

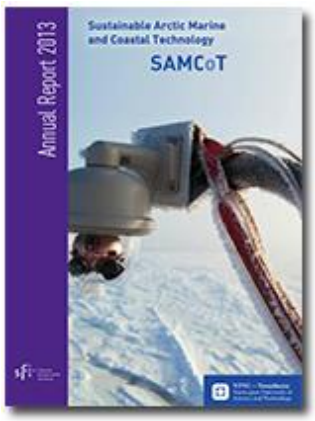
SAMCoT News Letter 02/2014 (Feb. – May 2014)

Work Package Adm.: Administrative reporting

Briefing on Activities:
SAMCoT SFI Centre director and coordinator visited the Research Council of Norway (RCN) in two different occasions during this period in relation with the Annual SFI Forum and the information meeting related to the Mid-Term Evaluation of the Centre. SAMCoT's Board and EIAC bodies received information about the upcoming Centre evaluation on May 5th and 8th.
The main purpose of the evaluation and the evaluation criteria are clearly stated in the doc. Terms of Reference provided by the RCN:

'To form the basis for a decision about whether to continue the individual Centre for the remainder of the overall eight-year term, or to wind it up after five years. The evaluation will also give advice to the Centres on aspects of their activity that should be improved.'
`The evaluation will assess the scientific results the Centres have achieved relative to the original project description, and consider whether the scientific results achieved and the competence accrued have helped corroborate the vision that the Centre's activities will lead to innovation, value creation and additional emphasis on long-term research in the participating business enterprises and ventures. Further, the evaluation is to assess the plans for the Centre's activities in the potential final three-year period. In addition to this evaluation, the Research Council of Norway will evaluate the administrative conditions at each Centre`.

Achievements:



- SAMCoT Annual Report 2013 available at www.ntnu.edu/samcot
- SAMCoT Scientific PhDs/Postdocs Seminar was successfully hosted at NTNU with more than 65 participants from SAMCoT Industry and Research Partners (May 6th and 7th, 2014)
- Fulbright Arctic Chair Prof. E. Schulson completed his 7 months visit period at NTNU under SAMCoT's framework.
- SAMCoT's new e-room was launched. The transition period concludes June 15th (deadline deactivation link to the old e-room).

- SAMCoT's communication team visited UNIS and the Svea field site to collect footage and information regarding HSE & International Research Collaboration at SAMCoT. Two articles and two videos will be produced in 2014 regarding these topics.
In the picture veteran journalist Nancy Bazilchuk is interviewing a logistics employee at UNIS.

Notifications:

- *SAMCoT 2nd Board Meeting 2014:* November 13th location Aalto, Helsinki.
- *SAMCoT Technical Workshop 2014:* September 17th&18th Trondheim, NTNU.
- *SAMCoT 1st 'SAMCoT Arctic HSE Workshop' 2014/15:* September 19th 2014 Trondheim, NTNU; March/April 2015 Longyearbyen, UNIS. (More information will be sent in the near future)
- *SAMCoT EIAC 2nd and 3th meetings 2014:* beginning of September Video Conference, NTNU. Final dates for the meetings TBD.
- *SAMCoT Self-evaluation forms delivery deadline:* December 10th 2014.

SAMCoT Scientific PhDs/Postdocs Seminar 2014

Work Package 1: Data Collection and Process Modelling

Briefing on Activities:
In the period from January to April 2014 laboratory and field activities were performed following the approved CTR for WP1.

Field work included:

- measurements of soil characteristics and tidal variations of sea level near pipeline landfall in Longyearbyen (February-March)
- drifting ice in the Barents Sea and Storfjord in Spitsbergen (April 22-29)
    - indentation and fixed-end beam tests
    - tests for the ice-ice friction
    - uniaxial compression tests
    - investigation of morphological properties of ice, ice ridges and icebergs
    - measurements of boundary layer characteristics below the ice
    - measurements of wave characteristics
    - acoustic Doppler current profiling
    - point measurements of sea currents below the ice
    - CTD profiling
    - deployment of ice trackers on flat ice and icebergs (equipped by thermistor string with 20 thermistors distanced on 0.5 m from each other)
- complex field works on land fast ice in Svea Bay (March 24-April 5) included:


In the Photo, Fulbright Arctic Chair E. Schulson during his visit to Svea

- measurements of ice stresses in coastal zone (project of PhD student David Wrangborg) and ice load on coal quay Kapp Amsterdam
- indentation tests: tests with fixed/ends and cantilever ice beams; tests for tensile and compressive strength
- measurements of tide induced variations of the water level and sea current velocities near the coal quay for the estimate of sediment transport
- measurements of sea water temperature and salinity in Sveasundet and in Braganzavågen for the study of river influx in winter season

The following images show how researchers use common tools for not-so-common scientific experiments. Here, scientists use an ice saw to cut huge blocks of ice out of the frozen sea for further experiments on ice strength (a); the indenter is made of a large hydraulic piston that presses one end of the instrument into blocks of ice. The piston has sensors on it that measure how much pressure is needed to crack or crush the ice. Ice engineers can use the information from the indenter to understand the characteristic of different kinds of sea ice. They can use the information to improve the design of ships, quays and piers in the Arctic (b); after a block of ice has been compressed by the indenter, researchers remove the block from the sea so they can further examine fracture patterns in the ice (c).

