



# Curriculum for the Master's Programme in Structural and Civil Engineering

Aalborg University

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**Preface:**

Pursuant to Act 261 of March 18, 2015 on Universities (the University Act) with subsequent changes, the following curriculum for the Master's programme in Structural and Civil Engineering is stipulated. The programme also follows the Joint Programme Regulations and the Examination Policies and Procedures for The Faculty of Engineering and Science.

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## ***Chapter 1: Legal Basis of the Curriculum, etc.***

### **1.1 Basis in ministerial orders**

The Master's programme in Structural and Civil Engineering is organised in accordance with the Ministry of Higher Education and Science's Order no. 1061 of June 30, 2016 on Bachelor's and Master's Programmes at Universities (the Ministerial Order of the Study Programmes) and Ministerial Order no. 1062 of June 30, 2016 on University Examinations (the Examination Order). Further reference is made to Ministerial Order no. 258 of March 18, 2015 (the Admission Order) and Ministerial Order no. 114 of February 3, 2015 (the Grading Scale Order) with subsequent changes.

### **1.2 Faculty affiliation**

The Master's programme falls under The Faculty of Engineering and Science, Aalborg University.

### **1.3 Board of Studies affiliation**

The Master's program falls under the Board of Studies for Civil Engineering

### **1.4. External Evaluation Corps**

The programme falls under the external evaluator corps: ingeniøruddannelernes censorkorps – bygning.

## ***Chapter 2: Admission, Degree Designation, Program Duration and Competence Profile***

### **2.1 Admission**

Admission to the Master's program in Structural and Civil Engineering requires a Bachelor's degree in one of the programmes listed below.

#### **Applicants with one of the following degrees are entitled to admission:**

- Bachelor of Science in Civil Engineering with specialisation in Structural and Civil Engineering, Aalborg University

#### **Applicants with one of the following degrees are entitled to admission:**

- Civil Engineering, Technical University of Denmark
- Bachelor of Engineering (Civil and Structural Engineering), Aarhus University – School of Engineering
- Civil Engineering, University of Southern Denmark

#### **Applicants without legal claim to admission:**

Students with another Bachelor's degree, upon application to the Board of Studies, will be admitted after a specific academic assessment if the applicant is deemed to have comparable educational prerequisites. The University can stipulate requirements concerning conducting additional exams prior to the start of study.

## 2.2 Degree designation in Danish and English

The Master's program entitles the graduate to the designation *civilingeniør, cand.polyt.* (candidatus/candidata polytechnices) i bygge- og anlægskonstruktion. The English designation is: Master of Science (MSc) in Engineering Structural and Civil Engineering.

## 2.3 The program's specification in ECTS credits

The Master's program is a 2-year, research-based, full-time study program. The program is set to 120 ECTS credits.

## 2.4 Competence profile on the diploma

The following competence profile will appear on the diploma:

### **A Candidatus graduate has the following competency profile:**

A Candidatus graduate has competencies that have been acquired via a course of study that has taken place in a research environment.

A Candidatus graduate is qualified for employment on the labour market on the basis of his or her academic discipline as well as for further research (PhD programmes). A Candidatus graduate has, compared to a Bachelor, developed his or her academic knowledge and independence so as to be able to apply scientific theory and method on an independent basis within both an academic and a professional context.

## 2.5 Competence profile of the program

The graduate of the Master's program:

Knowledge:

- Has scientifically based knowledge about the structural behavior of civil engineering structures regarding the static as well as the dynamic response.
- Has an understanding of geotechnical engineering and hydraulics as well as structure-soil and structure-fluid interaction based on scientific methods.
- Must understand analytical, numerical and experimental methods for analysis and design of engineering structures.
- Has knowledge about construction materials and soil regarding their mechanical behavior and modeling.
- Has knowledge about loads, especially environmental loads like wind and wave loads, and methods for their evaluation.
- Has knowledge about risk and reliability in engineering including uncertainties of loads, geometry, material properties, structural response and computational models.
- Has knowledge in one or more subject areas that is based on the highest international research within the fields of civil and structural engineering.

Skills:

- Excels in the scientific methods and tools as well as general skills related to employment within civil and structural engineering.

- Can communicate research-based knowledge and discuss professional and scientific problems with peers as well as non-specialists, using the correct terminology in civil engineering.
- Can apply appropriate methods of analysis for investigating civil engineering structures and construction materials
- Can assess loads on civil engineering structures, including environmental loading from wind and waves.
- Can assess the uncertainty connected with structural analysis, and judge the quality of the results.
- Can select and apply appropriate computational and experimental methods to investigate the static and dynamic response of civil engineering structures.
- Can apply experimental tests for obtaining material properties, calibrating computational models and assess uncertainties within the fields of structural and geotechnical engineering.

#### Competencies

- Can select and apply appropriate methods for solving a given problem within civil engineering and judge the results regarding their accuracy and validity.
- Can identify scientific problems within civil and structural engineering and select and apply proper scientific theories, methods and tools for their solution.
- Can develop and advance new analyses and solutions within civil and structural engineering.
- Can manage work-related situations that are complex and unpredictable, and which require new solutions.
- Can initiate and implement discipline-specific as well as interdisciplinary cooperation and assume professional responsibility.
- Can take responsibility for own professional development and specialization.

