4TU.

STUDY GUIDE
ACADEMIC YEAR 2018-2019

4TU Programme
Construction Management & Engineering

TU Delft Delft University of Technology

TU/e Technische Universiteit Eindhoven University of Technology

UNIVERSITEIT TWENTE.

TABLE OF CONTENTS

TABLE OF CONTENTS	1
FOCUS AT THE THREE CME LOCATIONS	2
GRADUATION THEMES AT THE THREE LOCATIONS	6
CAREER OPPORTUNITIES AFTER CME	8
ORGANISATION OF THE 4TU CME MASTER PROGRAMME	10
DIRECTORS OF EDUCATION / COORDINATORS AT THE THREE LOCATIONS	10
STUDY ADVISORS AT THE THREE LOCATIONS	11
EXAMINATION COMMITTEES AT THE THREE LOCATIONS	12
EDUCATION COMMITTEES AT THE THREE LOCATIONS	13
STUDY ASSOCIATIONS AT THE THREE LOCATIONS	14
ALUMNI ASSOCIATIONS AT THE THREE LOCATIONS	15
OVERVIEW OF THE COURSES IN DELFT	18
OVERVIEW OF THE COURSES IN EINDHOVEN	25
OVERVIEW OF THE COURSES IN TWENTE	35

FOCUS AT THE THREE CME LOCATIONS

THE CHALLENGE OF CONSTRUCTION MANAGEMENT & ENGINEERING (4TU)

Complex, innovative and multidisciplinary projects in a dynamic environment are calling for a new breed of manager able to competently combine engineering and organisation skills. Today's construction industry is changing fast. New techniques, shifting roles, complex logistics and globalization are only some of the factors affecting the character and management of projects in the building industry.

FOCUS IN DELFT

At TUD, the programme focuses on two aspects: 1) process and system innovation in the building industry in general and 2) the 'Integral Design Concept', which has been developed within the Infrastructure Design and Management section within the Faculty of Civil Engineering and Geosciences. There are six main research areas within this: stakeholder participation, tendering and outsourcing, supply chain integration, value creation, dynamic life cycle support and asset management. Topics that are characteristic of TUD include the Asset management, Project Management and Legal & Finance.

Recommended courses from other locations:

From UT:

- Construction Industry Dynamics
- Sustainability and Circularity in Civil Engineering

From TU/e:

- Managing place and property
- Fundamentals of BIM
- Project redevelopment of problem areas
- Housing systems and strategy
- Smart Urban Environment
- Project Big data and experiment for urban analysis

FOCUS IN EINDHOVEN

The master's degree program Construction Management and Engineering (CME) is offered by the Built Environment (BE) and Industrial Engineering & Innovation Sciences (IE&IS) departments, with their distinctive research-driven and project-oriented approach to education. In this interdepartmental program the focus is Construction Management & Urban Development: using urban/building sciences and management and innovation sciences to develop solutions for urban development with particular emphasis on smart cities. CME graduation projects are closely related to ongoing research projects in the BE and IE&IS departments.
Courses that are characteristic of TU/e include the following: Urban Research Methods, Technology Entrepreneurship, Entrepreneurial Marketing, Built environment and smart mobility, Research and Development project, Smart Urban Environments, Project BIG data experiments for urban analysis, Fundamentals of BIM and Urban Planning II.

Recommended courses from other locations:

From TUD:
- Probabilistic Design
- Financial Engineering

From UT:
- Construction Industry Dynamics
- Sustainability and Circularity in Civil Engineering
- BIM and 5D Planning

Focus in Twente

At the University of Twente, the 4TU Master's programme in CME focuses on the management of the design and construction process in the construction industry (buildings and infrastructure). Students gain thorough knowledge of both the engineering and organizational aspects of this intricate process. This combination is essential to mastering current practices in complex, innovative and multidisciplinary projects in dynamic environments.
The UT approach centres on the market and organizational environment and the organization of the construction industry and the management of the various stages of the design and building process. Keywords at UT include: cooperation through the entire lifecycle, helicopter view, stakeholder approach and engaged scholarship. The emphasis is on designing, managing and organizing the design and building process. Courses that are characteristic of UT include the following: Markets, Organisation & Innovation, Procurement Strategies and Tendering, Supply Chain Management and ICT, Collaborative Design & Engineering and Industrialisation & Innovation in Construction.

Recommended courses from other locations:

From TUD:
- Financial Engineering
- Probabilistic Design

From TU/e:
- Technology Entrepreneurship
- Fundamentals of BIM
- Parametric design
- Research and development project

Attending courses at another location

You have an automatically side registration at the two other universities that are not your 1st location of registration, so you can register for courses and exams (via electronic learning environment and online exam systems) at another location. That means that each 4TU student receives a letter containing registration information. With this registration information, you can register for courses and exams (via electronic learning environment and online exam systems) at another location.

