SOME PROJECT/MASTER TASK SUGGESTIONS IN MARINE CIVIL ENGINEERING (Marin byggteknikk/IBM) 2021/2022

Information in English. However, you may write your project report/master thesis in Norwegian if you prefer.

Prerequisites:

Student in the last year of study for a Master degree in a relevant field of Civil Engineering.

The student has acquired a minimum of 90 credits at Master level on the time of starting on the master thesis.

Passed exam in TBA4265 Arctic and Marine Civil Engineering and passed minimum one of the following NTNU courses or similar:

TBA4145 Port and Coastal Facilities

TBA4260 Ice Actions on Arctic Structures

TBA4270 Coastal Engineering

TBA4275 Dynamic Response to Irregular Loadings

Other prerequisites are given at each task description.

If you find some topics of interest or have your own ideas in some of these areas, contact the person at NTNU listed.

- Port Infrastructure and Coastal Engineering: Raed Lubbad (raed.lubbad@ntnu.no); Hans Bihs (hans.bihs@ntnu.no); Jomar Tørset (jomar.torset@ntnu.no)
- Arctic Marine and Cold Climate Engineering: Knut V. Høyland (knut.hoyland@ntnu.no); Raed Lubbad (raed.lubbad@ntnu.no)
- Offshore Wind Turbines: Michael Muskulus (michael.muskulus@ntnu.no)

For practical issues, contact: Knut V. Høyland (knut.hoyland@ntnu.no)

NTNU, 14.04.21

Øivind Arntsen

Contents

1 Port Infrastructure and Coastal Engineering

1.1 The Port of Fredrikstad

One of the largest ports in Norway – Fredrikstad havn – is a river harbour situated at the mouth of Glomma – the largest river in Norway. The harbour itself and nearby locations are steadily developing and several Civil Engineering challenges must be met by good technical solutions. Examples of such challenges are:

- Ships moving up in a river/channel whirls up sediments, with a consequence of changing the river bathymetry and thus the water speed distribution.
- Approach channel design for ship transport in Glomma.
- Removing 1 million m3 of sediments in the Røsvikrenna. What will be the consequences of water transport in the tributaries to Glomma as well in the environmental protected area «Øraresrvatet" south of Fredrikstad port?
- How will the salt water wedge change due this vast dredging?
- Quantification of the physical environment related to future development of autonoumous vessels in the port and upstream Glomma.
- …

If some of these issues find your interest, contact us.

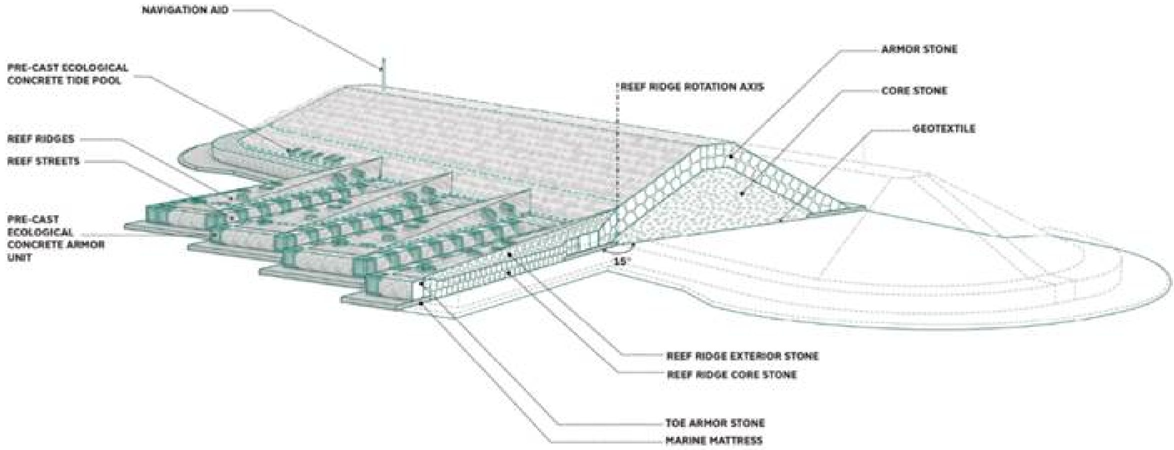
Our plan is to have a meeting with representatives from the Port of Fredrikstad, where those interested will be invited. The purpose of such meeting will be to clarify what topic could be of mutual interest to study.

Number of students: 1-4

Contact persons: Raed Lubbad (raed.lubbad@ntnu.no).

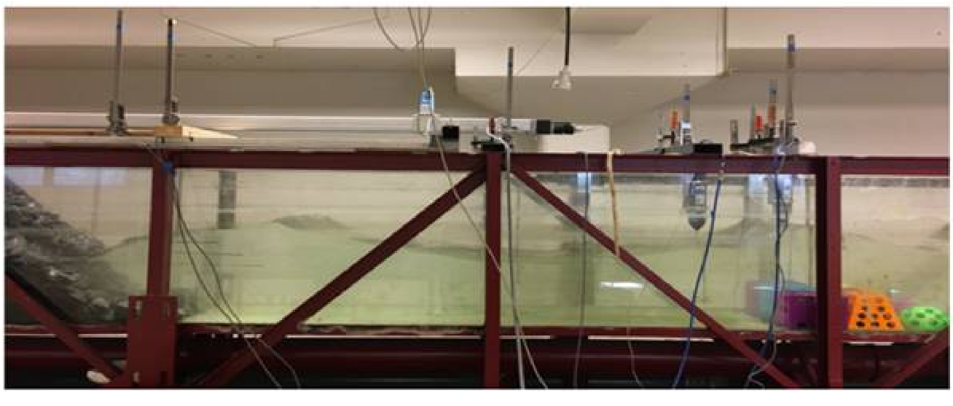
Co-Supervisors: Tore Lundestad (tore.lundestad@borg-havn.no)

1.2 Living Breakwaters



Climate change can pose threat to cities, existing infrastructures and coastlines. The threat is often manifested in terms of sea-level rise, increased intensity and frequency of storms and extreme events which can lead to coastal erosion, flooding, etc. To manage this, proper climate change mitigation and adaptation measures must be implemented. In this context, the emerging concept of "Living Breakwaters" appears as a promising adaptation measure. Here, Artificial Reefs (ARs) are used to improve the efficiency of existing breakwaters, to increase the stability of these structures and in the same time to enhance/restore the ecological conditions in the area. The turbulence created by the ARs contributes to the attenuation of waves and it can create suitable living conditions for different spices. In this study, the hydraulic performance of different configurations of ARs and their effects on the stability of a chosen breakwater and on the and the ecological conditions will be investigated experimentally. During the pre-project, the student will familiarise himself/herself with the research problem by conducting a thorough literature review and running pilot tests in the laboratory. The main experiments will be conducted during the work for the master thesis at the Harbour and Coastal Laboratories at NTNU with a wave flume of the following dimensions: 20m x 0.6m x 0.85m (length x width x height). The detailed geometry of the ARs will be modelled using 3D printing technology.

Recommended subject: TBA4265 Arctic and Marine Civil Engineering; TBA4145 Port and Coastal Facilities
Key words: Breakwaters, Climate change
Type of project: experimental work
Number of students: 1 to 2
Contact person at NTNU: Raed Lubbad
Continuation of project: Can be extended into a Master Thesis



1.3 Generation and propagation of extreme waves due to landslide events

Several regions in Norway such as around Åkneset in Møre and Romsdal, Stampa in Sogn and Fjordane susceptible to landslide events due to unstable mountain slopes along the fjords. Landslide events of large magnitude with impulsive impact of debris into the fjords can lead to the generation of extreme waves. The generation and propagation of these extreme waves has to be studied in detail to better understand the risk to the built-up areas around the fjords and reduce loss of life and property. Numerical modelling using Computational Fluid Dynamics (CFD) can provide a large amount of detail regarding the hydrodynamics involved in the process and several scenarios can be studied through a thorough parametric analysis.

The objective of this Masters thesis is to model the generation of extreme waves due to impact of a falling object into a water body and study the wave propagation characteristics. The effect of the volume and density of the falling body on the wave generation, wave kinematics of the extreme wave and the run-up on the coast will be studied. The study will be carried out using the open-source CFD model REEF3D. The six degrees-of-freedom (6DOF) algorithm in REEF3D will be used to model the falling object. The difference between a sub-aerial landslide and a submerged landslide and the characteristics of the consequent extreme waves generated will be studied.

Task type: Literature survey, numerical modelling, calculation.

