SESSION ON PERFORMANCE IN ICE−COVERED WATERS

Chairman: Prof. O. Krappinger

Performance in Ice−Covered Waters Committee Memberships: J. Schwarz (Chairman) − F. M. Williams (Secretary) − Y. N. Alekseyev − E. Enkvist − H. Kitagawa − D. D. Maksutov − S. Narita − J. C. Tatinclaux

Discussion of the Report and the Draft Recommendations of the Performance in Ice−Covered Waters Committee. (Cf Proceedings, Volume 1, p. 527 − 566.)

I. DISCUSSIONS

IC−1

Y. KAYO
Mitsubishi Heavy Ind., Ltd., Nagasaki, Japan

The test results scatter considerably among several ice tanks on the standard model as shown in the committee report. The cause may be attributed partially to the difference in the properties of model ice used such as strain modulus, compressive strength and fracture toughness. Since ice strengths can not be controlled separately at present, further discussions about the role of each strength parameter on icebreaking resistance seem difficult.

At the same time, it is not certain that these scatterings in ice resistance are the case for other hull forms. Therefore it may be worthwhile to make comparison on another ship model or a simpler body in shape among ice model basins to evaluate the resistance and fracture pattern in detail in the future.

The following is an example of comparative model test made by Mitsubishi and HSVA recently. The new ice model basin was constructed in 1986 in the Nagasaki Experimental Tank of Mitsubishi Heavy Ind., Ltd. The length of its test section is 20m, width is 9m and water depth is 2.3m. Further informations and its capability are introduced in the references [1, 2].

The model ice used in the basin at present is urea−doped ice and is formed by forced air circulation system. As a part of evaluation test on its performance, some comparative model tests with a cone, circular cylinders and an icebreaker model were conducted between MHI and HSVA.

The icebreaker was designed by MHI for service in the Baltic sea. Her principal dimensions are as follows.

L_{pp}	86.8m
B_{max}	24.0m
d	7.3m
Displacement	8600t

A wooden model in a scale of 1/19.6 was built by MHI and was shipped to HSVA.

Tests were made for three ice thicknesses of 0.5 m, 0.8m and 1.1m in full scale. The flexural strength was chosen as 600 kPa. The model ice of HSVA is carbamide and is also prepared by forced air circulation.

Fig. 1 shows the resistance test results of both ice model basins. Open circles correspond to MHI's measurement and solid ones are HSVA's results. The numbers in the figure mean ice thickness (mm) and flexural strength (kPa) respectively. Some of them differ slightly from target values, and the resistance data shown include no empirical corrections. Solid lines are drawn tentatively without any regression analysis.

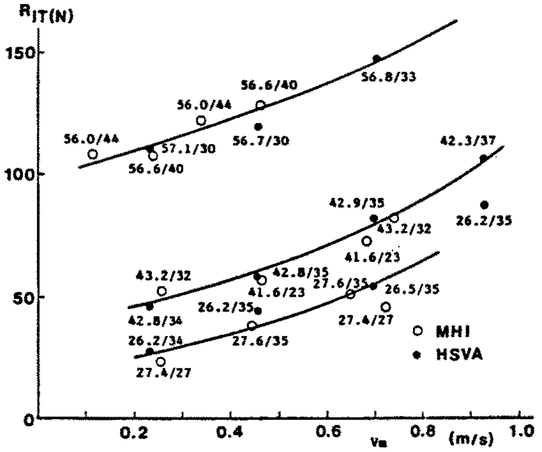

Fig.1 Total Resistance in Level Ice

Good agreement is observed in the results between MHI's and HSVA's. It may be considered that model tests made even in different ice model basins would seem to yield rather similar results when the model ices are the similar one. For detail analysis, however, more investigation is needed on ice properties and its influence on resistance.

References

[1] K. Takekuma et al.: "A New Facility for Ice Engineering of the Nagasaki Experimental Tank", IAHR 1986

[2] K. Takekuma, Y. Kayo and T. Fujita :"Ice Model Basin of the Nagasaki Experimental Tank", The West Japan Society of Naval Architect No. 74, 1987

IC−2

D. N. BAKER
Melville Shipping Ltd., Ottawa, Canada

I enjoyed reading the ITTC Ice Committee report and would like to thank the Committee for the opportunity to review the contents.