### ***Chapter 3: Content and Organization of the Program***

The program is structured in modules and organized as a problem-based study. A module is a program element or a group of program elements, which aims to give students a set of professional skills within a fixed time frame specified in ECTS credits, and concluding with one or more examinations within specific exam periods that are defined in the curriculum.

The program is based on a combination of academic, problem-oriented and interdisciplinary approaches and organized based on the following work and evaluation methods that combine skills and reflection:

- project work
- lectures
- classroom instructions
- study groups
- workshop



- exercises
- laboratory tests
- measurements and testing in the field
- portfolio work
- independent study

The modules are evaluated either through written or oral exams as stated in the description of the modules.

For individual written exams the study board selects among the following possibilities:

- Written exam based on handed out exercises
- Multiple choice
- Ongoing evaluation of written assignments

For individual oral exams the study board selects among the following possibilities:

- Oral exam with or without preparation
- Oral exam based on project report
- Oral exam based on presentation seminar
- Portfolio based oral exam

If the number of students following a module is small and/or if the number of students having to attend a re-exam is small the study board can decide that an exam is conducted either as an oral or written individual exam for economic reasons. In the first case decision must be notified before the start of the teaching activity in the latter case the students must be notified when the examination date is decided.

### 3.1 Overview of the program

All modules are assessed through individual grading according to the 7-point scale or Pass/Fail. All modules are assessed by external examination (external grading) or internal examination (internal grading or by assessment by the supervisor only).

Of a total of 120 ECTS, 120 ECTS are assessed by the 7-point scale and 45-75 ECTS are assessed by external examination.

Semester	Module	ECTS	Assessment	Exam	
1 <sup>st</sup>	Introduction to Problem Based Learning within Structural and Mechanical Engineering (P) <sup>3)</sup>	5	7-point scale	Internal	
	Stiffness Analysis of Load-Bearing Structures (P)	10	7-point scale	Internal	
	Structural Mechanics and Dynamics	5	7-point scale	Internal	
	Material Modelling in Mechanical Design	5	7-point scale	Internal	
	Fluid and Wave Dynamics	5	7-point scale	Internal	
2 <sup>nd</sup>	The Excitation and Foundation of Marine Structures (P)	15	7-point scale	External	
	Coastal, Offshore and Port Engineering	5	7-point scale	Internal	
	Risk and Reliability in Engineering	5	7-point scale	Internal	
	Advanced Structural Engineering	5	7-point scale	Internal	
3 <sup>rd</sup>	A	Analysis and Solution of Advanced Civil and/or Structural Engineering Problems	15	7-point scale	Internal
		Renewable Energy Structures: Wind Turbines and Wave Energy Devices <sup>4)</sup>	5	7-point scale	Internal
		Wind Loads on Structures <sup>4)</sup>	5	7-point scale	Internal
		Advanced Geotechnical Engineering <sup>4)</sup>	5	7-point scale	Internal
		Fracture Mechanics and Fatigue <sup>4)</sup>	5	7-point scale	Internal
	B	Academic Internship <sup>1)</sup>	30	7-point scale	Internal
	C	Study at Other University <sup>2)</sup>	15-30	See below	-
3 <sup>rd</sup> - 4 <sup>th</sup>	Master's Thesis after 3 of the 3 <sup>rd</sup> semester courses	45	7-point scale	External	
3 <sup>rd</sup> -4 <sup>th</sup>	Master's Thesis	60	7-point scale	External	
4 <sup>th</sup>	Master's Thesis	30	7-point scale	External	
Total		120			

1) The study board must approve on the content of the Internship before it is commenced.

2) Assessment and exam according to the curriculum at the other university. The study board must approve on the contents before the study is commenced.

3) Students not familiar with Problem-based Learning at Aalborg University must attend the course "Problem-based Learning (PBL) and Project Management" as an integrated part of the project module on 1st, 2nd or 3rd semester, at the first semester studying at Aalborg University.

4) The student must choose three out of the four course modules. The modules will not be given with a small number of students.

If option C is chosen on the 3<sup>rd</sup> Semester - the study board must approve on the contents before the study is commenced. The amount of ECTS followed at the other university must be 15 or 30 ECTS such that the size of the master's thesis is the remainder of the ECTS up to 60 ECTS for both the 3<sup>rd</sup> and the 4<sup>th</sup> Semester.

If the longer Master's Thesis option is selected, the master's thesis is 45 ECTS and three course modules on the third semester must be selected to reach 60 ECTS for the 3<sup>rd</sup> and 4<sup>th</sup> Semester in total.

The students are given options in the project modules as they can select among different projects within the same general theme. Moreover, the Master's Thesis can be selected freely within the field of structural and civil engineering.

The study board of civil engineering can decide, that the contents of a course module on a semester is taught in the project module in the same semester, by increasing the ECTS extend of the project module by the same number of ECTS. The decision is taken regarding to capacity and/or economy.