Numerical simulations in Comsol Multiphysics were used for the investigation of sea current in ridged ice, thermal expansion of fresh ice samples bounded by steel pipes, indentation tests in ice and tests with fixed-ends beams.

Laboratory work included:

- indentation tests in the ice tank, performed in continuous ice and consolidated ice rubble
- analysis of thin sections
- tests on thermal expansion of saline ice and frozen soil samples

Experiments on thermal expansion of frozen soil samples saturated by saline water show negative coefficient of thermal expansion in wide temperature range from -2 C to -25°C. Experiments with soil samples saturated by fresh water demonstrated negative thermal expansion when temperature changed from 0 C to -5°C. The range of negative thermal expansion depends on the size of soil particles.

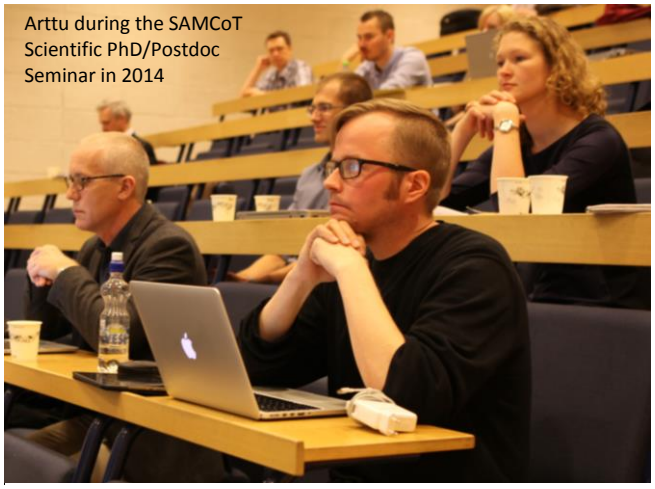
Achievements:

- Model of iceberg drift and rotation was elaborated taking into account added mass effects and theory of bluff bodies resistance in water flow.
- Different scenarios of fixed-ends beams were observed in the experiments and interpreted with numerical modelling.
- Two papers were accepted for OMAE 2014, and 7 papers were submitted for IAHR Ice Symposium 2014.
- A journal paper has been published in CRST.
- Results of research work were presented on Ice rubble workshop at NTNU and at different meetings at the Memorial University of Newfoundland and C-CORE in Canada.

Work Package 2: Material Modelling

Briefing on Activities:

Arttu Polojärvi has continued his work on 3D punch through tests on freeze bonded rubble and have a set of preliminary results. More results on this should be available quite soon. A conference paper has been produced out of this work at this point. Polojärvi has been participating into the work on statistical modelling of ice loads with our new doctoral student Janne Ranta. At this point a conference paper has been prepeared based on this work.


Arttu during the SAMCoT Scientific PhD/Postdoc Seminar in 2014

Polojärvi wrote a conference paper on our study on freeze bond geometries and microstructures together with Jukka Tuhkuri. The next steps of this work is considering at the moment.

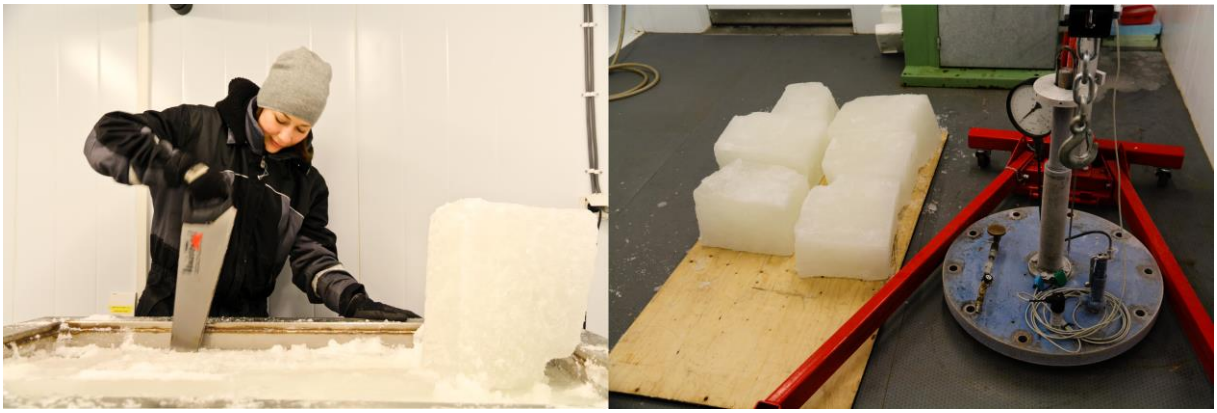
Polojärvi has been preparing a manuscript for a journal paper on DEM-modelling of direct shear box experiments on ice rubble, which we conducted last summer with Anna Pustogvar.

