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

Information in English, but 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 on the time of starting on the master thesis.

Passed exam in TBA4265 Arctic and Marine Civil Engineering and passed

minimum 1 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.

The Marine Civil Engineering group will not arrange a general information meeting.

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); Øivind A. Arntsen (oivind.arntsen@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: Øivind A. Arntsen (oivind.arntsen@ntnu.no)

This list of suggested projects may be updated before 15th May.

NTNU, 12.04.2019

Øivind Arntsen

Course coordinator TBA4920 Marine Civil Engineering Master Thesis

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 «Ørareservatet" 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.
- …
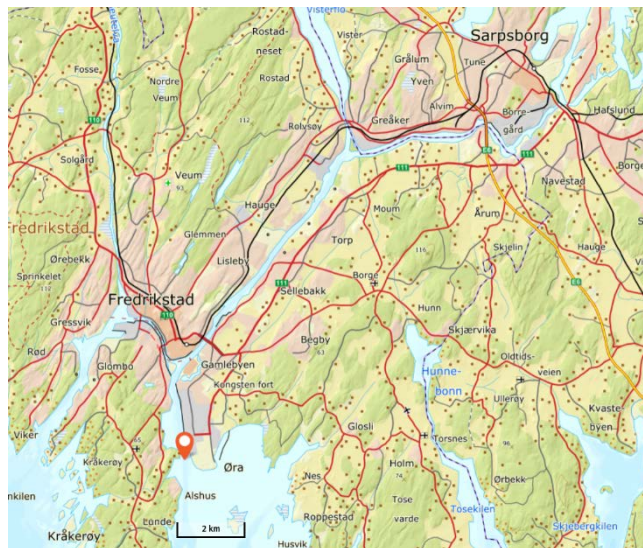
If some of these issues find your interest, contact us.

Our plan is to have a meeting with representatives from the Port of Fredrikstad before 15th of May, 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) , Roar Johansen (Roar.Johansen@borg-havn.no) .

1.2 Numerical modelling of wave interaction with a floating breakwater using REEF3D

Floating breakwaters have an advantage over conventional fixed-bottom breakwaters in areas with great depth and limited wave exposure. The cost of building a conventional breakwater increases significantly with water depth and for a number of marinas along the Norwegian coast, these solutions can be completely obsolete. The purpose of a wave absorber is to reduce the wave height on the leeward side relative to the incoming waves. Reduction in wave height inside occurs either because the waves lose energy by breaking and the energy passes into turbulence or due to reflection by the breakwater.

The objective of the Masters thesis is to simulate the interaction of waves with a floating breakwater using the open-source Computational Fluid Dynamics (CFD) model REEF3D and determine the wave reflection and transmission characteristics for various configurations of the floating breakwater. In addition, the mooring forces on the floating breakwaters can be calculated.

The floating breakwater is efficient against waves shorter than half of its width. In the case of longer waves, combination of a submerged breakwater in front the floating breakwater can be used to reduce the incident wavelength on the floating breakwater as shown in Figure 1.7.

Task type: Literature survey, numerical modelling, calculation.

Prerequisites:TBA4265 Marine Physical Environment.
Number of students: 1-2
Contact person at NTNU: Hans Bihs hans.bihs@ntnu.no
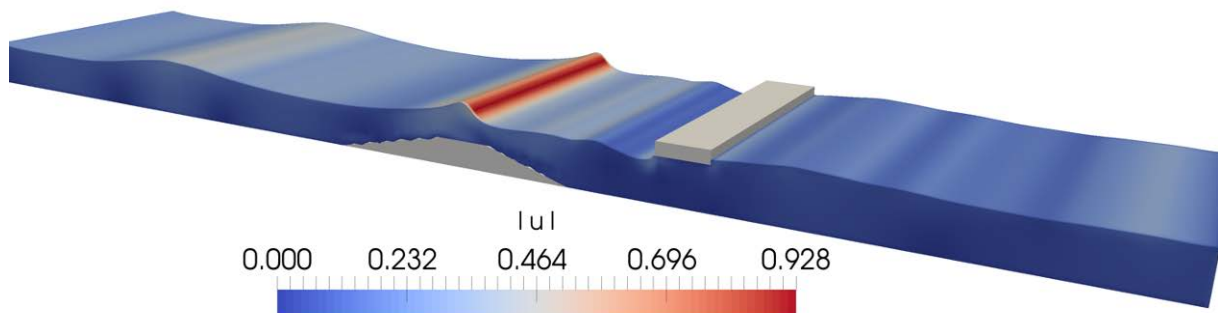
Figure 1.2 Incident wave with T= 2.02 s propagating over a submerged breakwater and incident on a floating breakwater.