Attending courses at the University of Twente; what to do?

1. You should have received a letter from the Central Student Administration (CSA) of the University of Twente with a student number, email address etc. With this data you have access to Blackboard in order to register for courses and Osiris in order to register for exams at the University of Twente.

   If you have not received this information, please mail to s.laudy@utwente.nl. He will organise this information through Central Student Administration for you.
   Are you a TU/e student and would you like to follow courses in Twente, but you don't have received the login details? Please contact stu@tue.nl (Mr. B. Viveen). They will then create new login details for you.

2. Register yourself for the course through Blackboard (https://blackboard.utwente.nl) and register for examinations at Osiris (http://osiris.utwente.nl). More information about Blackboard and Osiris:
   - http://www.utwente.nl/onderwijssystemen/en/about_the_applications/blackboard/
   - http://www.utwente.nl/onderwijssystemen/en/about_the_applications/osiris/
   - http://www.utwente.nl/ces/studentservices/osiris/Osiris/

3. Sign up at the study advisor at the UT ir. J. Krabbenbos (J.Krabbenbos@utwente.nl) for more specific information about studying in Twente.

Attending courses at the Delft University of Technology; what to do?

1. You should have received a letter/mail from the Central Student Administration (CSA) of the University of Delft with a student number, email address etc. With this data you have access to Blackboard in order to register for courses and Osiris in order to register for exams at the University of Delft.

   If you have not received this information, please mail to s.laudy@utwente.nl. He will organise this information through Central Student Administration for you.
   Are you a TU/e student and would you like to follow courses in Delft, but you have not received the login details? Please contact stu@tue.nl (Mr. B. Viveen). They will then create new login details for you

2. Register yourself for the course through Blackboard (https://blackboard.tudelft.nl)

3. Register yourself for the examinations of the course through Osiris (Osiris via Blackboard)

4. Sign up at the study advisor at the TUD, Mr. K.O. Karsen, (k.o.karsen@tudelft.nl) for more specific information about studying in Delft.

Attending courses at the Eindhoven University of Technology; what to do?

1. You should have received a letter/mail from the Education and Student Affairs (ESA) of the Eindhoven University of Technology with a student number, email address etc. With this data you have access to Osiris in order to register for courses and exams at the Eindhoven University of Technology.

   If you have not received this information, please mail to s.laudy@utwente.nl. He will organise this information through Education and Student Affairs (ESA) for you.

2. Register yourself for the course and examinations through Osiris (https://osiris.tue.nl)

Sign up at the study advisor at the TU/e, Mrs. J.A.M. Pulles (J.A.M.Pulles@tue.nl for more specific information about studying in Eindhoven.

Transferring ECTS from one location (TU) to another

To receive your ECTS at your first University of registration is a manual action!

1. Make sure the course you successfully finished is registered at the location you attended the course including final mark, i.e. in Osiris.
2. Get yourself a certified copy of your marks
   a certified copy is a photocopy with an official stamp and signature to verify that it is a true copy of the original document. You can get a certified copy at the student administration of the TU you attended the course.
3. You hand over the copy to the University of 1st registration. This can be done at the Centre for Educational Support of the respective universities. This department will administer the course and grading.

Graduation Themes at the three locations

Graduation themes in Delft

The central theme throughout the different research programmes is about the "process and innovating systems in the construction industry". The thesis mainly focuses on the generic properties of research questions that are of relevance to practical problems. Examples of this are themes such as:

- Stakeholder participation in the construction process
- Forms of tendering and outsourcing
- Transition management
- Financial engineering
- Policy and governance aspects
- Supply chain integration and reversal
- Dynamic life cycle support
- Building Information Modelling (BIM)
- Asset management

Graduation themes in Eindhoven

At the TU/e the graduation specialisation of CME consists of `Construction Management & Urban Development' (CMUD). The final graduation project has a clear scientific signature, and is grounded in actual CMUD challenges. CME graduation projects are often executed in collaboration with industry partners, engineering offices or government institutes. CMUD borrows from two scientific domains: (i) urban science and systems and (ii) management and innovation sciences.

The graduation project is executed across the two aforementioned scientific domains. Within this cross section students can choose from a list of subjects that are strongly related to on-going projects in the TU/e departments Built Environment (BE), and Industrial Engineering and Innovation Sciences (IE&IS). All subjects are clustered into the following research areas:

- Process engineering:
  When cities or urban districts are to be developed or redeveloped, complex decision-making and information processes are needed in order to bring shareholders and stakeholders together. Developing models for negotiation, data management, simulation of expected results and process governance are the focus of these graduation projects.
- Business engineering:
  Cities and urban districts are considered and approached in terms of entrepreneurial entities: profit and non-profit companies. In the individual graduation projects, the subjects are value features, exploitation possibilities, management and financing concepts.