This manuscript is quite well underway.

Sergey Kulyakhtin and Anna Pustogvar performed oedometer tests on rubble ice at the cold laboratory, NTNU during the period of February - March. The paper describing the test set up and presenting preliminary results was submitted to the IAHR conference.

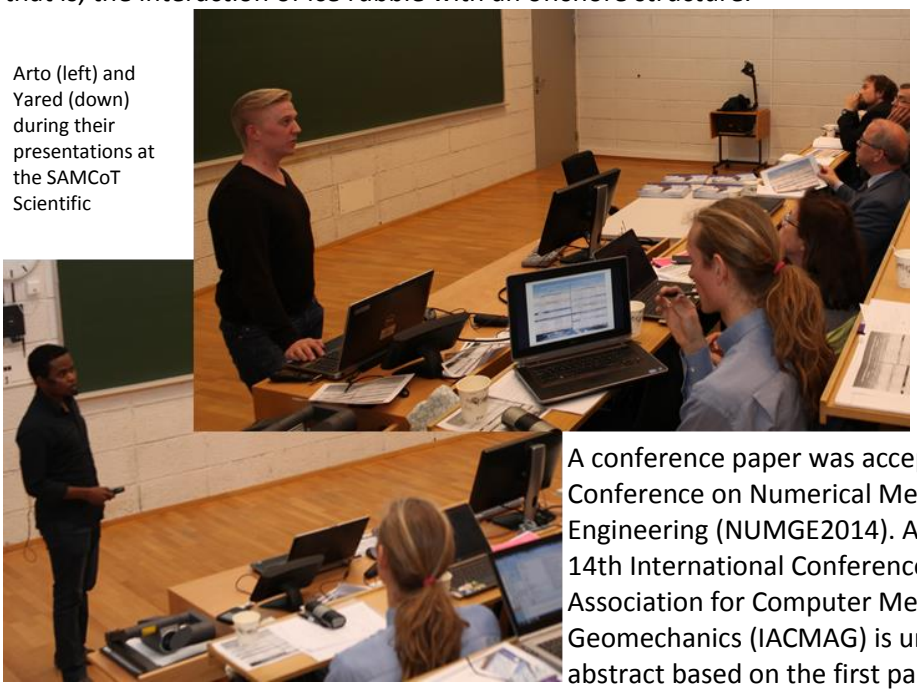
Anna Pustogvar has also taking the course Applied Statistics at NTNU. She wrote the semester `Design of Experiment (DOE)´ project about density measurements of saline ice by applying hydrostatic weighing technique in paraffin.

Experiments for the project were performed in the cold laboratory at NTNU.
The picture below shows part of the activity related to the preparation of the Ice.



In addition to laboratory experiments Sergey Kulyakhtin worked comparing abilities of different models for granular media to predict volumetric behaviour of ice rubble. This work is described in the accepted paper for the OMAE conference listed under achievements. Based on the results of this work the material model has been implemented in Abaqus software. Validation of this model on data of model scale tests, which were performed during the RITAS Associated project, is ongoing. Another paper has been submitted to the IAHR conference describing analysis of ice block sizes distribution in pressure ice ridges.

PhD candidate Arto Sorsimo (VTT) has been mostly reviewing and proofreading his journal paper (CRST) and his IAHR paper. At the same time, he has been meeting possible clients that could have use for the simulation model. In addition, he has done preparations for the next step in the research, that is, the interaction of ice rubble with an offshore structure.



Arto (left) and Yared (down) during their presentations at the SAMCoT Scientific

PhD candidate Yared Bekele has been working in the numerical implementation of the fully coupled thermo-hydro-mechanical (THM) finite element model. The implementation is being performed using the isogeometric finite element method and an open-source platform from SINTEF ICT called IFEM is used.

A conference paper was accepted at the 8th European Conference on Numerical Methods in Geotechnical Engineering (NUMGE2014). Also a conference paper for the 14th International Conference of the International Association for Computer Methods and Advances in Geomechanics (IACMAG) is under preparation. An extended abstract based on the first part of the numerical implementation (Hydraulic Processes) has been submitted to the 11th World Congress on Computational Mechanics.

Achievements:

Accepted:

- Kulyakhtin,S., Høyland, K. (2014). Study of volumetric behaviour of ice rubble based on bi-axial compression data. In The proceedings of the 33rd International Conference on Ocean, Offshore and Arctic Engineering, OMAE2014, 8-13 June, San Francisco, California
- Pustogvar, A., Høyland, K., Polojärvi, A. and Bueide, I.M. (2014). Laboratory scale direct shear box experiments on ice rubble: the effect of block to box size ratio. In the proceedings of the 33rd International Conference on Ocean, Offshore and Arctic Engineering, OMAE2014, 8-13 June, San Francisco, California.

