MSc in Civil Engineering (Cycle 2, level 4)

Specialisation: Concrete Technology

MSc in Civil Engineering with specialization in Concrete Technology is a 2 year full-time graduate study program of 120 ECTS credits (4 semesters, 30 ECTS each semester). Courses are 3-8 ECTS credits, usually run as intensive courses. Students generally take 60 ECTS in specialized courses and a 60 ECTS research-based thesis. The minimum requirement of concrete technology related courses is 30 ECTS, elective courses from other disciplines are optional. A 90 ECTS thesis is optional.

The program is highly research based, closely tied to the ICI Rheocenter, a leading research institute in materials science run jointly by Reykjavik University and the Innovation Center of Iceland. Research is a part of almost all courses and is conducted in all main fields of concrete science i.e. rheology, microstructure, mechanical properties including fracture mechanics, high performance concrete including self-compacting concrete and durability of concrete. There is a large contribution to the program from visiting professors and invited lecturers who are leading specialists in their respective fields. There is also emphasis on cooperation with the industry through the students´ thesis. The goal of the program is to prepare students for leading careers in industry and/or further academic study.

Reykjavik University offers programs leading to the MSc degree in Civil Engineering in four different fields of specialization: Structural Design, Construction Management, Concrete Technology and Traffic and Urban Planning. Emphasis is on interdisciplinary cooperation between these MSc. Civil Engineering programs.

Admission requirements are a BSc degree in engineering. Minimum requirements in applied sciences (i.e. mathematics, physics) and in basic subjects fundamental to civil engineering generally (i.e. mechanics, material science, etc.) as well as to concrete technology specifically have to be fulfilled.

After successful completion of the programme the student is awarded the degree Master of Science in Civil Engineering with specialization in Concrete Technology. The programme is designed to meet the curriculum requirements for the professional title of Chartered Engineer (Icelandic: verkfræðingur), as defined by the Ministry of Industry and the Association of Chartered Engineers in Iceland.

On the completion of the MSc program in addition to relevant undergraduate studies, the following criteria shall be fulfilled, in addition to the criteria fulfilled at former levels. For further information, i.e. learning outcomes for each course, see the Course Catalog www.ru.is

KNOWLEDGE AND UNDERSTANDING

On completion of the MSc program, the student shall possess a systematic understanding and knowledge of the following topics:

- Basic theoretical principles in concrete science, including: The effects of various types of cemetisious materials, pozzolanes and chemical admixtures. The characteristic of aggregates for concrete and their influence. The influence of volume of water in the concrete, also relative to cement content.

- The mechanisms of: Hydration and the potential hydration product. Heat of hydration and hydration kinetic. Shrinkage and its potential to generate cracks in concrete, including chemical-, autogen-, drying- and carbonation shrinkage. Creep of concrete and the influence of load history. Deterioration due to alkali silica reaction, freeze/thaw attack, sulfate attack. Deterioration due to carbonation. Corrosion of reinforcement. Coagulation of colloidal particles and workability loss in concrete.

- The basic principle of mix-designing various types of concrete as well as curing technology required for each of the following types: Conventional concrete in various strength classes according to the EN 206 standard, with and without air-entrainment. High performance concrete. Ultra high strength concrete. Self-compacting concrete. Underwater concrete.

- How to evaluate the microstructure of cementitious materials, which tools can be used and their limitation, such as: ESEM, FE-SEM, TEM, AFM, X-ray tomography.

- Research methodology, including the fundamentals of scientific writing, literature search, how to give a scientific presentation, how to evaluate a scientific paper, and research ethics.

TYPE OF KNOWLEDGE

On completion of the MSc program, the student should have developed advanced knowledge and understanding of all of the following fundamental engineering subjects and should be able to make use of that knowledge in exercising engineering methodology and judgment in all tasks:

- Mathematics: Calculus in one and more dimensions, statistics, linear algebra and geometry, ordinary differential equations, numerical analysis.
- Physical sciences: Statics, dynamics, hydraulics, thermodynamics, electronics, chemical sciences, materials science, structural mechanics, soil mechanics.
- Technology: Programming, computer aided design, numerical modelling, design according to standards, project management.

Most of the above the student will have acquired in previous studies but some of it the student will acquire in the MSc program.

On completion of the MSc program, the student shall possess significant knowledge and understanding of the research leading to his or her MSc thesis:

- The theories introduced during the specialized courses and the application of these theories to analyzing and solving problems in the field of concrete technology.
- The practical skills taught in the specialized laboratory part of the courses and of the laboratory work necessary to carry out research in the field of concrete technology.
- The ability to think and work as a researcher in concrete science.
- The background and theoretical base in the chosen research area.
- State-of-the-art knowledge in the chosen research area.
- The student will have established knowledge and be competent in the applications of techniques developed within the chosen area of research.