For both research areas the following relevant societal and engineering topics, regarding smart city development are in focus:

- Energy management
- Urban management
- Information management

Graduation themes in Twente

The 4TU Master's programme in CME in Twente uses cutting-edge technology to dissect and understand processes which integrate governance issues, societal trends and management methodologies. CME at the UT has two graduation themes:

- *Markets & Organization in Construction*
  The specialisation Markets & Organisation in Construction focuses on aspects of market dynamics and organisational structures that are typical for the construction industry. Typical characteristics of the construction industry are often unique products (no mass-production), with a long planning and production phase, a long life time, constructed in public space, with many involved stakeholders.
- *Digital Technologies in Construction*
  Digital Technologies in Construction focuses on the analysis and management of the design and construction process in the building and construction industry, the coordination of the activities and roles of parties involved.

Career opportunities after CME

After the CME master you can choose out of several options, such as directly ***working in industry***, a paid combination of education and working on a practical design in industry (***PDEng***), or a scientific career (***PhD***).

Career in industry

Career opportunities for CME graduates can be found across the full spectrum of the building and construction industry, in the Netherlands and abroad. Future employers may include building and construction companies, organisations such as insurers with their own project development department, engineering and design offices and consultancy firms, government and NGOs such as Rijkswaterstaat, and institutes of research and education.

Positions may vary from company or division manager, construction supervisor or construction manager to project manager, technical consultant, project engineer or process manager. Given the wide range of knowledge and skills provided by this MSc programme and the current situation within the industry, opportunities are very promising.

PDEng - Post-Master Technological Design Programmes

Instead of directly working in the building- and construction industry, there is the opportunity to follow one of the Post-Master's designer programmes in Civil engineering at the 4TU Stan Ackermans Institute.
The ***practical focused*** PDEng (Professional Doctorate in Engineering) programmes in Civil Engineering (UT) and Smart Buildings and Cities (TU/e) are open for CME graduates.
During the program you will increase your technological knowledge, but you also learn how to apply it in practice. As well as that you work on your professional skills to increase your career opportunities. It encourages to actively look beyond the perimeters of a discipline and to recognise the challenges and restrictions imposed by product chain management, time and money.

A PDEng programme consists of an educational programme on a post-MSc level (50%) and a design project within an organization (50%). During projects students bring industrial and academic knowledge together and apply them in real industrial designs. A PDEng programme is fulltime and takes two years to complete.

By doing a PDEng programme you will become a qualified designer. When the trainee successfully completes the programme, he/she will receive a certified diploma and will be entitled to use the academic degree PDEng. During both years PDEng trainees receive a salary.

For more information you can check the websites of the PDEng Civil Engineering and the PDEng Smart Buildings and Cities:

- PDEng Civil Engineering: www.utwente.nl/go/pdeng-civil-engineering
- PDEng Smart Buildings and Cities: www.tue.nl/sbc

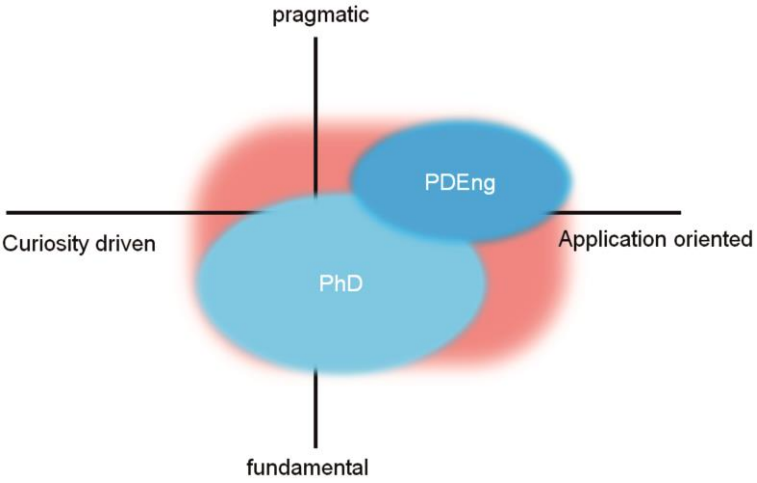
PhD - Doctoral Programmes

After completing your Master of Science degree, you also could opt for a career in ***research***. This involves spending four years studying a particular research area in depth. An integral part of this is writing your PhD thesis, and at the end of your PhD period you will present and defend your research in public. After successfully completing your PhD, you will be awarded the title of Doctor (Dr.).

