3rd Semester and Master's Thesis Ideas 2011

M.Sc. in Civil and Structural Engineering

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M.Sc. in Civil and Structural Engineering: 3rd Semester and Candidate Project Ideas

The following pages contain a list of project ideas proposed by the scientific staff at the Department of Civil Engineering, Aalborg University, and a number of companies. Most of the project ideas in this catalogue may form the basis for long and short candidate projects as well as regular 3rd semester projects at the M.Sc. programme in Civil and Structural Engineering.

Each project description provides a brief overview of the purpose as well as the main activities. Further, a weighting between theoretical analysis, experimental work and computer modelling has been proposed. Usually, this weighting can be changed slightly in accordance with the wishes of the students. The contact persons listed will act as primary supervisors. Questions regarding details about each proposed project should be asked to these persons. Further, other ideas for projects may be discussed with a potential supervisor.

The preferred group size is two to four students. In the interest of students as well as supervisors, single-student projects are generally not recommended.

As a final remark, a signed project plan must be handed to the head of the School of Engineering and Science at latest one month after the initiation of the project. This project plan must contain information about the project, in particular regarding the educational goals of the project. These must be defined in accordance with the Master Curriculum (danish: Studieordningen) for the M.Sc. Programme in Civil and Structural Engineering at the School of Civil Engineering, Aalborg University. The curriculum can be found at the School of Civil Engineering homepage at http://www.ses.aau.dk/digitalAssets/14/14964_msc_k_250610.pdf. A document template for the project plan is available at the homepage of the Study board of Civil Engineering:
http://www.byggeri.aau.dk/studienaevnet/skabeloner/praktikskabeloner.

Aalborg, 19 May 2011 Johan Clausen, *semester coordinator*

Detailed Calculation of Kinematics in Nearly Breaking Irregular Waves

Purpose: Kinematics of nearly breaking and breaking waves are not very well understood. Nevertheless, accurate estimations of wave kinematics are very important for estimation of loads on marine structures in shallow water. This can easily be demonstrated for example by looking on run-up on a pile, cf. Fig. 1.

Fig. 1: Large scale testing of loads on wind turbine access platforms.

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One of the project goals IS to improve calculation models for loads on secondary structures like, for example, access platforms for offshore wind turbines and boat landings. These calculations can be performed in CFD but an alternative is a local Fourier approximation, leading to an approximation of the stream function in irregular waves. This makes it possible to calculate wave kinematics in waves that are not symmetrical around the wave crest.

Main activities: Implementation of code in MatLab or other programming language is the main activity and thus good programming skills are needed. The main activities are:

- Look at newly performed model tests to quantify importance of wave shape on run-up on piles and loads on secondary structures
- Implementation of Local Fourier approximation code in MatLab or other programming language
- Application of method to newly performed tests. Additional verification tests can be performed in the laboratory if needed.
- CFD computations can be included if time permits.

Contact person: Thomas Lykke Andersen

Theory: ☒☒☒ **Experimental work:** ☐☐☐ **Computer modelling:** ☒☒☒

Projects on Breakwater Design

Purpose: A number of different projects are available within breakwater design. We can discuss different possibilities within caisson breakwaters and rubble mound breakwaters depending on main interest area.

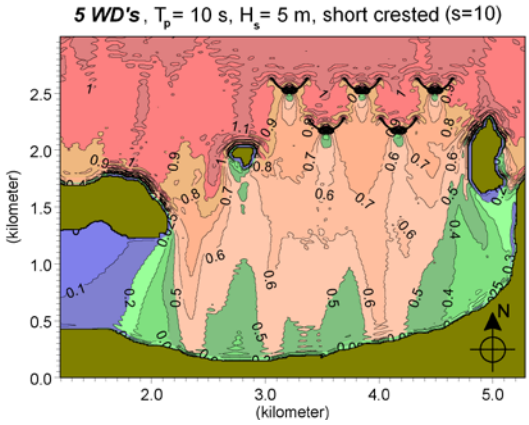
The main activity would for most projects be laboratory model tests but also projects with detailed computer modelling are available.

Contact person: Thomas Lykke Andersen

Wave energy converters for use in coastal protection

Purpose: The purpose is to adopt wave energy converters for mitigation of flooding and coastal erosion hazard in the context of increasing storminess and sea level rise. A proposal is to place wave energy converters close to the shoreline for contemporary attenuating wave attacks and thereby produce a secondary benefit.

Physical model tests on a single Wave Dragon wave energy converter have already been performed at AAU in scale 1:50 to measure the wave height reduction behind the device. Measurements from the tests have been further used in the calibration of a numerical wave propagation model. The tests are performed in relation with an on-going research project funded by the European Commision. However, additional tests are still needed to perform more detailed analysis on the wave scattering from the devices. Especially the measurement of wave height reduction in the laboratory from multiple devices positioned in an array is so far uncovered.



Main activities: The project will contribute to the on-going research on the subject and thus the following activities can be included:

- Experimental and/or numerical modelling of wave scattering from floating devices positioned in different arrays
- Case study on the influence on wave climate at specific site
- Case study on the influence on sediment transport at specific site
- Theoretical assessment of wave transmission through a wave energy converter

Contact persons: Jørgen Harck Nørgaard, Thomas Lykke Andersen

Theory: ☒☐☐ **Experimental work:** ☒☒☒ **Computer modelling:** ☒☒☐

Design of high performance concrete floaters for wave energy converter machines

Purpose: The objective of the proposed project is to devise a structural design of a high performance hemisphere-shaped concrete floater so as to minimize its wall thickness, under typical service load scenarios, anticipating or measuring relevant materials properties, and possibly to validate the computations by laboratory tests.

Background: Wave energy is a promising source of clean energy, and currently a number of different technologies are proposed to utilize wave energy. One such technology forms the basis of the so-called Wave Star® machine which consists of an oblong platform held by piles resting on the sea floor. On each side of the Wave Star® machine a number of hollow hemisphere shaped floaters are moving up and down with the waves. Each floater is mounted on an arm connected to the machine which converts the vertical movement to electricity through a system of oil hydraulics and generators.

Due to the harsh marine service environment, and the desire of minimizing both the production cost and the extent of maintenance, the optimal choice of material for construction of the floaters – with diameters up to 10 m – seems to be high performance concrete (HPC), preferably with steel fiber reinforcement only, and optionally with steel bar reinforcement as well. The wall thickness of the floater hemispheres should be minimized, not only to provide buoyancy but also to permit the arms to lift the floaters out of the water during storms with excessive wave heights.

Main activities: Using typical service load scenarios from the wave action, structural design of the floater can be performed by means of Finite Element Method (FEM) analysis, to minimize the wall thickness, when specific mechanical properties of the HPC are anticipated. The HPC properties may be either known or measured by laboratory experiments, and the FEM computations may be subsequently validated by structural laboratory tests. The extent of laboratory work can be discussed and adjusted prior to the start of the project.

Contact persons: Morten Kramer (wave loads, Wave Star® machine),
Johan Clausen (FEM design), and Eigil V. Sørensen (HPC properties).

Theory: ☒☒☐ **Experimental work:** ☒☒☐ **Computer modelling:** ☒☒☒

Ready mixed lightweight concrete

Purpose: The objective of the proposed project is to provide a basis for rational production of ready mixed lightweight concrete for structural as well as civil applications by combining new and current methods and ideas of manufacture, and documenting procedures and properties of the hardened concrete by laboratory and possibly full scale tests.

Background: The demand for ready mixed lightweight concrete is increasing these years, for several reasons: New building regulations require better thermal insulation, tall building structures require lower dead weights, lower energy consumption and smaller carbon footprint of the construction sector is possible by easier transportation and handling of the lightweight concrete, both in structural and civil applications.

Currently ready mixed lightweight concrete is produced either by using lightweight aggregate or by using foam entrainment in the fresh concrete. Lately it has been proposed to use expanded polystyrene beads or perlite particles as well as various other lightweight aggregates. Apart from the aggregates, the cement paste/mortar may be manipulated to achieve varying properties.

Each of the above methods has both advantages and drawbacks in connection with the production process as well as with the properties of the hardened material and the cost of the end product. However, they provide a large number of potential options for optimization.

Main activities: The project is relatively open concerning the specific approach to the subject. However, in any case the activities will include:

- Getting to know current ready mixed lightweight concrete and its constituents, its production and its applications
- Determination and selection of focus areas
- Analysis and theoretical assessment of optimization of the main parameters
- Design and performance of tests in the laboratory and possibly in full scale
- Recommendation of best practices for the optimal production of ready mixed lightweight concrete with targeted properties.

The project will be carried out in close cooperation with Unicon A/S

Contact person: Eigil V. Sørensen.

Theory: ☒☒☐ **Experimental work:** ☒☒☒

Compositon and properties of fibre-cement materials

Purpose: The objective of the proposed project is to provide a basis for optimization of mechanical and durability properties of fibre-cement materials by varying the mix design of the material.

Background: Fibre-cement is a cement based fibre reinforced composite which is widely used throughout the world for a number of applications, notably lightweight roofing and cladding. One of the largest European producers of fibre-cement is the Cembrit Group with headquarters and R&D centre located in Aalborg.

Fibre-cement is composed of cement, microsilica, inorganic fillers, and natural and synthetic fibres, and is produced through a highly specialized process. Various characteristics of the material, such as moisture induced shrinkage and swelling, and resistance against freezing/thawing attack, in addition to mechanical properties such as strength and stiffness, are important to secure the proper functioning and adequate service life of the products. These characteristics depend on the nature of the microstructure of the material which in turn can be manipulated through the type and relative amounts of the constituent materials in the mix design.

Main activities: The project is relatively open concerning the specific approach to the subject. However, in any case the activities will include:

- Getting to know fibre-cement products and production
- Identification of focus areas based on literature review and theoretical considerations
- Preparation of specimens and measurement of properties as a function of composition variations, at the AAU Concrete Laboratory and at Cembrit's laboratories.
- Discussion of results in relation to theory.
- Recommendation of optimization options.

The project will be carried out in close cooperation with the R&D department of Cembrit.

Contact person: Eigil V. Sørensen.

Theory: ☒☒☐ **Experimental work:** ☒☒☒

Carbonation hardening of fibre-cement materials

Purpose: The objective of the proposed project is to establish a method for carbonation hardening of fibre-cement materials and to determine the main properties of the carbonation hardened products as compared to air cured materials.

Background: Fibre-cement is a cement based fibre reinforced composite which is widely used throughout the world for a number of applications, notably lightweight roofing and cladding. One of the largest European producers of fibre-cement is the Cembrit Group with headquarters and R&D centre located in Aalborg.

