Master of Science programme

Civil Engineering

2022 - 2023

MASTER CIVIL ENGINEERING

Preface

TU Delft is one of the universities offering a master of science programme in Civil Engineering. It has a unique position and has been in the top 5 of the QS World University Ranking for years in a row.

This brochure contains fairly detailed information about the MSc programme, meant primarily for students considering to enroll. Much attention is payed to how the programme is structured, the focus of the various programme components and their mutual coherence, options for students to develop and specialise in specific fields of Civil Engineering, as well as prerequisites and pre-master programmes.

Please do not hesitate to contact us with questions beyond the scope of this brochure. For general questions about the master programme, please mail us at MSc-Civil-Engineering@tudelft.nl. However, if your question concerns admission requirements or procedures in particular, use admission-CIE-CEG@tudelft.nl.

Most of the text in blue in this brochure is a hyperlink, enabling you to quickly navigate back and forth through it. In stead of a table of contents, a menu with hyperlinks is at the bottom of each page.

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Programme description

Civil Engineering is the discipline that deals with the design and maintenance of structures, infrastructures and systems vital to the economic and societal developments in a rapidly changing environment. These so-called civil engineering systems include, among others, bridges, buildings, hydraulic and offshore structures, natural and artificial flood defences, tunnels, transport networks, utility infrastructure, and specific interventions in the natural and built environment. The major challenge for today's civil engineers is to have these systems meet comparatively short-term functional requirements, while handling long-term concerns regarding climate change, sea-level rise, resource depletion, as well as effects of population growth, urbanisation, ageing of infrastructure, increasing transport of people and commodities, and many more.

The MSc Programme in Civil Engineering at TU Delft equips students with scientific and engineering knowledge and skills necessary to rise to this major challenge. Students develop in-depth knowledge in their fields of expertise and broaden themselves in related fields. They are trained to think and operate on a high academic level. This enables them to responsibly and creatively rise to the challenge, and to acquire new knowledge and skills throughout their professional life, either in research or engineering applications.

Graduates of the MSc programme Civil Engineering have the scientific and engineering knowledge and skills to design, develop, construct, operate, monitor, assess, maintain, decommission, analyse and investigate civil engineering systems. They have developed verbal and writing skills to communicate within a multidisciplinary team of professionals with diverse backgrounds and to a broader audience. Together with other professionals inside and outside their own field of expertise they contribute to civil engineering-oriented solutions for problems related to the mentioned challenge.

The Master of Science Civil Engineering is a full time programme, nominally covering two years and a total of 120 EC (EC = European Credit; 1 EC corresponds roughly to 28 hours of study load).

Programme outline

- Modelling, Uncertainty and Data for Engineers: MUDE This module (12 EC) deals with advanced, generic skills on the mentioned topics. It is shared with the MSc programmes Environmantal Engineering and Applied Earth Sciences.
- Programme base module on Advanced Mechanics and Civil Engineering Systems (9EC)
- Six tracks (39EC in each of them):
  - Construction Materials
  - Geotechnical Engineering
  - Hydraulic Engineering
  - Hydraulic and Offshore Structures

  - Structural Engineering
  - Traffic and Transport Engineering

  Each track consists of a track base module (15 EC), followed by a module type A (9 EC) and a module type B (15 EC). These three modules offer progressive specialisation. The Track base module is compulsory for all students in the track, as is at least one module of type A and at least one of type B.
- Embedded learning lines on
  - Ethics
  - Monitoring and Data Science

  Learning lines are embedded in the sense that the concerned topic is addressed in consecutive modules of the programme and in the context of the content of those modules. For the one on Ethics, students build on a portfolio that is winded up with a reflection on the master thesis proposal (as part of the Thesis preparation).
- Projects and electives (15EC)
- Cross-over modules. A selection of topics at the tangent of tracks or that of the fields of Civil Engineering, Environmental Engineering and Applied Earth Sciences, are addressed in cross-over modules (10 EC).
- Thesis preparation (5EC)
- Thesis (30EC)

Modelling, Uncertainty and Data for Engineers

All students have common needs at the start of their programme to further develop knowledge and skills to meet the standards of the TU Delft and its research- and design-oriented MSc programmes.

The MUDE is one integrated module in which topics related to data, modelling and uncertainty quantification are applied to real engineering challenges. It comprises two interlinked parts. The Theory, Application and Coding part focuses on teaching and applying the fundamental concepts on modelling, uncertainty and data, as well as coding skills. In the Project part, students work on examples and applications at the interface area where the three topics overlap, creating opportunities for more integrated applications and the ability to focus on fields of interest per programme (when needed) while satisfying the same set of learning objectives. A gradually increasing complexity and openness of inquiry is applied.

Programme base

The Programme Base module serves as a foundation for the six tracks, both with respect to technical topics and the responsibilities of the civil engineer in a wider societal context. The technical part is focused on advanced mechanics of structures, fluids and soils, building on the corresponding fundamentals the students have acquired in previous education. The other part is dedicated to the embedding of civil engineering structures, infrastructures and systems in the natural and built environment, as well as in society. Attention is paid to the responsibility of a civil engineer, which extends beyond providing technical answers and solutions to modern challenges. Provided solutions need to comply with complex societal needs and preferences, for instance regarding health, cultural diversity, nature and resource preservation, sustainability, and ethical considerations. These themes are addressed at an aggregated level in the Programme Base Module. In the tracks these themes are merged with technical content to stimulate students to responsibly integrate societal needs in technical solutions.

Projects and electives

The first educational period of the second year of the master programme offers a choice of electives and projects. Four options are avaliable:

- Electives (adding up to 15EC)
- Multidisciplinary Project (15EC)
- Joint Interdisciplinary Project (15EC)
- Reseach Project (10EC) in combination with electives (5EC)

Electives

On the one hand, electives are meant typically to provide in-depth knowledge and skills. Their content is closely related to scientific niches and preferably (but not necessarily exclusively) to recent developments therein. On the other hand, electives provide an opportunity to explore beyond the boundaries of the programme and complement knowledge and skills.