## 3.2 Structural and Civil Engineering 1st Semester

### 3.2.1 Introduction to Problem Based Learning within Structural and Mechanical Engineering

*Introduktion til problembaseret læring inden for bygge- og anlægskonstruktion*

#### Objective

Students who complete the module:

#### Knowledge

- Must have knowledge about Problem Based Learning (PBL).
- Must have knowledge about the Aalborg model approach to PBL.
- Must have knowledge about various techniques for planning and management of the group-based project work.
- Must have a basic fundamental knowledge about analytical, numerical and experimental work for estimating the response of a simple structural part (deformations and/or stresses and strains).
- Have a basic knowledge about uncertainties and limitations of different types of modelling and testing when analyzing a simple structural part.

#### Skills

- Must be able to plan and manage a problem-based and project-organized study project carried out by a project group.
- Must be able to communicate project results and processes in a coherent, structured and understandable manner, both in writing, verbally and graphically.
- Must be able to analyze and evaluate own study efforts and learning in relation to a problem-based group work with a view to continued professional development.
- Must be able to analyze and evaluate collective learning processes for joint knowledge development and exchange of experience.
- Be able to perform analytical, numerical and experimental analysis in order to obtain the response of a simple structural part.
- Be able to compare results and reflect upon assumptions and uncertainties.

#### Competencies

- Must be able to engage in, reflect on and optimize own participation in a group-based project.
- Must be able to consciously reflect on and develop own learning.
- Must be able to engage in, reflect on and optimize collective learning processes in relation to analyzing a simple structural part.

#### Type of instruction

Project work with supervision supplemented with instructions lab tests, etc.

#### Exam format

Individual oral exam based on presentation seminar and project rapport.

#### Evaluation criteria

As stated in the Joint Programme Regulations.

### **3.2.2 Problem Based Learning and Project Management**

#### *Problembaseret læring og projektledelse*

##### Objective

The objective is to make newly started Master students coming from institutions other than AAU prepared to enter the problem based learning environment at AAU and manage study projects in close collaboration with peers.

##### Type of instruction

Three half day workshops centered around the individual student working with an individual challenge or curiosity in relation to using a PBL approach. Peer learning is also a hallmark, since the students will discuss and reflect their individual challenges/curiosities in a peer learning group.

##### Learning outcomes

After completion of the course the student should be able to

##### Day 1:

- describe and discuss the Aalborg PBL model based on the three key words: group work, project work, problem orientation
- identify an initial individual challenge when using a PBL approach

##### Day 2:

- develop and practice peer feedback skills
- practice collaborative learning in a group
- design a plan of action to deal with an initial individual PBL challenge or curiosity

##### Day 3:

- practice presentation skills
- practice critical skills when giving feedback to peers
- reflect on own and peer skills in relation to PBL practice

##### Exam format

Internal assessment during the course/class participation according to the rules in the Examination Policies and Procedures of Faculty of Engineering and Science, Aalborg University. In this case the assessment is primarily based on the oral performance during the course, which means that the student has to be active during the course time and participate in discussions. The course is an integrated part of the project for those not acquainted to the Aalborg PBL model, and is a precondition for participation in the project examination. In this way there will be no diploma for the course and it will not be visible on the academic transcripts.

##### Evaluation criteria

As stated in the Joint Programme Regulations.

### 3.2.3 Stiffness Analysis of Load-Bearing Structures

#### *Stivhedsanalyse af bærende konstruktioner*

#### Prerequisite

Students holding a bachelor degree from another university than Aalborg University must pass the module Problem Based Learning and Project Management at Aalborg University, prior to sitting the exam.

The module builds on knowledge gained in the courses Structural Mechanics and Dynamics, Material Modelling in Civil Engineering, Fluid and Water Wave Dynamics.

#### Objective

Students who complete the module:

#### Knowledge

- Know fundamental theories and methods for analysis of structures subject to static loads.
- Understand the behaviour of structures subject to static loading regarding their deformation.
- Understand the solution procedure in Finite Element Analysis of linear elastic static problems.
- Understand methodology for design of experiments and test series and for reduction of ambiguity of experimental results, and for comparability with model predictions.
- Understand elementary and advanced quantification tools, and their application to validation between model and experiment data.
- Have a basic knowledge and understanding of experimental work, including test planning, test conduction, different types of test equipment, modelling of uncertainties and comparison of model and test results using statistical methods.

#### Skills

- Use the correct terminology for structural analysis and design.
- Be able to apply analytical solution methods based on continuum mechanics for selected static problems.
- Be able to develop and implement a Finite Element software code for analysis of a selected simple structure subject to static loading.
- Be able to use a commercial Finite Element code for analysing a given static structural problem.
- Be able to plan and set up a test for determining basic material properties.
- Be able to plan and set up a test for finding the strength and stiffness of a given structure.
- Be able to perform a probabilistic study of the experimental data in order to quantify the influence of individual parameters.
- Be able to scrutinize a model (analytical or numerical) for comparison with an appropriate experimental study.
- Be able to perform a probabilistic study of the model in order to quantify the level of confidence.
- Be able to count for the level of coherence between test results and model predictions.
- Be able to identify invalid data (outliers).
- Be able to account for common errors and limitations in the processing of model data of experimentally obtained data.