Prerequisites:TBA4265 Arctic and Marine Civil Engineering.
Number of students: 1
Contact person at NTNU: Hans Bihs hans.bihs@ntnu.no

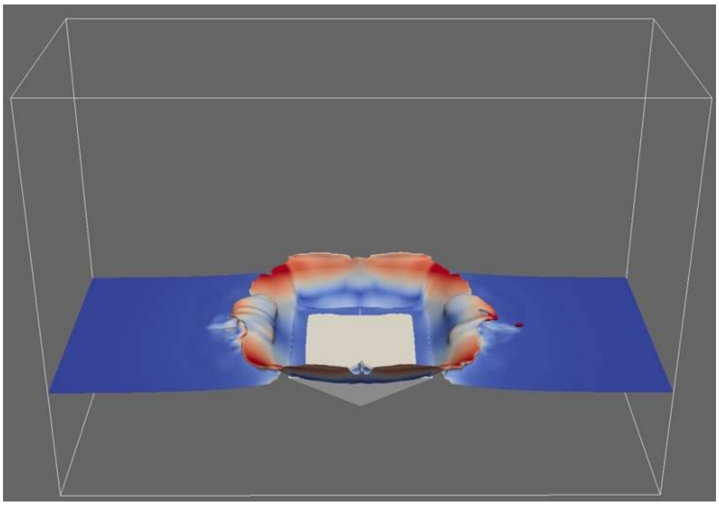


Figure 1.3: Impact of a freely falling wedge on water simulated using the 6DOF algorithm in REEF3D

1.4 Hydrodynamics of a floating bridge pontoon

The E39 project envisioned by the Norwegian Public Roads Administration involves replacing the ferry crossing along the highway with floating bridges and tunnels. The floating bridges and tunnels will be supported by moored floating pontoons. The wave and current interaction with such floating pontoons is to be studied in detail to obtain a better insight into the safety and stability of the floating bridges and tunnels. Conventional wave modelling techniques with potential flow and Boussinesq wave modelling can provide an overview on the wave and current propagation characteristics on a large scale. Whereas the near-field interaction with the floating pontoon has to be studied with a focus on detailed hydrodynamics around the structure. This includes diffraction around the pontoon, the mooring forces and the motion of the pontoon.

The objective of this Masters thesis is to simulate the wave and current interaction with a floating pontoon using the open-source Computational Fluid Dynamics (CFD) model REEF3D which provides detailed information of the flow features around the pontoon. The interaction of the pontoon with waves of different heights and wavelengths and currents will be studied. The mooring forces on the the pontoon and the motion of the pontoon under the action of waves and currents will be calculated. The six degrees-of-freedom (6DOF) equations implemented in REEF3D will be used to model the motion of the pontoon and calculate the forces and moments.

Task type: Literature survey, numerical modelling, calculation.

Prerequisites:TBA4265 Arctic and Marine Civil Engineering..
Number of students: 1
Contact person at NTNU: Hans Bihs hans.bihs@ntnu.no

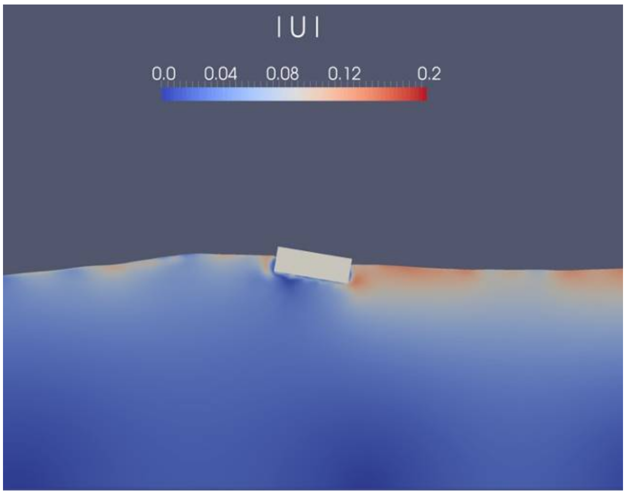


Figure 1.4: Roll motion of a rectangular barge under wave action modelled using 6DOF algorithm in REEF3D

1.5 Modelling of wave interaction with a breakwater using REEF3D

Breakwaters are the most common coastal constructions used to control wave action in a near-coastal region and protect the coastline form erosion or provide harbour tranquillity. The rubble mound breakwater is a type of commonly used breakwaters. Here, the breakwater is made of several layers and the porosity of the layers reduces towards the core of the structure. In order to model such structures, the numerical modelling of porous objects should be studied in detail, including the pore pressure and the velocity of the water through the porous layer. A computational fluid dynamics (CFD) model can calculate the wave hydrodynamics accurately and further research is required to include the hydrodynamics of a porous breakwater.

The objective of this Master's thesis is to model wave interaction with a breakwater including the porosity of the layers using the open-source CFD model REEF3D. Different approaches for the inclusion of the porosity will be explored. The results for the pressure, the free surface and velocities will be compared to experimental data. Simulations in three-dimensions will be carried out to study wave interaction including diffraction around the breakwater, erosion at the toe due to the action of waves and breakwater toe stability.

Task type: Literature survey, numerical modelling, calculation.

Prerequisites:TBA4265 Arctic and Marine Civil Engineering.
Number of students: 1
Contact person at NTNU: Hans Bihs hans.bihs@ntnu.no

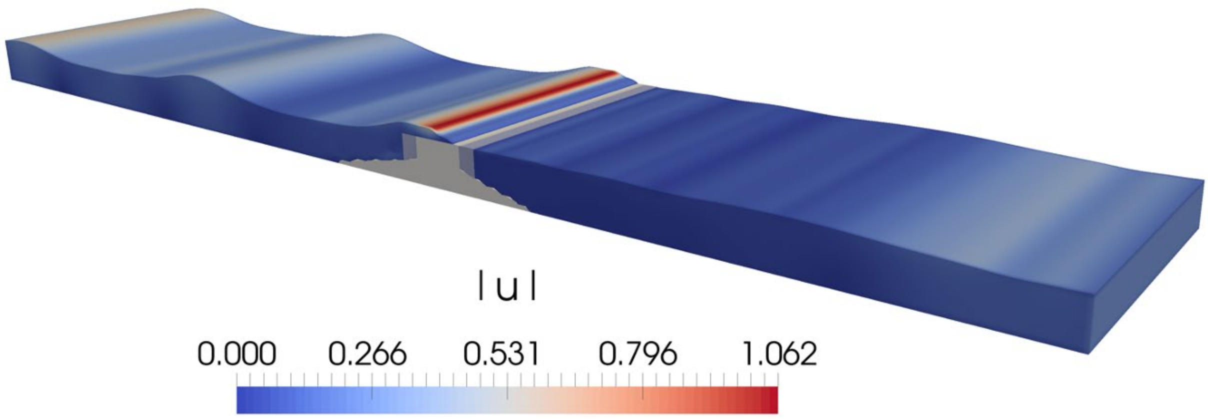


Figure 1.5 Wave interaction with a breakwater modelled with a porous layer around the crest.

1.6 Application of REEF3D to the study of wave overtopping

Wave overtopping is an important physical process on coastal structures such as sea walls and breakwaters. Excess overtopping volumes over coastal structures leads to flooding of the area behind the structure leading to loss of property or maintenance and operational problems. In current practice, overtopping is calculated using empirical formulae and further research can provide deeper insight into the overtopping process and the contribute to the design process.

The objective of this Master's thesis is to model wave overtopping using the open-source CFD model REEF3D. The water free surface undergoes complex deformations including wave breaking as it approaches the overtopping structure and further parts of the water volume propagate over the structure. The numerical model will be used to evaluate the free surface deformations on approach, over the structure and the overtopping water volume. The numerical results will be compared to experimental data. The effect of different slopes and crest heights of the overtopping structure on the free surface, the overtopping distance and the overtopping volume will be investigated in the thesis work.

Task type: Literature survey, numerical modelling, calculation.

Prerequisites:TBA4265 Arctic and Marine Civil Engineering..
Number of students: 1
Contact person at NTNU: Hans Bihs hans.bihs@ntnu.no

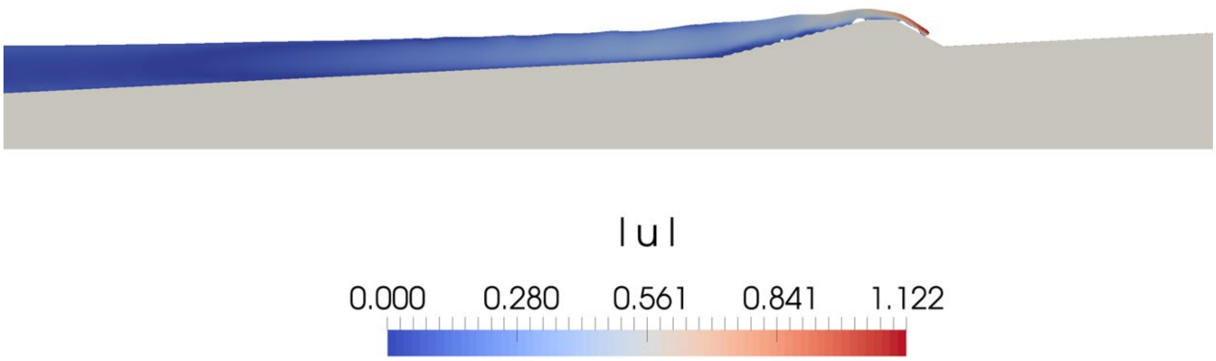
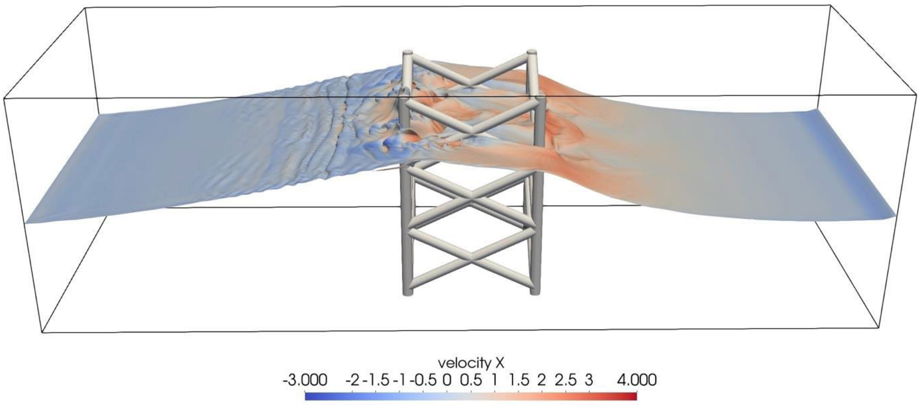