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 Marine Physical Environment.
Number of students: 1
Contact person at NTNU: Hans Bihs hans.bihs@ntnu.no
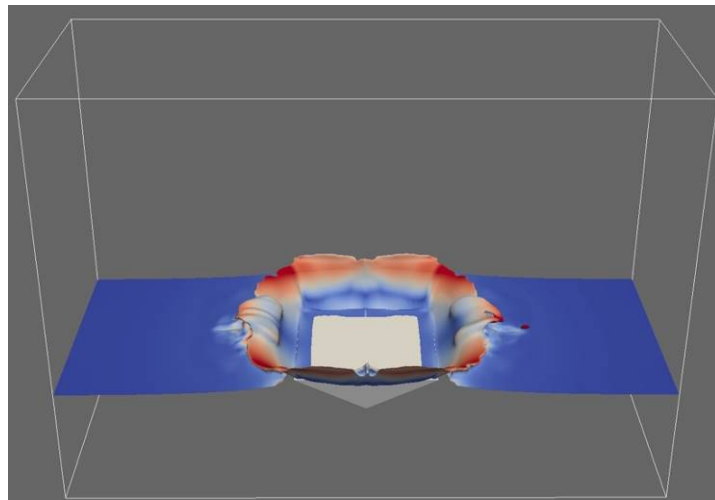
Figure 1.3: Impact of a freely falling wedge on water simulated using the 6DOF algorithm in REEF3D

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 Marine Physical Environment.
Number of students: 1
Contact person at NTNU: Hans Bihs hans.bihs@ntnu.no
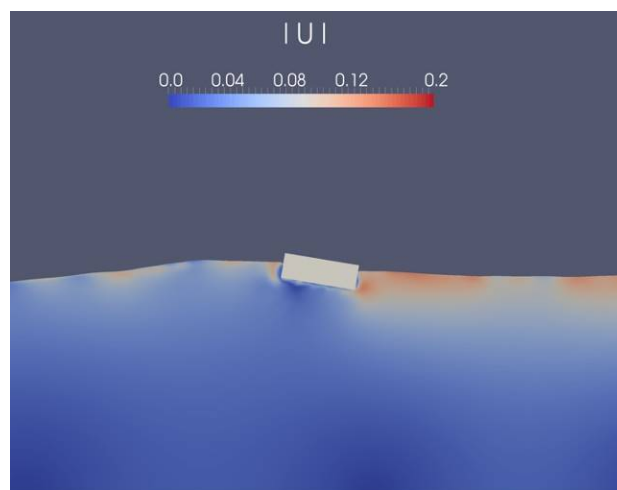
Figure 1.4: Roll motion of a rectangular barge under wave action modelled using 6DOF algorithm in REEF3D

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 research is required to include the hydrodynamics of a porous breakwater.

The objective of this Masters 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 Marine Physical Environment.
Number of students: 1
Contact person at NTNU: Hans Bihs hans.bihs@ntnu.no
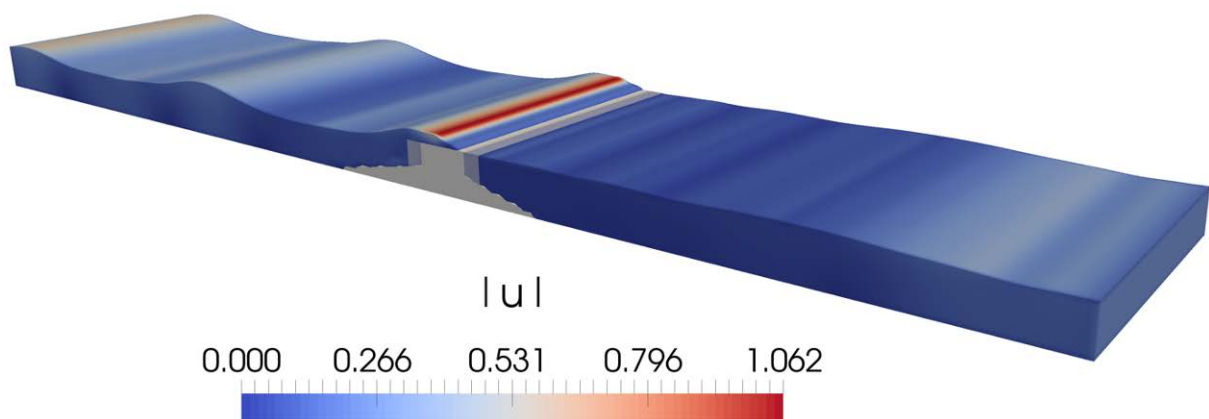
Figure 1.5 Wave interaction with a breakwater modelled with a porous layer around the crest.

