Technical Committee on Ice

2017-2021

Chairman : Topi Leiviskä (Aker Arctic Technology inc)
Members : Franz von Bock und Polach, Nils Reimer, Alexey Dobrodeev, John Wang, Yinghui Wang, Yan Huang, Jinho Jang, Pentti Kujala, Takatoshi Matsuzawa

Contents

- Members, meetings and ice model basins
- Current trends of ice related topics in research and business
- Terms of reference
- Actions and outcomes of each task
- Recommendations for the future committee

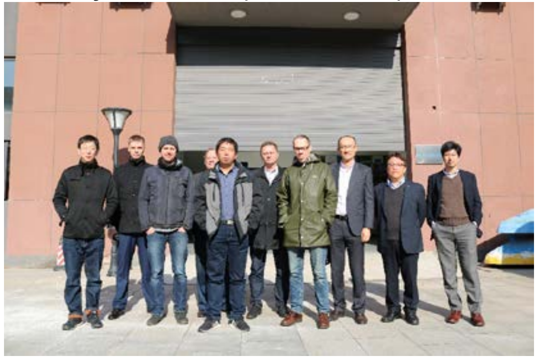
Members

1. Topi Leiviskä (Chair), Aker Arctic Technology inc, Finland
2. Franz von Bock und Polach (Secretary), Hamburg University of Technology, Germany
3. John Wang, National Research Council of Canada, Canada
4. Yinghui Wang, China Ship Scientific Research Centre (CSSRC), China
5. Nils Reimer, Hamburgische Schiffbau-Versuchsanstalt GmbH (HSVA), Germany
6. Yan Huang, Tianjin University, China
7. Takatoshi Matsuzawa, National Maritime Research Institute (NMRI), Japan
8. Aleksei Alekseevich Dobrodeev, Krylov State Research Centre (KSRC), Russia
9. Jinho Jang, Korea Research Institute of Ships and Ocean Engineering (KRISO), Korea
10. Pentti Kujala, Aalto University, Finland (Mikko Suominen 2017-2018)

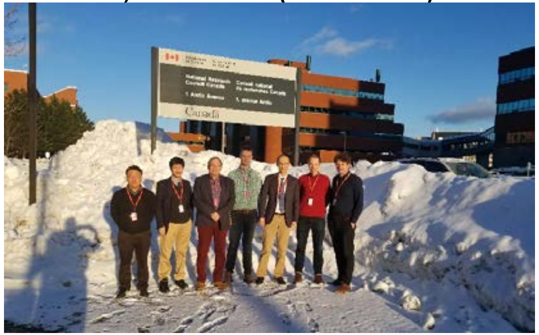
Committee Meetings

Helsinki, Finland (Jan. 2018)

Tianjin, China (Nov. 2018)



St. Johns, Cananda (Jan. 2020)



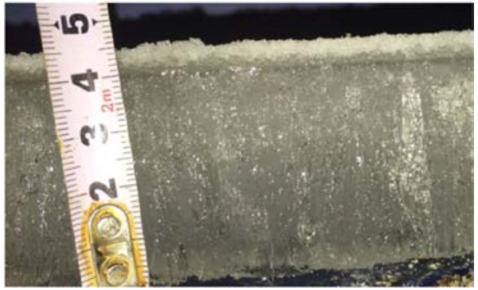
Continuous virtual discussions

Ice model basins

	Ice Tank Facility	Committee Member
1.	Aalto University, Finland	X
2.	Aker Arctic Technology inc, Finland	X
3.	Japan Marine United, Japan	
4.	Krylov State Research Center (KSRC), Russia	X
5.	National Research Council Canada. Ocean, Coastal and River Engineering (NRC-OCRE), Canada	X
6.	Maritime Ocean Engineering Research Institute (KRISO), Korea	X
7.	National Maritime Research Institute of Japan (NMRI), Japan	X
8.	The Hamburg Ship Model Basin (HSVA), Germany	X
9.	Tianjin University, China	X
10.	China Ship Science Research Center (CSSRC), China	X