Unlike in many other countries, most PhD researchers in the Netherlands are paid employees, often working directly for the university.

For more information you can check de websites of the graduate schools of each location:

- TU Delft: http://graduateschool.tudelft.nl/
- TU Eindhoven: https://www.tue.nl/en/education/tue-graduate-school/phd-programs/
- University of Twente: www.utwente.nl/tgs



Organisation of the 4TU CME Master programme

Directors of Education / Coordinators at the three locations

Director of Education in Delft (untill 1-11-2018, from 1-11-2018: n/a)
Drs.ir. J.G. (Jules) Verlaan
Room: Building 23, room 3.48
Telephone: 015 278 7467
E-mail: j.g.verlaan@tudelft.nl

Coordinator in Eindhoven
Dr. Q. (Qi) Han
Room: VRT 8.12
Telephone: 040 247 5403
E-mail: q.han@tue.nl

Coordinator in Twente
Dr.sc.techn. A. (Andreas) Hartmann
Room: Horst HT305
Telephone: 053 489 2084
E-mail: a.hartmann@utwente.nl

Programme Developer 4TU-CME
Ir. S. (Sven) Laudy
Telephone: 06-41035617
E-mail: s.laudy@utwente.nl

Study Advisors at the three locations

Study Advisors in Delft

K.O. (Karel) Karsen
Room: Building 23, room 77.1
Telephone: 015 278 3337
E-mail: k.o.karsen@tudelft.nl

Drs. P. (Pascal) de Smidt
Room: Building 23, room 2.77
Telephone: 015 278 1068
E-mail: p.desmidt@tudelft.nl

Study Advisor in Eindhoven

Mrs. J.A.M. (Josée) Pulles
Room: VRT 2.12
Telephone: 040-247 8725 (if no answer: 040-247 3990)
E-mail: j.a.m.pulles@tue.nl

Study Advisor in Twente

Ir. J. (Judith) Roos-Krabbenbos
Room: Horst Z-214
Telephone: 053-489 2341
E-mail: j.roos-krabbenbos@utwente.nl

Examination Committees at the three locations

Examination Committee in Delft

Members of the Examination Committee in Delft:

- Chairman: Dr. M. Leijten
- Member: Dr. M.L.C. de Bruijne
- Member: Mr.dr. F.A.M. Hobma
- Extern member: Drs. K. Taselaar

Examination Committee in Eindhoven

Members of the Examination Committee in Eindhoven:

- Chairman: Dr.ir. A.D.A.M. Kemperman
- Ad interim vice chairman: Dr. Q. Han (CME)
- Member: Ir. R.A. Rutgers
- Member: Dr. ir. G.I. Curulli
- Member: Dr. ir. M.G.L.C. Loomans, Ad interim replacement by ir. M.P.J. Aarts
- Member: Dr. ir. E. Bosco (Emanuela)
- Advisor: Mrs. J.A.M. Pulles (CME/GS)
- Advisor: Mrs. J.H. Steetskamp (BC)
- Secretary: G.L.C. Bruinewoud-Klaessen

Examination Committee in Twente

Members of the Examination Committee in Twente:

- Chairman: Prof.dr.ir. J.I.M. Halman (Construction Management and Engineering)
- Secretary: Ing. K.M. van Zuilekom
- Member: Dr.ir. D.C.M. Augustijn (Water Engineering and Management)
- Member: Prof.dr.ir. E.C. van Berkum (Centre of Transport Studies)
- Member: Dr. G.A.M. Jeurnink (faculty EWI, department AAMP)
- Member: Dr. J.T. Voordijk (Construction Management and Engineering)
- Advisor: Dr.ir. C.M. Dohmen-Janssen (director of education)
- Register: Drs. E. Ruijgh

Education Committees at the three locations

Education Committee in Delft

Members of the Education Committee in Delft:

- Chairman: Prof.dr.ir. M.J.C.M. Hertogh
- Member: Dr.ir. M.G.C. Bosch-Rekveldt
- Member: Vacancy
- Student member: n/a
- Secretary: M.H. Geldof

Education Committee in Eindhoven

Members of the Education Committee in Eindhoven:

- Chairman: Dr.ir. S.P.G. Moonen
- Member: Dr. ir. M.C.J. Hornikx
- Member: Dr. J. Kim (USRE)
- Member: Dr. D. Yang (CME)
- Member: Dr. S. Krishnamurthy (AUDE)
- Student member: K. Uesaraie (CME)
- Student member: Ms S. Tax (Cheops)
- Student member: Ms A. Offermans
- Student member: Ms D. Kerindongo (Koers)
- Student member: Ms C. Graafland (AnArchi)
- Secretary: Mrs F.M. Clijsters (VRT 2.08) f.m.clijsters@tue.nl - 040-2472711