Submitted:

- Polojärvi, A., Tuhkuri, J., and Pustogvar, A. (2014). 2D DEM simulations of model scale direct shear box experiments. In The proceedings of 22nd IAHR International Symposium on Ice, IAHR, 11-15 August, Singapore.
- Polojärvi, A. and Tuhkuri J. (2014). 3D DEM for Freeze Bonded Ice Rubble Consisting of Polyhedral Blocks. In The proceedings of 22nd IAHR International Symposium on Ice, IAHR, 11-15 August, Singapore.
- Tuhkuri, J. and Polojärvi, A. (2014). Preliminary Results from a Study on Full Scale Freeze Bond Geometry and Microstructure. In The proceedings of 22nd IAHR International Symposium on Ice, IAHR, 11-15 August, Singapore.
- Høyland, K. V. and Møllegaard, A. (2014) Mechanical behaviour of laboratory made freeze-bonds as a function of submersion time, initial ice temperature and sample size. In The proceedings of 22nd IAHR International Symposium on Ice, IAHR, 11-15 August, Singapore.
- Pustogvar, A., Kulyakhtin, S., Høyland, K.V. (2014) Laboratory oedometer tests on rubble ice. In The proceedings of 22nd IAHR International Symposium on Ice, IAHR, 11-15 August, Singapore.
- Kulyakhtin, S. (2014).Distribution of ice block sizes in sails of pressure ice ridges. In The proceedings of 22nd IAHR International Symposium on Ice, IAHR, 11-15 August, Singapore.

Work Package 3: Fixed Structures in Ice

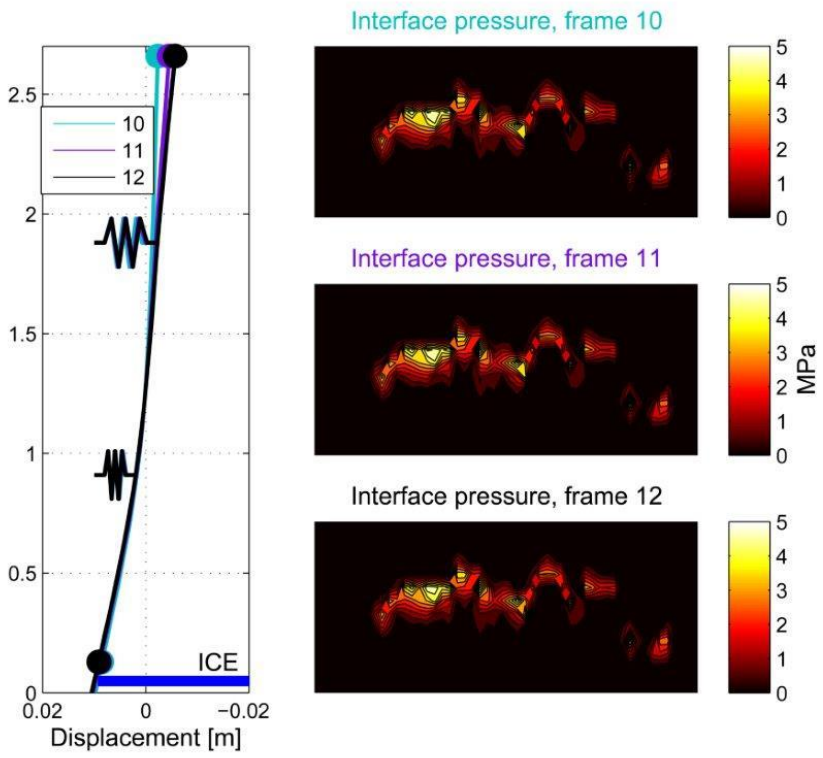
Briefing on Activities:
PhD candidate Hendrikse submitted a journal paper on modelling of ice induced vibrations to the journal CRST. The model has been presented at the last SAMCoT PhD workshop.
Currently work on scaling of ice induced vibrations and the importance of the extrusion of broken ice is ongoing. A master project in cooperation with SAMCoT partner HSVA is also ongoing. The focus of this project is the effect of the slope angle on crushing failure and dynamic interaction between ice and structures.

PhD candidate Sinitsyna conducted simulation of influence of ice strength heterogeneity on ice loads using lognormal distribution of ice strength over the area. Comparison of the influence of normal and lognormal distributions of ice strength on ice loads was performed.

PhD candidate Janne Ranta joined SAMCoT on Sep 2013. Janne has worked with an existing 2D FEM-DEM model and he has analysed peak ice load data from over 200 earlier simulations by utilizing the multivariate linear regression approach. Results of the analysis will be published in IAHR ICE 2014 conference paper.