### Competencies

- Be able to select appropriate analysis methods for a given structural problem, including analytical, numerical and experimental analysis methods.
- Be able to compare results obtained from different analysis methods and be able to judge the quality of the results.
- Be able to undertake experiment planning and execution for refinement and validation (or rejection) of model-based predictions of phenomena within structural and civil Engineering.
- Be able to quantify errors associated with different types of analysis and evaluate the methods regarding assumptions and simplifications.
- Must be able to communicate the results of the project work in a project report.
- Must be able to contribute successfully to teamwork within the problem area and make a common presentation of the result of the project work.

### Type of instruction

Project work with supervision supplemented with instructions, workshops, presentation seminars, lab tests, etc.

### Exam format

Individual oral exam based on presentation seminar and project rapport.

### Evaluation criteria

As stated in the Joint Programme Regulations.

### 3.2.4 Structural Mechanics and Dynamics

#### *Strukturel Mekanik og Dynamik*

##### Objective

Students who complete the module:

##### Knowledge

- Understand how kinematics of different structural elements are related to general continuum mechanics.
- Understand fundamental properties of structural systems with emphasis on their impact on the dynamic response.
- Know fundamental theories and methods for analysis of dynamic structural response.
- Have an understanding of the solution procedure in Finite Element Analysis of linear elastic dynamic problems.
- Have a basic knowledge and understanding of experimental work related to dynamic testing of structures.

##### Skills

- Use correct terminology for structural dynamic analysis.
- Based on general continuum mechanics, be able to formulate a model for a given structural problem, and based on the assumed kinematics, to establish a finite element formulation with the aid of the principle of virtual work.
- Be able to analyse the dynamic response of single-degree-of-freedom systems.
- Be able to analyse the dynamic response of multi-degree-of-freedom systems.
- Be able to analyse the dynamic response of structures in time domain and frequency domain.
- Be able to conduct modal analysis of structures.
- Develop and implement a Finite Element software code for dynamic analysis of a multi-degree-of-freedom system.
- Be able to use a commercial Finite Element code for analysing the dynamic response of a given structure.
- Be able to plan and set up a test for determining dynamic structural response.

##### Competencies

- Be able to analyse the dynamic response of a civil engineering structure.
- Be able to select appropriate analysis methods for the analysis of dynamic structural response.
- Be able to compare results obtained from different analysis methods and be able to judge the quality of the results.
- Be able to quantify errors associated with different types of analysis and evaluate the methods regarding assumptions and simplifications.

##### Type of instruction

Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests.

##### Exam format

Individual oral or written exam. Exam format is decided on by start of semester.

##### Evaluation criteria

As stated in the Joint Programme Regulations.



### **3.2.5 Material Modelling in Mechanical Design**

*Materialemodellering i maskinteknik*

#### Objective

Students who complete the module:

#### Knowledge

- Understand fundamental properties of structures and construction materials in civil engineering with emphasis on their mechanical response.
- Understand fundamental theories and methods for analysis of structural material behaviour, including elasticity and plasticity.
- 
- Understand fundamental continuum mechanics theories for solids, plates and beams.
- Have a basic knowledge and understanding of experimental work related to calibration of material models.

#### Skills

- Use correct terminology regarding the behaviour and modelling of construction materials.
- Be able to formulate a constitutive model for the behaviour of a construction material.
- Be able to set up the static, kinematic and constitutive relations for solving a mechanical problem.
- Be able to apply the principle of virtual work in solving mechanical problems.
- Be able to apply classical elastic and plastic material models for simulating structural material behaviour.

#### Competencies

- Be able to analyse the behaviour of structures and construction materials.
- Be able to select and apply appropriate material models for the analysis of structural behaviour under different load conditions.
- Be able to compare results obtained by different constitutive models and be able to judge the quality of the results.
- Be able to compare results obtained by different structural models and be able to judge the quality of the results.

#### Type of instruction

Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests.

#### Exam format

Individual oral or written exam. Exam format is decided on by start of semester.

#### Evaluation criteria

As stated in the Joint Programme Regulations.

### 3.2.6 Fluid and Water Wave Dynamics

*Strømningslære og bølgehydraulik*

#### Objective

Students who complete the module:

#### Knowledge

- Must have knowledge about fluid kinematics.
- Must have knowledge about stresses in fluids, equation of motion, constitutive models and Navier-Stokes equations.
- Must have knowledge about ideal fluids and potential flows, including application of potential theory to simple problems for example circular cylinder and calculation of hydrodynamic mass.
- Must have knowledge and understanding of Reynolds averaging and turbulence models.
- Must be able to describe turbulent and laminar boundary layers including understanding of momentum equation for boundary layers.
- Must be able to describe wind generated waves.
- Must understand the application of potential theory to linear surface waves on a horizontal bed, including description and linearisation of boundary conditions, solving Laplace equation and the dispersion equation.
- Kinematic and dynamic description of linear surface waves, including particle velocities and accelerations, pressure field, particle paths, wave energy, energy flux and group velocity.
- Description of waves in shallow water, i.e. shoaling, refraction, diffraction and wave breaking.
- Statistical description of waves in time and frequency domain.

