Civil and Architectural Engineering

Study plan for third-cycle subject

The subject plan was approved by Fakultetsnämnden (Faculty Board) November 30, 2010. Valid from Spring 11.

Subject title

Civil and Architectural Engineering (Byggvetenskap)

Subject description and programme outcomes

Scientific field

The subject of Civil and Architectural Engineering at the doctoral level includes scientific studies of buildings as technical systems. Both houses and civil engineering constructions are treated. The focus on the public construction sector has traditionally been on new construction but is now also focused on operational and maintenance aspects. This is reflected in the research profile within Civil and Architectural Engineering. The wide-ranging expertise at the Department of Civil and Architectural Engineering provides a solid foundation for treating buildings as technical systems in a professional manner as well as processing and solving technical problems related to building and construction.

This version of the programme description with attachments is valid for PhD students admitted to the programme during 2011-01-01 until 2013-12-31.

Description of possible specialisation

1. Common for all specialisations
2. Concrete Structures
3. Structural Design and Bridges
4. Building Materials Technology
5. Building Technology
6. Building Services Engineering
7. Soil and Rock Mechanics
8. Fluid and Climate Theory

Specification of how the programme outcomes are to be achieved

The goals for the education are achieved through courses according to the individual study plan, participation in seminars, participation in national and international conferences and through supervision.

Common for all specialisations

Description of the specialisation

The areas of specialisation in Civil and Architectural Engineering deal with applied technical areas of industrial relevance and high scientific potential. The subject has seven areas of specialisation:

- Concrete Structures
- Structural Design and Bridges
- Building Materials Technology
• Building Technology
• Building Services Engineering
• Soil and Rock Mechanics
• Fluid and Climate Theory

All areas of specialisation are based on the fundamental science subjects of physics, mechanics, chemistry and mathematics. The basics are also widely shared in engineering sciences. Important fundamentals exist in structural mechanics, flow mechanics, materials science and thermo-dynamics.

Current research
See each section for the relevant specialisation.

Programme structure
Doctoral studies consist of coursework and a thesis/dissertation part. Coursework may be in the form of lectures, literature studies and problem-solving. Courses can be studied within the department or in collaboration with other national and international research institutions. The introductory section of doctoral studies includes obligatory courses. The coursework may include participation in project implementation tasks that prepare the student for independent work as a researcher.

Studies are conducted under the direction of one principal supervisor and one or more assistant supervisors in accordance with an individual study plan approved by the doctoral officer. Students’ individual study plans will be adapted to their dissertation/thesis. Doctoral students’ progress will be assessed at least once a year in connection with the review of the individual study plan, carried out jointly by students and principal supervisors.

Doctoral students should participate in national and international conferences in their fields of knowledge, and publish research results in international scientific journals.

Compulsory and recommended courses
The coursework for both licentiate and doctoral degrees consists of courses in obligatory fields of knowledge and recommended courses in specialised areas of research and related subjects. Courses listed as advanced courses in other area of specialisation are recommended as broadening courses in an area of specialisation. The courses will be studied in accordance with the agreement made between students and their main supervisors, as documented in the individual study plan.

The licentiate degree consists of courses of 30 ECTS and a dissertation part of 90 ECTS, totalling 120 ECTS.

The doctor's degree consists of courses of 60 ECTS and a thesis part of 180 ECTS, totalling 240 ECTS.

Compulsory courses
All areas of specialisation in the subject of Civil and Architectural Engineering require compulsory courses equivalent to at least 22.5 ECTS for both the licentiate degree and doctor's degree. Advanced courses vary with the area of specialisation and are specified below in sections 3-10. The obligatory courses shall be completed before the licentiate degree, or when 50% of the work for a doctoral thesis has been completed, and course credits are as follows:

• Specialisation advanced studies (see sections 3–10) 7.5 ECTS Advanced course
• 1N5113 Scientific theory and research methodology 7.5 ECTS Research skills course
• AF3008 Research within Civil and Architectural Engineering 7.5 ECTS Broadening course

Recommended, optional courses
Courses that are recommended for a single area of specialisation are specified for each specialisation according to the following sections. It is also recommended for all areas of specialisation in the subject of Civil and Architectural Engineering, to take courses listed below as recommended research skills courses:
Doctoral students who teach in education at first or second levels must have completed initial university teacher training.