Figure 1.6 Solitary wave overtopping modelled using REEF3D

1.7 Numerical study of the irregular wave forces on a truss structure

Substructures of the offshore wind turbines are exposed to the irregular sea states. Interaction of the waves with the offshore structures is a vital factor in the safety and design of the offshore structures. The substructure can be a monopile or a truss structure. The waves undergo transformations due to non-linear, wave-wave interactions and due to interaction with the structures they are incident on. The wave forces on structures placed in such a wave field are influenced by the stochastic nature of the incident waves.



The objective of this study is to investigate irregular wave interaction with a truss structure. Numerical simulations will be carried out using the open-source CFD model REEF3D (www.reef3d.com), to simulate the irregular waves with the different peak periods and the different significant wave heights and their interaction with a truss structure. The numerical model will be validated by comparing the numerical results with the experimental results. The wave forces and the free surface features during wave-structure interaction for every member of the truss will be analysed in detail.

Task type: Literature survey, numerical modelling, calculation.

Prerequisites: TBA4265 Arctic and Marine Civil Engineering.
Number of students: 1
Contact person at NTNU: Hans Bihs hans.bihs@ntnu.no

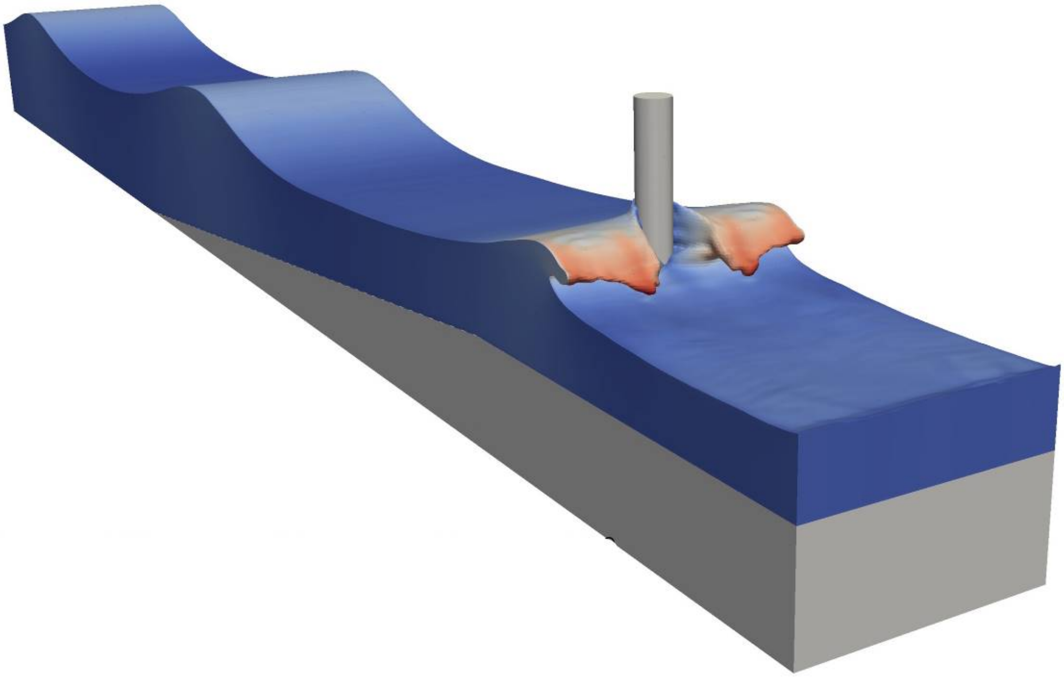
1.8 Breaking Wave Forces on Offshore Wind Substructures

Breaking wave forces a highly non-linear and very difficult to estimate with simplified approaches. For offshore wind substructures, such as monopoles, tripods or truss structures, the breaking wave impact forces are design critical. With computational fluid dynamics (CFD), the wave hydrodynamics can be resolved with a large degree of accuracy and detail. Also, the extremely complex wave breaking process can be simulated in a very realistic manner.

In the current project, the in-house open-source CFD code REEF3D (www.reef3d.com) will be used to calculate breaking wave forces on different types of offshore wind structures. The model calculates the flow for water and air and has advanced methods for capturing the interface between the two phases. The model is fully parallelized and runs on NTNU's supercomputer facilities. In this project, the breaking wave kinematics and the hydrodynamic loads will be analysed for different wave, structure and sea bed properties.

Task type: Literature survey, numerical modelling, calculation.

Prerequisites: TBA4265 Arctic and Marine Civil Engineering.
Number of students: 1
Contact person at NTNU: Hans Bihs hans.bihs@ntnu.no



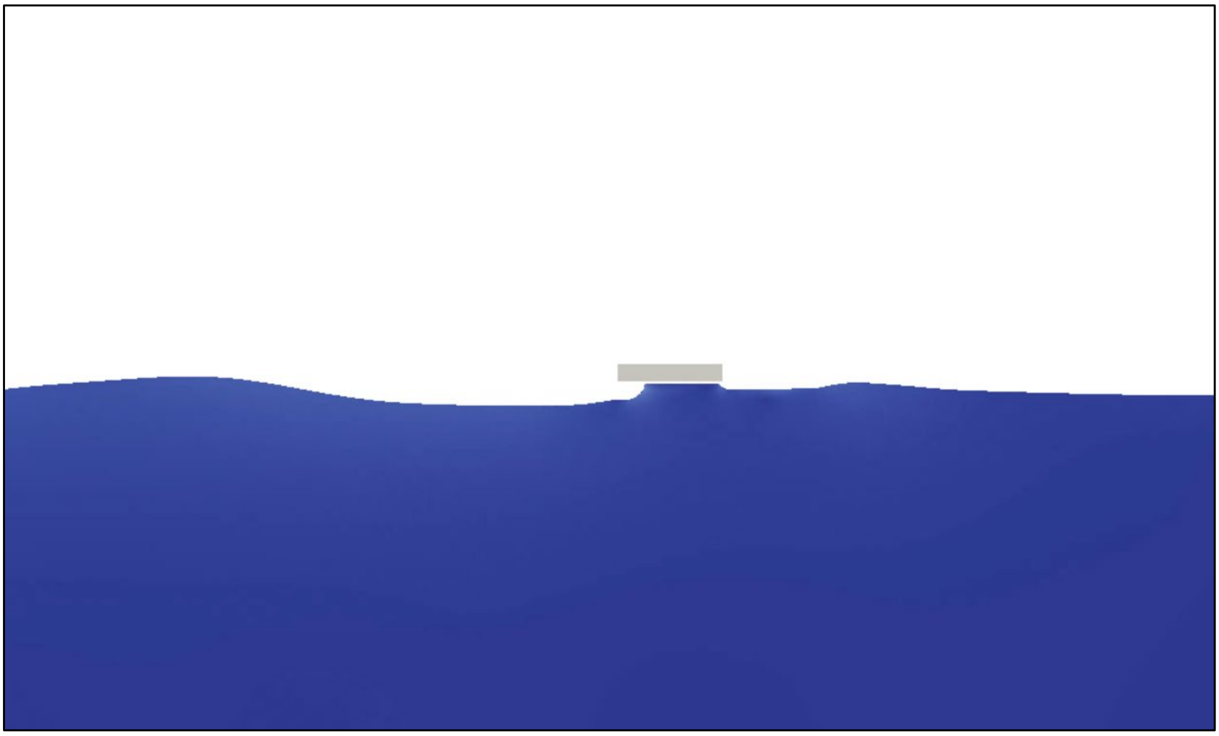
1.9 CFD simulations to analyse wave impact and uplift forces on a horizontal platform

The phenomenon of wave impact on structures is important from the point of view of design, stability and safety of a marine structure. Understanding the action of extreme waves under a horizontal structure located close the free surface can help in better design for these conditions. Decks of coastal and marine structures are built of many independent units placed together. The failure of these decks could be either due to the global failure of the whole platform or due to the local failures of the individual members. Wave impact can cause high local forces, which can cause failure of the individual members. Wave slamming involves a rapidly varying peak uplift pressure and a slowly varying uplift pressure. The forces resulting from the rapidly varying peak pressure have can cause local failure of the members of a platform.