The programme includes some 40 electives on a wide variety of topics. Each elective amounts to 5EC. Students are free to choose courses from other master programmes as electives, provided that they comply with the intended learning outcomes of Civil Engineering.

Multidisciplinary Project (MDP)

In an MDP a real-life challange is tackled. Every MDP is unique in its kind and requires students to act as engineering consultants and designers. The project is carried out by a group of students with different backgrounds to ensure that the challenge is approached from the perspective of different disciplines. The assignment is to produce a joint and coherent answer. That requires cross-discipline co-operation. It forces students to see and understand values beyond the scope of their own discipline and to align their domain-specific input with that. This way, the MDP combines specialist engineering with application in a broad context.

An MDP essentially differs from a JIP (see the next item) in two ways. One is that students contribute from their own discipline to a project that also involves other disciplines, thus forcing them to co-operate, reflect and empathize beyond their field. In a JIP, on the other hand, students are challenged to operate outside their field. The other difference is that, other than a JIP, an MDP has a strong international component that relates to inter-cultural as well as social and economical diversity aspects commonly encountered in professional life.

Joint Interdisciplinary Project (JIP)

In a JIP, students are challenged to operate outside the scope of the programme they are in. This forces them to familiarise with for them new topics up to level necessary to complete some assignment. Like an MDP, this concerns group work, but the backgrounds of the participating students are far more apart and the emphasis is almost primarily on development of soft skills. In-depth elements play a minor role.

Reseach Project (RP)

Reseach projects are close to scientific developments as students are actually involved in the execution of ongoing reseach work. Although the student's involvement is limited to a dedicated, well-defined part of such a project, the outcome of the RP is never determined in advance. Also the RP is typically of an in-depth nature.

An RP can be carried out at a university, a research institute or a private enterprise. It always includes reflection on business or organisational processes in the context of which the project is carried out.

Cross-over modules

A selection of topics at the interfaces of Civil Engineering and related master programmes and at the interfaces of tracks within the Civil Engineering programme, is addressed in cross-over modules (10 EC). Students may choose one of these topics, independent of the track they are in.

Accross programmes

Delta Technology - Due to climate change and socio-economic developments, deltas are under pressure. In this module students learn to understand the atmospheric, land and oceanic influences on deltas, the impact of natural and man-made variability, climate projections and engineering solutions. This is done through series of lectures, modelling exercises, journal clubs and a multidisciplinary group project in which students develop adaptation pathways for a delta.

Engineering for Global Development - Many Delft engineers mobilize their skills within global engineering initiatives promoting societal development. As views on what is desirable development are diverse, engineering solutions are always positioned within a social political debate. With the use of several workshops including discussions, guest lectures, design sessions etc and a project in a team of 5 to 7 students based on a real life issue, students learn how to recognize different ideas, how to engage their own expertise within debates with experts and other stakeholders, and how to employ co-creative practices when developing technologies.

Subsurface Storage: Energy and Climate - The subsurface, when used properly, is a good solution to store fluids associated with energy and can be used for climate change mitigation. In this module students learn the available and under development key technologies for subsurface storage and the key aspects of fluid flow in the subsurface by means of lectures and lab sessions. The module is finalized with a design project in which for an energy scenario the most appropriate storage concept must be designed in detail.

Data Science and Artificial Intelligence for Engineers - In the era of digitalization, engineers require enhanced data-related skills to solve outstanding challenges. This module teaches students how to use data science and artificial intelligence to tackle engineering problems related to the natural, the living and the built environments. Students learn foundational as well as advanced topics, moving from basic data handling skills to state-of-the-art machine learning techniques (e.g., Deep Learning). Students work on realistic datasets and learn how to develop workable solutions.

Noise and Vibrations - With growing cities and populations, and the expanding anthropogenic activities nearshore and offshore, nuisance increases with adverse effects on both leaving species and society. In this module, the student learns in a series of lectures the mathematical background of noise and vibration problems including the underpinning physics, and apply this knowledge in an environmental noise and vibration group project.

Advanced Topics in Probability and Statistics in Engineering - Modelling real life problems comes with uncertainties. In this module, students learn about probabilistic approaches such as extreme value theory, dependence modelling, and expert elicitation. Students also learn how to apply these methods to real world problems. The module is of the methodological type and is given by means of lectures and small assignments. Students learn to write computer code for fundamental aspects and to apply existing computer code and software for the more advanced methods. In a group project, the students apply a specific probabilistic technique from the course to a problem of their choice.

Understanding Mud - Mud is a mixture of mineral clay, organic material and water. In liquid form, it is dredged, fot instance for port maintenance purposes. As a slurry, it is dewatered and used in engineered structures like dikes. In this module, the biochemical and physical properties of mud are reviewed. The way to assess these properties is studied from the water phase to the soil phase. The module consists of lectures, group assignments and practical work (lab/in-situ).

Monitoring of Structural Health and Geohazards - A large variety of specialized equipment and techniques can nowadays be used to monitor the health or integrity of civil structures, rocks, and soil masses. In this module, the student learns the importance of monitoring, the state of the art methods that are being applied, how to collect/process/interpret the data, and how to create models from the data including uncertainties. The module is taught using theoretical sessions on monitoring methods and data collection/processing, lab demonstrations, and live coding sessions. The module is concluded with a case study project in which groups of students collect data themselves during lab or field experiments.

Sustainable Cities - Current society desires sustainable cities and therefore aged or desolate cities and infrastructures need to be converted to climate resilient, healthy, liveable and circular ones. In this module an existing city quarter is quantitatively analysed for climate resilience and environmental quality, followed by a review of possible nature-based improvement methods, concepts and products. Finally, in a case study assignment, the gathered knowledge is applied by designing an integral nature-based solution.

