KTH Byggvetenskap

ABE-02-ST-BYV

Syllabus for doctoral studies in the subject of CIVIL AND ARCHITECTURAL ENGINEERING

at the School of Architecture and the Built Environment, KTH

General regulations and guidelines for doctoral studies are found in the comprehensive KTH regulations for doctoral studies. This syllabus for the subject of Civil and Architectural Engineering at the doctoral level complements the general regulations and guidelines with the following specific instructions for the area of specialization.

1. Subject description and goals of the programme

1.1 Subject description and goals of the programme

The overall goals for doctoral studies in the subject of Civil and Architectural Engineering correspond to the objectives for KTH doctoral studies. They are set out in the box below:

The purpose of KTH doctoral studies is to provide society with competent researchers who can contribute to its sustainable development.
The goal of KTH doctoral studies is for doctoral students to become independent and excellent researchers. After completing their studies, doctoral students will be able to:
- describe and explain theories and empirical results in the field in question
- formulate specific research issues in the field in question
- use scientific method and develop new knowledge through their own scientific studies
- critically analyze and evaluate the methods and results from own and others' scientific studies
- present and discuss research findings in the scientific community
- present research in an educational way outside the scientific community and in educational contexts
- assess the ethical aspects of research within the field in question and act on these
- identify needs for new knowledge, and understand how to initiate and direct research projects.

Education at the doctoral level shall also strive to ensure that students after graduation are able to:
- participate in interdisciplinary collaboration within the field in question
- analyze the role of research in sustainable development.

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.

The goal of the doctoral programme is to provide industry and society in general with exceptionally well trained employees in the long-term. This requires research at a high international level and good relations to industry and society.

1.2 Areas of specialization

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

- Concrete Structures
- Structural Engineering and Bridges
- Building Materials
- Building Technology
- Hydraulic and Hydrologic Engineering
- Building Service and Energy Systems
- Soil and Rock Mechanics
- Fluid and Climate Theory

All areas of specialization 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.

2. Common for all areas of specialization

2.1 Structure of the programme

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.

2.2 Obligatory and recommended courses

The coursework for both licentiate and doctoral degrees consists of courses in obligatory fields of knowledge and recommended courses in specialized areas of research and related subjects. Courses listed as advanced courses in other area of specialization are recommended as broadening courses in an area of specialization. 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.

Obligatory courses
All areas of specialization in the subject of Civil and Architectural Engineering require obligatory courses equivalent to at least 22.5 ECTS for both the licentiate degree and doctor's degree. Advanced courses vary with the area of specialization 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:

- Specialization advanced studies (see sections 3–10) 7.5 ECTS Advanced course
- Scientific theory and research methodology 7.5 ECTS Research skills course
- Research within Civil and Architectural Engineering 7.5 ECTS Broadening course

Recommended, optional courses
Courses that are recommended for a single area of specialization are specified below in sections 3–10. For all areas of specialization in the subject of Civil and Architectural Engineering, the following courses are recommended:

- English for scientific writing 7.5 ECTS Research skills course
- Mathematics continuation course 7.5 ECTS Research skills course
- Differential equations 7.5 ECTS Research skills course
- Applied statistics 7.5 ECTS Research skills course
- Applied numerical methods 7.5 ECTS Research skills course

Doctoral students who teach in education at first or second levels must have completed initial university teacher training

2.3 Licentiate dissertation and doctoral 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.

3. Specialization in Concrete Structures

3.1 Description of the area of specialization

Specialization 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 specialization 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.

3.2 Ongoing research

Research is currently being conducted in the following areas:

- Concrete material properties at early ages
- Advanced analysis of large concrete structures
- Concrete structures for the hydropower industry
- Concrete structures for rock reinforcement
- Protective structures in concrete and rock
- Constructon of concrete structures

3.3 Obligatory and recommended courses

For the specialization in Concrete Structures, the obligatory advanced courses are:

- Project in Concrete Structures 7.5 ECTS Advanced course

It is recommended that one or more of the following courses are included in the syllabus:

- Advanced course in Concrete Materials 7.5 ECTS Advanced course
- Finite Element Modelling 7.5 ECTS Advanced course
- Advanced Structural Dynamics 7.5 ECTS Advanced course

4. Specialization in Structural Engineering and Bridges

4.1 Description of the area of specialization

Specialization in Structural Engineering and Bridges covers planning and design of structures and bridges for new construction and renewal, considering loads, structural capacity, stability, reliability, functionality and durability. This specialization also includes condition monitoring (structural health monitoring) as well as design and analysis of structural components of steel, aluminium and timber and steel in composite action with other materials.