Fibre-cement is composed of cement, microsilica, inorganic fillers, and natural and synthetic fibres, and is produced through a highly specialized process. Currently the materials are hardened by simple air curing. It has been found that the rate of hardening may be significantly enhanced by curing the materials in a concentrated carbon dioxide atmosphere. It is also known that such carbonation hardening will produce a different microstructure of the hardened material as compared to air curing. As a consequence, the properties of the final products, e.g. moisture induced shrinkage and swelling, resistance against freezing/thawing attack, and strength and stiffness, will be affected.

The proposed production method is environmentally friendly since carbon dioxide is consumed by the curing process.

Main activities: The project is relatively open concerning the specific approach to the subject. However, in any case the activities will include:

- Getting to know fibre-cement products and production
- Literature review of carbonation hardening of cement based materials.
- Design and set-up of carbonation curing facilities at a laboratory scale
- Preparation and curing of specimens and measurement of properties as a function of curing method.
- Discussion of results in relation to theory.
- Recommendation of production method based on carbonation curing.

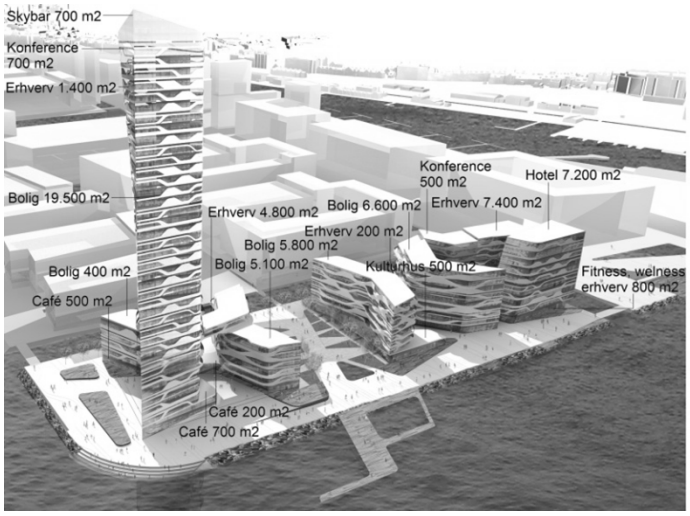
The project will be carried out in close cooperation with the R&D department of Cembrit.

Contact person: Eigil V. Sørensen.

Theory: ☒☒☐ **Experimental work:** ☒☒☒

Fundering af Light*house på Århus Nordhavn

Purpose: Light*house er et bolig- og erhvervsområde, der skal opføres som led i et større byggeprojekt, hvor den nuværende containerterminal på Nordhavnen i Århus skal omdannes fra industriområde til byområde. De eksisterende pier på havnen skal omdannes til en række kunstige øer, og på den yderste ø ud mod Århus Bugt skal bebyggelserne, der under ét kaldes Light*house, opføres. Områdets varetegn skal være et Danmarks højeste hus, 142 meter, placeret yderst på den anlagte ø ud mod Århus Bugt. Under hele området skal der anlægges et underjordisk parkeringsanlæg. En af de geotekniske udfordringer i forbindelse med byggeprojektet bliver at undersøge, hvordan højhuset kan funderes under hensyntagen til anlæggelsen af parkeringskælderen samt påvirkninger fra de omkringliggende bygninger. Projektet gennemføres i samarbejde med Grontmij | Carl Bro



Main activities: Dette projekt tager udgangspunkt i højhusbyggeriet Light*house på Århus Nordhavn Hovedfokus er hvordan styrke og deformationsegenskaber for den tertiære ler, der på lokaliteten findes til 70 - 90m dybde, kan bestemmes ud fra geotekniske forsøg og hvordan disse resultater kan anvendes i 3D finit element modellering.

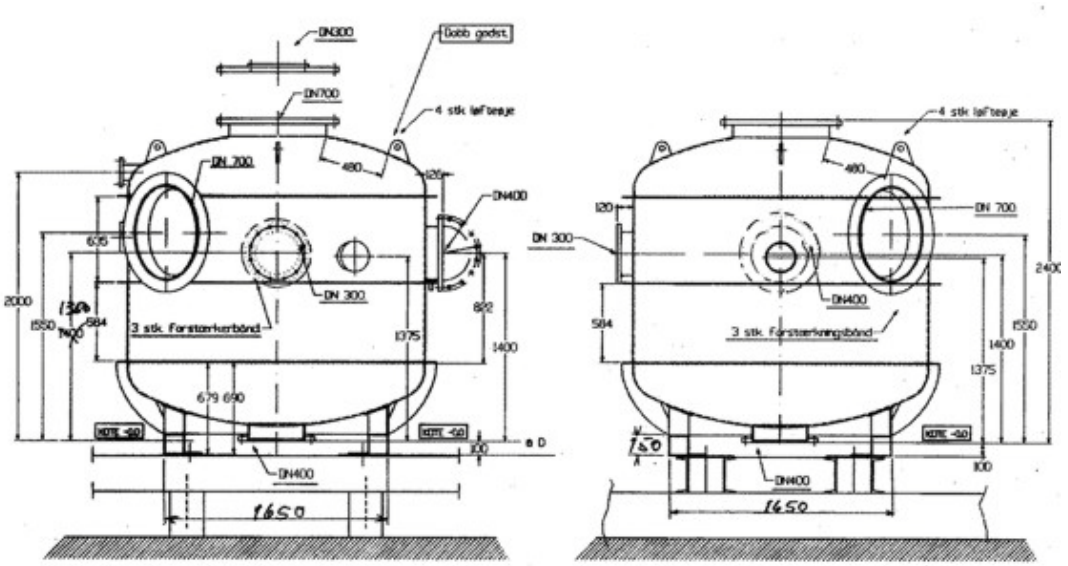
- Jordens egenskaber analyseres ud fra boreprøver samt CPT-boringer foretaget på projektlokaliteten. I forbindelse med boringerne er der foretaget vingeforsøg, og der er optaget en række prøver hvorudfra vandindhold, kalkindhold, pH-værdi samt konsistensgrænser er bestemt.
- Intakte prøver fra boringerne analyseres vha. konsolideringsforsøg , **c**onstant **r**ate of **s**train-forsøg (CRS-forsøg) og triaxialforsøg.
- Alle de foretagne undersøgelser anvendes til at bestemme, hvordan jordens egenskaber varierer med dybden. Forsøgsresultaterne anvendes til at kalibrere de numeriske beregningsmodeller.
- Der gennemføres 3D Plaxis beregninger af sammenspil mellem funderingen af højhuset og parkeringskælderen.

Contact persons: Lars Bo Ibsen, Benjamin Nordahl Nielsen

Theory: ☒☒☐ **Experimental work:** ☒☒☐ **Computer modelling:** ☒☒☐

Bøttefundamentets styrke- og deformationsegenskaber ved cyklisk belastning

Purpose: De kræfter der virker på vindmøller, transient og cykliske i natur, giver anledning til elastiske oscillationer og muligvis til liquefaction af sandet inde i bøtten. Sådan sand liquefaction vil sandsynligvis føre til fuldstændige bæreevnesvigt, hvorfor liquefaction skal undgås.



Main activities: Forholdene, der kan føre til sådanne tilstande, skal undersøges og fastlægges ved eksperimenter. En forsøgstank indeholdende faciliteter til udlejring af jorden samt mulighed for statisk og transient og cyklisk belastning er udviklet i dette forår ved laboratoriet for fundering, Aalborg Universitet, se figuren. Tanken ønskes gennem dette projekt at blive gjort fuld operationel. Tankens belastningssystem er opbygget således, at det kan benyttes til cykliske udmattelsesforsøg. Herved kan risikoen for liquefaction undersøges:

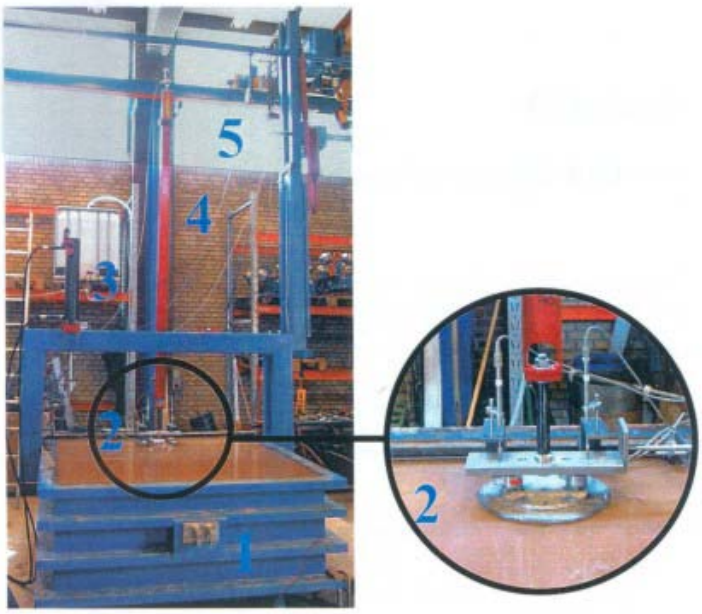
Resultaterne af disse forsøg sammenholdes med resultaterne fra de statiske forsøg. Herved kan det evalueres, om den varierende belastning har indflydelse på fundamentets bæreevne, stivhed samt plastiske deformationer.
Den elastiske opførsel under cyklisk belastning er vigtig for interaktionen med tårnet, og dette skal kortlægges ved hjælp af eksperimenter, analyse og beregning på baggrund af elasticitetsteori udfra de udførte forsøg noget til sidst.

Contact person: Lars Bo Ibsen

Theory: ☒☒☐ **Experimental work:** ☒☒☐ **Computer modelling:** ☒☒☐

Bøttefundamentets styrke- og deformationsegenskaber ved installation i ler

Purpose: 3-D numerisk simulering af forskellige typer af bøttefundamenter installeret i ler foretages. Deres anvendelighed til offshore vindmøller undersøges med henblik på forståelse af deres opførsel under normale og ekstreme laster når den funderes i ler.



Main activities: Resultater fra en række modelforsøg (fra afsluttet afgangsprojekt) skal simuleres numerisk og sammenlignes med resultater fra analytiske modeller. I de numeriske simuleringer vil der blive arbejdet med en avanceret konstitutiv model for jorden, Single Hardening modellen, og det tilsigtes at jord/struktur behandles så realistisk som muligt. Denne model er implementeret i det kommercielle finite element program 3D PLAXIS som eksternt defineret materialemodel. Materialeparametre findes fra triaksialforsøg udført på jordprøver fra de relevante offshore lokaliteter og fra kalibrerede CPT-forsøg udført ved siden af borehullerne.