PRACTICAL SKILLS

On completion of the MSc program, the student shall be able to:

- Analyze complex real-world problems and devise efficient and well-documented computer-based solutions for those. Use mathematical models and their associated analysis techniques in the design and evaluation of solutions for problems.
- Mix-design different types of concrete.
- Evaluate material composition with respect to environmental and cost benefit optimization.
- Choose between different types of concrete depending on intended application and requirement to strength and environment.
- Evaluate raw materials for their suitability for concrete production and durability, in particular the quality and porosity of aggregates.
- Use models for lifetime prediction of concrete.
- Evaluate the risk of deterioration of structural concrete and the influence of the environmental and loading conditions.
- Come up with means to increase the lifetime of concrete construction.
- Inspect damaged concrete and come up with solutions.
- Evaluate the results from microanalyses and in particular know the limitation of the analyses.
- Know how to evaluate each of the properties of concrete such as compressive-, flexural- and tensile strength, durability and workability, including rheology and microstructure.
- Know the advances, side effects and limitation of chemical admixture for concrete.
- Know the production process of both cement and concrete and be able to evaluate stability and segregation and to prevent bleeding.
- Have a comprehensive overview of the environmental exposure classes according to the EN-206 standard.
- Propose, plan and manage well defined research projects involving a team of individuals.
- Prioritise, organise and schedule work activities effectively and comply

with project deadlines.

- Work effectively in a team of individuals.
- Interpret and critically assess existing theories, models, methods and results, both qualitatively and quantitatively, within a broad engineering and physical science framework.
- Recognize and appreciate problems inherent in a given engineering system or approach, and be able to synthesise, and propose evaluation methods or develop alternative solution strategies.
- Have the ability to assess engineering projects, identify the key factors in a given situation, and develop an approach to a solution.
- Work with technical uncertainty.
- Appreciate the meaning and importance of professionalism, including integrity and adherence to independent informed judgement.

THEORETICAL SKILLS

On completion of the MSc program, the student shall have sufficient, comprehensive understanding of the following topics:

- Chemical reactions, both under the hardening process of concrete and decoration promoted by substance like chloride, sulphate, carbon, etc
- Development of crystalline hydration products in cement paste.
- Models for the microstructure of hydrates in cement paste.
- Colloidal forces, coagulation, interaction energy which are relevant for cement based particle suspension.
- Rheology of fresh cement based particle suspensions and know the theoretical basics for each testing devices, like coaxial cylinder viscometers.
- How each ingredient of concrete influences shear viscosity of fresh concrete.
- Non-Newtonian fluid mechanics.
- The fracture mechanics of concrete.
- Transport processes of fluids and ions in and into concrete.
- The structure in solid state of a cementisious system from nano to macro scale.
- The mechanical properties of concrete materials, including the ability to calculate approximately the modulus of elasticity of multiphase system.
- Influence of porosity on both strength and permeability.
- Influence of the interface zone between cement paste and aggregates as well overview of means to influence it.
- The factors in lifetime models.
- Available chemical admixtures and their use in concrete. The student will have a comprehensive overview and understand their mechanism

of action, and interaction with cement as well as their limitations.

Furthermore, the students shall be able to:

- Assimilate and integrate their knowledge, make assessments and utilize their knowledge and understanding in solving relevant problems in the field of civil engineering generally and concrete technology specifically.
- Identify, adapt and develop models appropriate to the study of a wide-range of different problems relevant to concrete technology.
- Apply standard scientific principles and theories to develop engineering solutions to a range of practical problems.

COMMUNICATION SKILLS AND INFORMATION LITERACY

On completion of the MSc program, the student should be able to:

- Work effectively in a team.
- Communicate effectively and professionally and formulate sound arguments, both in writing and by means of presentations using appropriate technical language.
- Find information that is relevant to research using search engines, on line libraries and repositories. Effectively utilize modern information resources and technologies.
- Analyze and communicate statistical data.
- Report on their work, and that of others, both to a specialist and a general audience.
- Discuss ethical issues in research work with their peers in an informed and reasoned fashion.
- Understand use of technical literature and other information sources.

LEARNING SKILLS

On completion of the MSc program, the student should be able to:

- Solve non-trivial problems independently using the acquired skills or knowledge.
- Ask new questions based on available information and knowledge and use known facts to create new ones.
- Make creative use of known information, methods, concepts and theories in new situations.
- Generalize from a collection of specific instances. Infer possible causes from the available data, discovering patterns in the available information.
- Interpret facts by comparing them and contrasting them with one another, drawing conclusions and predicting possible outcomes.

- Make choices based on reasoned arguments, and evaluate the outcomes of those choices by comparing them with alternative solutions.
- Know how to assess one´s own work against accepted standards of performance. Appreciate the factors that evaluators look for when considering proposals, including proposals for research work.
- Understand the need for, and the basis of, peer-group assessment. Understand how performance in a research project is judged and the basis of the criteria for judgement.
- Recognise and apply different approaches to learning.
- Appreciate the importance of continuing education and lifelong learning and undertake the study required to maintain and expand professional competence and keep up with evolving technology.
- Continue studies within this field towards an advanced degree i.e. at PhD level, having developed the necessary personal autonomy and independence to do so.