#### Skills

- Must be able to describe assumptions and limitations of mathematical models for different types of flows.
- Must be able to apply analytical and semi-empirical methods for mathematical description of fluid dynamic problems.
- Must be able to calculate of kinematics and dynamics of regular linear waves on deep and shallow water.
- Must be able to analyse irregular waves in time and frequency domain.

#### Competencies

- Must be able to apply proper terminology in oral, written and graphical communication and documentation within fluid and water wave dynamics.

#### Type of instruction

Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests.

#### Exam format

Individual oral or written exam. Exam format is decided on by start of semester.

#### Evaluation criteria

As stated in the Joint Programme Regulations.

### **3.3 Structural and Civil Engineering 2nd Semester**

#### **3.3.1 The Excitation and Foundation of Marine Structures**

*Marine konstruktioners belastning og fundering*

##### Prerequisites

The module adds to the knowledge obtained in 1<sup>st</sup> Semester.

##### Objective

Students who complete the module:

##### Knowledge

- Must have knowledge about design rules for marine structures including methods for deterministic and probabilistic assessment of loads on marine structures.
- Must have knowledge about analytical, numerical and experimental methods for investigation of marine and geotechnical problems.

##### Skills

- Must be able to perform a marine and geotechnical site assessment and a design basis.
- Must be able to apply advanced numerical and experimental methods for analysis and assessment of loads and geotechnical response of marine structures.
- Must be able to compare and evaluate limitations and uncertainties related to simple and advanced methods for estimation of environmental load as well as geotechnical bearing capacity and deformations.
- Must be able to evaluate the safety by application of probabilistic methods for assessment of loads and bearing capacity of marine structures.

##### Competencies

- Must be able to apply proper terminology in oral, written and graphical communication and documentation of problems and solutions within marine structures.
- Must have an overview of design aspects related to marine structures.
- Must be able to communicate the results of the project work in a project report.
- Must be able to contribute successfully to teamwork within the problem area and make a common presentation of the result of the project work.

##### Type of instruction

Project work with supervision supplemented with instructions, workshops, presentation seminars, lab tests, etc.

##### Exam format

Individual oral exam based on presentation seminar and project rapport.

##### Evaluation criteria

As stated in the Joint Programme Regulations.

### **3.3.2 Coastal, Offshore and Port Engineering**

#### *Vandbygning*

#### Prerequisites

The module adds to the knowledge obtained in Fluid and Water Wave Dynamics.

#### Objective

Students who complete the module:

#### Knowledge

- Must have knowledge about non-linear waves, including 2<sup>nd</sup> and 5<sup>th</sup> order and stream function theory.
- Must have knowledge about methods for extreme climate analysis.
- Must have knowledge about currents and water level variations in the coastal zone.
- Must have knowledge about environmental loads on coastal, offshore and port structures including ice, wave, current and wind loads.
- Must have knowledge about sediment transport, scour and scour protection.
- Must have knowledge about port layout and design of breakwaters.

#### Skills

- Must be able to calculate design wave height from wave observations.
- Must be able to make a conceptual calculation of characteristic wave loads for coastal, offshore and port structures.

#### Competencies

- Must be able to apply proper terminology in oral, written and graphical communication and documentation within coastal, offshore and port engineering.

#### Type of instruction

Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests

#### Exam format

Individual oral or written exam. Exam format is decided on by start of semester.

#### Evaluation criteria

As stated in the Joint Programme Regulations.

### **3.3.4 Risk and Reliability in Engineering**

*Risiko og sikkerhed af konstruktioner*

#### Prerequisites

The module adds to the knowledge obtained in Probability Theory and Statistics.

#### Objective

Students who complete the module:

#### Knowledge

- Understand the concepts risk, uncertainty, reliability and safety.
- Know statistical methods for modeling physical, model, statistical and measurement uncertainties.
- Know methods for assessment of reliability of structural systems using probabilistic methods.
- Know methods for systems reliability for non-structural components and its applications in engineering.

#### Skills

- Be able to model physical, statistical, model and measurement uncertainties.
- Be able to use failure rates and hazard functions to model failures in systems reliability for non-structural components.
- Be able to model uncertainties for loads and strengths.
- Be able to estimate the reliability by FORM/SORM methods (reliability index method) and by simulation.
- Be able to model system behavior and estimate the reliability of series and parallel systems.
- Understand basic concepts of stochastic processes and time-variant reliability methods.
- Be able to estimate characteristic and design values for strength parameters and load bearing capacities, and for environmental loads and load effects using test data and measurements.
- Be able to calibrate partial safety factors and load combination factors.
- Be able to apply Bayesian statistical methods.
- Be able to apply risk and reliability methods for probabilistic design of engineering structures such as buildings, bridges, offshore structures, coastal structures, wind turbines etc.
- Use correct professional terminology.