My major comment with respect to the ITTC report is one that I could equally apply to earlier ITTC reports, and that is one of application.

As designers, our primary interest is to evaluate the performance of a prototype ship in some standard ice condition (typically level homogeneous ice). Based on the R−Class data presented in the report, the different ice tanks yield a huge difference in performance prediction.

In the report the Committee mentions that only the original data is used. As a result, if each tank has different types of ice, scaling procedures, test procedures, and correlation procedures, then these large differences may be acceptable, but surely the comparisons are of very little value.

What performance does each tank predict the R−Class can achieve? What are the differences? How does a designer decide on which is the most accurate? These are the questions which I would consider require clarification. The Committee is in an ideal, in fact unique, position to conduct the work that will start to answer the questions.

IC－3

G. LILJESTRÖM and S. MOBERG
Marine Structures and Operations Hydrodynamics, Götaverken Arendal Ab., Göteborg, Sweden

We have studied the report with much interest and have found it most stimulating to witness the rapid development of the ice model testing technique and as well the cooperation between the different laboratories represented within ITTC.

We regret that we are not at present prepared to comment upon the presented subjects. We would only like to use this opportunity to ask you if possible to make ITTC launch some kind of extended program for icebreaker manoeuvrability in model ice including selfmanoeuvered models. We believe this will prove important for the future development of icebreaker model testing.

IC－4

V. KOSTILAINEN
Helsinki University of Technology,
Helsinki, Finland

The Committee has performed an excellent report. However, I would like to make one suggestion to the recommendations of the Committee for future work. In these recommendations nothing is mentioned about the manoeuvrability of ice－transiting ships, though already now there exist ice model tanks which are wide enough at least for PMM－tests in ice.

In addition to this, a large square ice model basin 40 × 40 × 2.8m of our university will be ready in May of 1988. The general arrangement is shown in Fig. 1. The X－Y－carriage of this basin makes both captive model testing and testing with free running models possible. I propose therefore that following item is added to the recommendations of the Committee: "Initiate work on collecting information for manoeuvrability model tests in ice".