Accross tracks of Civil Engineering

Engineering Management Systems - The goal of this crossover for civil engineering students is to learn about different engineering management systems to support the engineering management processes over the entire service life cycle. Engineering management systems are a group of information concepts, tools and methods for decision support for effective and efficient engineering assets management and/or construction projects management.

This allows civil engineering students to broaden their horizon within a systems engineering and management context. Rather than only focusing on what to engineer, this crossover focuses especially on how to manage and organize the construction projects - and engineering asset management processes. The cross-over focusses on applications within the context of international operating contractors who are responsible for engineering, procurement construction and/or maintenance services. Participation in this crossover leads to civil engineering students that are better prepared for real-life asset and construction projects management practices resulting in open integrative professionals rather than in purely specialized engineers. This crossover is based on the principles of Open Design Learning concept, which is a reflective, creative and engaged learning approach that opens human development and unlocks new knowledge and design solutions in a constructive manner.

Thesis

The master thesis project (30 EC) serves as a platform for students to demonstrate their ability to combine the theory, knowledge and skills gathered in the various modules, electives, projects and cross-overs included in the master programme Civil Engineering into successful completion of an individual assignment with a focus on either research or design. Project subjects typically align with challenges topical for the track a student has chosen.

Subjects for the master thesis project are innovative by nature and may arise from a wide variety of backgrounds. Projects may be inspired by in-house research projects where specific elements qualify for a more or less isolated approach in a master thesis projects, or from dedicated research or design quests brought to the attention by private enterprises or research institutes.

The project is always preceeded by a thesis preparation. This is a 5 EC module (in addition to the 30 EC of the thesis itself) comprising

- formulation of a research or design objective for the master thesis project,
- a literature survey as part of that project,
- a project plan,
- specific attention to research methodology,
- a reflection on ethical aspects of the project as part of completing the learning line on ethics.

Results of the master thesis project are presented in a written report and a public oral presentation.

MASTER CIVIL ENGINEERING

Learning lines

Ethics

The learning line Ethics requires students to examine the context in which they function more closely. Which stakeholders are there? What are their values? How can we incorporate their values in (re)designs for civil engineering structures and systems. Students are introduced to and practice with value-sensitive design methods. In addition, the learning line provides them with tools and techniques to pro-actively discuss ethical issues with their colleagues, their employers, and the stakeholders of their designs. To do so, students study their responsibilities as a person, researcher, and/or engineer in the design process and the impacts that their actions have on civil engineering designs and stakeholders of civil engineering designs.

The learning line on Ethics is embedded in all the tracks of the master curriculum. A basis is laid in the Programme base module. During the following year, students develop a personalized portfolio comprised of short ethical reflections that are linked to their expertise. During Thesis Preparation, the Ethics learning line is finalized with a peer-review and discussion workshop.

Monitoring and data science

The ground-work on the three themes 1) modeling, 2) uncertainty (risk), and 3) data/monitoring is laid in the MUDE. In the tracks, we follow-up on this module with, as the central theme, 'measurement meets model' (or, the other way around), meaning that the three themes get connected and combined.

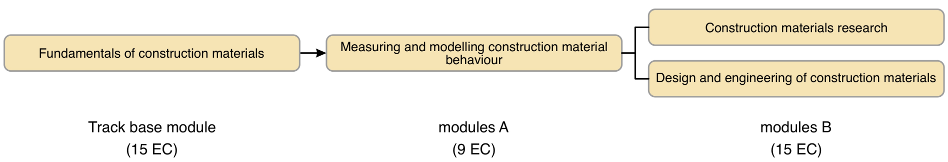
The learning line on Monitoring and Data Science is embedded in the tracks in an integrated way, meaning that these aspects get addressed, in their context, in already planned modules and units (they are part of). Generally, no separate elements are included in the programme to realize this learning line. Also assessment takes place as part of the already planned modules (no separate assessment). Therefore the learning line, and in particular the above mentioned synthesis of the themes, is explicitly reflected in the various modules of each track.

Construction materials

The Construction Materials track provides students with in-depth knowledge, skills and methods to choose, develop and manufacture construction materials that are optimised for application in structural components and civil structures for a more resilient and sustainable built environment. Students develop the ability to research, monitor and assess the effect of (changing) environmental conditions on the durability and degradation of materials within the existing structures. Students are taught how to take into account aspects of technical performance, like structural, mechanical, and chemical resistance. The second focus point is on performance in time, taking into account degradation mechanisms, durability and ageing. The third important aspect is sustainability. The emphasis is on materials that demand less or greener resources, materials that need less energy for production as well as materials and structural components that can be reused, easily separated or recycled.

Education focuses on the technical knowledge and skills needed to understand material behaviour and performance. Students will learn advanced experimental and computational techniques, applicable to a broad spectrum of materials at different length scales, and to investigate how materials function inside a structure. Mastering these techniques is the basis for investigating degradation mechanisms, monitoring the performance in time and improving the material properties and functionality. The application of experimental and computational tools is the key to understand and optimise civil engineering materials, such as concrete, steel, asphalt, timber, masonry and composites. Special focus is put on interfaces, as the interface properties between material constituents, phases or different materials in composite systems govern the fracture and transport processes. Close attention is also be paid to new construction methods like additive manufacturing, to the tools to optimise materials and processes for these techniques, and to the way to bring them to structural applications. Students gain insight into laboratory research varying from testing materials at nano-scale to testing structural elements.

Modules



Track base: Fundamentals of construction materials - fundamentals of material chemistry and mechanics to explore the chemical roots of mechanical behaviour of construction materials.

A: Measuring and modelling construction material behaviour - safe engineering with construction materials requires that material behaviour has been experimentally tested under controlled conditions and that the performance of the material under expected conditions can be predicted with simulations.