De simulerede bøttefundamentforsøg er de ovenfor beskrevne modelforsøg og de forsøg. Disse inkluderer udrænede forsøg, i hvilke bøtterne er påvirket af moment, horisontale og vertikale kræfter. De numeriske analyser er i stand til at simulere ændringen i størrelse og form af brudfladen i H-M/D planet, svarende til de eksperimentelle observationer.

Contact person: Lars Bo Ibsen

Theory: ☒☒☐ **Experimental work:** ☒☒☐ **Computer modelling:** ☒☒☐

Bender elements for the measurement of soil stiffness

Purpose: Using Bender elements to determine the dynamic elastic shear modulus Gmax, for soils.

The measurement of soil stiffness is of great importance to geotechnical design. Especially for analysing and designing constructions such as wind turbines the soil stiffness is a key-parameter.

Resent research have provided dynamic methods for the measurement of soil stiffness at very small strains using piezo-ceramic plates called bender elements.

Main activities: The project can include:

- Getting to know bender elements
- Gathering and analysis of current design material
- Determination of focus areas
- Laboratory tests and theoretical assessment
- Computational modelling
- Design model creation.

Part of the project may be carried out together with geotechnical firms taking soil samples and making input for actual design problems.

Contact persons: Benjaminn Nordahl Nielsen and Lars Bo Ibsen

Theory: ☒☒☐ **Experimental work:** ☒☒☒ **Computer modelling:** ☒☐☐

Optimisation of push core sampler for maximal recovery

Purpose: Prior to any offshore field development, a geophysical and geotechnical survey is carried out in the field with the purpose of identifying soil layers and soil properties.

The geophysical survey can be carried out from vessels such as seen on picture below. The vessels are typically priced 1 million kr./day. Thus, the amount of soil sample recover becomes the key factor determining the cost and efficiency of the work.

Main activities: The push core sampler is gently pushed into the seabed utilising a ROV (remote operated vehicle). The water inside the push core sampler is released through an one-way valve on top of the push core sampler. This valve is sealed before the push core sampler is pulled out of the seabed. The underpressure is generated within the sealed sampler and the sample is recovered.

The purpose is to optimise the design for the push core sampler:

- Preparation of analytic approach to determine the effect of the parameters
- Full-scale testing on very soft clay
- Finite element analysis
- Comparison of analytic results to data provided by Subsea7
- Recommendations for a new core catcher

The project is to be carried out together with Acergy / Subsea7 I Norway.

Contact persons: Benjaminn Nordahl Nielsen and Lars Bo Ibsen

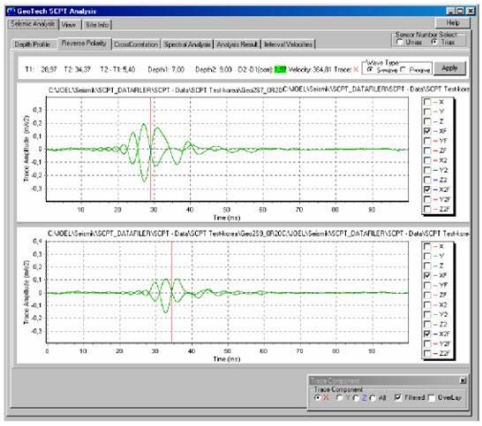
Theory: ☒☒☐ **Experimental work:** ☒☒☒ **Computer modelling:** ☒☐☐

SCPT - Seismic CPT

Purpose: For onshore and offshore constructions there is a growing need for analysing and determination of the elastic soil parameters.

With the seismic CPT adapter mounted on the CPT probe it is possible to carry out CPT and seismic test during the same penetration.

Best practice is needed to be carried out.



Main activities: The project is open with concern to the problem to be analysed. However the focus is on field testing. The project may include:

- Getting to know SCPT – seismic CPT
- Gathering and analysis of current design material
- Determination of focus areas
- Field tests
- Theoretical assessment
- Computational modelling of SCPT

The project can include experimental field testing on different locations in Denmark togheter with geotechnical engineering firms.

Contact persons: Benjaminn Nordahl Nielsen and Lars Bo Ibsen

Theory: ☒☒☐ **Experimental work:** ☒☒☐ **Computer modelling:** ☒☐☐

Light Weight Deflectometer

Purpose: The Light Weight Deflectometer offers measuring of the bearing capacity for subsoil and foundation layers directly in the field.

Currently the equipment used is isotope measuring using radioactive sources with is not especially environmental friendly and safe. The LWD gives at direct output for the soil stiffness, however no systematic use for design and analysing have been setup.

Main activities: The project is relatively open with concern to the problem to be analysed. However, in any case the activities will include:

- Getting to know Light Weight Deflectometer
- Gathering and analysis of current design material
- Determination of focus areas
- Field and laboratory Tests
- Theoretical assessment
- Design model creation / best practise.

The project may be carried out as engineering practice, and it may be possible to perform experimental tests together with Grontmij/Pavement who have introduced the equipment on the Danish market.

Contact persons: Benjaminn Nordahl Nielsen and Lars Bo Ibsen

Theory: ☒☒☐ **Experimental work:** ☒☒☐ **Computer modelling:** ☒☐☐

Improved FEM-modeling of non-associated plasticity

Purpose: The most common material model for soils is the Mohr-Coulomb model where the soil strength is controlled by the cohesion strength and the friction angle. The deformation during plastic flow is controlled by the dilation angle. When the model is associated, i.e. friction angle = dilation angle reliable calculation methods are abundant both in the elasto-plastic as well as the rigid-plastic case. Experimental observations, however, predicts that the dilation angle should be much lower (often ~30°) than the friction angle. Unfortunately this causes a lot of computational problems. Random errors seem to occur and simulations break down.

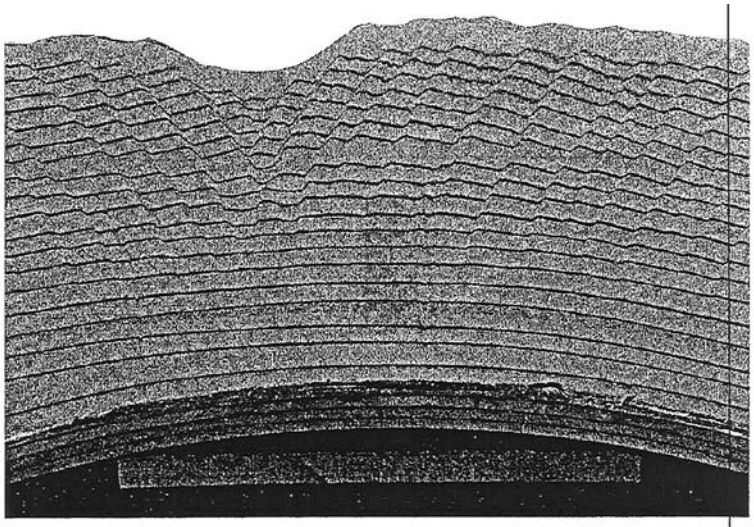


Fig. 8.2 Crestal faults over arch of uniform curvature, simulated in a sand box (Mandl, 1984).

In this project the goal is to examine how we should model non-associated soil behaviour with the finite element method. The different result of different methods could be quantified using simple benchmark calculations, e.g. a surface footing or a sheet pile wall. This project will involve a considerable amount of MatLab-programming.

Examples of main activities:

- What are the symptoms of non-associated problems? A computational and literature review.
- What do the commercial codes do (e.g. Abaqus, Plaxis, Ansys)?
- Do we have other methods of remediating the problem?
- Quantification of different results with different methods using own MatLab code

Contact person: Johan Clausen

Theory: ☒☒☐ **Experimental work:** ☐☐☐ **Computer modelling:** ☒☒☒

Implementation of plasticity model into the finite element method 1: Unified Strength Theory

Purpose: In geotechnical engineering the most widely used material model is the Mohr-Coulomb model. When the Mohr-Coulomb yield surfaces is visualised in principal stress space it consists of six planes making up an irregular pyramid with an apex and six corner lines. A characteristic of the Mohr-Coulomb model is that the intermediate principal stress does not influence the material strength, whereas true triaxial tests show that the intermediate principal stress do influence the material strength. This is the reason for the rule of thumb that the plane friction angle is 10% higher than the triaxial one. A simple remedy for this deficiency is to introduce an extra corner in the Mohr-Coulomb model. This model is known as the Unified Strength Theory. As of yet the literature have not reported any stress update schemes for this model for use with the finite element method. The challenge in such an implementation would be to include the effect of the many corners of the yield surface. This can be achieved with a recently published method on Mohr-Coulomb plasticity.

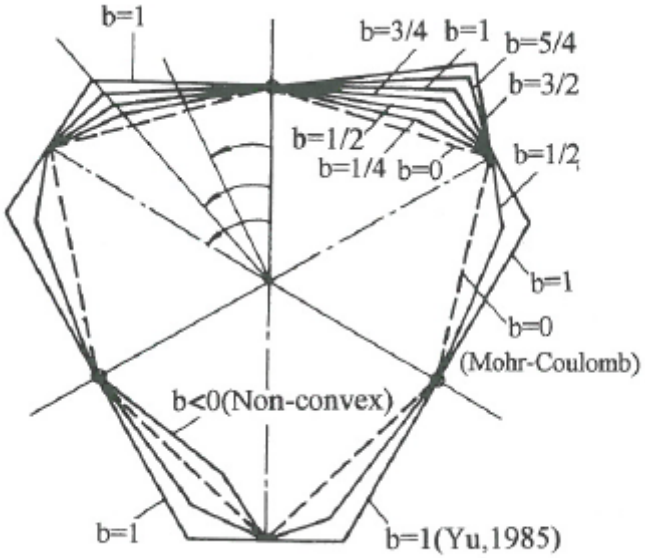


Fig. 7.7. Limit loci of the unified strength theory on the deviatoric plane

Main activities: The main activity of the project would be to implement the Unified Strength Theory in a return mapping stress update scheme. When implemented, the effect of the intermediate stress on geotechnical problems can be quantified, for example the bearing capacity of footings.

