the primary considerations given to their design is the response of the tethers and their tethers and risers to environmental loading. Both are affected by the heave. I would suggest that some consideration be given to research investigating the discrepancy between the measured and computed coefficients.

OE-8

M. TRIANTAFYLLOU
MIT, Massachussets, U.S.A.

COMMENTS ON THE REPORT OF THE OCEAN ENGINEERING COMMITTEE

The report contains a comprehensive survey of extensive literature and the committee is to be congratulated for their considerable effort. I would like to discuss two points in the report:

(1) Section 7. Low Frequency Damping and Low Frequency Response Measurements

The drag coefficient of a mooring line increases as out-of-plane oscillations develop due to slowly varying, large amplitude in-plane motions. These out-of-plane motions are high frequency motions, and their interaction with the slowly varying motions can cause a significant increase in mooring line damping. The interaction is caused by the formation of alternating vortices in the wake of the mooring line.

(2) Section 8. Numerical Modelling of Flow around Cylinders

A correction is to be made on the use of spectral element methods for the direct simulation of the Navier-Stokes equations (reference 8.18 of the report): The limitation of Reynolds number 1000, mentioned in the report, is **inapplicable** to the method of spectral elements. The only limitations are due to computer power limitations (speed, memory size, expense).

An issue of extreme importance, not raised in the report, as far as direct simulation is concerned, is the capability for **three dimensional** simulation when turbulence is involved. Three-dimensionality is an intrinsic feature of turbulence, and its simulation poses severe limitations on the range of applicability of direct Navier-Stokes simulation, given the size and power of today's computers, irrespective of method used.

OE-9

G. VAN OORTMERSSEN
MARIN, The Netherlands

RECOMMENDATION 8.4

First of all I should like to express my appreciation for the work done by the Committee. Ocean Engineering is a relatively young field within the ITTC and covers a wide variety of difficult problems, and this committee has therefore a difficult task.

My comment concerns Recommendation 8.4. I fully support the first part of this recommendation concerning validation of computational methods. It is the last sentence which says: "As part of this task it is suggested that the comparative calculation from the 17th and 18th ITTC be repeated", that I have difficulty with. We all know that there are some yet unresolved problems related to this comparative excercise, and I welcome attempts to solve these, but I feel that just repeating the excercise will not help us much. The problem was the poor prediction of the heave added mass. As shown in the report of the 18th ITTC Ocean Engineering Committee, increasing the number of panels did not improve the prediction. The most credible explanation for the discrepancy is the influence of vortex shedding. Although some programs may be improved since the time the calculations were made, none of these will include the effect of vortex shedding and therefore I feel there is not much merit in repeating the calculations.

II. REPLIES BY THE OCEAN ENGINEERING COMMITTEE

Reply to Dr. WICHERS

We thank Dr. Wichers for his contribution regarding the importance of dynamic wind loading on moored offshore platforms.

The Committee is aware that currently there are four different wind spectra namely: Davenport, Harris, Kaimal and Hino used by the offshore industry. These spectra were derived from land based measurements for application to civil engineering structures. The characteristics of each of these spectra are different and each yields significantly different results when they are applied to response predictions of various types of compliant offshore platforms.

The importance of the dynamic wind load calculations and the sensitivity of the prediction to different spectral shapes were quantified by calculating the dynamic and structural response values of different types of compliant offshore structures by a research group at the University of Glasgow. The results of these investigations were presented during the contributions to the 18th ITTC Ocean Engineering Committee report and in the Proceedings of the Third Integrity of Offshore Structures Symposium held in 1986, and in the Proceedings of the OMAE'88.

The Committee recognises the importance of the topic and encourages the development of wind spectra for offshore locations utilising recently completed and/or ongoing full scale wind velocity measurements.

The draft recommendations of the Committee on this topic were included in our report under the broad title of further work on prediction and experimental techniques for low frequency motions.

The Committee agrees that the present day mathematical models for the horizontal low frequency motions of moored vessels are incomplete. For instance, the way we separate excitation from damping and mass terms is of course a simplification of the real world. However, we consider that present day models can already be useful in providing a certain insight into the important issues of statistics and scale effects. In fact, Dr. Wichers' own publications demonstrate this.