B1: Construction materials research - behaviour of construction materials under various environmental and loading conditions, with a focus on degradation mechanisms and durability, imposed deformations, and constitutive modelling.

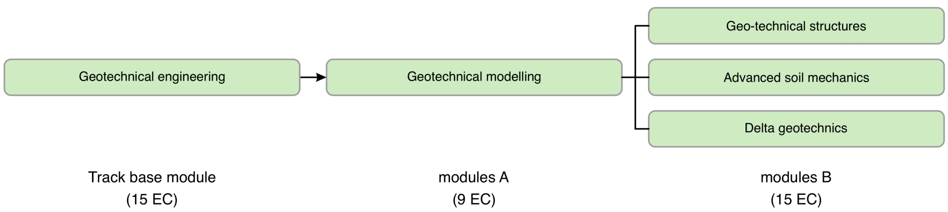
B2: Design and Engineering of Construction Materials - design and engineering of smart materials, self-healing materials, composite materials, bio-based materials, and emerging new materials, with special attention to 3D printing, recycling and renewable construction materials.

Geotechnical engineering

The track Geotechnical Engineering provides students with in-depth knowledge, skills and methods to develop engineering solutions to build on, in and with soils. Students learn to design and perform a site investigation survey for a given engineering project based on existing knowledge of the geological environment. They learn how to select and perform relevant laboratory tests to further characterise the behaviour of soils under various conditions. Students are taught how to translate the observed soil behaviour into a constitutive model. The track provides insight into the aspects of modelling, teaching students to formulate geotechnical problems with numerical models. In particular, students are taught how to select and apply numerical models to simulate and predict the response of geotechnical structures to mechanical and environmental loads. Students learn to design, construct and monitor geotechnical structures, such as foundations, dikes and embankments, deep excavations and tunnels. They have the ability recognise the challenges associated with sustainability, resilience and adaptability of these structures in interaction with the natural and societal environment.

In particular, the track recognises the specific challenges associated with geotechnical engineering, including the non-linear, hydro-mechanically coupled, dynamic and time-dependent behaviour of soils, structures and systems, and the subsurface heterogeneity and uncertainties associated with engineering in soils and rocks.

Modules



Track base: Fundamentals of geotechnical engineering - the fundamentals include theory and modelling of geo-processes, testing and modelling of soil behaviour, and foundations and excavations.

A: Geotechnical modelling - geology in an engineering context provides the starting point for geotechnical analyses and predictions by numerical models, of which the results are to be interpreted in a geological context.

B1: Geotechnical Structures - design, monitoring and assessment of geotechnical structures by measurement, characterisation and numerical modelling of spatial variability, the evaluation of risk and uncertainty in geotechnical engineering, the interaction between soil layers and the geotechnical structure, and the impact of geotechnical structures on other structures in an urban environment.

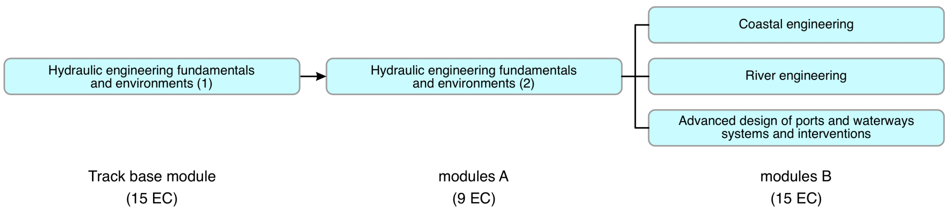
B2: Advanced soil mechanics - non-standard aspects of soil mechanics, in terms of both techniques for analysis and modelling, and geotechnical applications.

B3: Delta geotechnics - meeting geotechnical design challenges associated to soft, and possibly unstable, soils typical for delta areas, require fundamental understanding and simulation of detailed soil behaviour.

Hydraulic engineering

The track Hydraulic Engineering provides students with in-depth knowledge, skills and methods to develop engineering solutions to complex problems in water systems (rivers, estuaries, coasts, coastal seas and oceans). Students learn how to design interventions that serve flood protection, navigation, ecology, freshwater supply, water quality, and portoperability. They learn how to observe and analyse water systems, using their in-depth knowledge on the physics of waves, flow and sediment transport processes, mathematical tools, and numerical modelling. They learn to predict the impact of both natural and anthropogenic forcing on water systems. They know how to perform flood risk analyses and account for uncertainties in a changing environment. They learn how to design port areas and coastal and river protection systems in a sustainable way. As such, the track addresses the design and assessment of interventions in water systems, considering their impact on the water system and associated functions, the consequences of climate change, and stakeholder interests.

Modules



Track base: Hydraulic Engineering Fundamentals and Environments Part I - introduction to knowledge and skills (viz. modelling, monitoring and data science) on hydraulic engineering systems and the fundamental physical processes that are relevant in these systems.

A: Hydraulic Engineering Fundamentals and Environments Part 2 - morphodynamical behaviour of coastal and estuarine systems, coastal protection, ports and waterways systems.

B1: Coastal Engineering - coastal engineering problems and human interventions, specifically the assessment of the impact of these interventions and their technical design.

B2: River Engineering - physics of river systems, river functions and management, (flood safety, navigation, freshwater availability, nature values) and schematization and modelling of the natural behaviour of rivers and their response to interventions..

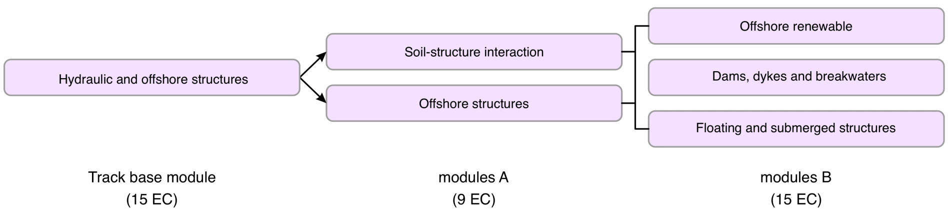
B3: Advanced Design of Ports and Waterways Systems and Interventions - advanced design of ports, waterways, and networks in a societal, environmental, and economic context, based on a thorough understanding of the logistical and natural processes at play.