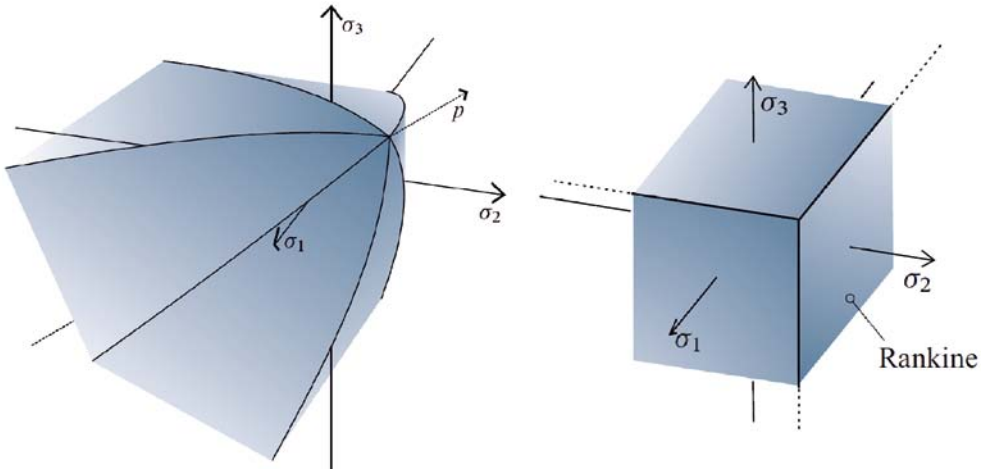
An interest in programming, e.g. MatLab, is essential. If the implementation is successful the outcome of the project may be a paper rather than a report.

Contact person: Johan Clausen

Theory: ☒☒☐ **Experimental work:** ☐☐☐ **Computer modelling:** ☒☒☒

Implementation of plasticity model into the finite element method 2: Modified Hoek-Brown model

Purpose: The strength of rock materials is, like soils, dependent on the hydrostatic pressure. For this reason the Mohr-Coulomb model was often used to model rock masses in numerical applications. But a better material model for rock masses is the Hoek-Brown model which resembles the Mohr-Coulomb yield surface with curved edges. In some applications, however, it turns out the Hoek-Brown model overpredicts the tensile strength of the rock material. This has a significant impact on the results when simulating certain problems in mining and tunnelling, i.e. cavities in rock masses. A simple way of mending this problem is to include a tension cut-off, i.e. a Rankine surface in the model, as it is often done with the Mohr-Coulomb model. Such a model is not yet implemented into finite element codes, whereas the standard Hoek-Brown model is.



Main activities: The main activity of the project would be to implement a Modified Hoek-Brown model in a return mapping stress update scheme. When implemented, the effect of the tension cut-off on relevant tunnelling and mining problems can be quantified.

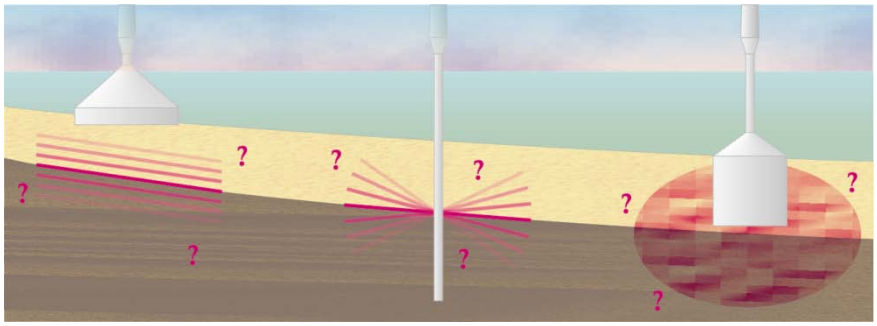
An interest in programming, e.g. MatLab, is essential.

Contact person: Johan Clausen

Theory: ☒☒☐ **Experimental work:** ☐☐☐ **Computer modelling:** ☒☒☒

Stochastic modelling of soil

Purpose: Soil is a heterogeneous material at different levels. Thus, the ground is stratified, i.e. several soil deposits lie on top of each other, and the material within each layer is in itself heterogeneous on a local scale as seen in the figure. However, when geotechnical analysis are carried out by computational methods, soil is usually modelled as a locally homogeneous material and the position of interfaces between two different material, e.g. sand and moraine, are based on few tests. This is a huge problem because failure in the soil will always find its way through the weakest part of the material. Hence, failure figures in real heterogeneous soil may be significantly different from the ones achieved by computational analysis ... and so may the bearing capacity and deformations.



Another interesting problem is related to the dynamics of soil. Recent research indicates that even a very sophisticated model can only predict the ground vibration from metro tunnels with an accuracy of 10 to 15 dB. This means that the actual ground motion may be about four times higher than the predicted response. The main reason is believed to be the missing consideration of heterogeneity.

Main activities: The project may focus on the bearing capacity and deformations of foundations or alternatively the ground vibration from, for example, railways. In any case, the activities to be carried may include:

- Studying the theory of soil mechanics and/or soil dynamics
- Developing models of the spatial variation of soil properties
- Creating a finite-element model for stochastic analysis of soil
- Parameter studies of bearing capacities and deformations or vibrations
- Comparison with the results of other models or tests
- Updating the design criteria for foundations.

Contact person: Lars Andersen

Theory: ☒☒☐ **Experimental work**: ☒☐☐ **Computer modelling**: ☒☒☒

Advanced probabilistic geotechnical site assessment for offshore wind farms

Purpose: Ved opførelse af store vindmølleparker til havs udgør funderingen ikke kun en betragtelig del at anlægsudgiften 25 - 35%, men er også den del af projektet, der indeholder de største usikkerheder. For at reducere disse usikkerheder foretages et omfattende geotekniske undersøgelsesprogram, hvilket kræver en stor investering tidligt i projektforløbet. Kravet til minimering af fundamenternes deformationer gør, at det altid er anvendelsesgrænsetilstanden, der bliver dimensionsgivende, dvs. at de elastiske parametre styrer designet. Ved in-situ forsøgene bestemmes de plastiske materialeparametre, der anvendes til brudanalyse, med stor nøjagtighed, mens de elastiske parametre bestemmes med stor usikkerhed. Der er derfor i dag en konflikt mellem de parametre, der driver designet, og det man får ud af de udførte in-situ forsøg. Fokuset er i dag forkert og bør drejes mod en bedre bestemmelse af de elastiske parametre. Dette projekt fokuserer på at udvikle en in-situ test metode, der sikre bedre bestemmelse af de elastiske designparametre. Ideen er at udvikle en "intelligent sandsynlighedsbaseret teststrategi", der kombinerer informationen, som er indhentet ved seismiske undersøgelser, med in-situ forsøg i form af "Seismic Cone Penetration Test". Herved kan de elastiske parametre fastlægges med stor nøjagtighed. Dette vil resultere i mere økonomiske funderingsløsninger idet de elastiske parametre i dag fastlægges alt for konservativt - dermed overdimensionerede fundamenter. Samtidigt forventes den nye teststrategi, at bidrage til en reduktion af det nødvendige antal in-situ målinger, hvorved den samlede omkostning til fundering af havbaserede vindmøller kan reduceres markant.

Main activities: Med projektets mål for øje vil forskningen fokusere på følgende:

- Udvikle og teste SCPTu målemetoder.
- Formulerer en metode til tolkning af SCPTu forsøgene. Tolkningen skal sikre pålidelig fastsættelse af både de elastiske og plastiske materialeparametre.
- Udvikle en metode der kan beskrives de målte parametre som stokastiske variabler og fastlægge variationen med dybden.
- Tilvejebringe tilstrækkeligt statistisk grundlag for at kunne udtale sig om variationen af materiale- parametre i horisontal retning.
- Formulering og opstilling af den sandsynlighedsbaserede teststrategi.

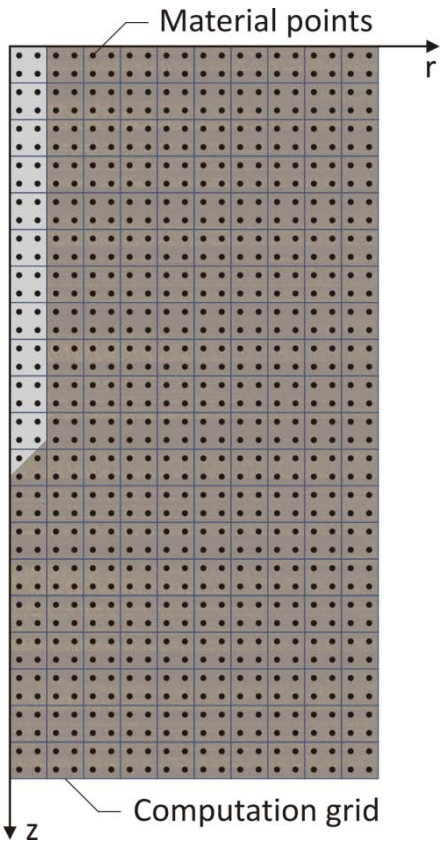
Dette projekt kan også gennemføres i relation til motorvejsbyggeri hvor samarbejdspartnerne vil være Vejdirektoratet.

Contact person: Lars Bo Ibsen

Theory: ☒☒☐ **Experimental work:** ☒☒☐ **Computer modelling:** ☒☒☐

Particle-based model of pile driving and CPT

Purpose: The Material-Point Method (MPM) has emerged as a computational tool for the analysis of dynamical problems related to civil engineering. Based on continuum mechanics, the method is developed from the principle of virtual work. However, in contrast to the standard finite-element method, the integration points carrying the material properties and state variables are allowed to move through the computational grid. This is ideal for the analysis of problems involving large deformations and contact between different materials and structures. Hence, the MPM is a promising tool for simulation of geotechnical problems such as pile driving and cone penetration testing (CPT).



Recently, a PhD project has being carried out at the Department of Civil Engineering, Aalborg University, regarding the analysis of landslides by utilisation of the so-called Generalised Interpolation Material Point Method (GIMP). This method is a further development of the MPM. The idea of the project is to develop a computer code based on the GIMP for the analysis of pile driving and CPT.

Main activities: The GIMP is a relatively new method, and this project is directly related to some of the on-going research at the university. The main activities are:

- Getting to know the MPM and the GIMP
- Formulation of the GIMP in cylindrical (axisymmetric) coordinates
- Programming the GIMP in MatLab or Fortran 95
- GIMP-analysis of CPT and/or pile driving
- Comparison of the GIMP results with experimental results.