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 Masters 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 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 Marine Physical Environment.
Number of students: 1
Contact person at NTNU: Hans Bihs hans.bihs@ntnu.no

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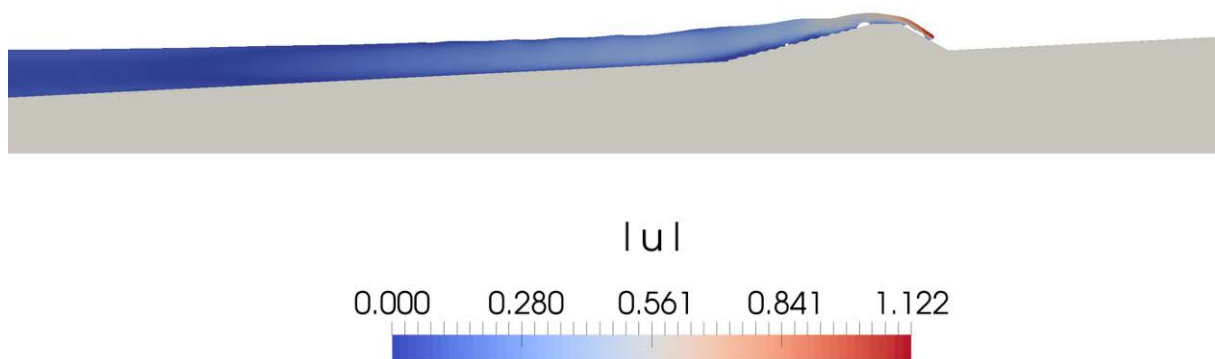
Figure 1.6 Solitary wave overtopping modelled using REEF3D

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.
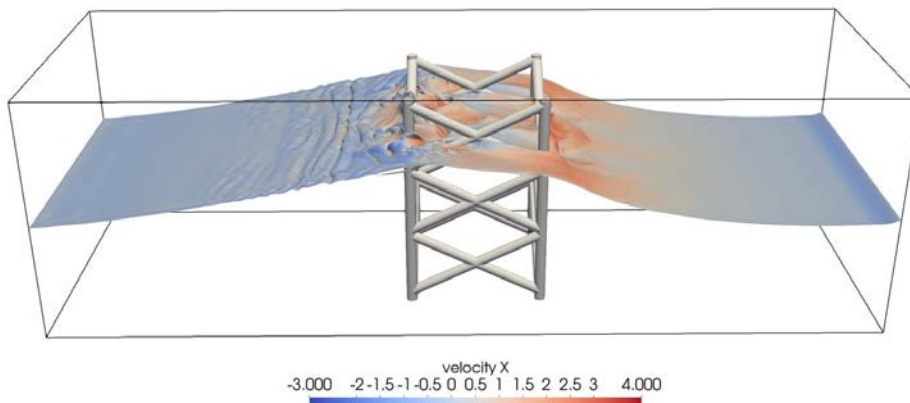
The objective of this study is to investigate irregular wave interaction with a truss structure. Numerical simulations will be carried out using the open-source CFD model REEF3D (www.reef3d.com), to simulate the irregular waves with the different peak periods and the different significant wave heights 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 Marine Physical Environment.
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 Marine Physical Environment.
Number of students: 1
Contact person at NTNU: Hans Bihs hans.bihs@ntnu.no
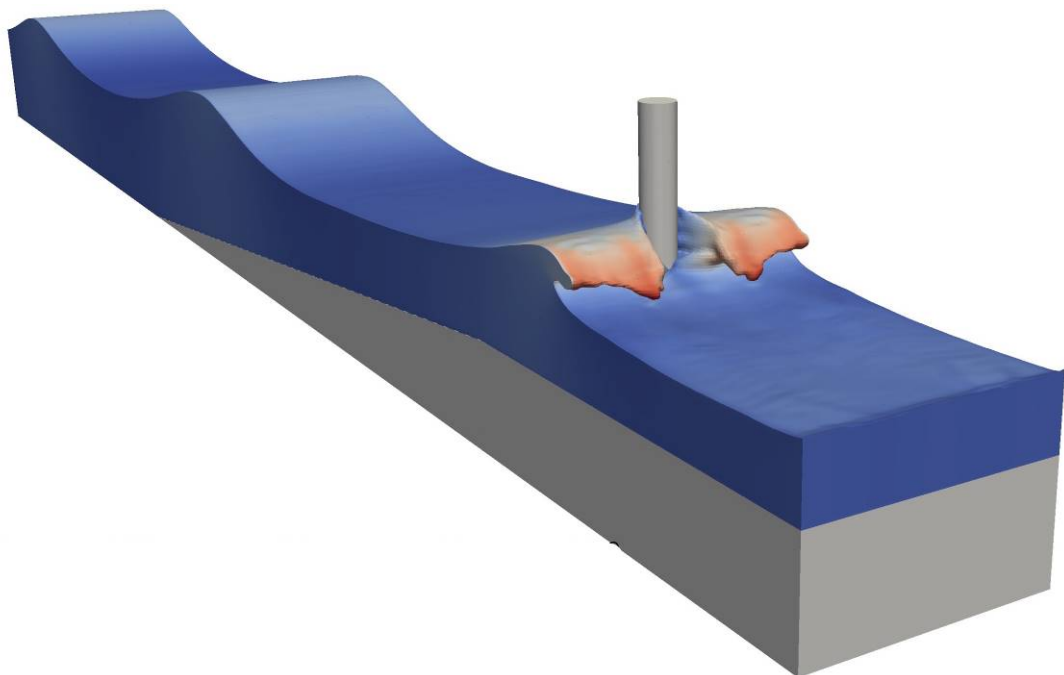
1.9 Investigation of the wave-structure interaction under irregular waves for a single cylinder and multiple cylinders using CFD