This project aims at simulating wave-structure interaction with a focus on uplift forces on a thin plate under the action of a solitary wave. The study will be carried out using a CFD model adapted to be a numerical wave tank, developed at the Department of Civil and Transport Engineering. The relation between the freeboard and the maximum uplift force is to be explored. The results obtained from the numerical simulations are to be compared with the experimental data.

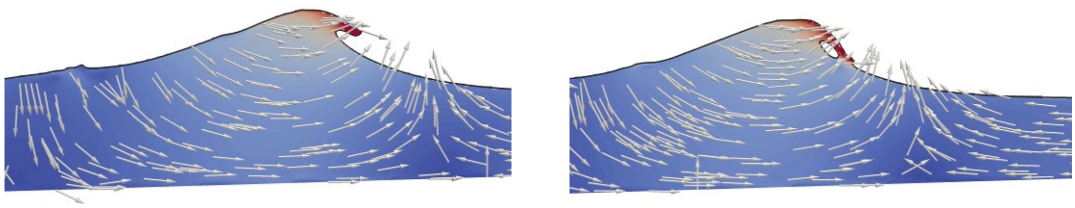
Task type: Literature survey, numerical modelling, calculation.

Prerequisites: TBA4265 Arctic and Marine Civil Engineering.
Number of students: 1
Contact person at NTNU: Hans Bihs hans.bihs@ntnu.no



1.10 Numerical investigation of shoaling and breaking characteristics of waves on beaches

The breaking process involves many complex parameters and breaking waves may occur at the site depending on the water depth, wave height, seabed slope, wave period and steepness. An exact numerical modeling of wave breaking process is still highly challenging due to the strong non-linear air-sea interaction at the free surface, air entrainment, and strong turbulent production by breaking is highly dissipative. Accurate assessment of wave shoaling and breaking wave characteristics is essential for an accurate prediction of wave forces on coastal structures.



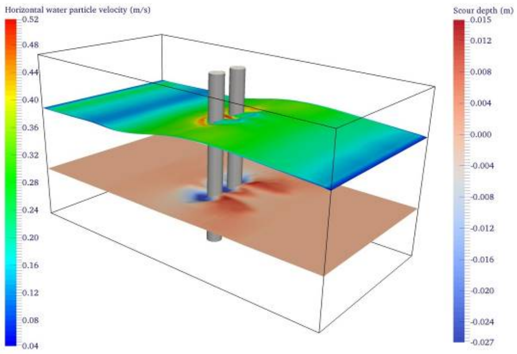
The main objective of the study is to investigate the shoaling and breaking characteristics of waves on plane beaches numerically. In the present study, the numerical experiments will be performed in a three-dimensional wave tank based on a two-phase flow CFD model REEF3D (www.reef3d.com), developed at the Department of Civil and Transport Engineering. The study investigates the features of the shoaling and the breaking process of waves over plane beaches in detail to gain more insight into the physical phenomenon. The outcomes of the project determine the key parameters of many field problems in nearshore coastal processes such as wave forces on coastal structures due to steep waves, non-breaking and breaking waves, surf-zone dynamics, sediment transport, run-up and scour around coastal structures etc.

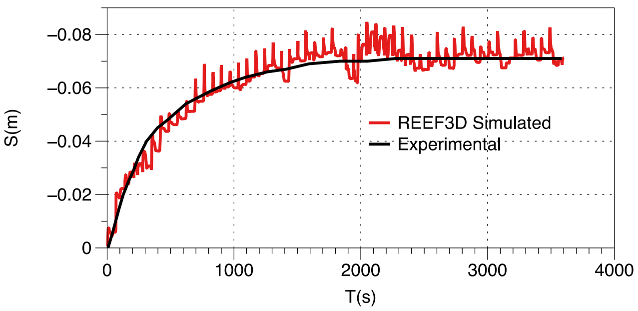
Task type: Literature survey, numerical modelling, calculation.

Prerequisites: TBA4265 Arctic and Marine Civil Engineering.
Number of students: 1
Contact person at NTNU: Hans Bihs hans.bihs@ntnu.no

1.11 3D Numerical modelling of local scour processes in coastal environment

Sediment transport plays an important role in many aspects of coastal and marine engineering such as local scour, beach erosion, scour below coastal pipelines and harbor accretion. Sediments are transported by waves or currents or sometimes through a combined action of both. An accurate prediction of sediment transport rates becomes an important element for the safety of hydraulic structures in coastal environments.





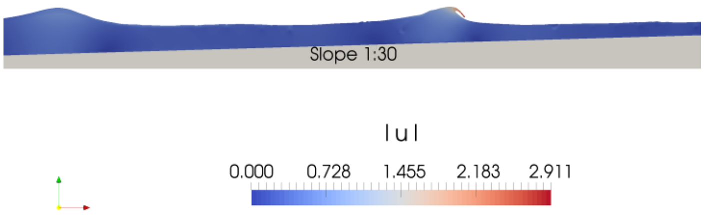
The main objective of the study is to investigate the local scour process in coastal environment using the open-source CFD model REEF3D. The task will focus on detailed analysis of the waves and current flow hydrodynamics, the resulting scour/deposition and the subsequent changes in the bed elevation using different sediment transport formulations available in the code. The numerical results will be compared with experimental data. The results shall be discussed in forms of time evolution of scour processes, the free surface profile and maximum scour/deposition contours.

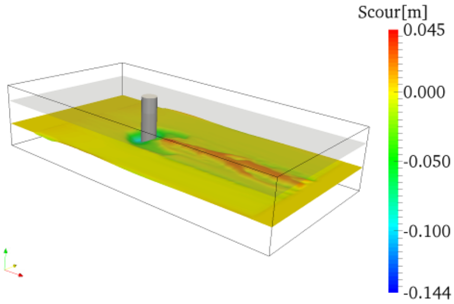
Task type: Literature survey, numerical modelling, calculation.

Prerequisites: TBA4265 Arctic and Marine Civil Engineering.
Number of students: 1
Contact person at NTNU: Hans Bihs hans.bihs@ntnu.no

1.12 3D Numerical modelling of cohesive sediment transport under wave and current action

Generally, cliffed-shorelines and foundations of coastal structures are composed of cohesive soils which consist of very fine grained silt and clay particles in a well bounded form. Continuous exposure of the cohesive sediment bed to waves or current causes horizontal and vertical erosion that can be a serious concern for the stability of structures on horizontal and sloping beds respectively. Further, suspended load due to higher fine particle concentration can also lead to other problems such high turbidity, live bed scour and beach accretion. The numerical modeling of cohesive sediment transport process is a challenging task, since unlike non-cohesive soils, there is a lack of practical measurements, numerical models and accepted guidelines on scour processes.





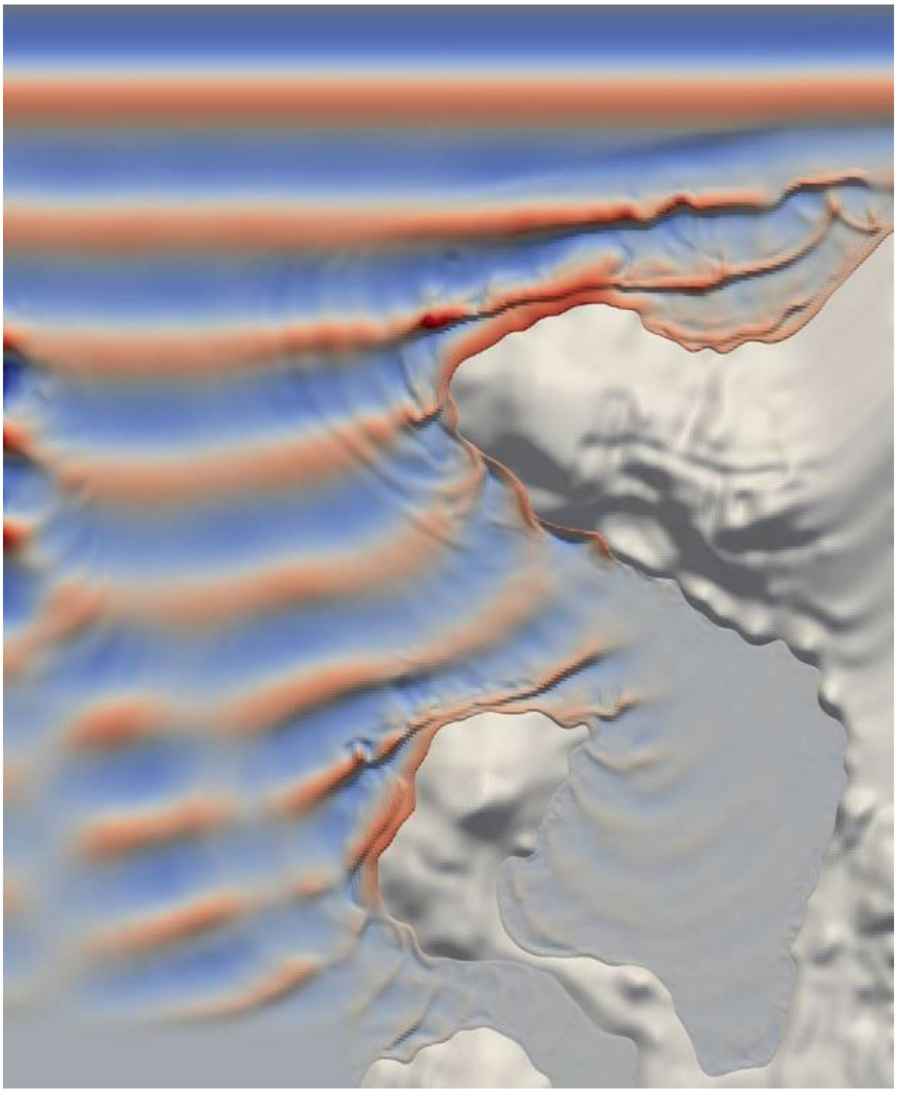
The study shall investigate cohesive sediment transport under waves and currents. The open-source CFD model REEF3D (www.reef3d.com) will be used. Emphasis shall be placed on analysis of hydrodynamics, resulting scour/deposition and subsequent change in bed elevation using different sediment formulations available in the code. The numerical results shall be compared with experimental observations. The expected results are an improved understanding of spatial and temporal distribution of suspended load concentrations, time evolution of scour processes, changes to the free surface profile and maximum scour/deposition contours.