Hydraulic and offshore structures

The track Hydraulic and Offshore Structures provides students with in-depth knowledge, skills and methods to develop engineering solutions for hydraulic and offshore structures in complex environments, for purposes such as energy and resource harvesting, as well as transport and flood protection. This track offers a comprehensive education covering the full structural life-cycle, from design and construction, to maintenance and finally decommissioning. Students are educated to develop solutions based on current and anticipated natural and societal needs, accounting for associated economic aspects and uncertainties in research and design.

Education builds on the available basic engineering skills (sketching, drawing, setting up engineering calculations, programming, reporting) to teach students to analyse hydraulic and offshore structures in interaction with the surrounding environment. Starting in the track, the students develop the fundamental knowledge on applied mechanics of materials and structures, fluid-structure and soil-structure interactions, and ocean, coastal and river engineering. On this basis, a wide range of aspects is addressed, from practical design, to numerical simulation, with a choice for students to develop novel civil engineering solutions in the areas of application of flood protection, offshore wind, and floating civil engineering structures, to enable students to apply and develop scientific knowledge in the field of hydraulic and offshore structures.

Modules



Track base - design, construction and operation of hydraulic and offshore structures by means of unifying the knowledge from structural engineering, hydraulic engineering and geotechnical engineering.

A1: Hydraulic Structures - from problem analyse to design objective, followed by a functional-spatial design and consecutive structural design of hydraulic structures, where next to stability and strength checks, constructability plays a major role.

A2: Offshore Structures - from problem analyse to design objective, followed by a functional-spatial design and consecutive structural design of offshore structures, where next to stability and strength checks, constructability plays a major role.

B1: Offshore Renewables - design, monitoring and assessment of offshore wind and ocean energy farms, in general, and different technologies (both bottom-fixed and floating), specifically, in an integrated manner, including control, installation, maintenance and economics.

B2: Dams, Dikes and Breakwaters - design of hydraulic structures that protect against the effects or impact of waves, currents and high-water levels, starting with understanding the underlying processes and related systems.

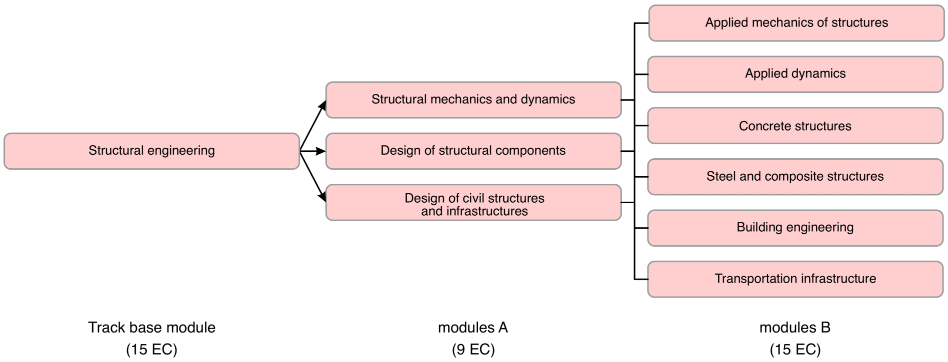
B3: Floating and Submerged Structures - design, monitoring and assessment of floating and (semi)-submerged civil engineering solutions for infrastructural and urban development applications, for instance floating bridges and moored tunnels, including control, installation, maintenance and economics.

Structural engineering

The Structural Engineering track focuses on ensuring structural safety, efficiency, reliability and resilience for both new and existing civil engineering structures, structures for energy transition and infrastructures. Civil Engineering structures are used daily by millions of people. Their safe and durable design, construction, performance monitoring, maintenance and assessment are essential for human well-being and society.

This track provides students with in-depth knowledge and understanding of the mechanics, dynamics, design and construction of various civil structures. Students learn to formulate and test models of materials and structures and their response to environmental and anthropogenic loads. A broad variety of loads are addressed including wind, traffic, earthquakes, and fire. The effect of these loads on the civil engineering structures, such as bridges, tunnels, buildings, wind turbines, high rise buildings and transport infrastructure, is analysed. Additionally, students learn to test and apply hand calculations for quick decision-making and to use computer simulations to determine whether a structure will comply with design specifications. They create complex structural models for endurance under stresses that might occur. Education is focused on providing technical knowledge and skills about how to monitor and assess the health and remaining service life of engineering structures and infrastructural components. Students will combine data-driven techniques and numerical models.They will devise approaches and methods for extending the service life of structures, whilst observing economic, technical and societal constraints. The track offers a comprehensive education, covering in-depth experimental and numerical analysis of structural behaviour of-components and systems made of widely used civil engineering materials, such as concrete, steel, asphalt, timber, masonry and fibre reinforced polymers. Students learn to apply the acquired knowledge of structural mechanics in the context of sustainability by using (and responsibly choosing between) traditional and innovative materials and systems. Thislearning process will prepare them to contribute to solutions for the rapidly changing builtand natural environment, dealing with climate change, population growth, ageing of infrastructureand resource depletion. Students gain insight into (ongoing) practical research varying from testing materials to full-scale structures.

Modules



Track base - application of theory of mechanical behaviour of structural members made of steel, (prestressed) concrete and timber in the design of sustainable construction members and systems as well as slender structures.

A1: Structural Mechanics and Dynamics - analysis of the stability of structures under both static and dynamics loads; computational techniques used in the static and dynamic analysis of complex structural systems; measurement and analysis of vibrations of engineering structures.