Further development of standard test procedures will indeed be an important item for the next Ocean Engineering Committee.

Reply to Mr. ABE

We thank Mr. Abe for his contribution. The Committee agrees with Mr. Abe that the next Committee should not restrict its activities only to the oil and gas related structures in the ocean but pay attention to other ocean engineering activities which are of interest to the ITTC member organisations. We believe this can be realised within specified areas for future work recommended by the 19th ITTC Ocean Engineering Committee without making further changes to these recommendations.

Reply to Dr. BOGDANOV and Dr. SPASSOV

The Committee thanks Drs. Bogdanov and Spassov for their contribution.

In the first part of the discussion we were presented with a recent investigation into the measurements of low frequency damping coefficients. The results presented in this discussion form a useful addition to the Committee's report.

We understand from the second part of the discussion that the discussers wish to see more emphasis being given to the design aspects of fixed jacket platforms, jack-up rigs and multi-body marine systems by the Ocean Engineering Committee. We value this suggestion and point out that specific topics relating to these structures have been included in various parts of our report. For example, fixed jacket structures and multi-body systems are referred to in sections on wave-current interaction and short crested-wave effects.

The Committee's draft recommendations also include further work on the prediction of non-linear effects, including extreme motions, capsize, etc. which are relevant to the design of the type of structures that were suggested by Drs. Bogdanov and Spassov.

Reply to Mr. OHMATS

Full scale measurements are limited. The test programme which is described by Mr. Ohmats for a full size structure (semi-submersible) which has been collecting data for 4 years represents a major contribution to such studies.

The Committee wishes to strongly encourage the publication and distribution of this data.

The stated goals of the ongoing analysis are extensive. Items (c) and (d) concerning model/full scale correlation should be achievable. In common with all full scale measurements it would be expected to be difficult to demonstrate such effects as:

(a) Directionality which would require two identical seas with different directional spreading.

(b) Wave-current interaction which would require identical seas with and without current (or more likely two different currents).

(c) Documentation of wind force effects which would require responses with and without wind – with same waves.

Items (f) (forces on cylinders) and (g) (mooring forces) can be analysed presuming that the intruments used to measure them are detailed. (Such information was not included with the summary as presented at the 19th ITTC Conference).

Reply to Dr. BOGDANOV and Dr. VASSILOV

The contribution in the report regarding the harmonic analysis technique was based on one of the recommendations of the 18th ITTC. The data available to the Committee consisted of results of a comparative study in which a number of institutes submitted the results of the harmonic analysis of a standard set of time records using their own standard techniques. The standard set of time records consisted of synthetised records with and without various forms of noise, with known harmonic components. Among the methods employed to extract the required data from the time records were both classical Fourier analysis and FFT methods.

The present Committee's recommendations regarding which method should be used are based on the rather pragmatic approach that we would recommend and give details of whichever method has given the most consistently correct results in the comparative study. As it turns out, this is the classical Fourier analysis technique.

We appreciate, however, that other methods may also yield results which are equally consistent.

One of the conclusions which can be drawn from the results of the study reported by the 18th ITTC Ocean Engineering Committee is that not only the basic equation used but also the experience of the analyst plays an important part in determining the quality of the results.

The Committee has not had the opportunity to study all the implications of the methods of analysis presented by Dr. Bogdanov and Dr. Vassilov, nor have we received data indicating how results based on this method compare with results of other methods.

We appreciate the offer made by Dr. Bodganov and Dr. Vassilov and look forward to seeing their data. Finally, we address the remarks made on the need for mathematical models of floating units from the point of view of modelling and design of DP systems. The Ocean Engineering Committee recommends that attention be given to theoretical developments regarding the low frequency and wave frequency behaviour of floating structures. This is a type of data which can also be used for the purpose stated by Dr. Bodganov and the Committee fully endorses Dr. Bogdanov's remarks on that issue.

Reply to Dr. HEARN

The Committee regrets if it has misinterpreted certain information in one of Dr. Hearns's publications and it appreciates his further elaboration of the comparison between the FG and ARG methods.