Education Committee in Twente

Members of the Education Committee in Twente:

- Chairman: Prof.dr.ir. K.T. Geurs
- Member: Dr.mr.ir. M. van Buiten
- Member: Dr.ir. R.S. de Graaf
- Member: Dr.ir. P.C. Roos
- Member: Dr.ir. M.J. Booij
- Student member: E. Berghuis
- Student member: R.J. Daggenvoorde
- Student member: H.J. Drenth
- Student member: H.B. Koopmans
- Student member: R.L.T. Oppers
- Advisor: Dr.ir. C.M. Dohmen-Janssen
- Advisor: S. Siebelink MSc
- Advisor: D.E.C. Blomjous
- Secretary: Drs. E. Ruijgh

Study Associations at the three locations

Study Association in Delft

Study Association CME Dispuut
Building 23, Room 3.53
Postbus 5048
2600 GA Delft

Location
Stevinweg 1
Building 23, Room 3.53
Phone: 015-2785012
E-mail: info@cmedispuut.nl
Website: www.cmedispuut.nl/

Study Association in Eindhoven

Study Association of CoUrsE!
Vertigo floor 8
Postbus 513
5600 MB Eindhoven

Location
Vertigo floor 2
De Zaale
Telephone: 040 247 5025
E-mail: info@ofcoursecme.nl
Website: www.ofcoursecme.nl

Study Association in Twente

Study Association ConcepT
Horst (basement) C-016 and C-018
Postbus 217
7500AE Enschede

Location
Horst (basement) C-016 and C-018
Drienerlolaan 5
Phone: 053 489 3884
E-Mail: ConcepT@ConcepT.utwente.nl
Website: www.concept.utwente.nl

Alumni Associations at the three locations

Alumni Association in Delft

CME Dispuut
Building 23, Room 3.53
Postbus 5048
2600 GA Delft

Location
Stevinweg 1
Building 23, Room 3.53
Phone: 015-2785012

E-mail: info@cmedispuut.nl
Website: www.cmedispuut.nl
LinkedIn: www.linkedin.com/groups/CME-Alumni-3663314

Alumni Association in Eindhoven

Association for Construction Management and Engineers (ACME)
Vertigo Vloer 9
Postbus 513
5600 MB Eindhoven

Email: acmeeindhoven@gmail.com
Telnr.: 040 247 2373
LinkedIn: https://www.linkedin.com/groups/126804

Alumni Association in Twente

Alumni Association ConcreeT
p/a Alumni bureau Universiteit Twente
Postbus 217
7500 AE Enschede

Email: concreet@utwente.nl
Website: https://www.concept.utwente.nl/praktijk/concreet
LinkedIn: www.linkedin.com/groups/55115

COMPULSORY COURSES AT THE THREE CME LOCATIONS

The study programme is composed as follows:

a. Core programme (compulsory courses), 28 – 37.5 EC
b. Specialism-related courses and electives, 50 – 56 EC
c. Graduation work, 36 – 40 EC

COMPULSORY CORE COURSES IN DELFT (28 EC)

Corner stones (28 EC)				
Course Code	**Name**	**Period**	**Responsible lecturer**	**EC**
AR8002TU	Legal & Governance	1	Mr. F.A.M. Hobma	7
SPM8000	Project Management	3	Drs. M. Leijten	7
SPM8002	Process Management	2	Drs. M. Leijten	7
CME1200	Collaborative Design & Engineering	4	Dr. R. Schoenmaker	7
Obligatory specialism-related courses (31 EC)				
Course Code	**Name**	**Period**	**Responsible lecturer**	**EC**
EPA1433	Cross-cultural Management	3	Prof.dr. W.M. de Jong	5
CME2300	Financial Engineering	1	Dr. D.F.J. Schraven	4
CIE4030	Methodology for Scientific Research	1,2,3,4	Prof.dr.ir. H.E.J.G. Schlangen	3
CIE4130	Probabilistic Design	2	Dr.ir. O. Morales Napoles	4
CME2200	Dynamic Control	4	Dr.ir. M.G.C. Bosch-Rekveldt	4
WM0312CIE	Philosophy, Technology Assessment and Ethics	4	Dr.mr.ir. N. Doorn	4

COMPULSORY COURSES IN EINDHOVEN (30 EC)