PhDs candidates Hendrikse, Sinitsyna and Ranta presenting their work to the SAMCoT participants at the Scientific PhDs/Postdocs Seminar.

The ongoing research by PhD candidate Nord involves the combination of input and state estimation together with pressure measurements at the interface during different crushing scenarios.
These three elements together enable to study the importance of how the structural modes participate in the response and ice force.



The left figure below shows the estimated motion of the structure during 30 ms, using Kalman filtering techniques.

Each frame corresponds to 10 ms.

The right figure shows the corresponding pressure at the interface between the structure and ice, measured by a tactile sensor installed on a cylindrical indenter.

This particular event illustrates how the superstructure unloads the ice edge.
When the superstructure advances in opposite direction of the ice drift, the ice edge will experience unloading. Loading of the ice edge will occur when the superstructure advances in the same direction as the ice drift. This process is entirely dependent on the mode shapes of the structure.

More explanations will appear in a paper that will be submitted to the journal CRSTC during this summer. The plan is to have a version ready for internal revision in June.

Achievements:

Accepted:

- Hendrikse, H., Renting, F., Metrikine, A., 2014. Analysis of the fatigue life of offshore wind turbine generators under combined ice- and aerodynamic loading. In the proceedings of the 33rd International Conference on Ocean, Offshore and Arctic Engineering, OMAE2014, 8-13 June, San Francisco, California.

Submitted:

- Hendrikse, H., Metrikine, A., 2014. Interpretation and prediction of ice induced vibrations based on contact area variation. Cold regions science and Technology. Submitted.
- Ranta, J., Tuhkuri, J., Polojärvi, A. and Paavilainen, J. (2014) Statistical reconstruction of peak ice load data based on 2D combined finite-discrete element method simulations of ice inter-actions against inclined wall. In The proceedings of 22nd IAHR International Symposium on Ice, IAHR, 11-15 August, Singapore.

Work Package 4: Floating Structures in Ice

Briefing on Activities:

After submitting a paper on global splitting of an ice floe, PhD candidate Wenjun Lu focused on the local failure of an ice floe interacting with a sloping structure (see Figure 1).