Current trends of ice related topics in research and business

- Ice resistance and performance of icebreaking vessels
  - Icebreakers
  - Arctic LNG-carriers
  - Research vessels
  - Arctic tankers
- Heavy tonnage vessels escorting by icebreaker
- Effect of brash ice properties on ice resistance in brash ice channels in model-scale and full-scale
- Effect of snow on ice resistance
- Ice interaction with offshore wind turbines and multi piled structures such as multi-piled piers
- Wave-ice interaction
- General research on model ice properties
- Ship-ice friction in model- and full scale
- Investigations on the spatial and temporal variations of the ship-ice floe impact loads in ice tank



Terms of Reference (TOR)

1. Continue to maintain, review and update existing accepted procedures and guidelines in accordance with current practice.
2. Review manoeuvring experiments in ice, and revise "7.5-02-04-02.3 Manoeuvring Tests in Ice" in cooperation with the Manoeuvring Committee.
3. Conduct survey of uncertainty in ice model experiments, and revise "7.5-02-04-02.5 Experimental Uncertainty Analysis for Ship Resistance in Ice Tank Testing."
4. Review of current analytical and numerical determination methods for the global ice load upon offshore structures of various types and compare to physical modelling.
5. Survey testing of platforms and monopiles in ice (such as wind turbine in frozen ocean) and consider establishing a new guideline or enhancing existing guidelines to cover such situation.
6. Update the Guideline 7.5-02-07-01.3 “Guidelines for Modelling of Complex Ice Environments” to cover additional complex conditions.

TOR 1: Continue to maintain, review and update existing accepted procedures and guidelines in accordance with current practice

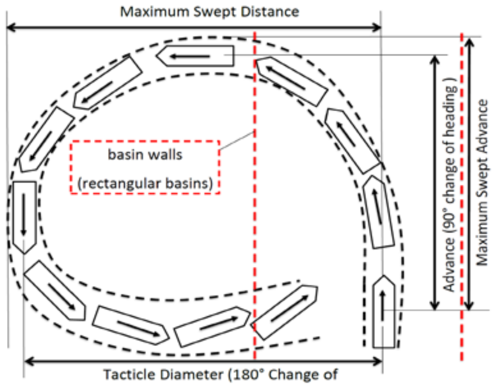
- All existing guidelines have been reviewed
- Some formulas have been corrected (7.5 -02- 04 Test Methods for Model Ice Properties)
- Some formulations have been modified to increase clarity in:
  - 7.5-02-04-02.3 Manoeuvring Tests in Ice
  - 7.5 -02- 04-02 Test Methods for Model Ice Properties
  - 7.5-02-07-01.3 Guidelines for Modelling of Complex Ice Environments

TOR 2: Review manoeuvring experiments in ice, and revise "7.5-02-04-02.3 Manoeuvring Tests in Ice" in cooperation with the Manoeuvring Committee

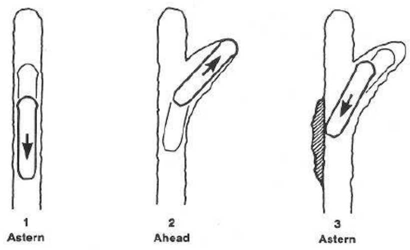
Addressed items in revision

1. Include Most important tests

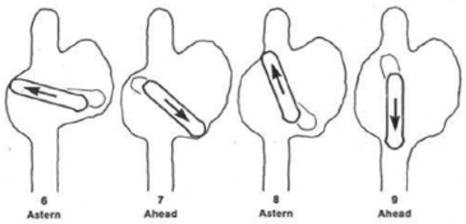
- turning circle test in ice
- break out of channel
- star manoeuvre