The sea state in reality is highly irregular. It is composed of the waves with the different wave heights and wave periods. A complete three-dimensional representation of the sea state requires the consideration of the sea surface as an irregular wave train. The offshore structures like wind turbines or oil platforms experience the irregular wave forces on the substructures perpetually. Thus, the study of the irregular wave force on the offshore structures is very important in the design of the structure. The structure is usually located in the relatively shallow depth. Thus, the breaking of the waves might be a vital phenomenon to be considered. CFD simulations can be used as a good tool to simulate and analyze the irregular wave kinematics and the wave forces on a single cylinder and multiple cylinders.
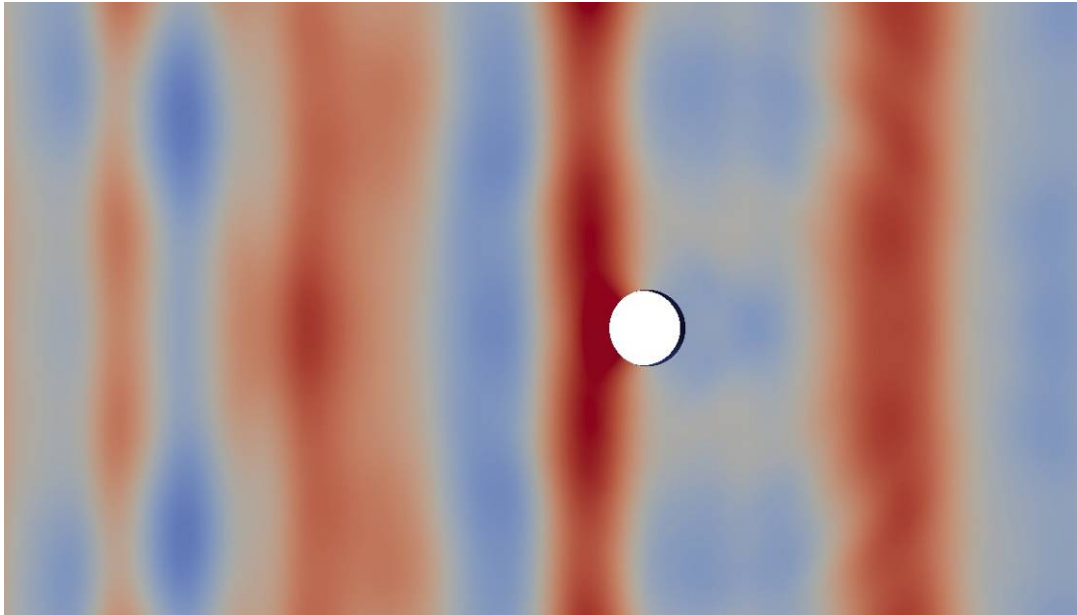
The main objective of this study is to simulate and study the behavior of irregular waves during the wave-cylinder interaction. In this study, the numerical tests will be carried out in a three-dimensional numerical wave tank using an open-source CFD model REEF3D (www.reef3d.com), developed at the Department of Civil and Transport Engineering. A detail analysis of the kinematics of the irregular wave during the wave-cylinder interaction with a single cylinder will be carried out in this study as an initial step. Next section of the study will deal with the investigation of the wave-cylinder interaction with an arrangement of multiple cylinders.