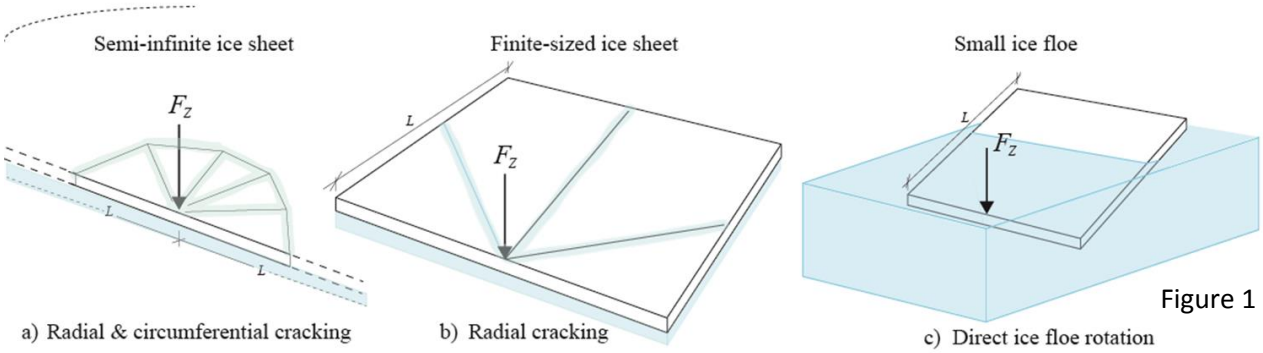


Figure 1

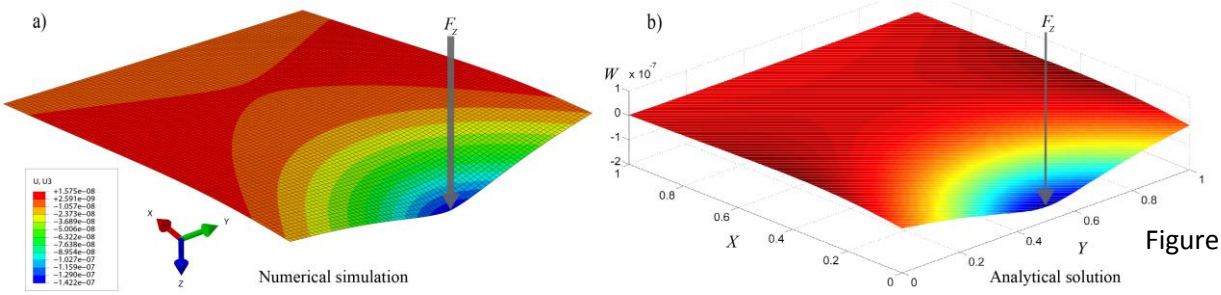
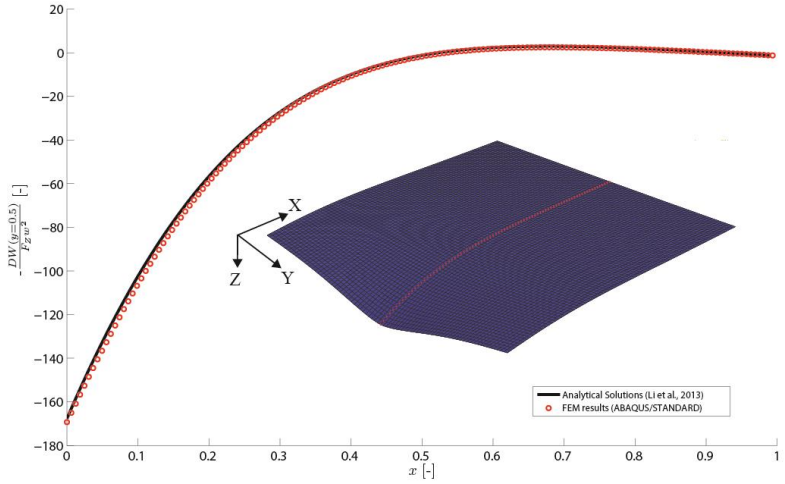


Figure 2



Generally, depending on the size of the isolated floe, locally, it can fail in rather different manners (see Figure 2).

A simplistic approach has been adopted to obtain the analytical solution of a finite-sized ice floe loaded at its edge. Comparison between analytical and numerical solutions is made in Figure 3.

PhD candidate Andrei Tsarau has been continuing his work on modelling hydrodynamic interactions between floating structures and ice. The newly developed numerical model was described and thoroughly studied in Tsarau et al. (2014). The same model was also used for a case study with the icebreaker MT Uikku in a simulated broken-ice field. This work will be presented at the International Marine Technology Conference 2014 (ICMT14), for which the following paper was prepared: "Numerical simulations of broken ice motion in the vicinity of a floating structure". Another paper titled "Propeller wash by an icebreaker" was submitted for the 22nd IAHR Symposium on Ice. The paper presents the propeller wash experiment conducted on board the Oden icebreaker during the recent Arctic research cruise (OATRC2013).

PhD candidate Chris Keijdener has finialized a contact model that allows the ice to crush at the interface with the vessel. This phenomenon was found to be very important when trying to model the transient stage of the ice-vessel interaction which becomes increasingly important at high interaction speeds. This contact model has been integrated with the ice model and will be used to

investigate frequency lock-in (FLI) for floaters. The contact model together with initial sensitivity studies of the breaking length, a key factor when looking at FLI, will be presented at the upcoming IAHR conference in Singapore. In the next few months Chris will continue studying FLI for floaters and aims to publish his findings in a journal paper soon after.

PhD candidate Ekaterina Kim has been preparing for her dissertation defense that took place on 9th of May. In addition to several commitments at the Marine Technology Department at NTNU, she has focused on some fundamental aspects of ice-structure interaction which results in:

1) together with E.M. Schulson they analyzed the situation where a hard, spherically shaped indenter is pressed rapidly into the flat ice surface. They offered a new constitutive-based, phenomenological explanation of the effects on ice pressure of both indentation size and indenter size. The constitutive-based explanation places ice within the context of non-linear inelastic behaviour of materials as a whole.
2) together with Høyland, K.V. they focused on the specific energy absorption of polycrystalline freshwater ice during crushing at small and medium scale. The main objective of this study was to test whether the specific energy (energy per unit mass of crushed ice) necessary to turn solid ice into crushed (pulverized) material can be considered as a size- and scale-independent characteristic. They found that the specific energy of the ice crushing process depends on the geometry, problem size and ice temperature. If the ice grains are sufficiently small compared with the penetration depth and indenter size, and the sample size (width and thickness) is sufficiently large compared with the indenter size and the penetration depth, the specific energy is a size- and scale-independent characteristic. However, if the grain size is sufficiently large compared with the indenter (and sample) size and the penetration depth, the specific energy exhibits a multi-scale character. Four draft papers (see below) were completed.

PhD candidate Martin Storheim has been working on a paper entitled “A volumetric approach to necking damage in coarse meshed shell structures”. Besides he has got the paper: “Design of offshore structures against accidental ship collisions” accepted in the Journal of Marine Structures.