Reply to Dr. MURRAY

The Committee thanks Dr. Murray for his comments. As a part of the reply to the first comment, a clarification of the use of the words deterministic and probabilistic is necessary. The deterministic wave generation is normally associated with the wave-by-wave reproduction of an elevation record measured in nature. The probabilistic approach is concerned with reproduction of some form of energy distribution, e.g. Jonswap or Pierson–Moskowitz. In that sense, Dr. Murray's question deals with different methods for probabilistic wave generation and the variability of the statistics due to finite test duration. The Committee believes that the most frequently used method is to synthesise a large number of wave components when the amplitudes are chosen to fit the spectral density at each frequency component and when the phases between the components are chosen at random. Compared to white noise filtering, this method is more straightforward and easier to implement on a computer. Given the same test duration, the superposition method yields the same variability of spectral quantities as white noise filtering. The Committee agrees with Dr. Murray that the test duration is most important for the statistical accuracy of the responses. This subject is discussed in the paper by Pinkster and Wichers, Ref. 7.23 in the Ocean Engineering Committee report.

The heave motions of tension leg platforms play a more important role in the prediction of the springing vibration of tendons in the high frequency range (sum frequency behaviour) than in the prediction of wave or low frequency motions. In calculating the high frequency responses the free surface effects are usually neglected, the heave added mass values are satisfactorily predicted by the potential theory and the radiation wave damping can be assumed to be negligible. As pointed out by Kim and Yue (Ref. 9.11 of the Ocean Engineering report) the wave excitation forces due to second–order potential could not be ignored in predicting the sum frequency behaviour.

Unfortunately the members of the present Committee are not aware of any published work which shows a discrepancy between the measured and computed added-mass values in the high frequency range where the springing vibrations of tendons of a tension leg platform occur. The possible reason for the discrepancy that Dr. Murray is referring to may come from vortex shedding which occurs in a flattering problem where phase lag of hydrodynamic forces depens on a reduced frequency.

Therefore, in order to give some consideration to investigate the discrepancy between the measured and computed heave added mass coefficients, the Committee feels that further information on this subject is required.

Reply to Prof. TRIANTAFYLLOU

Although not stated specifically in the report, the Committee certainly agrees that the transverse vibrations of the mooring lines will increase their apparent drag coefficients, and this increases the surge damping on the vessel. Our experience is that such vibrations frequently occur in wire lines but not in chain lines.

The Committee understands that the limitation of Reynolds number 1000 in Professor Triantafyllou's paper is due to computer power limitations. The Committee also agrees with Professor Triantafyllou's comment that the only limitations with Reynolds number are essentially due to computer power limitations. But once the speed, memory size and cost of a computer are fixed, then the limitation depends on the kind of computational scheme adopted. In one of the Japanese papers (since it was not written in English it was excluded from the reference list) it was stated that when direct simulation of Navier Stokes eauation is carried out using the Finite Element Method the Reynolds number is limited to 1000.

The Committee also appreciates Prof. Triantafyllou's contribution in which he pointed out the importance of the 3-D direct simulation capability when the flow is turbulent. Recent experimental investigations show the 3-D effect on flow pattern along the axis of a cylinder even for a separated flow around a cylinder. This flow phenomena is called chaotic phenomena. Generally speaking it is not easy to define 2-D separated flow around a cylinder experimentally. In any case, the turbulent model method, for instance, Large Eddy Simulation method can treat this 3-D effect. The Committee considers that this subject must be one of the important areas for future work.

Reply to Dr. van OORTMERSSEN

The Committee thanks Dr. van Oortmerssen for his kind words in appreciation of the Committee's effort.

Regarding the comments made by Dr. van Oortmerssen on requesting the comparative calculations reported by the 17th and 18th ITTC, the Committee feels that this exercise will be useful to generalise the conclusion reached during the comparative study FPS-2000 by repeating the exercise using another platform configuration. Whilst the Committee agrees with Dr. van Oortmerssen that the computer codes do not have the capability of modelling vortex shedding and therefore the predictions and measurements still may not correlate well, it would be useful to show that computer results can now correlate better with each other than they did with the comparative study reported by the 17th and 18th ITTC.