**Compulsory research proficiency courses**
- 1N5113 Theory of Science and Research Method, Technological and Natural Sciences 7.5 hp.

**Compulsory broad-based courses**
- AF3008 Research within Civil and Architectural Engineering 7.5 hp.

**Recommended research proficiency courses**
- SF2950 Applied Mathematical Statistics 7.5 hp.
- LS2429 Technical Communication in English 7.5 hp.
- SF3626 Mathematical Analysis for PhD - Students 7.5 hp.
- SF2739 Partial Differential Equations 7.5 hp.
- SF2520 Applied Numerical Methods 7.5 hp.

**Thesis**
The dissertation/thesis is an obligatory part of doctoral studies. A licentiate dissertation or doctoral thesis may be either written as a monograph or as a compilation of scientific articles. In the latter case there must be a specially written summary. The dissertation/thesis is normally written in English, with a summary in Swedish. A doctoral thesis may be based on a licentiate dissertation.

A licentiate thesis shall contain an application of existing scientific knowledge in an area that the student has developed through theoretical or empirical research. It will also include an overview of previous research in the chosen subject. Whether the licentiate dissertation is presented as a monograph or as a compilation of scientific articles, it should be of such quality that it is deemed to be a possible basis for at least two normal articles published in internationally recognized peer reviewed journals.

A doctoral thesis shall contain new theoretical or empirical research results in the chosen field that the student has developed through theoretical or empirical research. It shall also include an overview of previous research in the chosen field. Whether the thesis is presented as a monograph or as a compilation of scientific articles, it should be of such quality that it is deemed to be a possible basis for at least four normal articles published in internationally recognized peer reviewed journals.

**Concrete Structures**

**Description of the specialisation**
The specialisation in Concrete Structures deals with performance, modelling, dimensioning and constructive design of reinforced and pre-stressed concrete structures, fibre concrete, lightweight concrete and several cement-based materials and masonry constructions. Analyses of methods of construction, maintenance, repair and reinforcement are included.

The aim of the specialisation in Concrete Structures is for students to acquire scientific knowledge of the methods necessary for research and advanced studies in the field and its application in the public and private sectors.

**Current research**
Research is currently being conducted in the following areas:
- Concrete structures for rock reinforcement
- Concrete material properties at early ages
- Advanced analysis of large concrete structures
- Protective structures in concrete and rock

**Programme structure**
See *Common for all specialisations.*
**Compulsory and recommended courses**

For the specialisation in Concrete Structures, the compulsory advanced course is 1L5101 Project in Concrete Structures 7.5 ECTS. It is recommended that any/some of the courses listed below as recommended research skills courses are included in the study plan.

**Compulsory in-depth courses**

- 1L5101 Project in Concrete Structures 7.5 hp.

**Recommended in-depth courses**

- AF3212 Non-Linear FEM Civil Engineers 7.5 hp.
- AF3115 Concrete and Other Cement Based Materials 7.5 hp.
- AF3201 Advanced Structure Dynamics, Modelling and Measurements 7.5 hp.

**Thesis**

See *Common for all specialisations*.

**Structural Design and Bridges**

**Description of the specialisation**

The specialisation in Structural Design and Bridges covers planning and design of structures and bridges for new construction and renewal, considering structural capacity, stability, reliability, functionality and durability. This specialisation also includes design and analysis of structural components of steel, aluminium and timber and steel in composite action with other materials such as gypsum and plastics.

The aim of the doctoral programme in structural design and bridges is for students to acquire scientific knowledge on the methods necessary for research and advanced investigative work in the field and its applications in the public and private sectors.