Task type: Literature survey, numerical modelling, calculation.

Prerequisites: TBA4265 Arctic and Marine Civil Engineering.
Number of students: 1
Contact person at NTNU: Hans Bihs hans.bihs@ntnu.no

1.13 Large Wave Modeling of Norwegian Harbors with REEF3D::SFLOW

For harbors, diffraction effects are very important, prohibiting the use of phase-averaged spectral wave models. For large scale wave phase-resolved wave modelling, Boussinesq models are often used. Their drawback is a severe lack of robustness for real-world applications. A new and more robust class of phase-resolved large scale wave models are models that solve the shallow water equations and take dispersion into account through solving for the non-hydrostatic pressure.



The study shall investigate waves and currents in the vicinity of the coast, especially outside and inside harbors. The open-source hydrodynamics model REEF3D (www.reef3d.com) will be used with the wave model module REEF3D::SFLOW. Emphasis shall be placed on analysis of wave propagation and resulting wave conditions for ships berthing in the harbor. The numerical results shall be compared with experimental and field observations.

Task type: Literature survey, numerical modelling, calculation.

Prerequisites: TBA4265 Arctic and Marine Civil Engineering.
Number of students: 1
Contact person at NTNU: Hans Bihs hans.bihs@ntnu.no

1.14 Structural behavior of big «floating solar panels».

The goal of the project is to get familiar with **big floating structures** and how they behave in ocean. What impact have wave, wind and current on the structure dependent of where the structure is placed? All design loads must be defined (as in Trondheimsfjorden) that includes selfweight, stability and dynamic for different alternatives (for example 3 alternatives).

Learning objectives:

- How sea loads on large floating structures are modelled and simulated
- Give structural understanding with respect of response (forces, deflections) and how a structure behaves in water.

Approach:

- Literature study
- Modelling and analysis of "floating solar panels"

Prerequisites:

- Interest in design of ocean/offshore structures
- Knowledge of wind, waves and sea loads including dynamics
- Basic programming skills (e.g. Python, MATLAB, Fortran, R)

The work can also be continued in a master thesis.

Contact person: Jomar Tørset (jomar.torset@ntnu.no)

2 Arctic Technology (ice mechanics and ice actions on marine structures/vessels)

When designing coastal and marine structures (including vessels) the actions from floating ice covers often gives the most important environmental actions. There are mostly three scenarios that can be critical: icebergs, ice ridges and level ice.

2.1 Ice-induced Fatigue damage on Offshore Wind turbines or other bottom-fixed structures

Equinor, Multiconsult, Kværner and other Norwegian companies are active in the development of Offshore wind production in the Baltic and in many cases drifting ice needs to be taken into account so that ice actions become important. A project thesis can work with numerical or experimental aspect of ice actions on structures for the exploitation of wind energy. IBM leads a European project FATICE (https://www.martera.eu/projects/fatice) with partners from Germany and the Netherlands. Level ice action, ice-induced vibrations and uncertainties.
Contact person at NTNU: Knut V. Høyland, knut.hoyland@ntnu.no.

2.2 Ice action on typical structures in Norwegian waters

Ice actions on typical Norwegian structures in harbors, fjords, rivers and lakes have some different challenges that typical Arctic Offshore structures where the driving forces are often unlimited. The current regulations are adopted from the international standard for Arctic Offshore structures and not well suited for Norwegian waters. The IMB groups for Marine Civil Engineering (MB and Hydraulic structures (VT) works together with The Norwegian Road administration (SVV) and consulting companies through field work and modelling to improve the regulations.

- Field work in fjord and/or river
- Numerical analysis and development of standards

Contact person at NTNU: Knut V. Høyland, knut.hoyland@ntnu.no.

2.3 Ice ridges and ice ridge actions

- Ice ridge action on offshore structures - ice ridges as extreme ice features
- Ice ridge consolidation and properties – analyze data from the MOSAiC campaign (https://mosaic-expedition.org/)
- Probabilistic analysis of ridge properties and ridge action

Contact person at NTNU: Knut V. Høyland, knut.hoyland@ntnu.no.

2.4 Ice drift and ice action on structure

The drifting ice causes load and dynamic response of structures and in the design process statistics of ice conditions at site must be estimated. This is usually done as a combination of satellite data, local data and ice drift models, and the correlation between the relevant parameters (wind velocity, ice velocity, ice thickness and ice concentration) must be estimated. Wind and ice drift velocity are coupled through equations and a project thesis could be to carry out simple modelling of how the ice drift velocity relates to wind velocity.

Contact person at NTNU: Knut V. Høyland, knut.hoyland@ntnu.no.

2.5 Climate change and sea ice.

The world’s climate is changing and only minor changes in air temperature gives large changes in the sea ice cover. NTNU particiaptes in the MOSAiC campaign and the student could work with analysing data, or carrying out field or laboratory work to study this effect.

Contact person at NTNU: Knut V. Høyland, knut.hoyland@ntnu.no.

2.6 Icebergs

Contact person at NTNU: Sveinung Løset, Sveinung.loset@ntnu.no .

- Drift of icebergs in the Barents Sea

2.7 Icing

Contact person at NTNU: Sveinung Løset, Sveinung.loset@ntnu.no.

- Marine icing

2.8 Development of laboratory or full-scale procedures and instrumentation.

Contact person at NTNU: Knut V. Høyland, knut.hoyland@ntnu.no or Sveinung Løset, Sveinung.loset@ntnu.no.

- Instrumentation of ice growth tank and characterization of ice
- Study the reliability and accuracy of ice pressure sensors (tactile pressure sensors)

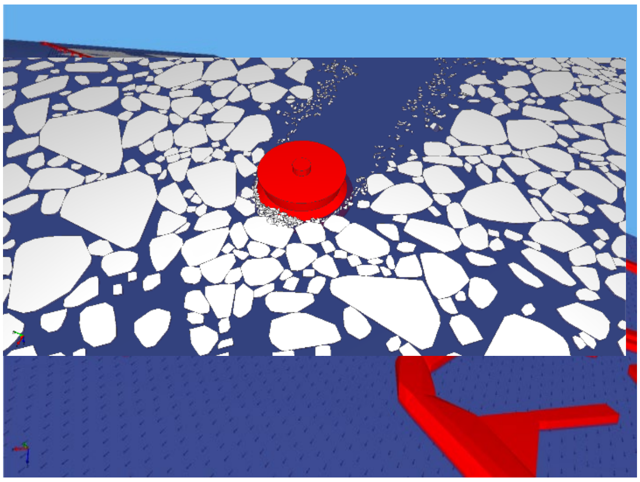
2.9 Ice thickness and level ice properties

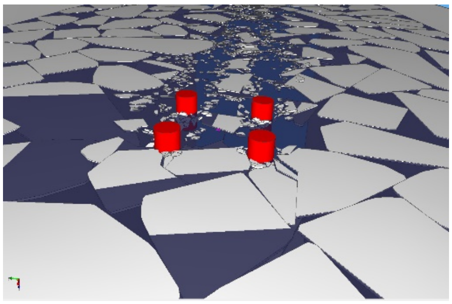
Contact person at NTNU: Knut V. Høyland, knut.hoyland@ntnu.no

- Level ice thickness in the Van Mijen fjord in Svalbard, analysis of existing data and / or perform new measurements on Svalbard / UNIS
- Ice texture and the brine and gas volume in first-year sea ice – seasonal development, measurements on Svalbard / UNIS

In most of these task it is possible to have a part-time stay at UNIS on Svalbard. Please get in touch with Sveinung Løset / Knut V. Høyland if you are interested in this.