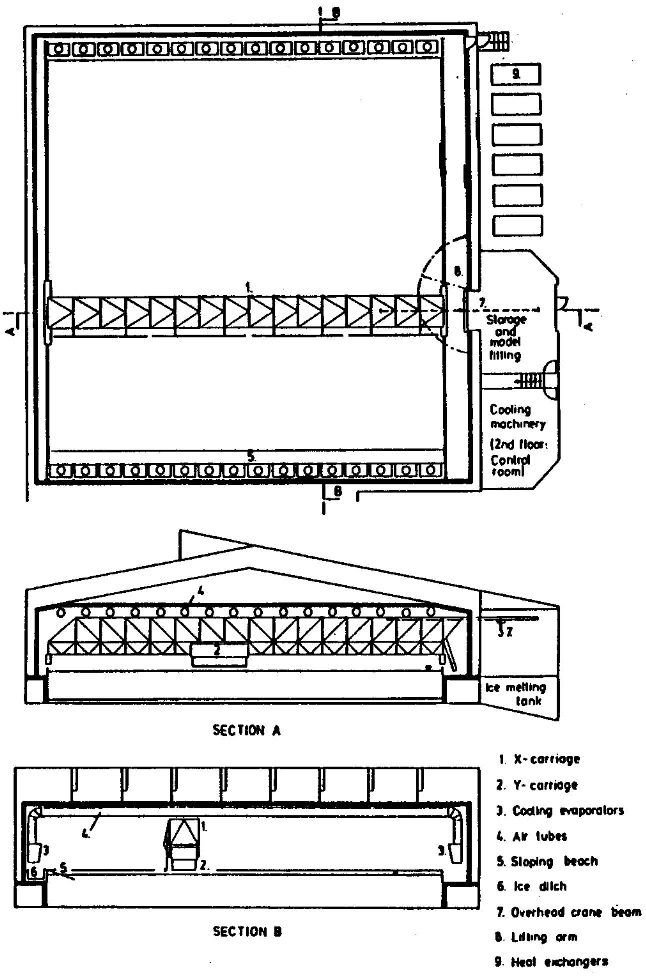

Fig.1 General Arrangement of the New Basin

II. REPLY BY THE PERFORMANCE IN ICE–COVERED WATERS COMMITTEE

The Committee appreciates **Dr. Kayo's** discussion and presentation of an example of comparative model tests results (IC–1).

As mentioned in the Committee report, uncontrolled mechanical properties of model ice may influence the resistance of the ship model in ice. Testing techniques, degree of freedom of motion, dynamic characteristics of dynamometer and guiding system will also affect the results. Furthermore, fluctuations with time of resistance in level ice are, in general, found to be significant, particularly when compared to those in calm water. Therefore, the measurements should be long enough to determine reasonable mean values. If not, this will also cause some errors, especially with some types of ship model.

Plotted lines in the figures for comparison of the resistance in the Committee report were determined by each laboratory through different procedure. For a simple comparison it will be better to compare the test results in a certain non–dimensional form. For instance, Dr. Tatinclaux presented such a comparison as shown in Fig. 1. Comparison of non–dimensional resistances analyzed by Dr. Tatinclaux indicates that the differences in those procedures may contribute to the discrepancies in the resistance between the laboratories. It would be interesting to have a similar non–dimensional presentation of Dr. Kayo's data.

The Committee is confident that satisfactory agreements between the test results will be achieved in the near future, once the effect of each particular factor is examined and clarified step by step. The Committee has performed the comparative model test for the last six years. The Committee will not continue this for the moment. If, sometime in future, the Committee has a chance to get a suitable ship model, the Committee will try again to perform a comparative model test program.

Mr. Baker's discussion (IC–2), which gives the designer's point of view, is a valuable comment on the Committee report. The standard model test series did not have the objective of comparing performance predictions. All of the member

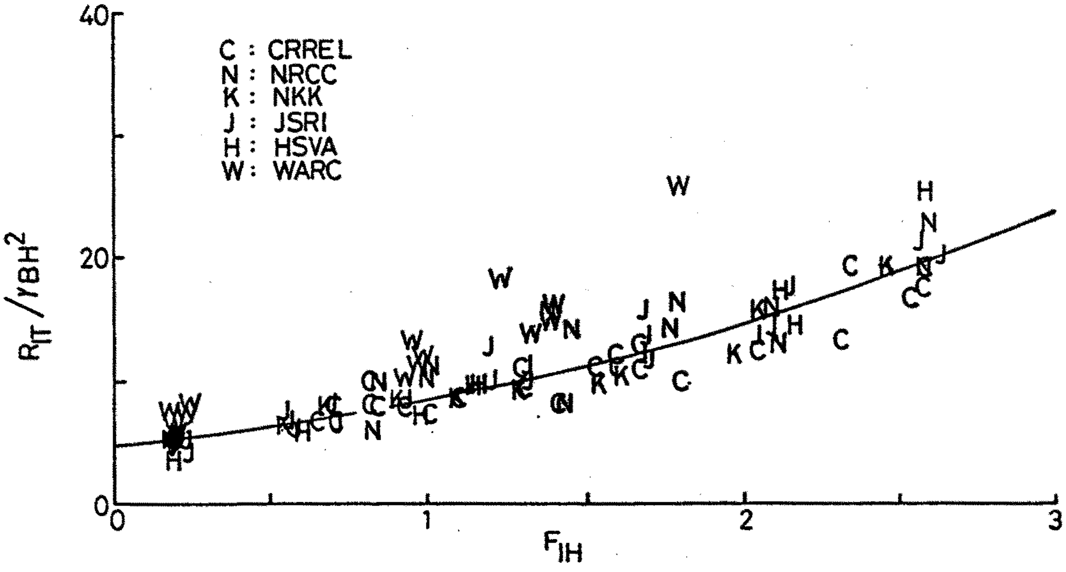

Fig. 1 Non–dimensional Resistance in Level Ice

tanks follow the principle that full scale performance predictions are obtained from model scale results using Froude scaling. Each tank considers other factors such as friction coefficients, components of icebreaking, and special ice properties in their extrapolations. The importance of these factors depends on hull form, the experience of the tank, and the scope of the test program. The uncertainty in the specification of full scale parameters such as ice thickness, strength, and type of snow cover may have a greater effect on the accuracy of a performance prediction than the variations among tank predictions.