#### Competencies

- Be able to participate in a dialog on modelling of uncertainties, risk analysis and assessment of reliability of structural and non-structural components and systems.
- Be able to model, calculate and communicate risk analysis, modelling of uncertainties and assessment of reliabilities for engineering problems.

#### Type of instruction

Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests.

Exam format

Individual oral or written exam. Exam format is decided on by start of semester.

Evaluation criteria

As stated in the Joint Programme Regulations.

### **3.3.5 Advanced Structural Engineering**

#### *Avancerede konstruktionsanalyser*

#### Prerequisites

The module adds to the knowledge obtained in 1<sup>st</sup> Semester.

#### Objective

Students who complete the module:

#### Knowledge

- Should have basic knowledge about non-linear effects in structural response, i.e. influence of large displacements, plasticity or other non-linear material behavior and dynamic effects.
- Should have knowledge about advanced structural analysis and its applications in engineering.
- Should have knowledge about non-linear behavior of thin-walled structures i.e. buckling and postbuckling behavior and influence of geometric imperfections.
- Should have knowledge of modelling joints in structures linear as well as non-linear.
- Should have knowledge about non-linear Finite Element analysis of thin-walled structures.

#### Skills

- Should be able to formulate a mechanical/mathematical model for structures behaving non-linearly.
- Should be able to formulate geometrically non-linear models for thin-walled structures involving buckling, postbuckling and imperfection sensitivity.
- Should be able to estimate the stability load for simplified thin-walled structures based on analytical models.
- Should be able to formulate mechanical/mathematical models for joints in structures e.g. flexible joints in frame structures.
- Should have sufficient background to choose an appropriate numerical model i.e. type of element and type of non-linear solution algorithm.
- Should be able to analyze a structure/structural component by a non-linear Finite Element code.
- Should be able to verify the numerical results from Finite Element calculations by analytical models or other simplified models.
- Should be able to interpret the results from a non-linear Finite Element calculation.

#### Competencies

- Should be able to participate in non-linear analysis of engineering structures and participate in a dialog on structural modifications in order to improve the structural response.
- Should be able to model and analyze thin-walled structures with geometric non-linear behavior and participate in a dialog of non-linear analysis of other structures.

#### Type of instruction

Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests.

Exam format

Individual oral or written exam. Exam format is decided on by start of semester.

Evaluation criteria

As stated in the Joint Programme Regulations.



### **3.4 Structural and Civil Engineering 3<sup>rd</sup> Semester**

#### **3.4.1 Analysis and Solution of Advanced Civil and/or Structural Engineering Problems**

*Analyse og løsning af avancerede problemer indenfor byggeri og/eller anlæg*

##### Prerequisites

The module adds to the knowledge obtained in 1st and 2nd Semester.

##### Objective

Students who complete the module

##### Knowledge

- Must have knowledge about analytical, numerical and experimental methods for investigation of the chosen problem.

##### Skills

- Must be able to apply advanced analytical and/or numerical and/or experimental methods for analysis and assessment of the chosen problem.
- Must be able to compare and evaluate limitations and uncertainties related to the methods used for solving the chosen problem.

##### Competencies

- Must be able to apply proper terminology in oral, written and graphical communication and documentation of problems and solutions within the chosen field.
- Must be able to communicate the results of the project work in a project report.
- Must be able to contribute successfully to teamwork within the problem area and make a common presentation of the result of the project work.

##### Type of instruction

Project work with supervision supplemented with instructions, workshops, presentation seminars, lab tests, etc.

##### Exam format

Individual oral exam based on presentation seminar and project rapport.

##### Evaluation criteria

As stated in the Joint Programme Regulations.

### **3.4.2 Renewable Energy Structures: Wind Turbines and Wave Energy Devices**

*Konstruktioner til vedvarende energi: vindmøller og bølgeenergianlæg*

#### Prerequisites

The module adds to the knowledge obtained in Structural Mechanics and Dynamics, Risk and Reliability in Engineering, Fluid and Water Wave Dynamics, Coastal, offshore and port engineering.

#### Objective

Students who complete the module:

#### Knowledge

- Understand basic functioning of wind turbines and wave energy devices.
- Know methods for design of main structural components for wind turbines and wave energy devices.

#### Skills

- Be able to assess wave energy resources and wave loads on wave energy devices.
- Be able to assess load effects in structural elements in wave energy devices, and verification for ULS and fatigue limit states.
- Be able to assess correlation between wind wave and current, incl. weather windows.
- Be able to apply methods for verification of sufficient reliability of wind turbines.
- Be able to apply basic aerodynamics, aeroelasticity and rotordynamics for wind turbines.
- Be able to assess wind energy resources.
- Be able to assess load effects in structural elements in wind turbines, and verification for ULS and fatigue during operation and stand-still.
- Use correct professional terminology.

#### Competencies

- Be able to understand and communicate basic design problems for wind turbines and wave energy devices.