2.10 Numerical Simulations of ice actions on fixed and floating structures





Numerical simulations of ice actions on coastal and offshore structures involve modelling a wide range of physical processes such as impacts, friction, buoyancy, hydrodynamics, fracture and fragmentation of ice. The Simulator for Arctic Marine Structures (SAMS) represents the state-of-the-art and it will used in this study. First, the design ice events must be determined. Thereafter, the numerical model should be configured, and numerical results generated. The numerical results should whenever possible be compared with available full-scale and model-scale data.

Recommended subject: TBA4265 Arctic and Marine Civil Engineering; TBA4260 - Ice Actions on Arctic Structures, AT327 Arctic Offshore Engineering
Key words: Coastal and offshore structures subjected to ice actions
Type of project: Numerical simulations and data analysis
Contact person at NTNU: Raed Lubbad raed.lubbad@ntnu.no
Continuation of project: Can be extended into a Master Thesis

2.11 Analysis of Model Ice Basin Tests of a ship in broken ice

A number of laboratory tests are performed with two vessels in broken ice in the Hamburg Ice Basin, Germany. The data from the tests will be made available for the student and he shall perform analysis of how the ice concentration, drift speed and floe size affect the load on the vessel. As an option the student may also study the effect of the characteristics (hull shape) of the two vessels on the loads.

Recommended subject: TBA4265 Arctic and Marine Civil Engineering; AT327 Arctic Offshore Engineering
Key words: Arctic offshore
Type of project: Numerical calculations
Cooperation with: Dynamic Positioning in Ice
Contact person at NTNU: Sveinung Løset
Continuation of project: Can be extended into a Master Thesis

2.12 Arctic coastal erosion

Arctic coastal erosion demands more attention as the global climate continues to change. Unlike those along low and mid latitude, sediments along Arctic coastlines are often frozen, even during summer.

Thermal and mechanical factors must be considered together when analysing Arctic coastal erosion. Two major erosion mechanisms in the Arctic have been identified: thermodenundation and thermoabrasion. Field observations of Arctic coastal erosion are available at sites in Russia and in Svalbard. The objective of this study is to model the observed coastal erosion. Xbeach will be used in this study. One core advantage to use XBeach is the avalanching mechanism of the dunes at the end of the beaches. Although the avalanche mechanism is designed for the sand, with proper modifications it can be applied to the Arctic coasts to simulate slumping, sliding and bluff collapse.

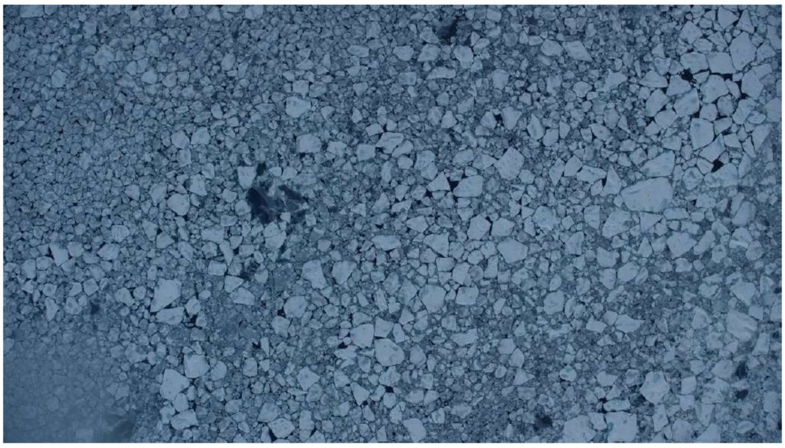
Recommended subject: TBA4265 Arctic and Marine Civil Engineering.
Key words: Arctic coast
Type of project: Numerical calculations
Contact person at NTNU: Raed Lubbad
Continuation of project: Can be extended into a Master Thesis

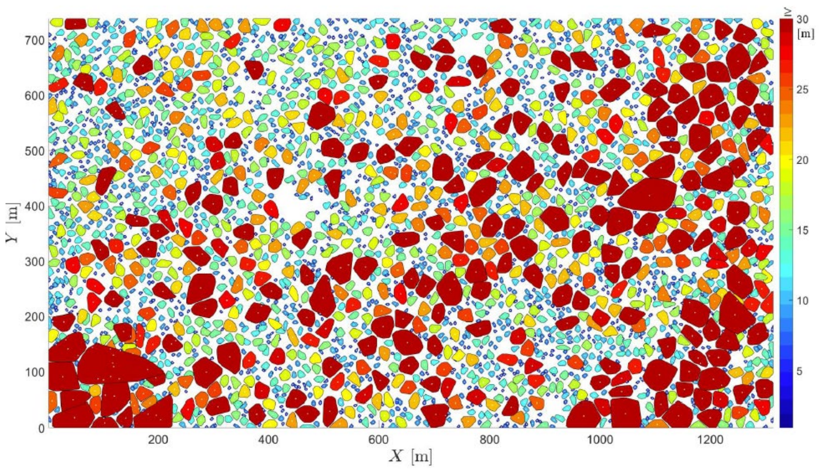
2.13 Characterizing the size and shape of sea ice floes

The size and shape of ice floes influence the overall ice drifting pattern as well as ice action on various structures in ice. Modern technology (e.g., satellite) enables us to survey/observe ice conditions at large scales and with great details. However, effort is still needed to extract and digitalize useful information for further studies.

The Norwegian University of Science and Technology (NTNU) participated the expedition, Oden Arctic Technology Research Cruise 2015 (OATRC'15) in the Arctic region in September, 2015. Among many scientific activities, a helicopter flight mission was accomplished when icebreaker Oden was transiting in the Marginal Ice Zone (MIZ). An optical camera mounted on a helicopter documents ice conditions at the MIZ; and many high-resolution images of sea ice were collected.

In this project, the student will have the opportunity to learn basic image processing technique and apply it to a relevant problem. The student shall digitalize the ice images through image processing. Thereafter, the size and floe shape information can be extracted from the digitalized information. The student shall gain great insight and contribute knowledge with regard to ice properties in the MIZ.





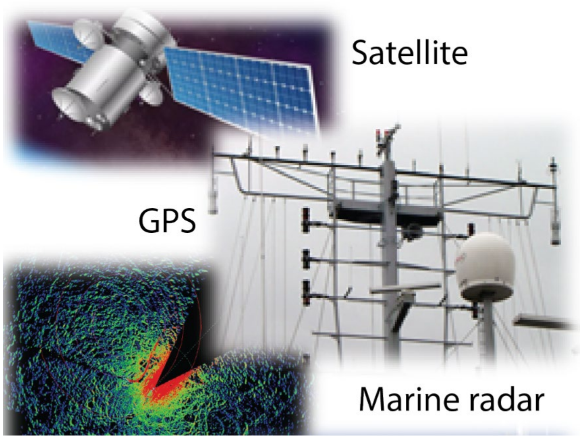
Recommended subject: TBA4265 Arctic and Marine Civil Engineering; TBA4260 - Ice Actions on Arctic Structures, AT327 Arctic Offshore Engineering

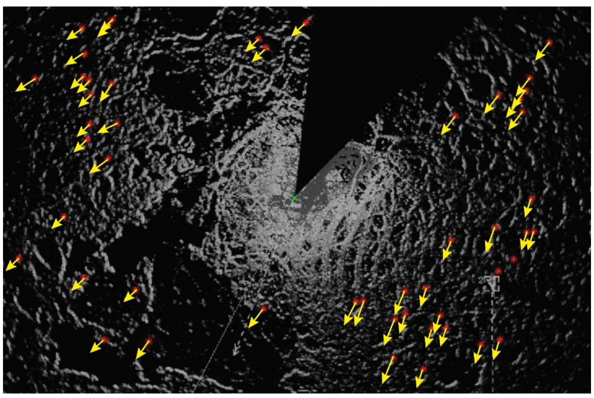
Key words: Digitalization, Ice floes, Image processing
Type of project: Digitalization
Contact person at NTNU: Wenjun Lu
Continuation of project: Can be extended into a Master Thesis

2.14 Tracking regional ice drift using marine radar images

Successive marine radar images not only tell people imminent ice environment but also the kinematics of the drifting sea ice. Instead of having an experienced ice expert watching and making interpretation of ice images, this process can be automated.

In this project, the student shall utilize image processing technique (marine radar images are available) and combine various source of information (e.g., GPS, vessel heading, satellite images) to give the best estimation of ice drift vectors.