Task type: Literature survey, numerical modelling, calculation.

Prerequisites:TBA4265 Marine Physical Environment.
Number of students: 1
Contact person at NTNU: Hans Bihs hans.bihs@ntnu.no

1.10 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 Marine Physical Environment.
Number of students: 1
Contact person at NTNU: Hans Bihs hans.bihs@ntnu.no

1.11 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.
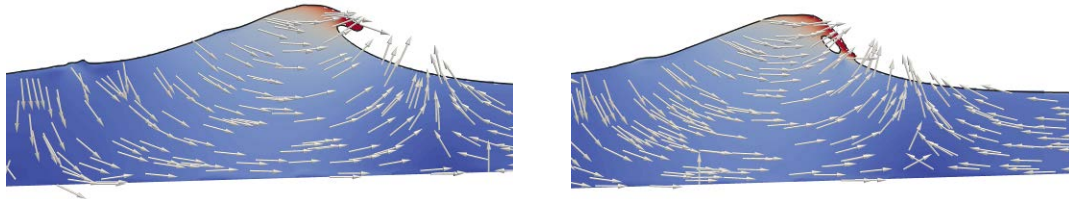
The main objective of the study is to investigate the shoaling and breaking characteristics of waves on plane beaches numerically. In the present study, the numerical experiments will be performed in a three-dimensional wave tank based on a two-phase flow CFD model REEF3D (www.reef3d.com), developed 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 Marine Physical Environment.
Number of students: 1
Contact person at NTNU: Hans Bihs hans.bihs@ntnu.no

1.12 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.
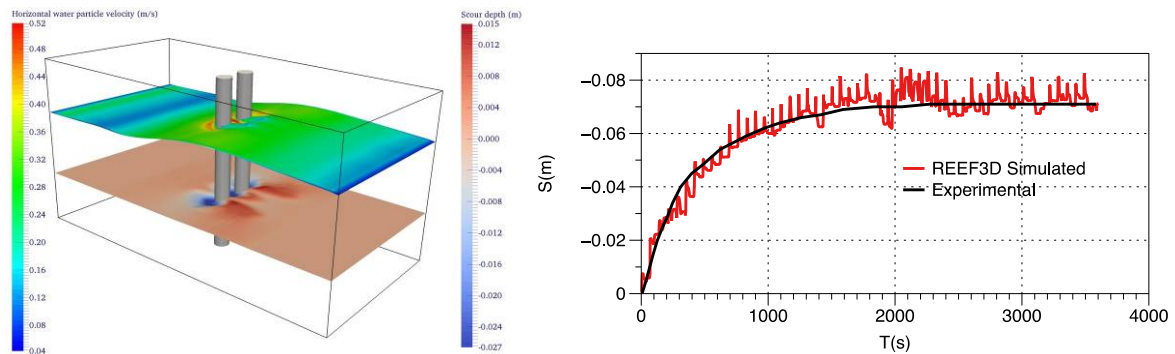
The main objective of the study is to investigate the local scour process in coastal environment using the open-source CFD model REEF3D. The task will focus on detailed analysis of the waves and current flow hydrodynamics, the resulting scour/deposition and the subsequent changes in the bed elevation 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 Marine Physical Environment.
Number of students: 1
Contact person at NTNU: Hans Bihs hans.bihs@ntnu.no