Contact person: Søren Mikkel Andersen & Lars Andersen

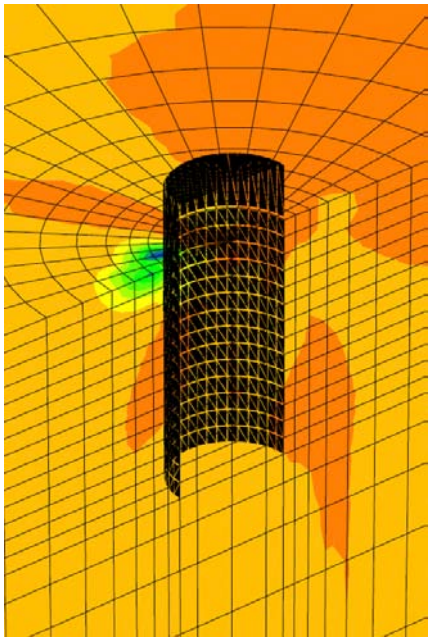
Theory: ☒☒☐ **Experimental work:** ☒☐☐ **Computer modelling:** ☒☒☒

Offshore Wind Turbine Foundations: Numerical evaluation of *p-y* and *p-Q* curves for piles in sand

A project in cooperation with

DONG energy

Purpose: The interactions between soil and laterally loaded piles are typically accounted for by use of *p-y* curves. A *p-y* curve defines the relationship *p*(*y*) between the soil resistance *p* arising from the non-uniform stress field surrounding the pile mobilised in response to the lateral pile displacement *y*, at any point along the pile. The *p-y* curves adopt the Winkler approach by uncoupling the response of various layers in the soil and can therefore easily include effects of non-linearity, soil layering and other soil properties.



Currently, *p-y* curves represent the state-of-the-art for design of monopiles in the offshore wind industry. However, the currently used p-y curves are clearly inadequate. Firstly, the current stiffness-formulation does not include diameter effects. This is of great importance since pile stiffness for often becomes the primary design driver for offshore wind turbine foundations. Secondly, the resistance of the pile toe is not considered in the current *p-y* methodology. Simple analytical considerations indicate that the ultimate moment resistance of a stiff monopile may increase by 25% if the pile toe resistance is included. Thus, the main emphasis of this project is to numerically evaluate diameter effects of p-y stiffness and evaluate the pile toe resistance in terms of *p-Q* curves.

Main activities:

- Develop a 3D finite element model of a monopile in PLAXIS (or ABAQUS).
- Calibrate constitutive behaviour to simulate Aalborg University Sand no. 1.
- Verify model by comparison to small-scale model tests performed in the pressure tank. (note: the scope of work does not include the model testing)
- Use numerical model to evaluate representative *p-y* and *p-Q* curves.

Contact persons: Lars Bo Ibsen, Søren P.H. Sørensen

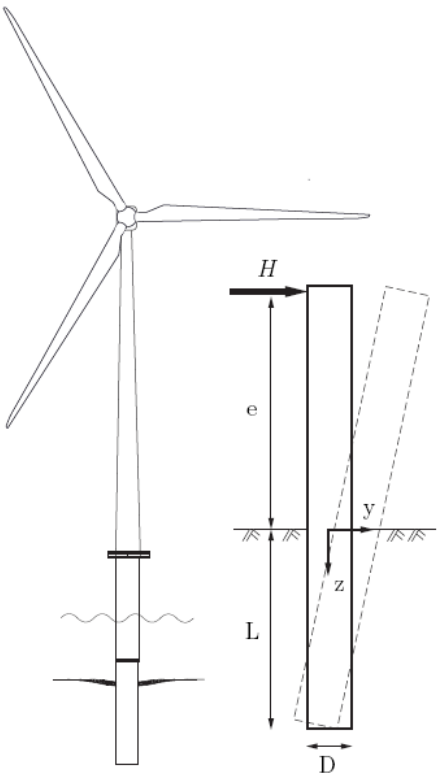
Theory: ☒☒☐ **Experimental work:** ☐☐☐ **Computer modelling:** ☒☒☒

Offshore Wind Turbine Foundations: Response of Stiff Piles to Long-term Cyclic Loading

A project in cooperation with

DONG energy

Purpose: There are several foundation concepts for offshore wind farms. Most current foundations are monopiles, which are stiff piles with large diameters, installed 20 m to 30 m into the seabed. The design of monopiles relies on standards and empirical data originating from the offshore oil and gas sector. However, the loading of an offshore wind turbine is very different in both magnitude and character to oil and gas installations. It is characteristic for offshore wind turbines that the sub-structure will be subjected to strong cyclic loading, originating from the wind and wave loads. This leads to accumulated rotation of the wind turbine tower, adversely affecting its ultimate strength or fatigue life. The long-term movements of the foundation may significantly impact all parts of the wind turbine, including the support structure, machine components and blades. Therefore, it is of great importance to investigate the effects of cyclic loading.



Series of laboratory tests shall be conducted using the pressure tank at AAU. The model tests must be conducted on a stiff pile installed in saturated sand and subjected to between 100 and 1000 cycles of combined moment and horizontal loading. A typical design for an offshore wind turbine monopile should be used as a basis for the study, to ensure that pile dimensions and loading ranges are realistic. A non-dimensional framework for stiff piles in sand must be applied to interpret the test results.

Main activities:

- A series of laboratory tests should be conducted on stiff piles in the pressure tank at AAU.
- Results should be used to develop methods assessing the change in stiffness and the accumulated rotation of a stiff pile due to long-term cyclic loading.

Contact persons: Lars Bo Ibsen, Søren P.H. Sørensen

Theory: ☒☒☐ **Experimental work:** ☒☒☒ **Computer modelling:** ☐☐☐

Extreme loads for Wind Turbines during Operation

For wind turbines the largest loads can often occur during operation where the wind turbine is producing power. Methods for estimating the extreme load in these cases are often inadequate and subjected to significant uncertainties. Therefore new and better methods along with a more thorough understanding of the response at high load levels for wind turbines are needed.

The present project focuses on three main topics:

- Comparison of existing methods based on simulated data
- Development of simple methods for load extrapolation
- Study the influence of contemporaneous loads (load combination)

The existing methods should be compared for a representative wind turbine in order to estimate the variation between the different methods. However, the existing methods are often complicated and time consuming to use. Therefore new and preferable simple methods should be developed. Also, the influence of combined loading of the individual cross-sections should be studied using probabilistic models.

The project will be performed in collaboration with Siemens Wind Power.

Contact person: Henrik Stensgaard Toft, John Dalsgaard Sørensen

SIEMENS
Siemens Wind Power GmbH

Theory: ☒☒☐ Experimental work: ☐☐☐ Computer modelling: ☒☒☐

Optimal Reliability Level for Wind Turbines

Description: For very large civil engineering structures such as bridges, high-rise buildings, offshore platforms, etc. are the optimal reliability level sometimes calculated in order to minimize the costs during the design life. For wind turbines could the optimal reliability level for the individual components (blade, hub, tower, foundation etc.) also be calculated and specified in the standard. The benefits of this to the society are enormous since wind turbines as opposed to normal civil engineering structures are series produced allowing for a more refined assessment of the reliability.

The purpose of the present project is to formulate models for the optimal reliability level for different components of the wind turbine. These models will be dependent on the initial cost of the wind turbine, the expenses to operation and maintenance and the risk for failure of the turbine. Also the risk for human fatalities and environmental aspects should be taken into account.
Based on the formulated models will the optimal reliability level for the individual components be determined by optimization and compared to the existing reliability for wind turbines and other civil engineering structures.

Main activities:

- Formulation of the optimal reliability level such that the owner obtains the maximal economic return by maximizing the total expected benefits minus costs to construction, operation, maintenance, repair and possible failure.
- Formulation of the reliability level which is optimal for the society, e.g. based on LQI (Life Quality Index) considerations, and including environmental aspects.

The models should be formulated for the main wind turbine components.

The project will be connected to ongoing research projects.

Contact person: John Dalsgaard Sørensen, Henrik Stensgaard Toft

Theory: ☒☒☐ Experimental work: ☐☐☐ Computer modelling: ☒☒☐

Reliability and Risk analysis of Wind Turbines

Wind turbines are a building / machine with many structural (tower, blades, foundation, …), mechanical (gearbox, bearings, …) and electrical (generator, …) components. The complete wind turbine is a complicated system where failure of some of the components can have serious consequences. Failure of a component can not only be critical for the wind turbine itself but also for the environment. The consequences for the environment can be loss of electricity supply which is serious if the supply from a complete offshore wind farm is lost. Another consequence in case of full or partial failure of e.g. a wind turbine blade is that people, buildings, etc. can be hit by a part from the wind turbine thrown several hundred meters away.

The purpose of this project is to establish an overview of risks associated with wind turbine failures. This includes description of failure modes, failure rates and consequences. Further to describe a methodology to assess these risks quantitatively and how to establish acceptable risks.

Main activities:

- Literature survey to give an overview of risks associated with wind turbine failures:
  - failure modes
  - failure rates
  - consequences
- Use principles from risk analysis to describe a methodology to assess
  - Risks related to the wind turbine itself
  - Risks related to the environment
  - What are the acceptable risks?
- Selection of representative part of the whole wind turbine system and implementation in a computer program using existing algorithms
- Illustrative example studies

The project will be connected to ongoing research projects

Contact person: John Dalsgaard Sørensen
Theory: ☒☒☐ **Experimental Work:** ☐☐☐ **Computer Modelling:** ☒☒☐

Collapse of wind turbine at Djursland, February 2008 – wind turbine parts thrown up to 400 m away!

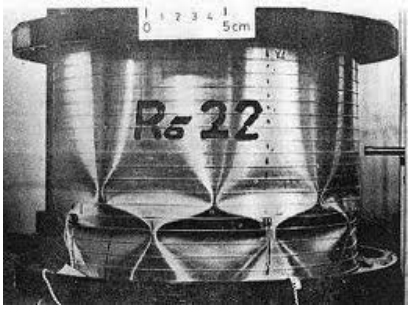
Design of steel shell structures for wind turbine tower

Shell structures are widely used in civil engineering structures e.g. chimneys, oil & gas structures and wind turbine towers. The design of these structures is often performed using the guidelines in EN 1993-1-6 which allows for at least four different design methods:

- Design using simple formulas based on membrane theory
- Linear finite element analysis
- Nonlinear (materials) finite element analysis
- Nonlinear (materials & geometry) finite element analysis

It is normally expected that the more detailed models are the most accurate. This could allow for smaller partial safety factors if these methods are used. However, on the other hand some hidden safety (conservatism) can be build into the simple formulas.

The objective of the present work is to compare the different design approaches with public available test results. Secondly, the uncertainty related to the different design methods will be estimated in order to establish probabilistic models for design of steel shell structures. Based on the probabilistic model the reliability related to the different design approaches can be estimated.