Key words: Digitalization, Ice drift, Image processing
Type of project: Digitalization
Contact person at NTNU: Wenjun Lu
Continuation of project: Can be extended into a Master Thesis

3 Offshore Wind Turbines

3.1 Estimation of bathtub failure curve

The failure rates of wind turbine components typically follow the so-called bathtub curve: In the first few years of operation the failure rate is somewhat higher, then drops to a more or less constant level after, while rising again at the end of the design lifetime. The objective of this project is to simulate failures randomly from an assumed bathtub failure curve and then try to estimate this curve as accurately as possible using statistics.

Learning objectives:
- How the failure of (wind turbine) mechanical components can be described and simulated
- How statistics can be used to estimate important information about wind turbine operation
- How to implement the developed method in a computer tool

Approach:
- Literature study, Programming a failure simulation, Programming a statistical method

Prerequisites:
- Interest in reliability and statistical modelling
- Basic programming skills (e.g. Python, Julia, MATLAB, Fortran, R, C++)

If successful, the project work can be published as a conference paper and presented at the DeepWind conference in Trondheim, or at an international conference. The research group will pay all costs related to this, such as travel costs and conference fees. The work can also be continued in a master thesis.

Contact person: Michael Muskulus (michael.muskulus@ntnu.no)

3.2 Meta-modelling of fatigue damage for an offshore wind turbine on a jacket / monopile

Offshore wind turbine support structures (e.g. monopile or jacket) are typically fatigue-driven. The fatigue damage is estimated from computer simulations with a multibody / finite-element software, but these are slow and expensive to run. The full fatigue assessment is based on a few thousand of such load simulations, covering all possible environmental conditions (wind speeds and sea states). The objective of this project is to use only a few such simulations and then fit a meta-model (e.g. a neural network) that predicts the damage also for other load cases that have not been simulated. The model is then tuned to obtain maximum accuracy of the predictions.

Learning objectives:
- How wind turbine support structures are designed and analyzed
- How meta-modelling and other machine learning techniques can be used to speed up the design process
- How to implement the developed method in a computer tool

Approach:
- Literature study, Wind turbine modelling and simulation, Programming and tuning a meta-model

Prerequisites:
- Interest in structural design and analysis
- Interest in neural network or statistics
- Basic programming skills (e.g. Python, MATLAB, Fortran, R)

If successful, the project work can be published as a conference paper and presented at the DeepWind conference in Trondheim, or at an international conference. The research group will pay all costs related to this, such as travel costs and conference fees. The work can also be continued in a master thesis.

Contact person: Michael Muskulus (michael.muskulus@ntnu.no)

3.3 Stress concentration factors for tubular joints of wind turbine support structure under time-varying loading

Offshore wind turbine support structures (e.g. monopile or jacket) are typically fatigue-driven. The fatigue damage is estimated from computer simulations with a multibody / finite-element software. The results of these simulations is data that contains the displacements and stress resultants at a number of different positions in the structure (e.g. in all joints of a jacket) at each point in time. These time series need to be post-processed to check if the design is safe according to current guidelines and standards (e.g. DNVGL and NORSOK).

Thereby, stress concentration factors (SFC) are used in order to account for geometrical influences which are not covered within the computer simulations. Especially for tubular joints within jacket structures, these SFCs are highly dependent on the prevalent loading situation. Despite the fact, that these loading situations vary over time, it is common practice to utilize constant SCFs for a single load case.

The objective of this project is to investigate the influence of these fixed SCFs on the fatigue design of tubular joints in comparison to SCFs which change over time in equal measure as the present loading situation.

Learning objectives:
- How wind turbine support structures are designed and analyzed
- How to perform the code checks that design codes and international standards require
- How to implement these checks in a computer tool

Approach:
- Literature study, Wind turbine modelling and simulation, Programming the post-processing of the simulation data

Prerequisites:
- Knowledge of structural design and analysis
- Interest in structural design codes
- Basic programming skills (e.g. Julia, Python, MATLAB, Fortran, R)

If successful, the project work can be published as a conference paper and presented at the DeepWind conference in Trondheim, or at an international conference. The research group will pay costs related to this, such as travel costs and conference fees. The work can also be continued in a master thesis.

Contact person: Michael Muskulus (michael.muskulus@ntnu.no)

3.4 Constrained short-crested extreme waves

Offshore wind turbines have to withstand extreme loads safely, both from extreme winds and extreme waves. These extreme events are checked with simulations, but only one-dimensional (long-crested) waves are normally used for this. Extreme linear waves are implemented by arranging the phases of the wave components such that large amplitudes can be obtained at a specific time in the simulations. The objective of this project is to extend this so-called "NewWave" approach to more realistic two-dimensional (short-crested) waves.

Learning objectives:
- How extreme wave events are modelled in the offshore and wind energy industry
- How two-dimensional waves can be simulated
- How wave simulations can be constrained

Approach:
- Literature study, Programming of a wave simulation, Programming the new approach

Prerequisites:
- Knowledge of linear waves
- Interest in offshore design against extreme events
- Basic knowledge of probability (conditional probability) and linear algebra (matrix inversion)
- Basic programming skills (e.g. Python, Julia, MATLAB, Fortran, R, C++)

If successful, the project work can be published as a conference paper and presented at the DeepWind conference in Trondheim, or at an international conference. The research group will pay all costs related to this, such as travel costs and conference fees. The work can also be continued in a master thesis.

Contact person: Michael Muskulus (michael.muskulus@ntnu.no)

3.5 Shared moorings for floating wind turbines

Floating wind turbines (such as Hywind) are used in deep water (from about 60m water depth). These need to be moored (e.g. using anchors and chains) to keep them from drifting away under wind and wave actions. Traditionally each wind turbine in a floating wind farm has its own mooring system, but since these are expensive, there is an interest in sharing the moorings between floaters and using less anchors. The objective of this project is to develop a simple numerical model for the dynamics of such a shared mooring, based on coupled springs and masses, and to perform some simulation studies to assess the motions and vibrations of the turbines and mooring elements.

Learning objectives:
- How floating wind turbines are designed
- How mooring systems for floating wind turbines can be simulated
- How to assess the performance of a mooring system

Approach:
- Literature study, Programming of a mooring system simulation, Case studies

Prerequisites:
- Interest in floating wind energy
- Basic knowledge of spring-mass systems and their vibrations
- Basic programming skills (e.g. Python, MATLAB, Fortran, R)

If successful, the project work can be published as a conference paper and presented at the DeepWind conference in Trondheim, or at an international conference. The research group will pay all costs related to this, such as travel costs and conference fees. The work can also be continued in a master thesis.

Contact person: Michael Muskulus (michael.muskulus@ntnu.no)

3.6 Quiescent periods in linear waves

Although sea surface waves are irregular, it often happens that the sea surface is relatively quiet for a certain period of time (on the order of 5-10 waves). If one would be able to predict the beginning of such "quiescent periods" using past measurements of the waves, this would be very interesting for a number of applications, such as access to wind turbines, or helicopter landing on ships. Two new approaches are suggested here: Either the use of a neural network, or estimating the wave components and their phases (the so-called "Prony-type" method). The objective of this project is to test one of these approaches using simulations.

Learning objectives:
- How to describe and model irregular linear waves
- How to estimate the waves in a seastate from measurements
- Experience with model fitting, neural networks and other machine learning techniques

Approach:
- Literature study, Programming an approach to predict future quiescent periods, Case studies

Prerequisites:
- Interest in offshore engineering
- Basic knowledge of linear algebra (matrix inversion)
- Basic programming skills (e.g. Python, Julia, MATLAB, Fortran, R, C++)

If successful, the project work can be published as a conference paper and presented at the DeepWind conference in Trondheim, or at an international conference. The research group will pay all costs related to this, such as travel costs and conference fees. The work can also be continued in a master thesis.

Contact person: Michael Muskulus (michael.muskulus@ntnu.no)

3.7 Detailed analysis of a simplified ice-structure interaction model

Ice loads are important for the design of offshore wind turbines in waters with potential sea ice risk. However, the interaction with the turbine is quite complex. Recently a stochastic ice-structure interaction model was developed that is capable of describing the most important features of this interaction, and which is also mathematically very interesting. The objective of this project is to implement a simplified version of this model and to conduct a large number of simulations of its behavior.

Learning objectives:

- How to assess ice-structure interaction using state-of-the-art models
- How to simulate / solve such a stochastic model numerically

Approach:

- Literature study, Programming the model; Case studies

Prerequisites:

- Interest in arctic engineering
- Some knowledge of numerical analysis (i.e. solution of ordinary differential equations)
- Basic programming skills (e.g. Python, Julia, MATLAB, Fortran, R, C++)

If successful, the project work can be published as a conference paper and presented at the DeepWind conference in Trondheim, or at an international conference. The research group will pay all costs related to this, such as travel costs and conference fees. The work can also be continued in a master thesis.

Contact person: Michael Muskulus (michael.muskulus@ntnu.no)

3.8 Improvement of simulations in Vindby, the serious wind farm computer game

During a recent master thesis a computer game was developed that lets the player build and develop wind farms. The game has been programmed in Python and is used as a teaching tool. A first version of the game can be found at: http://folk.ntnu.no/muskulus/vindby/
The objective of this project is to further improve the simulation behind Vindby, e.g., the models used for the environmental loads and project finance, and the gameplay.