1.13 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.
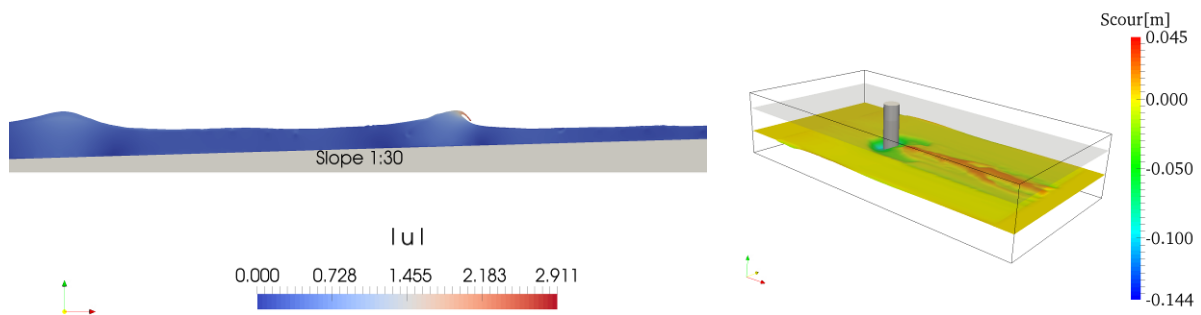
The study shall investigate cohesive sediment transport under waves and currents. The open-source CFD model REEF3D (www.reef3d.com) will be used. Emphasis shall be placed on analysis of hydrodynamics, resulting scour/deposition and subsequent change in bed elevation using different sediment formulations 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 Marine Physical Environment.
Number of students: 1
Contact person at NTNU: Hans Bihs hans.bihs@ntnu.no

1.14 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.
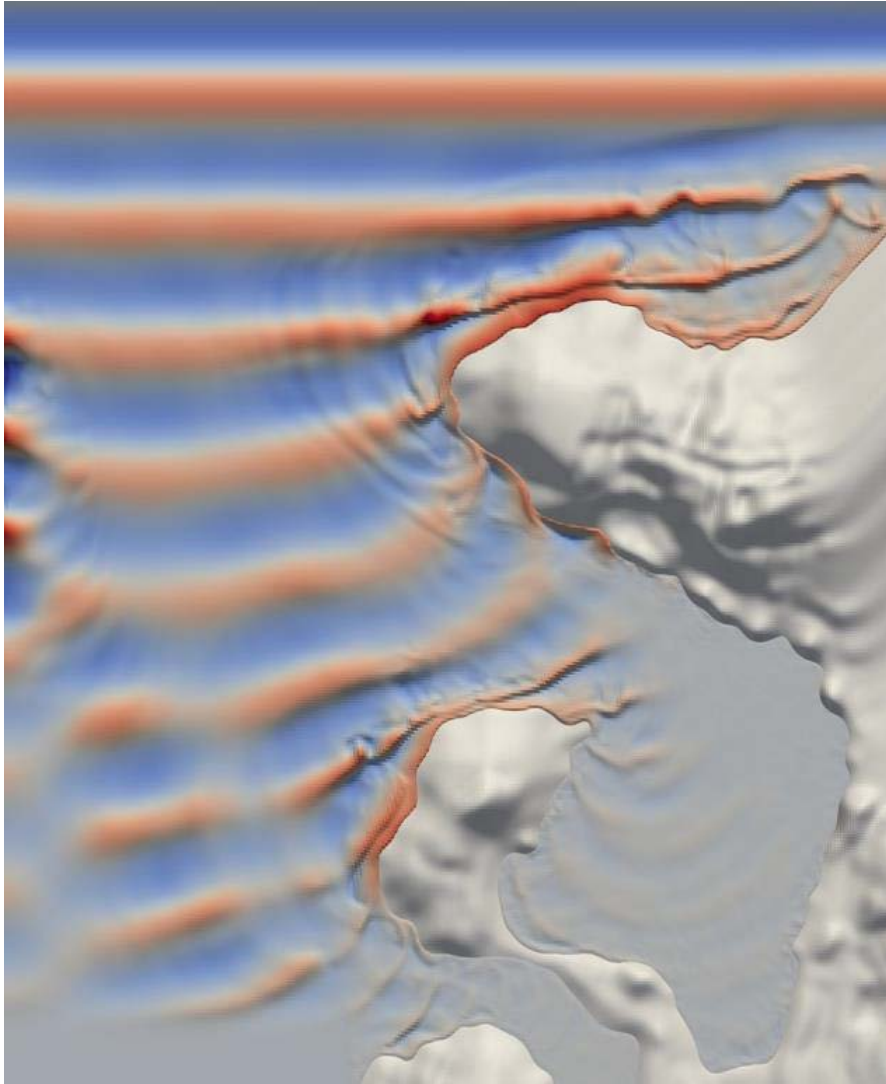
Prerequisites: TBA4265 Marine Physical Environment.
Number of students: 1
Contact person at NTNU: Hans Bihs hans.bihs@ntnu.no

1.15 Wave propagation over rough topography

Numerical wave transformation models (e.g. Spectral and Boussinesq models) are implemented in software packages such as MIKE21, Delft3D/SWAN, etc. These software packages are developed mainly for gentle variable bottom topography. The question becomes how well they can predict wave transformation on a rugged coast like the Norwegian coast.