#### Type of instruction

Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests.

#### Exam format

Individual oral or written exam. Exam format is decided on by start of semester.

#### Evaluation criteria

As stated in the Joint Programme Regulations.

### 3.4.3 Wind Loads on Structures

*Vindlast på konstruktioner*

#### Prerequisites

The module adds to the knowledge obtained in Structural Mechanics and Dynamics, Risk and Reliability in Engineering.

#### Objective

Students who complete the module

#### Knowledge

- Understand the nature of wind: wind profile, mean wind, extreme wind, turbulence, turbulence field – for applications for structures such as buildings, bridges and wind turbines.
- Understand modelling and calculation of wind loads on civil engineering structures
- Understand stochastic processes, stochastic dynamics and wind actions on structures.
- Understand basic stochastic dynamics and its applications in engineering, especially for wind actions.

#### Skills

- Be able to apply methods for stochastic dynamics for application in engineering, especially for wind actions.
- Be able to calculate static and dynamic wind loads on buildings.
- Be able to assess cross-wind load actions such as rhythmic vortex shedding and galloping.
- Be able to assess structures exposed to wind load in ULS and SLS (comfort).
- Be able to apply rules for wind actions in design codes.
- Be able to assess wind loads on bridges.
- Use correct professional terminology.

#### Competencies

- Be able to model, calculate and communicate wind loads on civil engineering structures.

#### Type of instruction

Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests.

#### Exam format

Individual oral or written exam. Exam format is decided on by start of semester.

#### Evaluation criteria

As stated in the Joint Programme Regulations.

### **3.4.4 Fracture Mechanics and Fatigue**

*Brudmekanik og udmattelse*

#### Prerequisites

The module adds to the knowledge obtained in Structural Mechanics.

#### Objective

Students who complete the module:

#### Knowledge

- Have gained a comprehensive understanding of fracture mechanics.
- Have gained knowledge in applying classical methods in designing against fatigue fracture by studying notches and their effect, by studying strainfatigue, and by analysing eigen-stress states.
- Have gained an understanding of how to apply fracture mechanics in the assessment of reliability of practical designs and machine elements.

#### Skills

- Be able to assess the stability of cracks using Griffith's and Irwin's fracture criteria, energy release rate, and toughness concepts.
- Be able to apply linear elastic solutions for sharp cracks and obtain the stress intensity factor.
- Be able to assess mixed mode loading and apply crack growth direction hypotheses.
- Be able to assess crack growth by fatigue, partial damage and load spectra.
- Be able to assess crack initiation, notches and their effect.
- Be able to determine life time and apply methods for improving the fatigue strength and life time of machine elements and welded details.

#### Competencies

- Be able to understand and apply linear elastic concepts in assessing the stability of cracked structures under static and fatigue loading.
- Be able to distinguish between different fatigue regimes, i.e. elastic or plastic, and un-cracked or pre-cracked, and apply correct methodology to each case in relevant structures.
- Be able to determine the lifetime of welded components, and explain fatigue in welded components on the basis of fracture mechanical concepts.

#### Type of instruction

Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests.

#### Exam format

Individual oral or written exam. Exam format is decided on by start of semester.

#### Evaluation criteria

As stated in the Joint Programme Regulations.

### **3.4.5 Advanced Geotechnical Engineering**

*Videregående geoteknik*

#### Prerequisites

The module adds to the knowledge obtained in Material Modelling in Civil Engineering and Advanced Soil Mechanics.

#### Objective

Students who complete the module

#### Knowledge

- Understand and use numerical methods, e.g. finite element method, to analyse soil-structure interaction problems for various geotechnical structures.
- Establish model for analysis of excavations and tunnel construction in urban areas.
- Have knowledge about common types of excavations, tunnels and problems related to the construction works.
- Finite-element analysis of wave propagation from earthquake, pile driven and traffic.
- Cyclic response and liquefaction of soil.

#### Skills

- To analyse and design complex geotechnical structures.
- To understand the basis of, and to use (with computers) numerical methods to solve deformation and failure problems for selected geotechnical structures.

#### Competencies

- Application of proper terminology in oral, written and graphical communication and documentation within geotechnical engineering.

#### Type of instruction

Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests.

#### Exam format

Individual oral or written exam. Exam format is decided on by start of semester.

#### Evaluation criteria

As stated in the Joint Programme Regulations.

### **3.4.6 Academic Internship**

*Projektorienteret forløb i en virksomhed*

#### Prerequisites

The module adds to the knowledge obtained in 1st and 2nd semester.

#### Objective

Students who complete the module

#### Knowledge

- Must have knowledge about analytical, numerical and/or experimental methods for investigation of advanced problems within the company's field.

#### Skills

- Must be able to apply advanced analytical, numerical and/or experimental methods for analysis and assessment of advanced problems within the company's field.
- Must be able to compare and evaluate limitations and uncertainties related to the methods used for solving advanced problems within the company's field.

#### Competencies

- Must be able to apply proper terminology in oral, written and graphical communication and documentation of problems and solutions within the company's field.
- Must be able to communicate the results of the project work in a project report.