Course Code	Name	Period	Responsible lecturer	EC
1CM900	Project Management	2	Dr. ir. R.A.C.M. Broekmeulen	2.5
1ZM65	System Dynamics	3	Dr.ir. B. Walrave	5
7ZM8M0	Collaborative Design	3	Prof.dr.ir. B. de Vries	5
7ZM3M0	Case Study Process Modelling	1	Dr. Q. Han	2.5
7ZM5M0	Process Modelling & Information Management	4	Dr. Q. Han	5
7ZM9M0	Systems Engineering	1	Prof.dr.ir. B. de Vries	2.5
7ZM6M0	Legal & Governance	1	Prof.dr.ir. B. de Vries	7.5

COMPULSORY COURSES IN TWENTE (30 EC)

Profile Markets & Organization of Construction

Course Code	Name	Period	Responsible lecturer	EC
195820400	Research Methodology and Academic Skills	2	Dr.sc.techn. A. Hartmann	7.5/ 5
Profile courses (minimum 30 EC including compulsory courses)				
201500097	Planning and Process Management	1	Prof.dr.ing. K.T. Geurs	5
195800100	Legal & Governance Aspects	1	Dr. P.J. Klok	7.5
201800072	Planning and Process management	1	Prof.dr.ing. K.T. Geurs	5
201800043	Sustainability and Circularity in Civil Engineering	1	dr. S. Bhochhibhoya	5
201800047	Construction Industry Dynamics	2	prof.dr.ir. A.G. Doree	5
201800029	Construction Process Management	2	dr.ir. W. Tijhuis	5
201800032	Systems Engineering in Construction	3	dr.ir. R.S. de Graaf	5
201800034	Infrastructure Asset Management	4	dr. A. Hartmann	5

Profile Digital Technologies in Construction

Course Code	Name	Period	Responsible lecturer	EC
195820400	Research Methodology and Academic Skills	2	Dr.sc.techn. A. Hartmann	7.5/ 5
Profile courses (minimum 30 EC including compulsory courses)				
201500097	Planning and Process Management	1	Prof.dr.ing. K.T. Geurs	5
195800100	Legal & Governance Aspects	1	Dr. P.J. Klok	7.5
201800072	Planning and Process management	1	Prof.dr.ing. K.T. Geurs	5
201800047	Construction Industry Dynamics	2	prof.dr.ir. A.G. Doree	5
201800029	Construction Process Management	2	dr.ir. W. Tijhuis	5
201800032	Systems Engineering in Construction	3	dr.ir. R.S. de Graaf	5
201800044	Digital Technologies for Civil Engineering	3	prof.dr.ir. A.M. Adriaanse	5
201800052	Technology and Innovation in Road Construction	4	dr. S.R. Miller	5

Overview of the courses in Delft

Compulsory corner stone courses in Delft

Legal & Governance	
Responsible lecturer:	Mr. F.A.M. Hobma
Course code:	AR8002TU
Period:	1
ECTS:	7

Course description:

This course holds two parts: a legal part and a governance part.

- Legal part: the planning and construction of buildings and infrastructure is surrounded by many legal issues like procurement, contracts, permits etcetera; the main legal aspects involved in the planning and construction of works of civil engineering nature will be discussed. Main topics include: contract law, Dutch and FIDIC conditions, European and Dutch procurement law, arbitration and dispute review, planning law, European environmental law, the Infrastructure Planning Act, land assembly, permits; the themes will be illustrated using real cases from Holland and abroad.
- The governance part is about actors in construction industry and their behaviour; networks, markets, hierarchy, public private partnerships.

Project Management	
Responsible lecturer:	Drs. M. Leijten
Course code:	SPM8000
Period:	3
ECTS:	7

Course description:

This course focuses on the project management of construction projects. Projects, in all contemporary industry sectors and specifically in construction, are becoming increasingly complex and challenging with the accelerated advances in technology, new business models, forms of collaboration, availability requirements, and an augmented demand to deliver economic value and a competitive advantage. Managing projects in this environment requires strong leadership skills and proficiency in project management knowledge and practice to be able to achieve the project and organizational objectives on time, on budget and to the satisfaction of stakeholders. The course is designed to provide students with scholarly knowledge in the practice of managing construction projects in order to enhance their career options and prepare them to move into management roles by developing their professionalism, versatility and leadership in an environment of constant change.

The course provides a thorough exploration of project management processes and tasks. These include Project organisation, Planning tasks and control strategies, Contracts and procurement methods, Communication and inter-relationships between project stakeholders.