Learning objectives:
- How wind farm development works
- How to improve an existing simulation game

Approach:
- Literature study, Design of new features, Programming and testing

Prerequisites:
- Interest in offshore wind energy (technical and/or financial)
- Interest in computer simulations
- Programming skills in Python

If successful, the project work can be published as a conference paper and presented at the DeepWind conference in Trondheim, or at an international conference. The research group will pay all costs related to this, such as travel costs and conference fees. The work can also be continued in a master thesis.

Contact person: Michael Muskulus (michael.muskulus@ntnu.no)

3.9 Design of a wind-turbine controller for an offshore wind turbine

A wind turbine controller tries to optimize power production. For smaller wind speeds it controls the power-take off in order to speed the rotor up or down. For each wind speed a different optimal rotor speed exists that maximizes power production, whereas for higher wind speeds the controller has to limit the power production. The goal of this project is to develop a simple, parametric controller (e.g. PID controller) that can be used with structural optimization studies (which so far only optimize the structure, but which ideally should also include the controller).

Learning objectives:
- How modern wind turbines operate
- How to design a controller suitable for a wind turbine

Approach:
- Literature study, Controller design, Programming and testing

Prerequisites:
- Interest in wind turbine dynamics
- Basic knowledge of control theory (e.g. PID controller)
- Basic programming skills (e.g. Python, Julia, MATLAB, Fortran, R, C++)

If successful, the project work can be published as a conference paper and presented at the DeepWind conference in Trondheim, or at an international conference. The research group will pay all costs related to this, such as travel costs and conference fees. The work can also be continued in a master thesis.

Contact person: Michael Muskulus (michael.muskulus@ntnu.no)

3.10 Implementing a multi-rotor floater in Simis ASHES

There is currently some interest in multi-rotor solutions where more than one wind turbine is mounted on the same floating structure. Up to now it has not been possible to evaluate the vibrations in such a structure. However, this is now possible with the latest ASHES software by Simis AS. The goal of this project is to implement a multi-rotor floater and to compare vibrations and fatigue damage against a single-rotor floater, in close cooperation with the company Simis AS.

Learning objectives:
- How modern wind turbines are simulated
- How to assess structural vibrations in a floating wind turbine system

Approach:
- Literature study, Modelling the turbine in ASHES software, Case studies

Prerequisites:
- Interest in wind turbine dynamics
- Basic knowledge of finite-element method
- Basic knowledge of engineering analysis software (e.g. ANSYS / ABAQUS)

If successful, the project work can be published as a conference paper and presented at the DeepWind conference in Trondheim, or at an international conference. The research group will pay all costs related to this, such as travel costs and conference fees. The work can also be continued in a master thesis.

Contact person: Michael Muskulus (michael.muskulus@ntnu.no)

3.11 Hydrodynamic loads on big floating structures

The goal of the project is to get familiar with the methods for calculation of hydrodynamic loads on big floating structures, based on the theory of diffraction implemented in the open source software Nemoh (https://lheea.ec-nantes.fr/research-impact/software-and-patents/nemoh-presentation), and to perform tests on relevant examples.

Nemoh is a Boundary Element Method (BEM) code developed over 30 years at Ecole Centrale de Nantes, and can calculate wave forces on offshore structures (added mass, radiation damping, and diffraction forces). Nemoh solves in the frequency-domain, so an important part of the assignment is to propose and test procedures for converting the results to time series for a given wave spectrum, in order to use them as load functions in a time-domain simulation of a floating structure.

Learning objectives:
- How sea loads on large floating structures are modelled and simulated
- How to convert between time- and frequency-domain in hydrodynamic modelling

Approach:
- Literature study, Installation and testing of Nemoh, Programming pre- and post-processing

Prerequisites:
- Interest in the dynamics of floating offshore structures
- Knowledge of waves and sea loads
- Basic programming skills (e.g. Python, MATLAB, Fortran, R)

If successful, the project work can be published as a conference paper and presented at the DeepWind conference in Trondheim, or at an international conference. The research group will pay all costs related to this, such as travel costs and conference fees. The work can also be continued in a master thesis.

Contact person: Michael Muskulus (michael.muskulus@ntnu.no)

3.12 Standing and/or propagating waves in offshore mooring lines

Standing waves have been shown to occur in the mooring lines of floating offshore bodies, especially for small floater movements. And when a floating structure is undergoing large motions, this can cause waves that propagate along the mooring lines. However, research on such standing or propagating waves in mooring lines is scarce. The goal of this project is to find out under which circumstances these phenomena can occur in mooring lines, especially for floating wind turbines, and which impact such waves have on mooring system reliability.

Learning Objectives:

- Deep understanding of mooring line dynamics
- Insights into floating wind turbine design and dynamics
- Understanding of wind turbine fatigue and reliability calculations

Approach:

- Literature study, simulation of standing / propagating waves (using e.g. MoorDyn software), determination of necessary model resolution (timesteps, number of finite elements), uncertainty quantification and load simulations to assess impact of standing / propagating waves on overall mooring reliability

Prerequisites:

- Background in physics or (offshore) engineering
- Interest in computer simulations
- Basic programming skills (e.g. Python, MATLAB, Julia, Fortran, C++)

If successful, the project work can be published as a conference paper and presented at the DeepWind conference in Trondheim, or at an international conference. The research group will pay all costs related to this, such as travel costs and conference fees. The work can also be continued in a master thesis.

Contact person: Michael Muskulus (michael.muskulus@ntnu.no)

3.13 Floating wind turbine power cable loads through geometry changes

The power cable is one of the most sensitive components of a floating wind turbine. Floater movements cause a change in the geometry of the power cable, leading to dynamic loads. The aim of this project is to investigate the changes in power cable geometry caused by (prescribed) floater movements. The observations can then be used to develop a simplified model for fatigue damage in such cables.

Learning Objectives:

- Insights into floating wind turbine design and dynamics
- Experience with finite element simulations of cables
- Understanding of fatigue damage in cables

Approach:

- Literature study, simulation of power cable using finite element software, analysis of geometry changes and loads, fatigue analysis

Prerequisites:

- Background in offshore engineering, mechanics, or physics
- Interest in computer simulations
- Basic programming skills (e.g. Python, MATLAB, Julia, Fortran, C++)

If successful, the project work can be published as a conference paper and presented at the DeepWind conference in Trondheim, or at an international conference. The research group will pay all costs related to this, such as travel costs and conference fees. The work can also be continued in a master thesis.

Contact person: Michael Muskulus (michael.muskulus@ntnu.no)

3.14 Vortex induced vibrations (VIV) in mooring lines of floating wind turbines

Vortex induced vibration (VIV) is a dynamic phenomenon where a steady flow around a structure causes vortices which excite the structure through time-varying lift forces. VIV has been investigated for offshore oil and gas applications in a lot of detail. However, VIV in mooring lines of floating wind turbines is mostly unexplored. Under what conditions can VIV occur here, and how does it impact the dynamics and reliability of mooring lines?

Learning Objectives:

- Knowledge of the VIV phenomenon and how to analyze it (its theoretical basis and practical assessment)
- Insights into floating wind turbine design and dynamics
- Experience with floater simulation and load analysis

Approach:

- Literature Review, Numerical modeling and simulation of VIV, Analysis of results

Prerequisites:

- Knowledge of basic hydrodynamics and/or offshore engineering
- Interest in computer simulations
- Basic programming skills (e.g. Python, MATLAB, Julia, Fortran, C++)

If successful, the project work can be published as a conference paper and presented at the DeepWind conference in Trondheim, or at an international conference. The research group will pay all costs related to this, such as travel costs and conference fees. The work can also be continued in a master thesis.

Contact person: Michael Muskulus (michael.muskulus@ntnu.no)

3.15 Optimization of the blade for a novel hybrid wind turbine concept

Power production and consequent cost of energy of a wind turbine are dependent on the design of its rotating blades, in particular the geometry of the blades. Given a suitable airfoil, the aerodynamic performance of a blade is largely determined by the variation of the chord length and twist angle along its span. The objective of this project is to implement an optimization process to search for an optimal blade geometry, varying these two parameters, for a new, unconventional wind turbine that is currently explored in an on-going European research project.

Learning objectives:

- Understanding of wind turbine dynamics and design
- Practical experience with design optimization
- Insights into what is needed to build an efficient wind turbine

Approach:

- Literature study, Wind turbine modelling and simulation, Programming the optimization methodology

Prerequisites:

- Basic knowledge of aerodynamics or fluid dynamics (lift / drag forces)
- Interest in wind turbine design and optimization
- Basic programming skills (e.g. Python, Julia, MATLAB, Fortran, R, C++)

If successful, the project work can be published as a conference paper and presented at the DeepWind conference in Trondheim, or at an international conference. The research group will pay costs related to this, such as travel costs and conference fees. The work can also be continued in a master thesis.

Contact person: Michael Muskulus (michael.muskulus@ntnu.no)