#### Type of instruction

Internship in a company and project work. The study board must approve on the content of the project work before the internship is commenced.

#### Exam format

Individual oral exam based on presentation seminar and project rapport.

#### Evaluation criteria

As stated in the Joint Programme Regulations.

## 3.5 Structural and Civil Engineering 4<sup>th</sup> Semester

### 3.5.1 Master's Thesis

#### *Kandidatspeciale*

The master thesis can be conducted as a long master thesis using both the 3<sup>rd</sup> and 4<sup>th</sup> Semester. If choosing to do a long master thesis, it has to include experimental work and has to be approved by the study board. The amount of experimental work must reflect the allotted ECTS.

#### Prerequisites

The module adds to the knowledge obtained in the first three semesters of the master programme.

#### Objective

After completion of the project, the student should within the following topics:

#### Knowledge

- Have knowledge and comprehension within the field of the specialization at the highest international level.
- Be able to critically evaluate knowledge and identify new scientific problems within the field of the specialization.
- Have understanding of implications within the related research area including research ethics.

#### Skills

- Independently explain choice of scientific theoretical and/or experimental methods.
- During the project and when finalising it make an independent and critical estimation of the chosen theories and methods as well as the analyses, results and conclusions.
- Be able to apply a wide range of engineering methods in research and development in the field of specialization.
- Be able to communicate relevant scientific and professional aspects of project work in a clear and systematic way both to specialists and the public.

#### Competencies

- Be able to work independently with a project on a specific problem within the field of the specialization at the highest international level.
- Independently be able to define and analyse scientific problems and based on that make and state the reasons for the decisions made.
- Be competent to solve new and complicated technical problems by the use of advanced mathematics, scientific and technological knowledge.
- Be able to evaluate the progress of the project independently and select and include additional literature, experiments or data when needed in order to maintain a scientific basis for the project.
- Be able to control complex and unexpected working situations and be able to develop new solutions.
- Must be able to communicate the results of the project work in a project report.

#### Type of instruction

Project work with supervision supplemented with instructions, workshops, presentation seminars, lab tests, etc.

Exam format

Individual oral exam based on presentation seminar and project rapport.

Evaluation criteria

As stated in the Joint Programme Regulations.



## **Chapter 4: Entry into Force, Interim Provisions and Revision**

The curriculum is approved by the Dean of the Faculties of Engineering, Science and Medicine and enters into force as of 1 September 2017.

Students who wish to complete their studies under the previous curriculum from 2010 must conclude their education by the summer examination period 2018 at the latest, since examinations under the previous curriculum are not offered after this time.

## **Chapter 5: Other Provisions**

### **5.1 Rules concerning written work, including the Master's thesis**

In the assessment of all written work, regardless of the language it is written in, weight is also given to the student's spelling and formulation ability, in addition to the academic content. Orthographic and grammatical correctness as well as stylistic proficiency are taken as a basis for the evaluation of language performance. Language performance must always be included as an independent dimension of the total evaluation. However, no examination can be assessed as 'Pass' on the basis of good language performance alone; similarly, an examination normally cannot be assessed as 'Fail' on the basis of poor language performance alone.

The Board of Studies can grant exemption from this in special cases (e.g., dyslexia or a native language other than Danish).

The Master's thesis must include an English summary.<sup>1</sup> If the project is written in English, the summary must be in Danish.<sup>2</sup> The summary must be at least 1 page and not more than 2 pages. The summary is included in the evaluation of the project as a whole.

### **5.2 Rules concerning credit transfer (*merit*), including the possibility for choice of modules that are part of another programme at a university in Denmark or abroad**

In the individual case, the Board of Studies can approve successfully completed (passed) programme elements from other Master's programmes in lieu of programme elements in this programme (credit transfer). The Board of Studies can also approve successfully completed (passed) programme elements from another Danish programme or a programme outside of Denmark at the same level in lieu of programme elements within this curriculum. Decisions on credit transfer are made by the Board of Studies based on an academic assessment. See the Joint Programme Regulations for the rules on credit transfer.

### **5.3 Rules for examinations**

The rules for examinations are stated in the Examination Policies and Procedures published by The Technical Faculty of IT and Design, The Faculty of Engineering and Science, and the Faculty of Medicine on their website.

### **5.4 Exemption**

In exceptional circumstances, the Board of Studies study can grant exemption from those parts of the curriculum that are not stipulated by law or ministerial order. Exemption regarding an examination applies to the immediate examination.

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<sup>1</sup> Or another foreign language (upon approval from the Board of Studies).

<sup>2</sup> The Board of Studies can grant exemption from this.

### **5.5 Rules and requirements for the reading of texts**

At programmes taught in Danish, it is assumed that the student can read academic texts in modern Danish, Norwegian, Swedish and English and use reference works, etc., in other European languages. At programmes taught in English, it is assumed that the student can read academic text and use reference works, etc., in English.

### **5.6 Additional information**

The current version of the curriculum is published on the Board of Studies' website, including more detailed information about the programme, including exams.