In the project work the student shall familiarize himself/herself with the use of MIKE21. In addition, the student shall develop routines to analyse wind and wave data provided by the Norwegian meteorological institute in order to establish the deep water sea state.
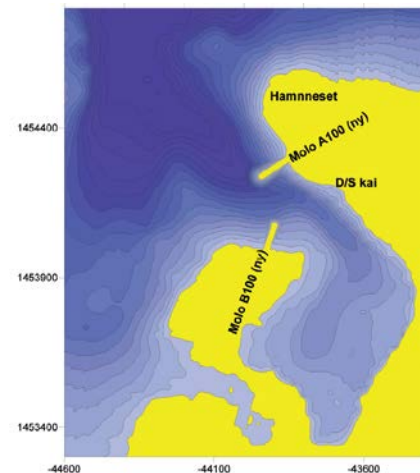
The project work is assumed to be continued in a thesis where the task is to use MIKE21 to transfer the deep water waves to a specific location on the Norwegian coast. The student will compare the results from the spectral wave models with those from the Boussinesq models and if possible with field data.

Type: Numerical modelling using commercial software
Prerequisites: TBA4265 Marine Physical Environment ,
Contact person at NTNU: Raed Lubbad, raed.lubbad@ntnu.no
Supervisor: Raed Lubbad.

1.16 Numerical modelling of sediment transport and coastline evolution

The coastal zone is an extensively used area for many activities and industries. Around half of the world's population live or work within one or two hundred kilometres of the coastline. Because of the high population density and the extensive development in these areas, it is very important to know the dynamics of the forcing and response of the coastal system involved and how to model them for an appropriate choice and design of measures.

There is a number of numerical models present that are available for predicting coastline evolution using different formulations. Some software packages such as Delft3D, TELEMAC etc. are available through open source whereas some packages such as MIKE21 are available commercially. The available models are also classified based on their temporal and spatial scale of application. Delft3D and MIKE21are applicable over a period of months to decades and can be applied to coastlines of kilometres whereas models such as XBeach are applied over a period of days to months and a cross a distance of several hundred meters only.

In the project work the student shall familiarize himself/herself with the use of MIKE21 or Delft3D. In addition, the student shall develop routines to analyse wind and wave data provided by the Norwegian meteorological institute in order to establish the deep water sea state

The project work is assumed to be continued in a thesis where the task is to use MIKE21or Delft3D to study the sediment transport and the coastline evolution at a specific location on the Norwegian coast. If possible, the student will compare the simulation results with field data.

Type: Numerical modelling using commercial software
Prerequisites: TBA4265 Marine Physical Environment ,
Contact person at NTNU: Raed Lubbad , raed.lubbad@nrnu.no

1.17 Tømmerkaier.

Norskspråklig kandidat er ønsket. (Only for students fluent in Norwegian)

Det skal bygges en del tømmerkaier langs kysten I tiden som kommer.
Oppgaven vil bestå av:
· Kostnadsoptimalisering av tømmerkaier
· Logistikkplanlegging

Hvilken konstruktiv struktur behøves?
Hvordan kan man lage en kaifront med tilstrekkelig lengde til å lagre nok tømmer til å fylle et skip uten mellomlagring?
Prosjektoppgaven går ut på dimensjonere en kai ut fra gitte kravspesifikasjoner og I følge gjeldende retningslinjer.
Masteroppgaven vil omfatte kostnadsoptimalisering og logistikkplanlegging av kaier for forskjellige kravspesifikasjoner, miljøforhold (bølger, vind og strøm), egenlast og nyttelast. Anbefalinger vil bli et viktig tema.
Oppgaven antas å være av spesiell interesse for Innovasjon Norge og for Kystverket.

Forutsetter: TBA4265 Arktisk og marin byggteknikk
Antall studenter: 1
Kontaktperson ved NTNU: Raed Lubbad (raed.lubbad@ntnu.no)
Ekstern veileder: Svein Ove Nyvoll, Nyvoll-consult.

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. The suggestions below are offered within the SAMCoT project (http://www.ntnu.edu/samcot).

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

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

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of Level ice action, ice-induced vibrations and uncertainties.

It is possible to choose a topic with joint supervision from Veritas (DNV) . Contact person at NTNU: Sveinung Løset, Sveinung.loset@ntnu.no .

- Variability and uncertainty related to measured ice properties

- Velocity effects of high pressure zones in ice-structure interaction. (with Ole Øiseth K-Tek)

- Ice mechanical experiments in NTNU ice-lab, e.g. beam experiments or cyclic testing.