A2: Design of Structural Components - the potential for achieving an optimum structural design and meanwhile limiting environmental impact of structures lies in integrating construction materials in structures where they best fit, given their mechanical and functional properties.

A3: Design of Civil Structures and Infrastructures - functional and technical design, with considerable level of detail of engineering (infra)structures within a realistic context: from scratch, investigating multiple variants and materials to find the most suitable design.

B1: Applied Mechanics of Structures - analytical and computational techniques for in-depth analysis of the mechanical behaviour of structures.

B2: Applied Dynamics of Structures - analysis of the dynamic behaviour of structures subjected to a wide class of the dynamic loads (earthquakes, wind and wave loading, road and railway loads), including soil-structure and fluid-structure interaction phenomena.

B3: Concrete Structures - understanding concrete and design of concrete structures, in particular advanced modelling of concrete members taking into account the unique behaviour of concrete, as well as the design and maintenance of complex concrete structures.

B4: Steel and Composite Structures - strength and durability of steel and composite structures and joints; heavy-duty and light-weight steel and composite structures.

B5: Building Engineering - architecture, building physics and façades; building structures, construction methods and foundations; design of spatial structures.

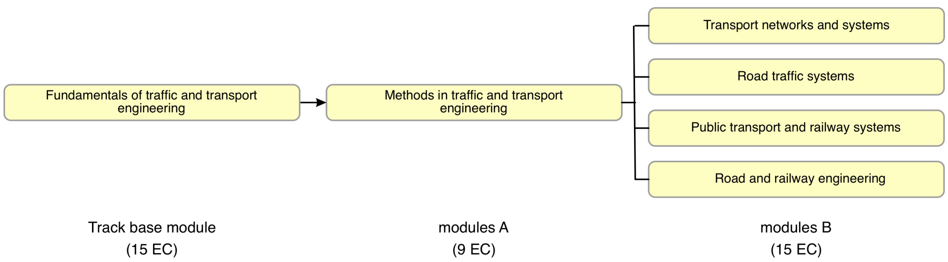
B6: Transportation Infrastructures - advanced construction processes and techniques to develop reliable and resilient transportation infrastructure, such as highways, railways, bridges, and tunnels, considering the entire design-construction-service cycle.

Traffic and transport engineering

The Traffic and Transport Engineering track provides students with in-depth knowledge, skills and methods to develop innovative engineering solutions to tackle traffic and transport related societal challenges, such as traffic congestion, air pollution, aging infrastructure, traffic accidents and delayed public transport, while anticipating and considering emerging societal trends, such as urbanisation, sustainability, critical infrastructure networks, frequent changes in transport demand, automation and connectivity, advances in ICT and flexible transport systems and services. Simultaneously, students develop a strong engineering profile to ensure safe and efficient transportation of people and goods.

The focus of the track Traffic and Transport Engineering is the planning, design, operation, assessment and management of roads, railways, transport systems and their related networks. Empirical data analysis, mathematical modelling, optimisation and simulation are important methods that are used to study the transport system and the behaviour of its users, and constitute the core competences of traffic and transport engineers. This track enables students to build up expertise across all main private and public transport modes for people and goods and their related infrastructure networks, ranging from strategic planning and tactical design to operational monitoring and control. The track also provides knowledge on the interrelation and interaction between human behaviour, traffic and transport management, network performance and road and rail (infrastructure) quality.

Modules



Track base: Fundamentals of Traffic and Transport Engineering - planning and design of traffic and transport networks and infrastructure, transport modelling and analysis, traffic modelling and management.

A: Methods in Traffic and Transport Engineering - empirical analysis for transport and traffic engineering, optimisation in transport engineering, simulation and uncertainty in transport engineering.

B1: Transport Networks and Systems - In-depth analysis of the functioning of transport networks for passenger and freight, the relevant performance characteristics for the users (individuals and enterprises) including the resilience, the interaction with economical and spatial development as well as the broader sustainability effects (societal, economic, environmental) of networks.

B2: Road traffic systems - road traffic operations, active mode traffic, traffic safety, intelligent and automated vehicles.

B3: Public Transport and Railway Systems - public transport planning and operations, public transport networks and modelling, railway operations and control.

B4: Road and Railway Engineering - design of road and railway infrastructures and their management, where the interface between traffic and transport as a service and infrastructure requirements for road and rail are fundamental.

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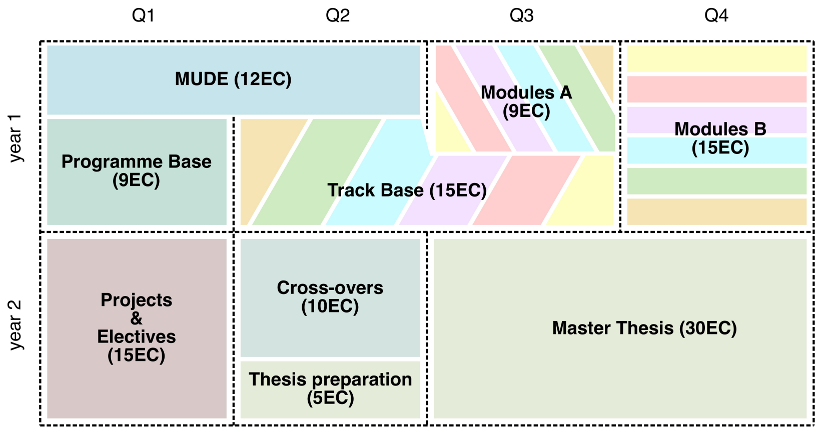
Overall schedule