The main activities in the project are:

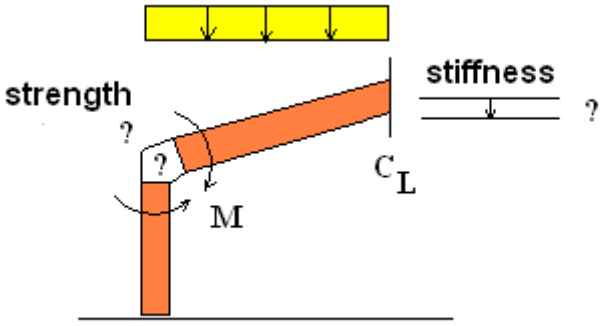
- Literature study on design of steel shell structures
- Nonlinear finite element modelling of shells including imperfections
- Probabilistic modelling of uncertainties and reliability evaluation

Contact persons: Henrik Stensgaard Toft

Theory: ☒☒☐ **Experimental work:** ☐☐☐ **Computer modelling:** ☒☒☐

The corner of laminated timber frames

Purpose: Laminated timber frames are, for instance, desirable in structures where the aesthetics of the structure is in focus. A weak point in a timber frame is the frame corner and its strength and stiffness. But perhaps the corner does not need be made of wood?



Could a reinforced concrete structure or a steel structure be employed in the corner instead? At least the drawbacks of a corner made of wood might be removed and by employing wood in the remaining part of the frame, the frame would still visually appear much like a full wooden frame.

Main activities: The aim of the project is to explore the stiffness and strength of a timber frame employing different solutions in the corner of the frame (steel and/or reinforced concrete and using the full timber frame as reference).

In the project you will develop numerical and analytical models for the various solutions and full-scale tests will be conducted aiming at verifying the strength and stiffness predicted by your models.

Should your investigations reveal that solutions with steel or reinforced concrete in the corner of the frame are feasible (in terms of strength and stiffness) it might indicate a potential for a new type of frame structures.

The project might involve co-operation with external parties having an interest in mapping the potential of alternative solutions for timber frames.

Contact persons: Lars Pedersen, Christian Frier

Theory: ☒☒☐ **Experimental work:**. ☒☒☐ **Computer modelling:** ☒☒☐

Advanced Analysis of Steel Frames

Purpose: In ultimate limit state analyses of steel frames compression forces and bending moments are of concern, as they may lead to global instability manifested in either buckling or lateral torsion failure.

The design guide Eurocode sets up procedures for evaluating the ultimate limit state and actually Eurocode (EC) suggests a number of different design approaches to choose from. Some EC-approaches are more simplifying than others, and this means that the final evaluation of the ultimate limit state depends on the method chosen for the evaluation. Or does it?

The purpose of the study is to highlight and quantify load carrying capacity of steel frames employing different methods, ranging from basic methods to more advanced methods (in all methods FE-analyses are required but to various degree of complexity).

In the initial part of the study focus will be on analysing a reference steel frame, but in order to highlight the degree of differences in calculated load carrying capacities it is useful to extend the study. This, for instance, by studying a range of steel frame configurations or to conduct some other type of parameter study focusing on sensitivity of outcome of your calculations to input assumptions related to structural modelling.

Main activities: Besides from a literature review focusing on the background for EC-guidance focus will be on

- Implementing and describing procedures
- Finite element modelling and analyses
- Parameter and sensitivity studies

so as to provide an overview of load carrying capacities of steel frames as computed using different methods.

As part of the study it might be useful also to analyse one of the steel frames which recently collapsed due to heavy snow loads.

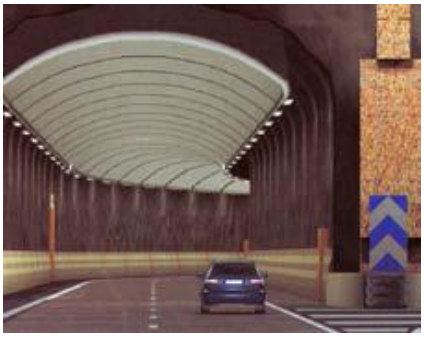
Contact persons: Lars Pedersen, Johan Clausen

Theory: ☒☐☐ **Experimental work:**. ☐☐☐ **Computer modelling:** ☒☒☐

Precast post tensioned CRC footbridge

Purpose: The objective of the proposed project is to theoretically, numerically and experimentally analyse and optimize post tensioning assemblage of a footbridge based on precast units of ultra high performance concrete.

Background: CRC (Compact Reinforced Composite) is an ultra high performance fibre reinforced concrete consisting of a dense and high strength cement based matrix with steel fibres added to achieve ductility, and with ordinary steel bars as the main reinforcement. Specialized prefabricated CRC units are produced for a wide range of applications by the company Hi-Con A/S in Hjallerup.



For many applications it would be advantageous to assemble precast CRC units in situ by post tensioning to construct long or tall structures. The proposed project will focus on a light and slender footbridge for urban areas. The wall thickness of the units, and thereby the maximum size of the anchorage zone for the tendons, is relatively small in order to minimize the dead weight of the bridge. However, due to the high strength and the ductility of CRC as compared to traditional concrete the forces can be carried by a smaller anchorage region, and it may even be expected that both the anchorage reinforcement and the reinforcement for the splitting tensile stresses generated by the concentrated loads are smaller than known from traditional concrete.

Main activities: The project is relatively open concerning the specific approach to the subject. However, in any case the activities will include:

- Getting to know ultra high performance fibre reinforced concrete (CRC), including potential applications and production and construction of CRC based structures
- By reference to the design of traditional post tensioned concrete structures analyse possibilities for simplifications of the anchorage zone reinforcement and enhancement of the overall performance of a footbridge constructed with precast CRC units, utilizing the special features of CRC.
- FEM-based computations and simulations
- Experimental investigations and validations of the calculations by testing specially produced and designed CRC units

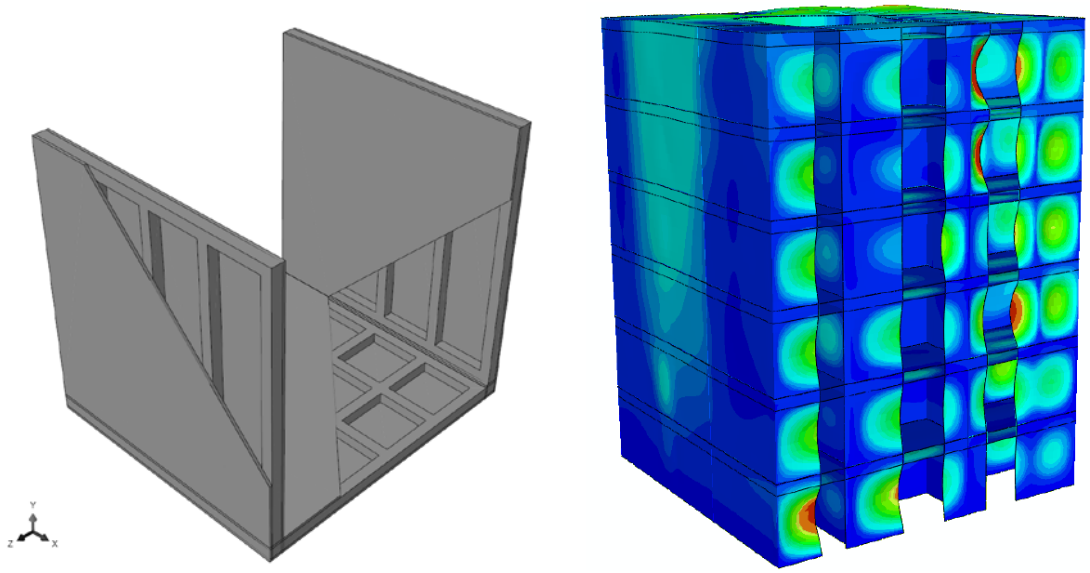
The project will be carried out in close cooperation with Hi-Con A/S.

Contact persons: Lars Pedersen and Eigil V. Sørensen.

Theory: ☒☒☐ **Experimental work:** ☒☒☐ **Computer modelling:** ☒☒☐

Noise and vibrations in lightweight building structures

Purpose: Walls and floors in lightweight timber structures are usually constructed as wooden panels. Depending on the geometry, material properties and boundary conditions, such panels may resonate at different frequencies within the audible range, leading to emission of noise. Furthermore, the panels may serve as waveguides, transmitting noise from one room to another or between floors. The project may concentrate on a global model for a building—or transmission paths may be studied at a local level, e.g. at a junction between a wall and a floor. Alternatively, the project may focus on an optimized design of wall or floor panels where the studs or joists are placed periodically to minimize noise transmission in the audible range.



Main activities: The project is relatively open with concern to the problem to be analysed. The activities may include:

- Literature study of building acoustics
- Formulation of models for dynamic analysis of periodic structures
- Design of joints in building structures for mitigation of noise
- Parameter studies to identify the influence of geometry and material properties on sound transmission in lightweight building structures
- Finite-element modelling of coupled acoustics and structural vibration
- Experimental testing of structural dynamics and acoustics.

Contact person: Lars Andersen & Poul Henning Kirkegaard

Theory: ☒☒☐ **Experimental work:** ☒☐☐ **Computer modelling:** ☒☒☐

Vibrations from railway traffic: The Femern Belt Link

Purpose: Currently the Femern Belt Link is in the project phase. In addition to the bridge or tunnel, several new road and railway structures are to be constructed as part of the link between Denmark and Germany.

Regarding the railway lines on the Danish side of the belt, new Danish regulations prescribe that the level of noise and vibrations along new railway lines must be documented in the project phase. Thus, based on in situ measurements of the dynamic properties of the soil, computational and empirical models must be applied in order to predict the vibration levels that can be expected along the planned railway line. Further, engineering solutions may be necessary along parts of the line to reduce the vibrations to an acceptable level.

Main activities: The project concerns the analysis of vibrations from trains running on the planned railway on the Danish side of the Femern Belt Link. The following items may be part of the project work:

- Literature study of wave propagation in soil and railway lines
- Numerical modelling of vibration transmission through the rails and subsoil
- Modelling of the train as a multi-degree-of-freedom system
- Design of trenches or other structures to minimise the emission of vibrations
- Design of an easy-to-use programme for evaluation of wave transmission.

The work may be carried out in collaboration with Rambøll Denmark who is the main contractor for the assessment of noise and vibrations from railway traffic on the Danish part of the Femern Belt Link.

Contact person: Lars Andersen

Theory: ☒☒☒ **Experimental work:** ☒☐☐ **Computer modelling:** ☒☒☐

Finite-element modelling of reinforced concrete

Purpose: Reinforced concrete is widely applied as a construction material in civil engineering. Concrete is a complex material, both chemically and mechanically, and the formulation of material models demands a deep knowledge of the behaviour during casting, curing, utilization and, eventually, degradation. The introduction of reinforcement results in a composite material. In this case the interaction between the concrete matrix and the steel reinforcement must be accounted for as well.



The idea in this project is to develop an ABAQUS model that can be applied to the finite-element analysis of reinforced concrete structures with a complex geometry, e.g. curved shells. The goal is to construct of a model that facilitates both a genuine model of the respective materials and, not least, a realistic description of the interfaces between concrete and steel. The project may focus on the analysis of a particular problem or structure.