Turning circle test



Break out of channel



Star Manoeuvre

TOR 2: Review manoeuvring experiments in ice, and revise "7.5-02-04-02.3 Manoeuvring Tests in Ice" in cooperation with the Manoeuvring Committee

2. Revision of general description of manoeuvring test types and requirements for determination of model and test conditions

3. Revision of uncertainty analysis for turning circle test in ice

4. List of reported parameters

- Rudder (or thruster) angle
- Yaw angle
- Ship’s track
- Ship's heading
- Roll angle
- Pitch angle
- Rudder forces in x- and y-direction
- Rudder torque
- Roll angle
- Velocity of the model on the curved path

TOR 3: Conduct survey of uncertainty in ice model experiments, and revise "7.5-02-04-02.5 Experimental Uncertainty Analysis for Ship Resistance in Ice Tank Testing."

Uncertainty Analysis for Ice Model Tests

- Uncertainty analysis of ice flexural strength at NRC-OCRE
- 32 flexural strength measurements were made from one ice sheet

	BeamId	MainBeam	X	Y	BeamLength	BeamWidth	BeamThickness	Load	FlexuralStrength	Outlier	Down	IceSheetNumber
count	32.000000	32.0	32.000000	32.000000	32.000000	32.000000	32.000000	32.000000	32.000000	32.0	32.0	32.0
mean	5747.781250	0.0	39.156250	5.812500	297.218750	125.253125	62.137500	5.709309	21.012500	0.0	1.0	1304.0
std	3.461627	0.0	16.946042	3.042044	10.165515	3.641250	0.997982	0.688940	2.294559	0.0	0.0	0.0
min	5742.000000	0.0	16.000000	3.000000	266.000000	118.600000	60.400000	3.922660	16.000000	0.0	1.0	1304.0
25%	5745.000000	0.0	22.000000	3.000000	293.750000	122.475000	61.200000	5.332366	19.375000	0.0	1.0	1304.0
50%	5748.000000	0.0	41.000000	3.000000	299.000000	124.650000	62.200000	5.785923	21.450000	0.0	1.0	1304.0
75%	5751.000000	0.0	55.000000	9.000000	305.000000	127.400000	62.925000	6.276256	22.425000	0.0	1.0	1304.0
max	5753.000000	0.0	61.000000	9.000000	314.000000	134.100000	63.900000	6.766589	25.000000	0.0	1.0	1304.0

TOR 3: Conduct survey of uncertainty in ice model experiments, and revise "7.5-02-04-02.5 Experimental Uncertainty Analysis for Ship Resistance in Ice Tank Testing."

Step 1: Apply Chauvenet Criteria

$$Chauv\ \# = \left|\frac{value - Mean}{Standard\ Deviation}\right|$$

Step 2: Uncertainty Calculation

$$U_{item}(\%) = \frac{U_{item}}{Mean^{*}} \times 100$$

$$U_{item} = \frac{t\ \times STD}{\sqrt{N}}$$

Step 3: Total Uncertainty for Flexural Strength

$$\sigma_f = \frac{6FL}{wh^2}$$

$$U_{Flexural} = \sqrt{(U_{Length}^2 +\ U_{Width}^2 +\ U_{Load}^2 + 2 *\ U_{Thickness}^2)}$$

TOR 3: Conduct survey of uncertainty in ice model experiments, and revise "7.5-02-04-02.5 Experimental Uncertainty Analysis for Ship Resistance in Ice Tank Testing."

Lesson Learned

- Uncertainty analysis for the ice flexural strength is explained.
- For the given dataset, the uncertainty of ice flexural strength was 4.85%
- Ice thickness uncertainty can be shown separately.
- Chauvenet criterion can be/should be applied based on each measurement.
- Other parameters may be assessed if the number of sample is more than 10~12. Compressive strength and density measurements can be applicable.
- Linkage between ice uncertainty and test performance uncertainty still needs to be studied.
- Benchmark tests among other ice basins are required

TOR 4: Review of current analytical and numerical determination methods for the global ice load upon offshore structures of various types and compare to physical modelling

This TOR is not addressed within this ITTC SC committee due to lack of time and furthermore this task is (continuously) carried out in various ISSC committees e.g. ISSC Environmental Loads, where Ice Committee members John Wang and Franz von Bock und Polach are also members.