The aim of the doctoral programme in structural engineering 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.

4.2 Ongoing 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
- Development and application of advanced analysis methods for structures
- 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 of design standards for steel and aluminium structures.

4.3 Obligatory and recommended courses

For the specialization in Structural Engineering and Bridges, the obligatory advanced courses are:

- Project in Structural Engineering 7.5 ECTS Advanced course

It is recommended that one or more of the following courses are included in the syllabus:

- Advanced course in Structural Design and Bridges 7.5 ECTS Advanced course
- Finite Element Modelling 7.5 ECTS Advanced course
- Advanced Structural Dynamics 7.5 ECTS Advanced course

5. Specialization in Building Materials

5.1 Description of the area of specialization

The area of specialization building materials 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 specialization 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 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 specialization 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.

5.2 Ongoing research

Research is currently being conducted in the following areas:

- Durability aspects of building materials
- Wood or biobased composites as building materials
- Surface characteristics of wood and wood-polymer compatibility
- Thermal-hydro-mechanical modification of wood.

5.3 Obligatory and recommended courses

For the specialization in Building Materials, the obligatory advanced courses are:

- Project in building materials technology 7.5 ECTS Advanced course

It is recommended that one or more of the following courses are included in the syllabus:

- Wood materials 7.5 ECTS Advanced course
- Wood physics 7.5 ECTS Advanced course
- Moisture mechanics 7.5 ECTS Advanced course
- The degradation mechanisms and lifespan of construction materials 7.5 ECTS Advanced course

6. Specialization in Building Technology

6.1 Description of the area of specialization

The subject 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.

Building physics is the scientific base, which include heat, air and moisture transport, sound propagation and vibrations, and also properties of building materials. 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.

6.2 Ongoing 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, also including the aspect of how to motivate building owners to perform renovation for improved energy efficiency.
- 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.

6.3 Obligatory and recommended courses

For the specialization in Building Technology, the obligatory advanced courses are:

- Low- Energy and Sustainable Construction 7.5 ECTS Advanced course

It is recommended that one or more of the following courses are included in the syllabus:

- Dampness in buildings 7.5 ECTS Advanced course
- Modelling of thermal processes in buildings 7.5 ECTS Advanced course
- Building Physics- Measurement Techniques 7.5 ECTS Advanced course

7. Specialization in Hydraulic and Hydrologic Engineering

7.1 Description of the area of specialization

The science (educational) discipline of hydraulic engineering comprises applied and environmental fluid mechanics, hydrologic engineering and water technology (structures) in contact with water in surface water and groundwater. Examples of technical applications are embankment dams, hydropower systems, spillways, wells, geological disposal of wastes, drainage systems, water supply and related water quality problems. Research wise the discipline comprises theoretical advancements in hydrology, computational fluid mechanics and experimental methods in field and laboratory.

7.2 Ongoing research

Research is currently being conducted in the following areas:

- Study on capabilities of hydropower regulation as part of balancing the introduction of renewable, intermittent energy sources on the grid
- Study on the air trapping in bottom spillways.
- Study on internal erosion in dams and leakage processes.
- Study on the effect of water structures in rivers and streams on the retention of nutrients and water quality of the recipient.
- Study on improved models for hydropower regulation with regard to description of lag-times for water between hydropower stations.