Main activities:

- Formulation of material models for concrete
- Modelling of composite shells in ABAQUS
- Modelling of interfaces between concrete and reinforcement
- Finite-element analysis of reinforced concrete structures
- Comparison of FE models with standard design methods.

Contact person: Lars Andersen

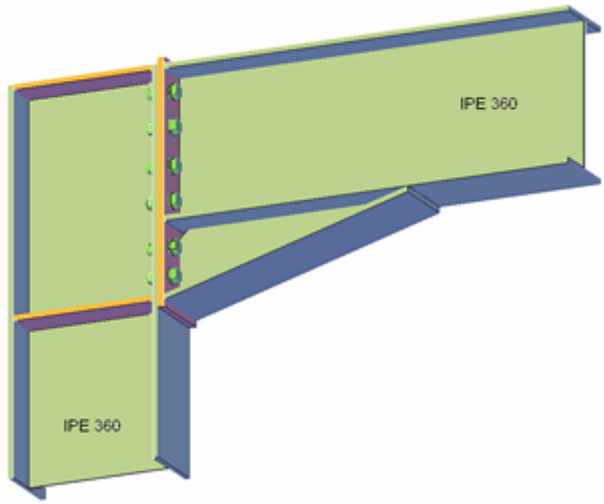
Theory: ☒☒☐ **Experimental work:** ☒☒☐ **Computer modelling:** ☒☒☒

Analysis of Joints in Steel Structures

Purpose: Joints in steel structures are frequently made using fasteners. These are not fully rigid which may play a role in terms of behaviour of the steel frame.

The purpose of the project is to investigate how flexibility in joints influences various global characteristics of the steel frame, and to study how Eurocode models these influences.

Another item of interest is to explore the load bearing capacity of joints made using fasteners (analytically, numerically, and experimentally) and to compare results with Eurocode models.



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Main activities: The project is relatively open with concern to the problem to be analysed. However, in any case the activities will include:

- A mixture of analytical, numerical and experimental investigations
- Comparison of results with Eurocode models.

Contact persons: Lars Pedersen

Theory: ☒☒☐ **Experimental work:** ☒☐☐ **Computer modelling:** ☒☒☐

Reliability assessment of existing and temporary structures

Generally reliability requirements and partial safety factors are related to permanent structures, e.g. with a design lifetime equal to 50 years. This is for example the case in the Eurocodes. For existing structures and for temporary structures, e.g. structures during execution and structures only used for a short time interval, no design requirements can generally be found in the codes, but are highly demanded by industry.

Both for existing and temporary structures it is sometimes argued, that the reliability level could be chosen lower than for permanent structures. But is that reasonable - e.g. for structures where people can be in danger in case of failure? And if the reliability level in some cases can de lowered, how much can the partial safety factors be decreased?

For existing structures, e.g. concrete bridges, information will often be available, e.g. in the form of measured concrete compression strengths of test samples, measured traffic loads, ... How can such information be used to assess the reliability of the structure, and eventually decrease the partial safety factors?

Main activities:

- Collect information from literature on assessment of reliability of temporary and existing structures
- Assess and describe methods to obtain the minimum reliability level using risk and reliability-based principles:
    - cost-benefit analyses: minimize lifecycle total expected costs
    - LQI (Life Quality Index) principles: requirements by society
- Transformation of reliability level to 'reduced' partial safety factors and/or reduced characteristic loads.
- Select one or more illustrative structures (an existing structure and/or a temporary structure), and for the selected structure(s):
    - Stochastic modelling of loads and strengths
    - Assessment of minimum reliability level to be required
    - Estimation of evt. reduced partial safety factors
- Write paper for joint JCSS / IABSE / IFED workshop on 'Reliability of temporary structures' in January 2012.

Contact person: John Dalsgaard Sørensen, Henrik Stensgaard Toft

Theory: ☒☒☐ **Experimental Work:** ☐☐☐ **Computer Modelling:** ☒☒☐

Robustness of structures

Professor A. Ostenfelds Guldmedaljefond
Prisopgave: Bærende konstruktioners robusthed

Formål
Professor A. Ostenfelds Guldmedaljefond udskriver herved følgende prisopgave, som ønskes besvaret i form af diplom- eller kandidatspecialer. Prisopgavens overordnede tema er: ***Bærende konstruktioners robusthed.***
Med prisopgaven ønsker fonden at øge opmærksomheden på robusthed af bærende konstruktioner blandt de kommende bygningsingeniører.
Der kan enten tages udgangspunkt i et af fondens projektforslag (se www.dsby.dk/ostenfeld) eller i et eget defineret projekt.
Analytiske, udredende såvel som eksperimentelt betonede projekter er velkomne.

Betingelser, tidsfrister og præmier
Besvarelser indsendes som artikel på max. 50 sider skrevet på baggrund af specialearbejdet. Dette kan enten være udarbejdet individuelt eller i samarbejde med medstuderende. Besvarelsen kan indsendes på dansk eller engelsk.
Besvarelser sendes til nedenstående adresse inden den 1. september 2012.

Professor A. Ostenfelds Guldmedaljefond,
c/o Rambøll A/S
Hannemanns Allé 53
DK-2300 København S
Att. Mogens G. Nielsen

Besvarelser, som bedømmes præmieværdigt, belønnes med et rejselegat samt en bronzemedalje.
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Kontakt
Kontaktperson for yderligere information:
Formand for fondens bestyrelse: Mogens G. Nielsen
Email: mon@ramboll.dk

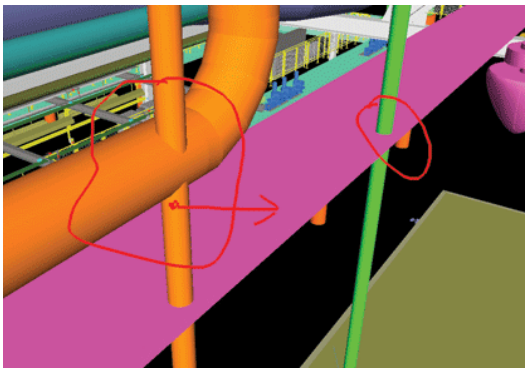
Yderligere oplysninger kan findes på www.dsby.dk/ostenfeld
samt i folderen "Bærende konstruktioners robusthed".

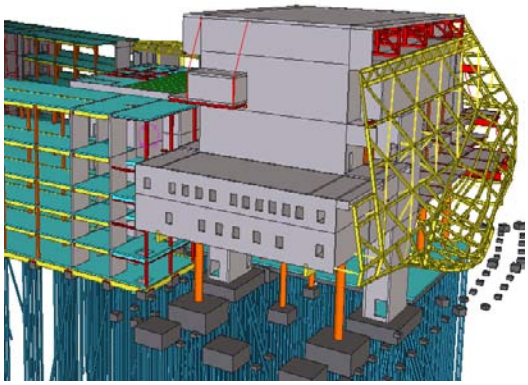
Contact person: John Dalsgaard Sørensen
Theory: ☒☒☐ **Experimental Work:** ☐☐☐ **Computer Modelling:** ☒☒☐

Structural modelling and design coordination

Purpose: The construction industry is changing from traditional CAD drawings to more intelligent 3D object based models of the entire building. There are many attempts to improve the structural design process by making a better connection between object based CAD systems and structural simulation tools. The simulation tools can be more or less integrated with specific CAD systems or they may exchange data through open international standards. An important issue for the structural engineer is also the often complicated coordination with requirements from other disciplines such as architecture, HVAC etc. New IT tools are introduced to assist this coordination.

The purpose of this project is to identify critical elements of the integrated design and coordination process and examine how new methods and information technology can assist us in the future construction industry.





Main activities:

- Identify strength and limitations in current practices and identify opportunities with upcoming technologies in the area
- Review of enabling Information and Communication technologies (ICT), including software, data models, international standards, and human computer interaction tools
- Examine today's possibilities with existing tools
- Identify needs for new ways of working and from that derive a list of requirements on technical solutions
- Demonstrate possible solutions for the near future and describe issues for future development

The work may be in collaboration with a consulting engineering company.

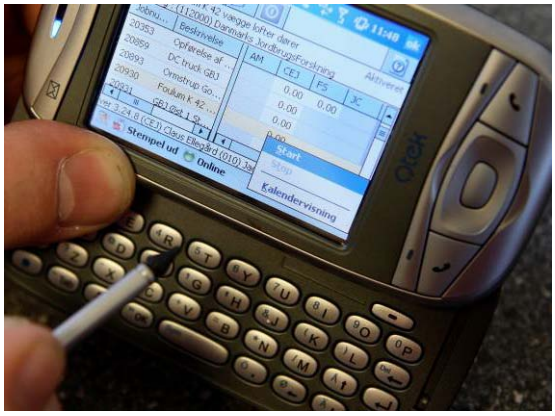
Contact persons: Kjeld Svidt

Theory: ☒☒☐ **Experimental Work:** ☒☒☐ **Computer Modelling:** ☒☒☐

Future information technology at the construction site

Purpose: In recent years, the construction industry has started changing from traditional 2D CAD drawings to more intelligent 3D object based models of the entire building. Such models give us a number of new possibilities for planning and controlling the activities at the construction site through advanced 4D models and possible links between the physical construction components and the virtual building model. New information and communication technology can improve the communication of correct instructions at the right time for the construction work as well as capturing information for quality assurance and as-built documentation.

The purpose of this project is to identify important problems within the area and propose solutions for future use of state-of-the-art information technology at the construction site.



Main activities:

- Identify current practices and problems in traditional construction projects
- Review of enabling technologies, software, hardware, international initiatives
- Test existing methods, software, hardware
- Identify needs and requirements for new solutions
- Build early prototypes with more or less functionality for initial tests

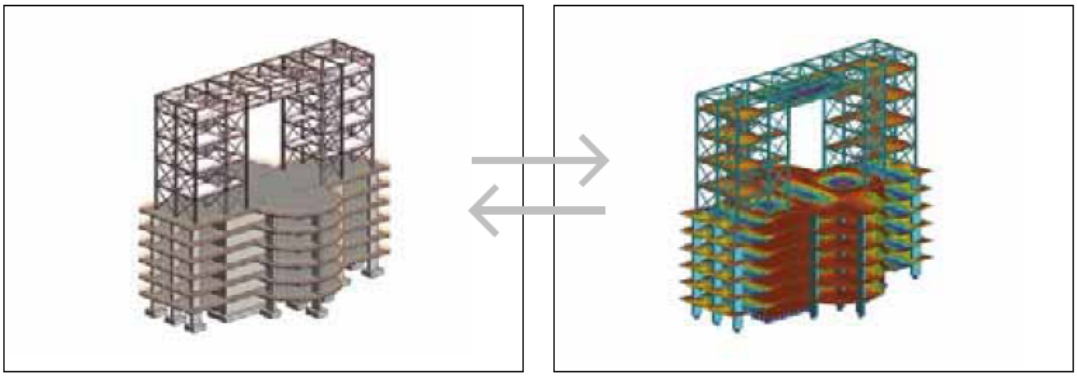
The work may be carried out in collaboration with a construction company.