2.2 Ice action on bridges

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

2.3 Ice ridges and ice ridge actions

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

- Ice ridge action on offshore structures - ice ridges as extreme ice features

- Ice ridge action on offshore structures – material modeling FEM (SAMCoT)

- Ice ridge action on offshore structures – experiments in NTNU ice-lab (SAMCoT)

- Ice ridge action on offshore structures – analysis of ice ridge geometry (how deep and how wide is the consolidated layer)

- Ice ridge action on offshore structures - How to produce sale-model ice ridges

2.4 Icebergs

It is possible to choose a topic with joint supervision from Veritas (DNV). Contact person at NTNU: Sveinung Løset, Sveinung.loset@ntnu.no .

- Drift of icebergs in the Barents Sea

2.5 Icing

It is possible to choose a topic with joint supervision from Veritas (DNV). Contact person at NTNU: Sveinung Løset, Sveinung.loset@ntnu.no.

- Marine icing

2.6 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
- Develop a practical and accurate method to determine the density of sea ice
- Study the reliability and accuracy of ice pressure sensors (tactile pressure sensors)

2.7 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.

2.8 Ship-ice interaction: Analysis of full-scale data

A better understanding of the interaction processes between ship and ice allow us to improve our models for ships operating in ice infested-waters, e.g. transporting, station keeping, performing ice management, etc.

Full-scale data from several surveys with the icebreaker KV-Svalbard will be available for this study. In additions to the ship measurements (movements, propulsion, etc.), video data from several cameras mounted on the ship are available. The video records capture the ice conditions in front of the ship and also the interaction processes between the incoming ice and the ship bow.

The student should analyse the video data and try to evaluate the icebreaking patterns, movement of the ice floes interacting with the ship, correlation between the ice conditions and ice resistance to the ship motion, etc.
    During this project the student will acquire knowledge on the underlying processes of ship-ice interaction. The student shall familiarize himelf/herself with data analysis techniques and especially the image analysis.

Recommended subject: TBA4265 Arctic and Marine Civil Engineering; AT327 Arctic Offshore Engineering
Key words: Arctic offshore
Type of project: Data analysis (Image analysis)
Number of students: 1 to 2
Cooperation with: SAMCoT
Contact person at NTNU: Raed Lubbad, raed.lubbad@ntnu.no
Continuation of project: Can be extended into a Master Thesis

2.9 Transport of ice along a structure

Numerical simulations of a floater (ship or buoy) in ice involve modelling a wide range of physical processes related to the dynamical coupled floater-ice-fluid interaction, such as impacts, friction, buoyancy, hydrodynamics, fracture and fragmentation of ice. The task should focus on how fluid flow models, e.g. FLUENT, can be used to model the transport of broken ice pieces along the hull of a floater. The numerical results should be compared with model-ice test results from the Hamburg Ice Basin, Germany. This gives the student an excellent opportunity to validate his simulations. The student will be offered a summer job in 2012 to work on the data as well as a visit to the Hamburg Ice Basin.

Recommended subject: TBA4265 Arctic and Marine Civil Engineering;; AT327 Arctic Offshore Engineering
Key words: Arctic offshore
Type of project: Numerical calculations
Number of students: 1 to 2
Cooperation with: SAMCoT
Contact person at NTNU: Sveinung Løset/Raed Lubbad
Continuation of project: Can be extended into a Master Thesis

2.10 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. The student will be offered a summer job in 2012 to work on the data as well as a visit to the Hamburg Ice Basin.

Recommended subject: TBA4265 Marine Physical Environment; AT327 Arctic Offshore Engineering
Key words: Arctic offshore
Type of project: Numerical calculations
Number of students: 1 to 2
Cooperation with: Dynamic Positioning in Ice
Contact person at NTNU: Sveinung Løset
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.

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 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, 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)

3.2 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 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 Code checks for wind turbine support structure analysis

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). The objective of this project is to implement a tool that performs all necessary design checks in an efficient way.

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. 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)

3.4 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 two-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 three-dimensional (short-crested) waves.

Learning objectives:
 - How extreme wave events are modelled in the offshore and wind energy industry
 - How three-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, 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)

3.5 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 model for 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 recurrent 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

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, 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)

3.7 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 by TU Delft 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
 - Background in numerics (e.g. solution of ordinary differential equations)
 - 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)

3.8 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. The 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 (PID controller)
 - 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)

3.10 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 (http://lheea.ec-nantes.fr/doku.php/emo/nemoh/start), 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)