Collaborative Design & Engineering	
Responsible lecturer:	Dr. R. Schoenmaker
Course code:	CME1200
Period:	4
ECTS:	7

Course description:
Collaborative Design and Engineering deals with processes in which multiple actors work together for a given civil engineering problem, in a complicated environment. In this course students gain understanding of the aspects of Collaborative Design and Engineering by carrying out a design project in collaboration. In this group assignment, students work together in large teams, deal with stakeholders with diverse interests, apply methods and concepts from the various BSc courses for solving the given problem and deal with the challenges of group dynamics.

Process Management	
Responsible lecturer:	Drs. M. Leijten
Course code:	SPM8002
Period:	2
ECTS:	7

Course description:
Complex construction and engineering projects require collaboration between a variety of actors within a complex and dynamic environment. An environment that is influenced by various social, political and physical factors. These actors may be related to a project in various ways, e.g. as decision makers, regulators, risk taking participants and stakeholders, each with different interests, resources and attitudes towards a project, being affected by a project and influencing it in different ways and degrees. In order to understand and adequately deal with these characteristics, process management is needed in addition to project management. Building on practical experiences and process management theory, this course aims at providing students with insights, concepts and skills needed to understand the nature of interaction between actors regarding the initiation and development of, and decision making on projects within uncertain and dynamic situations. They will learn to analyse, develop and apply strategies, tools and arrangements that are part of the process management approach, to understand the differences with line and project management and to recognize the conditions for applying process management.

SPECIALISATION COURSES IN DELFT (OBLIGATORY)

Dynamic Control of Projects	
Responsible lecturer:	M.G.C. Bosch-Rekveldt
Course code:	CME2200
Period:	4
ECTS:	4

Course description:
Each project is an intervention in an existing situation. The aim is to incorporate a system into an existing environment. A project is a specific and unique development, for a unique client, on a unique location, with a unique goal, to solve a unique problem, with a unique problem solver, etc. A project needs time for the development with a number of subsequent phases: design, engineering, production, etc. In most cases:

1) the state of the environment (politics, stakeholders, regulations, etc.) at the start of a project is totally different from the state of the environment during the project, at the end of the project and certainly during the operation phase during the lifetime of the system,
2) the information and knowledge about the desired system in its environment increases dramatically during the project, which leads to different views and options and
3) the state of the technology to be applied in a project changes during a project.

In consequence, we often develop systems with the ideas of yesterday and with today's technology for tomorrow's people.

To create value, we should not only work dynamically in an adaptive way with continuous change, but also take care that the systems we deliver are adaptable to changing circumstances. Inevitably, the traditional project management should realize that the construction world will also be a part of the new short-cyclic and circular economy. We need to play with complexity; allow for more dynamic approaches in project management and to strive for solutions that maximize value. Sustainability is a key issue.

After this course you are able to:

- Explain the dynamic character of a project, a product and a process,
- Perform a complexity assessment on a real life project, both individually and with a group,
- Recognize the relations between complex project systems and higher scale (context)systems,
- Apply methods to deal with the effectiveness and efficiency of projects in a changing world,
- Choose management approaches to deal with different types of project complexity,
- Describe the advantages and disadvantages of innovative ways for collaboration and contract types in complex environments.

Probabilistic Design	
Responsible lecturer:	Dr.ir. O. Morales Napoles
Course code:	CIE4130
Period:	2
ECTS:	4

Course description:
After the course, the student has to be able to do Level I, II and III calculations, risk-based optimisations and system probability calculations.

Financial Engineering	
Responsible lecturer:	Dr. D.F.J. Schraven
Course code:	CME2300
Period:	1
ECTS:	4

Course description:

This course deals with the finance issues related to the implementation of civil engineering projects. It introduces economic engineering concepts and finance-related topics such as project financing and financial accounting. This course requires the student to study in detail:

- Finance and the firm, covering topics such as sources of finance, cost of finance, financial structures, working capital management and financial accounting;
- Capital Budgeting Decisions and Risk, covering topics such as Capital Budgeting, Political and Social factors, Portfolio Management and Risk Considerations;
- Project finance, covering topics such as international capital markets, stakeholder/actors viewpoints and cash flow modelling of projects, open mining, infrastructure and office buildings.

The intended learning outcomes of this course are:

- To give students a knowledge of financing and financial implications of civil engineering projects from both a firm and a project perspective, including perspectives from financial involved actors;
- To give students an understanding of the project life-cycle and its impact on and relationship with project finance;
- The ability of students to deal with uncertain political and social factors and financial risks.

Methodology for Scientific Research	
Responsible lecturer:	Prof.dr.ir. H.E.J.G. Schlangen
Course code:	CIE4030
Period:	4
ECTS:	3

Course description:
This course is intended for students that would like to 'Design a Research Project". It is also a perfect preparation for the final project in the MSc. The topics that will be presented in this course are: Defining research objectives, Setting up a research framework, Formulating research questions, Different research concepts and strategies, Various research material, Planning your research, Analysing your research results, and Reporting and presenting your research.