**Current research**

Research is currently being conducted in the following areas:

- Static and dynamic traffic loads and traffic load effects on bridges - measurement and numerical simulation
- Long-term evaluation of the static and dynamic performance of bridges
- Life-cycle optimization of structures regarding cost and environmental impact
- Development of systems for optimizing the safety of bridges and structures
- Structures based on soil-structures interaction
- Development of new, safe, environmentally- and cost-effective bridge and building structures
- Temporary structures, scaffoldings and formworks
- Floor and road structures in concrete
- Operation, maintenance and strengthening of bridges
- Development and application of advanced analysis methods for structures
- Development of design standards for steel and aluminium structures.

**Programme structure**

See *Common for all specialisations*.

**Compulsory and recommended courses**

For the specialisation in Structural Design and Bridges, the compulsory advanced course is AF3005 Project in Structural Engineering 7.5 ECTS. It is recommended that any/some of the courses listed below as recommended research skills courses are included in the study plan.
Compulsory in-depth courses

- AF3005 Project in Structural Engineering 7.5 hp.

Recommended in-depth courses

- AF3201 Advanced Structure Dynamics, Modelling and Measurements 7.5 hp.
- 1C5034 Qualified Bridge Structures 7.5 hp.
- AF3212 Non-Linear FEM Civil Engineers 7.5 hp.

Thesis

See Common for all specialisations.

Building Materials Technology

Description of the specialisation

The area of specialisation in building materials technology includes theoretical and experimental analysis of building materials and the properties of building elements in general and long-term performance in particular, with special attention given to the uses and environmental factors. Both the analysis and modelling of degradation processes of individual materials in their intended use as well as measurement, characterization and modelling of environmental degradation are included in the area. Research in the area of specialisation aims to provide a basis for materials selection during the design, maintenance planning, life cycle evaluation and calculation of lifetime costs. Environmental consideration and resource optimization in construction and the built environment are strong driving forces for research.

An important area in research and doctoral studies in the area of building materials technology is the study of building materials' properties and behaviour in different environments based on fundamental materials physics and chemistry. There are currently several areas of specialisation in this field, such as building materials' environmental stress and long-term properties of materials, structural components and buildings. The area also includes characterization and modelling of the degradation environment and life planning of buildings. In connection with studies of individual materials'/products' degradation and long-term performance, research is also conducted into alternative materials such as wood composites, materials for production, utilization of residues from industrial processes and reuse of building materials, such as after filler material has been used in its primary function.

Current research

Research is currently being conducted in the following areas:

- Insulation materials' function over time
- Wood or biobased composites as building materials
- Aerogels as insulation materials

Programme structure

See Common for all specialisations.

Compulsory and recommended courses

For the specialisation in Building Materials Technology, the compulsory advanced course is AF3302 Project in building materials technology 7.5 ECTS. It is recommended that any/some of the courses listed below as recommended research skills courses are included in the study plan.

Compulsory in-depth courses

- AF3302 Project in Building Materials Technology 7.5 hp.

Recommended in-depth courses

- 1D5109 Moisture Mechanics 7.5 hp.
- 1L5303 Wood Physics 7.5 hp.
- 1D5132 Wood Science 7.5 hp.
- 1D5104 Degradation Mechanisms & Service Life of Building Material 7.5 hp.

**Thesis**

See *Common for all specialisations.*

**Building Technology**

**Description of the specialisation**

The subject area of the specialisation includes development by design, construction and dimensioning, and also by the building process, to improve building constructions and in particular the building envelope to achieve moisture safety, energy efficiency and a healthy indoor climate. Also building acoustics is included.

The aim of the research work is to apply fundamental and specific knowledge within the area of building technology together with experiences from other fields within natural sciences and technology, to adapt the behaviour of building constructions to the needs of their users within the limits provided by a sustainable society and with regard to the above mentioned aspects.

**Current research**

Research is currently being conducted in the following areas:

- Buildings: technical design, with development and innovations
- Planning and monitoring of experimental buildings, including consideration of the construction process
- Analysis of technical functions based on the application of building physics and empirical evaluations
- Materials' function and durability in construction with respect to dampness and other factors
- Development of theory, measurement techniques and methodology used in building physics with moisture processes
- Development of tools for building physics analyses in both for research in building technology and for the practice
- Analysis of energy flows in buildings and their surroundings for the development of methods to reduce energy use, both regarding quantity and quality.