For similar tasks in future a closer cooperation and synergy with the ISSC is proposed.

TOR 5: Survey testing of platforms and monopiles in ice (such as wind turbine in frozen ocean) and consider establishing a new guideline or enhancing existing guidelines to cover such situation.

In this stage it was decided to prepare an outline for the next Special Committee on Ice

Tests for Fixed Structures in Ice

1. PURPOSE OF PROCEDURE
2. TESTS FOR FIXED STRUCTURES IN ICE
   - 2.1 Ice load tests for pile foundation structures
   - 2.2 Ice load tests for shallow foundation structures
   - 2.3 Ice induced vibration tests
3. PARAMETERS
   - 3.1 Parameters to be Measured
   - 3.2 Ice parameters to be measured
4. VALIDATION
   - 4.1 Uncertainty Analysis
   - 4.2 Benchmark Tests
5. REFERENCES

TOR 6: Update the Guideline "7.5-02-07-01.3 Guidelines for Modelling of Complex Ice Environments" to cover additional complex conditions

Purpose of the guideline:

- Provision of modelling methods for complex ice environments in model scale
- Supporting guideline to understand the nature of complex environments

Compressive (pressured) ice:

Defined relationship between the compression level S_{IC} the closing speed of the channel V_C:

Towing tests of ship in compressive ice (KSRC)

$$V_C = 0{,}005 S_{IC} + 0{,}03762 S_{IC}^2$$

A ship model is driven or pulled through an open channel and one side of the ice field is pushed perpendicular towards the heading of the model.

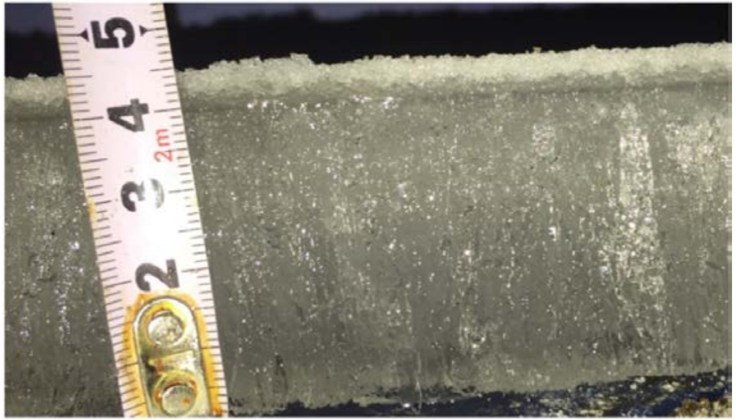
TOR 6: Update the Guideline "7.5-02-07-01.3 Guidelines for Modelling of Complex Ice Environments" to cover additional complex conditions

Snow cover ice

An effective ice thickness h_I', which is introduced to include the snow effect on the ship's performance in ice, is defined as the ice thickness h_I plus snow thickness h_{SN}:

$$h_I' = h_I + k_e h_{SN}$$

The main approach for preparing snow in model basin is a modeling as an additional thickness to the ice sheet.



Artificially produced snow on model ice sheet (Huang, 2018)

Recommendations for the future committee

1. Guidelines for tests with offshore structures
2. Guideline for ice trials – It is suggested to prepare in principle a new guideline because the previous guideline cannot be considered applicable anymore as it is outdated. In. The guideline should include the performance of the tests, ice measurement practises and analysis methods.
3. Review on numerical methods to predict the performance of ships in ice in cooperation with ISSC.
4. Guideline or proposal for waves in ice which is a topic gaining increasing attention.
5. Uncertainty analysis