Contact persons: Kjeld Svidt

Theory: ☒☒☐ **Experimental Work:** ☒☒☐ **Computer Modelling:** ☒☒☐

Structural modelling and analysis using BIM tools

Purpose: Although 2D and 3D modeling software has been used for decades to analyze and design structures, over the past few years a wave of new 3D modeling tools are allowing structural engineers and designers to create models for documentation and coordination as well. As a result, more and more structural engineering firms are embracing the Building Information Modeling (BIM) movement. BIM software is based on the object-oriented programming paradigm, in which instances of structural members are assembled to create a building structure. Each member possesses the information and functionality that fully defines it. In other words, a beam element knows its properties (e.g. material, sectional properties…), as well as its purpose within the structure (i.e. a horizontal member on level X, spanning between column Y and girder Z). The resulting BIM model contains a wealth of information which can be useful for inter-discipline coordination as well as internal coordination. Recently many add-on BIM tools have been presented which integrated the structural analysis of e.g. reinfored concrete and steel structures into the BIM framework.
The purpose of the present project is to perform an evaluation of add-on tools for structural analysis.



Main activities:

- Identify strength and limitations in current add-on BIM tools and identify opportunities with upcoming technologies in the area
- Modelling and structural analysis of different structures and comparison with theory and traditional FEM results.

The work may be in collaboration with RAMBØLL.

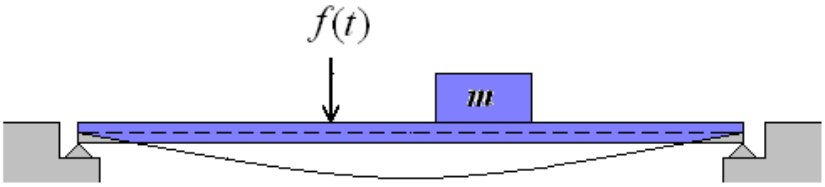
Contact person: Poul Henning Kirkegaard

Theory: ☒☒☐ **Experimental Work:** ☐☐☐ **Computer Modelling:** ☒☒☒

Dynamic human-structure interaction

Background: In static calculus, passive (sitting/standing) humans are modelled as a rigid mass attached to the structure. In dynamics, humans in motion (people walking or jumping) are modelled as a dynamic load bringing the supporting structure into vibration.

Human in motion Passive person



In assessments of vibration levels of slender structures carrying humans (such as footbridges, stadia-structures, or office floors) these models are conventionally employed. But are they reasonable?

Purpose: The aim of the project is to study mechanisms of human-structure interaction focusing on areas where the models mentioned above are inadequate. Prior to codifying new models describing the phenomena, they need to be properly researched.

In the project you will plan and conduct experiments striving to highlight the true mechanisms of human-structure interaction on slender structures. Measured vibration data will allow you to calibrate alternative models of the interaction accounting for the flaws in existing models.

Implications of findings (new models of the interaction) you may illustrate through computer simulations of structural response to the dynamic loads generated by humans.

Contact person: Lars Pedersen

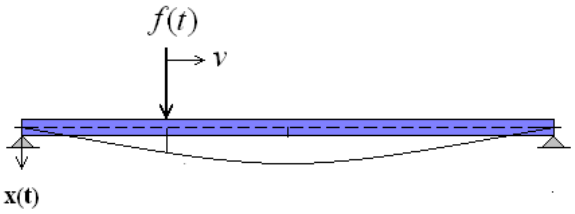
Theory: ☒☐☐ **Experimental work:** ☒☒☐ **Computer modelling:** ☒☒☐

Dynamic human loading and stochastic models for estimating structural responses

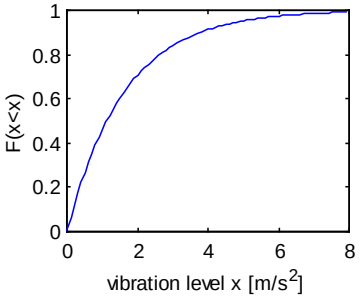
Background: Some civil structures are so slender that their modes of vibration may be excited by the basic frequency of human motion resulting in resonant structural action. The undesired resonant action may for instance occur in footbridges, stadia structures or in open-space office floors as a result of walking or jumping.

Codes and standards handle the phenomenon semi-empirically or even fully deterministic although fundamentally the loading generated by humans in motion is stochastic.

Purpose: The aim of the project is to develop and test stochastic models describing the loading and the structural response. An essential contribution would be to derive statistical distributions of structural responses to human-induced loading, as this would provide valuable information for assessing structural safety or serviceability. Specifically, the risk of exceeding various vibration levels is of interest although it is actually a parameter not given much/any focus in existing design codes.



Walking load when $v > 0$ m/s, "Jumping load " when $v = 0$ m/s



Statistical distribution of response

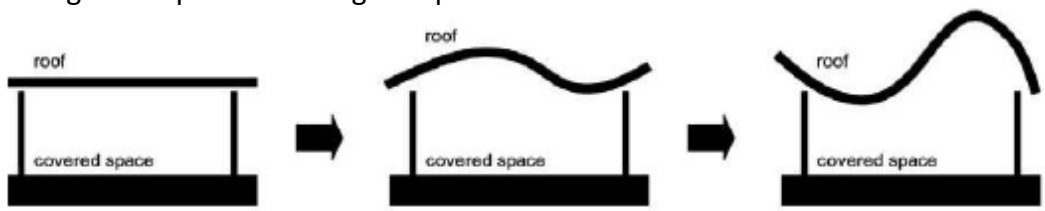
Through the project you will learn how to model the dynamic excitation of humans in motion, deterministically as well as stochastically. You will conduct parametric studies and numerical simulations to highlight essential implications of stochastic modelling of the phenomenon. Experimental verification of models is a possibility if so desired.

Contact persons: Lars Pedersen, Christian Frier

Theory: ☒☐☐ **Experimental works:** ☐☐☐ **Computer modelling:** ☒☒☒
(The amount of experimental work can be decided during the project)

MBS modelling of kinetic structures

Purpose: Kinetic structures follows a new trend emerging in architecture related to the physical movement of structural building elements that can result to the spatial movement of a structure as an entirety or just part of it. More particularly, this kind of architecture can be defined as: Buildings and/or building components with variable mobility, location and/or geometry. Structural solutions must be considered in parallel both the *ways* and *means* for kinetic operability. The *ways* in which a kinetic structural solution performs may include among others, folding, sliding, expanding, and transforming in both size and shape. Shape control within architectural kinetic structures is a natural extension to the practice of engineering and architectural design. Structural shape control is of major interest within responsive architecture because it is the primary ingredient needed to produce building envelopes that change shape.



Developing of responsive kinetic architecture requires that one could simulate such a mechatonic system as a multibody system (MBS) combined with a shape control method.

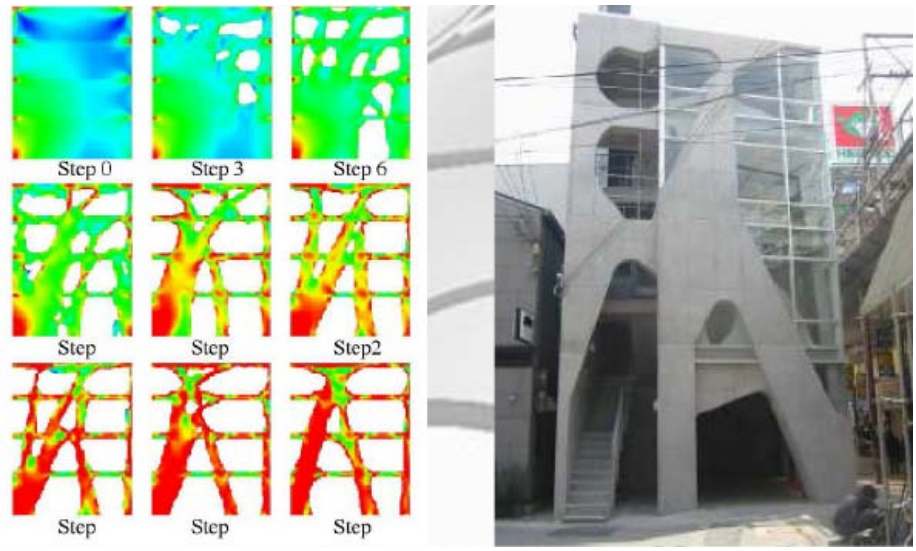
Main activities: The project will be related to ongoing research at the university where the MBS method is used related to wind turbines and kinetic structures. The main activities in the project will be:

- Getting to know the MBS method (FEM method)
- Getting to know shape control methods
- MBS modelling of a kinetic structure using the software packages ADAMS and Simulink.

Contact persons: Poul Henning Kirkegaard, Søren R.K. Nielsen

Theory: ☒☒☒ Experimental work: ☐☐☐ Computer modelling: ☒☒☒

Structural Design using Structural Optimization



Purpose: In the last few years a number of computational methods have been developed for structural optimization, methods for structural shape optimizationor for topology optimization like evolutionary structural optimization methods (ESO / Extended ESO). Most of these methods are based on dissecting the element into numerous parts for the optimization process and by deleting or adding parts after individually being tested against the design objective, which is achieved by variation of the design variables who are subjected to the design constraints in a process of multiple iterations. Over the past two decades there has been an increasing interest in using what has come to be called Evolutionary Computation (EC) in the analysis and optimization of structural systems. These methods include Genetic Algorithms (GA), Evolution Strategies (ES), Simulated Annealing and other stochastic based numerical methods. Each of these methods shares the drawback that they are very computationally intensive compared to deterministic methods. Furthermore, the computational burden can rapidly increase as the size of the analyzed structure increases. This project will consider how shape and topology optimization methods can be used for structural design.

Main activities:

- Knowledge of shape an topology optimization methods in civil engineering
- Evaluating the FEM program OptiStruct
- Comparative case studies evaluating a broader range of good solutions

Contact person: Poul Henning Kirkegaard, Lars Andersen

Theory: ☒☒☐ **Experimental Work:** ☐☐☐ **Computer Modelling:** ☒☒☒

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