Achievements:

- Kim et al. (2014): A phenomenological explanation of the pressure-area relationship for the indentation of ice: Size-effects during indentation. Submitted to Cold Regions Science and Technology
- Kim et al. (2014): Some secrets of the pressure-area curve for the indentation of ice. Submitted to IAHR 2014
- Kim et al. (2014): Experimental investigations of the energy absorption capacity of ice during crushing. Is the specific energy scale independent? Submitted to IAHR 2014
- Kim et al. (2014): Findings and lessons learned from implementing ice-structure impact tests in water and air. Submitted for presentation at the HYDRALAB user meeting.
- Lu et al. (2014): Physical model and theoretical model study of level ice and wide sloping structure interactions. CRST, Vol. 101(2014), pp. 40-72.
- Lu et al. (2014): Simulating Ice-Sloping Structure Interactions with the Cohesive Element Method. JOMAE, Vol. 136/031501-1, 16 p.
- Lu et al. (2014): Fracture of an ice floe: a theoretical study on the splitting failure model. CRST (submitted).
- Storheim et al. (2914): Design of offshore structures against accidental ship collisions”. Journal of Marine Structures (accepted).
- Tsarau et al. (2014): A numerical model for simulation of the hydrodynamic interactions between a marine floater and fragmented sea ice, CRST, Vol. 103, pp. 1-14.
- Tsarau et al. (2014): Numerical simulations of broken ice motion in the vicinity of a floating structure”. IAHR2014.
- Tsarau et al. (2014) “Propeller wash by an icebreaker”. IAHR2014.

Work Package 5: Ice Management and Design Philosophy

Briefing on Activities:

Farzad Farid-Afshin, in collaboration with Statoil, submitted an article to IAHR Ice Symposium 2014. The paper presents the ice management trials performed during OARTC2013 together with preliminary analyses of the data obtained using the different technologies that were taken onboard. It is an interesting article to read regarding the operational experience gained through performing short-term systematic icebreaking patterns offshore northeast Greenland.

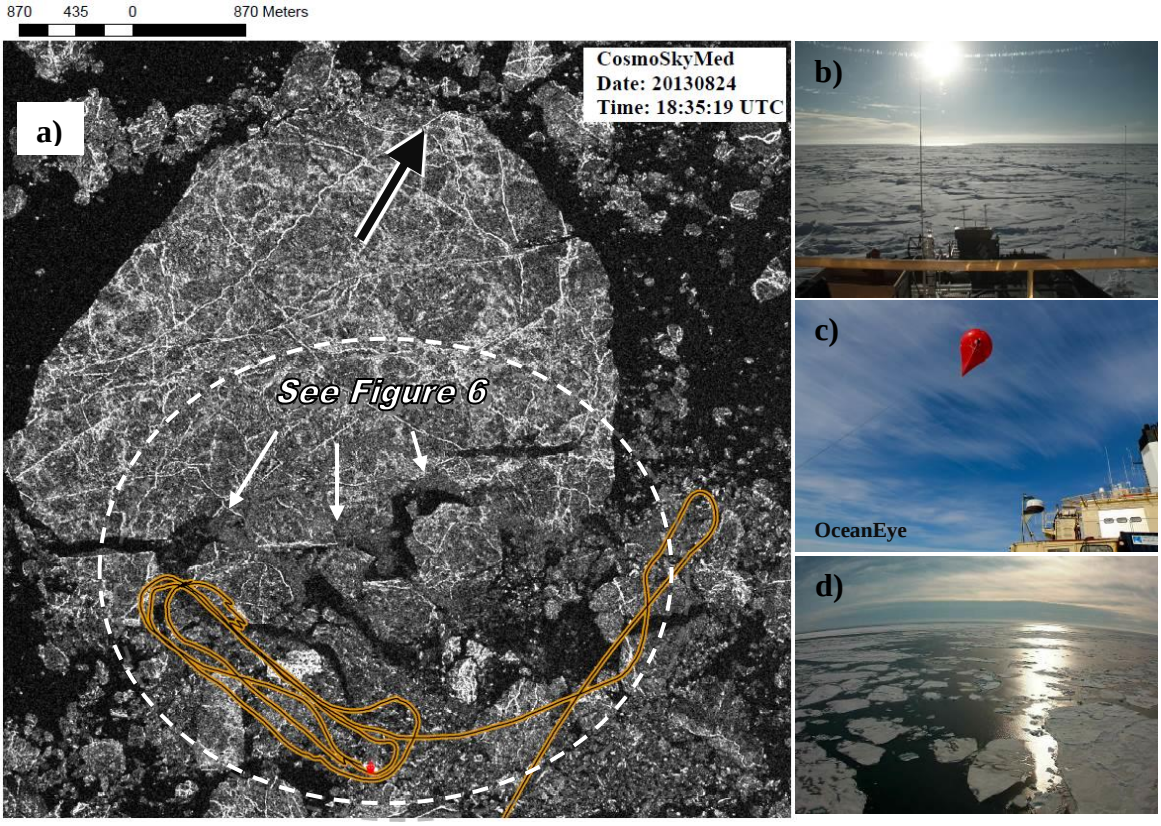


Figure 1: a) High-resolution satellite photo taken after approximately 3 racetrack-loops. The black arrow shows the direction of the initial drift heading which was the basis for planning the racetracks. The yellow line is the ship track function ψ . b) Initial ice condition (photo by Farzad Farid) c) OceanEye was launched at 19:00 (photo by Anna Pustogvar). d) Overview of the managed area at the end of operation (photo taken by OceanEye).