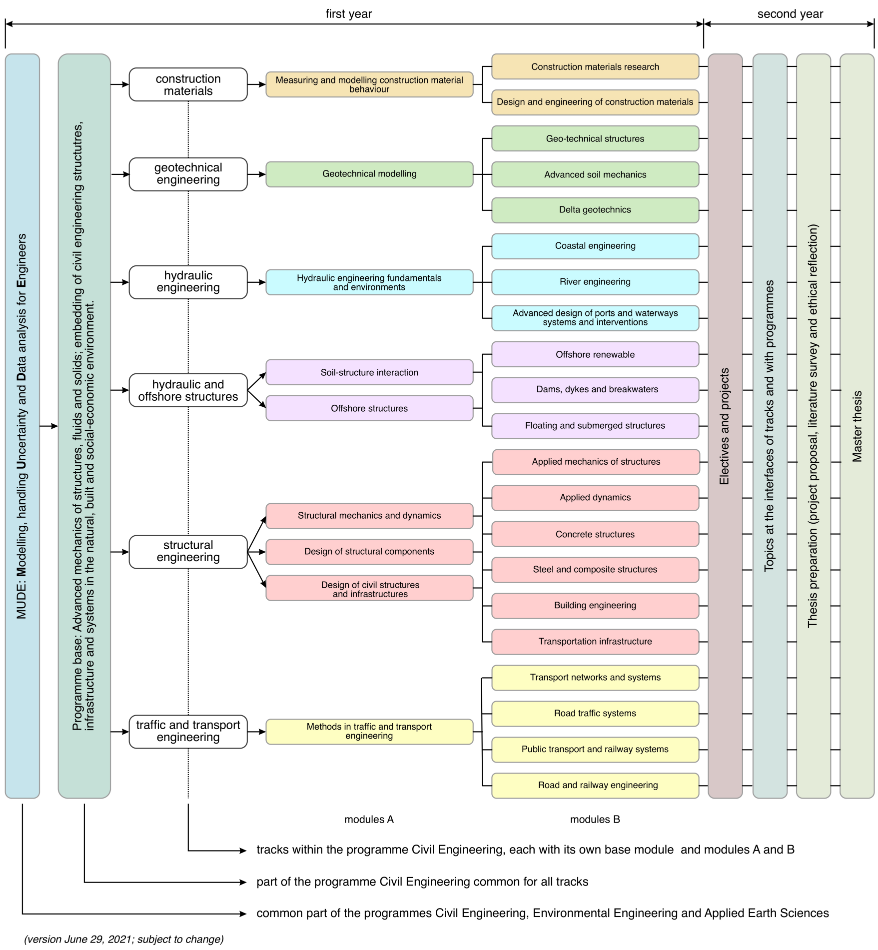
The Master of Science Programme Civil Engineering covers two full years and a total of 120 EC (15 EC per quarter of the academic year).

- Modelling, Uncertainty and Data for Engineers: MUDE (Q1 and Q2 of year 1)
- Programme base module (Q1 of year 1)
- Six tracks (Q2, Q3 and Q4 of year 1)
  - Construction Materials
  - Geotechnical Engineering
  - Hydraulic Engineering
  - Hydraulic and Offshore Structures
  - Structural Engineering
  - Traffic and Transport Engineering
- Projects and electives(Q1 of year 2)
- Cross-over modules (Q2 of year 2)
- Thesis preparation (Q2 of year 2)
- Thesis (Q3 and Q4 of year 2)



MASTER CIVIL ENGINEERING

Programme chart



Programme components	Tracks	Miscellaneous
MUDE	Construction materials	Pre-master
Programme base	Geotechnical engineering	Programme chart
Projects & electives	Hydraulic engineering	Overall schedule
Cross-overs	Hydraulic and offshore structures	Admission
Thesis	Structural engineering	Intended learning outcomes
Learning lines	Traffic and transport engineering	Programme description

MASTER CIVIL ENGINEERING

Intended learning outcomes

- Design safe, sustainable, resilient and adaptable civil engineering structures, infrastructures or systems.
- Analyse, model, predict and explain the behaviour of civil engineering systems at multiple scales.
- Assess the influence of civil engineering systems on society and the environment and vice versa.
- Critically assess and apply civil engineering design practices in a complex natural and societal environment.
- Identify and appreciate societal needs, anticipate future ones and formulate them as civil engineering challenges where appropriate.
- Operate in international, multicultural, interdisciplinary teams.
- Formulate a research or a design question and conduct a project to answer that question.
- Develop creative and innovative, both scientifically and ethically sound answers to civil engineering challenges.
- Effectively communicate results and opinions with stakeholders of diverse backgrounds.
- Acquire new knowledge and skills to continue operating effectively.

These ILO's (Intended Learning Outcomes) are a composition of the abilities essential for a graduate to commence and excel at a career within the context of the societal relevance of civil engineering. ILO's 1-4 and 7 have a strong focus on design and physics of structures (in various forms). In this respect, design is a comprehensive notion, referring to the both creative and technical process of generating and evaluating alternatives, the quantitative elaboration and assessment of structural and functional properties of alternatives and the guidance towards the preferred one. This requires the knowledge of, the understanding of, and the capability to apply relevant practices and physics at an academic level to the benefit of society and the natural environment. The emphasis of the educational programme is on these five attainments.

ILO's 5, 6, 8 and 9 cover the so-called soft-skills every civil engineer should master to properly execute the profession. They deal with the connection with other disciplines as well as with cultural diversity and ethics. Both are essential from the viewpoint that civil engineering is always connected to interacting social, economic and natural systems.

Finally, ILO 10 refers to the inherent limitations regarding any educational programme. It is impossible to ensure that a graduate is equipped with all knowledge and skills required for an entire career. The intention of the MSc Programme in

Civil Engineering is to provide the essentials for such a career, comprising advanced academic knowledge and skills, a scientifically sound and critical attitude and, last but not least, the ability to continuously acquire additional knowledge and skills.