7.3 Obligatory and recommended courses

For the specialization in Hydraulic and Hydrologic Engineering, the obligatory advanced courses are:

- Hydrological transport processes 7.5 ECTS Advanced course

It is recommended that one or more of the following courses are included in the syllabus:

- Hydrological transport processes 7.5 ECTS Advanced course
- River Engineering 7.5 ECTS Advanced course
- Project course in hydraulic and hydrologic engineering 7.5 ECTS Advanced course
- Hydrology for Hydropower Purposes 2.0 ECTS Advanced course
- Courses part of a research educational programme of the Swedish hydropower centre (SVC.nu)

8. Specialization in Building Service and Energy Systems

8.1 Description of the area of specialization

The area of specialization Building Service and Energy Systems deals with energy systems and services for (high-performance) buildings, as well as issues related to the quality of the indoor environment in buildings. The interactions between users (human systems) and technical systems are studied, as are the cross-relationships between buildings and surrounding (e.g. urban) systems. Intelligent building control and performance assessment systems, as well as low- and near-zero energy systems for the built environment are key research areas.
The purpose of doctoral studies in Building Service and Energy Systems 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.

8.2 Ongoing research

Current research and doctoral studies in the domain of Building Service and Energy Systems are mainly focused on energy systems/services for high-performance buildings and urban districts, the measurement and visualization of building performance, as well as issues related to the quality of the indoor environment in buildings. Relevant aspects of human-technical system interaction are keenly explored.

Research is currently being conducted in the following areas:

- High performance buildings (nZEB)
- Energy system/service optimization for high-performance buildings and urban districts
- Energy quality management in urban districts
- Early-stage design of high-performance buildings
- Integrated building performance assessment
- Visualization of building (energy) performance
- Waste-water heat recovery
- Resource-efficient building retrofitting
- Typology-based retrofitting kits for industrialized building refurbishment
- Operational safety and service quality in HVAC-systems
- Automated fault detection in HVAC-Systems
- Indoor climate modelling in buildings
- Indoor climate control in high-performance buildings
- BIM-based applications for building and energy Services
- User-related/behavioural aspects of energy use in buildings.

8.3 Obligatory and recommended courses

For the specialization in Building Service and Energy Systems, the obligatory advanced courses are:

- Project in Building Services Engineering 7.5 ECTS Advanced course

It is recommended that one or more of the following courses are included in the syllabus:

- Fluid mechanics 7.5 ECTS Advanced course
- Indoor climate technology, systems 7.5 ECTS Advanced course
- Heat transfer 7.5 ECTS Advanced course

9. Specialization in Soil and Rock Mechanics

9.1 Description of the area of specialization

The area of specialization 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.

9.2 Ongoing research

Research is currently being conducted in the following areas:

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

9.3 Obligatory and recommended courses

For the specialization in Soil and Rock Mechanics, the obligatory advanced courses are:

• Soil Mechanics	7.5 ECTS	Advanced course

It is recommended that one or more of the following courses are included in the syllabus:

• Geotechnics	7.5 ECTS	Advanced course
• Underground Excavation in Rock	7.5 ECTS	Advanced course
• Applied risk analysis	7.5 ECTS	Advanced course
• Information-based design in soil and rock mechanics	7.5 ECTS	Advanced course
• Theoretical rock mechanics	7.5 ECTS	Advanced course

10. Specialization in Fluid and Climate Theory

10.1 Description of the area of specialization

The area of specialization 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.

10.2 Ongoing 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.

10.3 Obligatory and recommended courses

For the specialization in Fluid and Climate Theory, the obligatory advanced courses are:

- Fluid and climate theory 7.5 ECTS Advanced course

It is recommended that one or more of the following courses are included in the syllabus:

- Technology and health 7.5 ECTS Advanced course
- Heat transfer 7.5 ECTS Advanced course
- CFD (Computational Fluid Dynamics) in design and development 7.5 ECTS Advanced course

11. Eligibility and selection

11.1 Basic and special eligibility 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.

11.2 Guidelines for selection

Admissions to studies at the doctoral level are decided by the director of the School of Architecture and the Built Environment after preparation by the principal supervisor and, where appropriate, the research training officer (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.

12. Examinations and tests during the programme

12.1 Licentiate and doctoral degrees

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.

12.2 Examinations included in the programme

There will be a written examination in each of the eight areas of specialization 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.

KTH, Stockholm

26th November 2013