**Programme structure**

See *Common for all specialisations.*

**Compulsory and recommended courses**

For the specialisation in Building Material, the compulsory advanced course is 1D5223 Low- Energy and Sustainable Construction 7.5 ECTS.

It is recommended that any/some of the courses listed below as recommended research skills courses are included in the study plan.

**Compulsory in-depth courses**

- 1D5223 Low- Energy and Sustainable Construction 7.5 hp.

**Recommended in-depth courses**

- AF3401 Dampness in Buildings 7.5 hp.
- 1L5401 Modeling of Thermal Processes in Building 7.5 hp.
- 1D5224 Building Physics- Measurement Techniques 7.5 hp.

**Thesis**

See *Common for all specialisations.*
Building Services Engineering

**Description of the specialisation**

The area of specialisation in Building Services Engineering deals with space conditioning systems for (high-performance) buildings, installations for water supply, electricity, communications, and other technical systems including sanitary, transport and other subsystems. The interactions between users (human systems) and technical systems are studied, as are the cross-relations between buildings and surrounding (e.g. urban) systems. Intelligent building control and performance assessment systems, as well as low- and near-zero energy/emission systems for the built environment are additional key research areas.

The purpose of doctoral studies in Building Services Engineering is for students to acquire scientific knowledge on the methods necessary for research and advanced investigative studies in the field and their applications in the public and private sectors.

**Current research**

Current research and doctoral studies in the domain of Building Services Engineering are mainly focused on space conditioning and other building services for high-performance buildings, including relevant aspects of human-technical system interaction. Research is further conducted into the control of airborne contaminants in industrial environments with relevance to the protection of personnel and industrial processes.

Research is currently being conducted in the following areas:

- Indoor climate modelling in buildings
- Protective and special-purpose ventilation
- Automatic fault detection in installations (FDD)
- Operational safety and service quality in HVAC-systems
- Intelligent control systems for buildings
- Tunnel ventilation

**Programme structure**

See Common for all specialisations.

**Compulsory and recommended courses**

For the specialisation in Building Services Engineering, the compulsory advanced course is 1D5998 Project in Building Services Engineering 7.5 ECTS. It is recommended that any/some of the courses listed below as recommended research skills courses are included in the study plan.

**Compulsory in-depth courses**

- 1D5998 Project in Building Services Engineering 7.5 hp.

**Recommended in-depth courses**

- 1D5301 Fluid Mechanics 7.5 hp.
- 1D5302 Heat Transfer 7.5 hp.
- 1D5304 Climate Technology, Systems 7.5 hp.

**Thesis**

See Common for all specialisations.
Soil and Rock Mechanics

Description of the specialisation

The area of specialisation in Soil and Rock Mechanics consists of theoretical and experimental studies of various soil and rock mechanics problems related to construction activities and public building.

The aim of doctoral studies in Soil and Rock Mechanics is for students to master the area of knowledge to a sufficient depth to engage in advanced projects with a strong focus on expert knowledge or scientific work in both private and public sectors.

Current research

Research is currently being conducted in the following areas:

- Ground improvement
- Geoconstructions
- Vibrations from traffic and other construction activities
- Grouting of rock masses
- Tunneling with little or no rock cover
- Tunnel design
- Foundation of heavy constructions on rock
- Risk analysis of work in soil and rock

Programme structure

See Common for all specialisations.

Compulsory and recommended courses

For the specialisation in Soil and Rock Mechanics, the compulsory advanced course is AF3604 Soil Mechanics 7.5 ECTS. It is recommended that any/some of the courses listed below as recommended research skills courses are included in the study plan.

Compulsory in-depth courses

- AF3604 Soil Mechanics 7.5 hp.

Recommended in-depth courses

- AF3601 Literature Course - Vibrations of Soils and Foundations 6.0 hp.
- AF3605 Underground Excavation in Rock 7.5 hp.
- AH3452 Risk Analysis 7.5 hp.
- AF3602 Theoretical Rock Mechanics 7.5 hp.
- AF3603 Information Based Design in Soil and Rock Mechanics 7.5 hp.
- 1B5422 Geotechnology 7.5 hp.