Pre-master programmes

Admission to the master programme Civil Egineering may require prior completion of a pre-master programme, depending on previous education. It is important to note that pre-master programmes are meant to compensate limited discrepancies between previous education and required prior knowledge only. If the required pre-master exceeds 50EC, the concerned student is referred to the BSc Civil Engineering of TU Delft.

Students holding a BSc from a Dutch WO Institute

The table below offers an overview of pre-master programmes that apply to students holding one of the mentioned BSc diplomas. Students holding a BSc in Civil Engineering from either TU Delft of UTwente are directly admissible. Pre-masters for other previous education are issued upon request.

WO Bachelor

period	EC	course code	course title	Applied earth sciences	Architecture (TUD, TU/e)	Electrical engineering	Applied mathematics	Applied physics	Engineering and policy analysis	Aerospace engineering	Mechanical engineering	Maritime engineering	Bodem, water, atmosfeer (WUR)
1	3	CTB2100	Differential equations		■								■
1	3	CT1730	Introduction geotechnical engineering		■	■	■	■	■	■	■	■	■
1–2	6	CTB1001	Analysis		■								
1–2	2	CTB2001WO-20	Computer programming										■
2	5	CTB1210	Dynamics and modelling		■	■	■		■				■
2	3	CTB2200	Probability and statistics		■								
2	5	CTB2220-14	Concrete and steel structures	■		■	■	■	■	■	■	■	■
3–4	6	CTB1002	Linear algebra		■								
3	5	CTB1310	Structural mechanics 2	■		■	■		■				■
3	3	CTB2300	Dynamics of systems		■	■	■		■				■
3	4	CTB3335	Concrete structures 2	■	■								
3	4	CTB3350	Open channel flow	■		■	■	■	■	■	■	■	
4	3	CTB2400	Numerical analysis		■			■					■
4	4	CTB3420	Integral design of infrastructure	■		■	■	■	■	■	■	■	
1	5	CTB2110	Fluid mechanics	■	○	■	■		■	■	■	■	○
2	5	CTB2210	Structural mechanics 3	■	○	■	■	■	■	■	■	■	○
3	5	CTB2320-17	Design of structures and foundations 2	○		○	○	■	○	■	■	■	■
3	4	CTB3370-18	Geometrical design of roads and railways	○	○	○	○	■	○	■	■	■	
3	4	CTB3355	Hydraulic structures	○	○	○	○	○	○	○	○	○	○
4	5	CTB2410	Hydraulic engineering					○		○	○	○	○
			Total EC:	37	45	44	44	38	44	40	40	40	44

■ compulsory ○ choose one

The official language of pre-master programmes is Dutch. English versions are being developed, but not available yet.

Programme components	Tracks	Miscellaneous
MUDE	Construction materials	Pre-master
Programme base	Geotechnical engineering	Programme chart
Projects & electives	Hydraulic engineering	Overall schedule
Cross-overs	Hydraulic and offshore structures	Admission
Thesis	Structural engineering	Intended learning outcomes
Learning lines	Traffic and transport engineering	Programme description

Students holding a BSc from a Dutch HBO Institute

The table below offers an overview of pre-master programmes that apply to students holding a BSc in either Civil Engineering or Built Environment from a Dutch HBO Institute. Students with other HBO diplomas are not admissible.

HBO Bachelor

period & EC 1	2	3	4	course code	course title	Civil Engineering	Built Environment
3				WI1708TH1	Analysis 1	compulsory	compulsory
3				WI1807TH1	Linear Algebra (part 1)	compulsory	compulsory
3				CT1730HBO	Introduction to Geotechnical Engineering	compulsory	compulsory
	5			CTB1210	Dynamics and Modelling	compulsory	compulsory
	3			WI1708TH2	Analysis 2	compulsory	compulsory
	3			WI1909TH	Differential Equations	compulsory	compulsory
		3		CTB2300	Dynamics of Systems	compulsory	compulsory
		3		WI1708TH3	Analysis 3	compulsory	compulsory
		3		CTB2001HBO-16	Computer Programming HBO	compulsory	compulsory
			3	CTB2400	Numerical Analysis	compulsory	compulsory
			3	WI2031TH	Probability and statistics (HBO)	compulsory	compulsory
5				CTB2110	Fluid mechanics	choose one	compulsory
	5			CTB2210	Structural mechanics 3	choose one	compulsory
		4		CTB3340-15	Building structures 1	choose one	
		4		CTB3355	Hydraulic structures	choose one	
		4		CTB3370-18	Geometrical design of roads and railways	choose one	
			4	CTB3420	Integral Design of Infrastructure	choose one	
					Total EC:	44	45

compulsory · choose one

Admission

Prerequisite knowledge

For admission to the MSc Civil Engineering, knowledge and skills at undergraduate level are required in seven fields:

Materials – commonly used civil engineering materials, resources, life cycle, microstructure, physical and mechanical behaviour, sustainability and durability, production.

Geo-engineering – soil characteristics, groundwater, geomechanics, strength of soils, foundations, retaining structures and slopes.

Structures – design and verification of civil engineering structures in steel and concrete, general construction technology

Fluids – characteristics and properties of fluids, hydrostatics, kinematics, balance equations of mass, volume, momentum and energy, flows around bodies or walls, gradually varying flows in open channels, waves, tides.

Mechanics – statics, solid mechanics, structural analysis, dynamics of civil engineering structures.

Transport – design of transport infrastructures (road, rail), transport and traffic modelling.

Mathematics – calculus, linear algebra, probability and statistics, numerical methods.

In addition, it is assumed that students opting for our MSc adequately master basics of civil engineering, physics and computer programming.

Most bachelor programmes in civil engineering sufficiently include the above topics. In the case of deficiencies, a pre-master programme may apply. Students are advised to check by themselves for possible deficiencies and prevent or reduce them whenever possible, for instance by deploying the elective space in their bachelor programme.

Application

Information on application procedures for both national and international students can be found on our website.