In reply to both of the comments by **Liljestrom** and **Moberg** (IC−3) and by **Kostilainen** (IC−4), the Committee is aware that, so far, only two ITTC member organizations have carried out manoeuvering tests. Therefore we feel that it is too early to recommend an extended test program to the ITTC member ice tanks. But it may indeed be appropriate to initiate work on collecting information for manoeuvrability model tests in ice, as proposed by Prof. Kostilainen. The Committee, therefore, appreciates the comments of both discussions.

Ⅲ. SUPPLEMENT TO THE COMMITTEE REPORT −SUMMARY AND CONCLUSIONS−

1. The reanalysis of the results of various full scale trials with R−class icebreakers in level ice shows good correlation between reduced ice thickness and speed for a certain power level if 50% of snow cover thickness is added to the ice thickness. This factor 0.5 depends, however, on the shape of the icebreaker and on the density of the snow.

2. The results of resistance tests in level ice with the roughened model of the R−class icebreaker at six different ice laboratories scatter. This is to a certain extent related to the different kinds of model ice in use at the various ice tanks, all of which, most likely, do not sufficiently fulfill all similarity requirements. However, the R−class model seems, on the other hand, not to be ideal for comparative tests because several laboratories reported that the measured resistance varied significantly in repeated model tests. After the completion of two sets of comparative tests with the standard R−class icebreaker model over the past six years the Committee does not believe that further testing of this model is useful.

3. The analysis of self−propulsion tests with the ITTC standard model of the R−class icebreaker carried out at one institution indicates that without direct propeller−ice interaction the wake and the relative rotative efficiency is not significantly affected. If, in this particular case, however, the propeller interacts with ice, the torque coefficient increases and the thrust coefficient decreases slightly. These results seem to be in agreement with full scale results of this icebreaker. One should be careful in concluding from this single result that the icebreaker resistance in general can be calculated by the use of open water thrust deduction fraction. Discrepancies between model and full scale torque coefficients found by other institutions may be related to floe size, density differences between model ice and water, hydrodynamic differences due to the existence of the ice cover, and lack of simulation of the drive train system. All this means that much more researches are necessary in order to be confident with self propulsion test results for icebreakers.

4. Test procedures for establishing the friction coefficient between ice and model surfaces have been established and their use is urgently recommended.

   Coating procedures have been developed at various institutions, which are able to produce a friction factor deviating only slightly from the target value with a high degree of reproducibility.

   Full scale friction tests have been carried out in the bow area of icebreaking ships. The results show the effect of velocity, normal load and wet and dry snow cover on the friction coefficient. The results can be used as a basis for further studies on the friction problem.

   Altogether it can be stated that some progress has been achieved in the research on ice friction. However, the few results show that the research on friction is in an early stage and much more basic studies are needed to better understand the friction problem.

5. The chapter on model tests on offshore structures defines governing factors for ice/structure interaction for the various types of structures and ice conditions. The performance of measurements and data processing is described and similarity requirement are discussed. Mathematical models and theories of ice structure interaction are mentioned and a combination of physical and mathematical modelling of ice forces on structures including probability analysis is thought to be appropriate to rationally evaluate ultimate ice loads on structures.

   Further research should be dedicated in developing modelling techniques to simulate other than first year level ice, i.e. multiyear ridges, floes and ice islands, and to check the prediction techniques of physical model tests and theoretical calculations by full scale measurements.

   Validation is considered to be especially essential in offshore structure investigations.