Thesis

See Common for all specialisations.

Fluid and Climate Theory

Description of the specialisation

The area of specialisation in Fluid and Climate Theory includes the theory, models and technical solutions that contribute to a favourable development of health, comfort and safety in construction and the built environment. In order to succeed with investigations in this area where traditional measurement techniques encounter economic and technical difficulties, new advanced simulation software is being developed and applied. Computational fluid dynamics (CFD) and modern visualization methods have clearly created new opportunities for understanding the important connections.
in this area. Theoretical work includes the use of the finite volume method and associated turbulence modelling. Key elements of research methodology are mathematical modelling and analysis, numerical computation techniques and methods of validation for calculated results. Thermodynamic processes and heat transfer mechanisms for efficient and sustainable energy solutions are included. Technical solutions are developed in collaboration with industry. Research will help to create optimum air quality and thermal comfort in indoor environments and promote sound energy use and, in the long-term, improve human health, welfare and productivity at work.

Current research
Research is currently being conducted in the following areas:

- Air pollution in indoor environments. Measures are being studied to reduce exposure in various indoor environments (schools, offices, health units, residences), and exposure effects on health, welfare and productivity at work.
- Efficient, environmentally friendly heating and thermal comfort. Heat transfer to indoor air and heat distribution in rooms with low supply temperatures are studied. Heat exchanging surfaces and convection conditions are varied. System solutions using integrated heat pumps and supply air units are included.
- Internal and external flows in buildings and the built environment are studied, such as flows in and around buildings, flows along the roof, flows in reservoirs, fluid flow and heat transfer in ducts.

Programme structure
See Common for all specialisations.

Compulsory and recommended courses
For the specialisation in Fluid and Climate Theory, the compulsory advanced course is AF3704 Fluid and climate theory 7.5 ECTS. It is recommended that any/some of the courses listed below as recommended research skills courses are included in the study plan.

Compulsory in-depth courses
- AF3704 Fluid and Climate Theory 7.5 hp.

Recommended in-depth courses
- 1D5302 Heat Transfer 7.5 hp.
- 6L5025 Technology and Health 7.5 hp.
- AF3703 Computational Fluid Dynamics, CFD, in Design and Development 7.5 hp.

Thesis
See Common for all specialisations.

Entry requirements and selection

General and special admission requirements and prior knowledge
The KTH general eligibility requirements for admission to doctoral level apply.

Doctoral students are expected to read and write scientific English and speak English fluently.

Selection rules and procedures
Admissions to studies at the doctoral level are decided by the Dean of the School of Architecture and the Built Environment after preparation by the principal supervisor and, where appropriate, Director of Third Cycle Education (for examination of eligibility).

In addition to the examination of eligibility of candidates, the degree of maturity and capacity for independent judgement and critical analysis will provide a basis for selection. Of particular interest in this assessment are prior studies in advanced courses or independently conducted scientific studies. To obtain an overall basis for decisions,
interviews will be conducted by subject representatives, where appropriate, together with prospective supervisors. Contact is usually made with previous teachers of the applicant. Selection of applicants for doctoral studies is carried out by the department in connection with admission.

**The programme’s degrees and examinations**

**Degree of Licentiate and Degree of Doctor (PhD)**

The licentiate degree consists of coursework of 30 ECTS and a dissertation of 90 ECTS. The licentiate dissertation shall be presented and defended in accordance with KTH general regulations.

The doctoral degree consists of coursework of 60 ECTS and a thesis of 180 ECTS. The thesis shall be presented and defended in accordance with KTH’s general regulations. Courses and thesis work included in the licentiate degree may also be included in a doctoral degree.

**The programme’s examinations**

There will be a written examination in each of the seven areas of specialisation in the subject of Civil and Architectural Engineering. In some cases this may be replaced by oral examination. The format of the examination shall in all cases be such that examiners can be convinced that the student has assimilated the full course content.