Martin Hassel started his PhD on January 1st and he is currently taking classes and writing his research plan. In addition, he has been able to write an article that highlights the need for an updated tool to better model ship-installation collision scenarios. The article will serve as an introduction to more in-depth and focused research of suitable risk models and methodologies for marine operations such as collision and other work involving vessels.
The title of the paper is "Analysis of the Main Challenges with the Current Risk Model for Collisions between Ships and Offshore Installations on the Norwegian Continental Shelf" and it will be presented at the PSAM (Probabilistic Safety Assessment & Management) conference in June.

Martin is currently working on an alternative collision risk model, using a Bayesian Belief Network to better account for influencing factors. The work is still in its infancy, but Martin has a workshop scheduled in early May with a group of experts to get feedback on the model.

Petter Norgren is in good progress with his courses. He submitted to IAHR Ice Symposium 2014 a survey paper about underwater vehicles in the Arctic, combined with some experiences from OATRC2013. In February, Petter was in Longyearbyen and in Ny-Ålesund operating the REMUS AUV and mini-ROVs and assisting with the field work related to the UNIS course AB334/834, i.e. *Underwater Robotics in the Arctic polar night*. Petter participated also in the course *Arctic Offshore Engineering field course* in Svea.

Figure 2: A photo of Petter Norgren during the field work in Svalbard.

Marat Kashafutdinov has developed a numerical model to couple the drift and thermal erosion of an iceberg. The iceberg in the model is subjected to forces from wind, waves and currents. The effects from wave-induced motions of an iceberg on its melting are included in the model where the iceberg is represented as a submerged cylinder in the presence of incident wave; the iceberg has motions with three degrees of freedom (surge, heave and pitch). The model allows calculating the velocity potential, added mass and added damping due to surge, heave and pitch. Further, the velocity field in the vicinity of iceberg's surface serves as input parameter for heat transfer model. Thus, it will be possible to study melting of the iceberg due to wave induced motion of the iceberg. In addition, the model allows calculating horizontal force acting on the iceberg. The force can be used as an input force from waves for iceberg drift model. Marat submitted a paper to IAHR Ice Symposium 2014 about wave-induced iceberg deterioration and he is currently making a progress in writing a journal paper describing the development of his numerical model and the main findings.

Renat Yulmetov continued to improve and document his numerical model for the simulation of icebergs drift and towing in pack-ice. He submitted a paper to IAHR Ice Symposium 2014 describing an algorithm to generate an ice field and he is about to submit a manuscript to CRST describing in details his numerical model. Renat is also quite active in collecting and analysing full-scale data to be used for model validation. He analysed full-scale data from OATRC2013 and submitted a paper to IAHR Ice Symposium 2014 about kinematic drift characteristics of icebergs in the Greenland Sea. Renat participated in the fieldwork in Svea, with AT-307F course and also in the fieldwork on board of RV Lance, AT-211 course.

Work Package 6: Coastal Technology

Briefing on Activities:

Anatoly Sinitsyn started as researcher in 60% position at SINTEF from 9th of January 2014. In addition Anatoly has a 40 % position at UNIS. In the period January-April 2014 Anatoly Sinitsyn was working on Scope of Work (SoW) for additional field work in Varandey area, Barents Sea. SoW was discussed with State Oceanographic Institute, Moscow (SOI). As result of discussion SAMCoT got an offer from SOI for implementation of field works.

In Feb 2014 Anatoly Sinitsyn and Emilie Guegan made presentation " Use of Satellite Images for Coastal Erosion Studies in Varandey, Barents Sea" on DUE Permafrost 2014.

Anatoly Sinitsyn and Emilie Guegan are currently writing a journal article "Coastal Erosion Investigations in Varandey area, Barents Sea", planned for submission in early May.

Evangeline Sessford, Maj Gøril Bæverfjord and Anne Hormes have submitted the journal article "Terrestrial processes affecting unconsolidated coastal erosion disparities in central fjords of Svalbard".

On February 24 SINTEF arranged an open meeting in Longyearbyen, Svalbard presenting all previous and ongoing SINTEF activities in Svalbad- starting from the early 70 until today. SAMCoT as a project was presented together with a brief information about ongoing and planned activities.

Christian Recker and Arnstein Watn participated in a Technical work-shop in Technische Universität Münster (TUM) in Germany focusing on new and innovative use of geosynthetics. A MSc student from TUM has been visiting SINTEF and UNIS working in relation to SAMCoT on the development of frost resistant concrete based on local aggregates from Svalbard in combination with geosynthetics, Arnstein Watn presented Arctic challenges and activities and presented SAMCoT in general and with a special focus on geosynthetics for arctic conditions.