Study goals:

- To be able to clearly describe a research goal.
- To be able to design a scientific research.
- To be able to analyse the results of a scientific research.
- To be able to formulate the structure of a scientific report

The course will be given with Online-lectures.

Intercultural relations and project management	
Responsible lecturer:	Prof.dr. W.M. de Jong
Course code:	EPA1433
Period:	1
ECTS:	5

Course description:
This course introduces students to some theories and dimensions on national culture as defined by Hofstede and others. Furthermore, students shall become acquainted with the dynamics of intercultural and interdisciplinary (project) teams. Through exercises, workshops and assignments students engage with the theory and reflect on their own intercultural experience and develop their cross-cultural sensitivity.

After taking this course the student

- Is able to point out the effects of globalization, realizes and recognizes the existence of different rationales, behaviours and cultures in translating scientific knowledge into effective policy-making and policy implementation when addressing the global challenges.
- Can discover and discuss cultural dimensions in given social/organisational phenomena and events.
- Demonstrates cultural awareness by developing an appropriate attitude towards cross-cultural collaboration and communication in given cultural contexts.
- Has experienced, analysed and evaluated the dynamics of an intercultural and interdisciplinary team.
- Can recognize and interpret the effects of cross-cultural communication and groups dynamics and develop a fitting coping strategy.
- Can appraise and evaluate group dynamics in intercultural and interdisciplinary teams and support such teams in goal attainment.
- Will have knowledge and skills needed to perform a series of different roles in (public)

projects

Philosophy, Technology Assessment and Ethics	
Responsible lecturer:	Dr.ir. N. Doorn
Course code:	WM0312CIE
Period:	4
ECTS:	4

Course description:

This is a course that provides the student more knowledge on philosophy and ethics within the construction world. It consists of three modules:

Philosophy Module

- What is science, and what is technology? Brief overview of their history; positions on the influence of science and technology on society;
- The fact/value distinction; logic and argumentation theory;
- Methodology: foundations of scientific and technological knowledge; role of scientific explanations.

Technology Assessment Module

- Why does technology fail? Technology Assessment as bridging the gap between society and the engineering community;
- Introduction to TA-methods and traditional forecasting: extrapolations, experts interview and the 'common sense'-method, scenarios, scenario workshops;
- Drivers of technological change, the relation between technological change and society
- Constructive Technology Assessment, participatory technology development;
- Practice of TA; politics, steering technological innovation of Sustainable Development.

Ethics Module

- Introduction to moral dilemmas in engineering practice;
- Analysis of moral dilemmas in engineering practice and their backgrounds; professional codes of conduct and conflicting loyalties; legal rights and duties of engineers;
- Ethics, i.e. the foundation of judgments about good and bad / responsible and irresponsible acts;
- Introduction to some topics especially relevant for engineering: risks, responsibility and sustainability.

Graduation in Delft

Master Thesis Preparation	
Responsible lecturer:	Dr. R. Schoenmaker
Course code:	CME2001
Period:	1, 2, 3, 4
ECTS:	4

Course description:
Preparation for graduation; this involves drawing up a learning plan and completing a preparatory course of study or desk research, which will be recorded in a start report by using a research methodology. Used literature should be listed in a list of references.

Master Thesis	
Responsible lecturer:	Dr. R. Schoenmaker
Course code:	CME2000
Period:	1, 2, 3, 4
ECTS:	32

Course description:
Students have to carry out an individual project to round off the CME programme. The subject for the research project may be chosen in respect to, or independent from, a specific area of technology and possible elective profile, though students are stimulated to find some connectivity in their choices. Within this project, students must demonstrate their capacity for academic analysis, synthesis, design, reflection and written communication on a particular issue in the field of engineering and policy analysis.

Overview of the courses in Eindhoven

Compulsory courses in Eindhoven

Programme overview

	EC	Quartile
Core courses (30 ECTS)		
Project Management	2.5	2
System Dynamics	5	3
Process Modelling and Information Management	5	4
Case Study Process Modelling	2.5	1
Collaborative Design	5	3
Systems Engineering	2.5	1
Legal and Governance	7.5	1
Specialisation electives (35 ECTS out of 50 ECTS)		
Urban Research Methods	5	3
Smart Urban Environments	5	2
Fundamentals of BIM	5	2
Technology Entrepreneurship	5	2
Entrepreneurial Marketing	5	2
Built Environment and Smart Mobility	5	4
Research and Development Project	10	1,2,3,4
Big data and experiments for urban analysis	10	3,4
Urban Planning II	5	1
Free Electives course (15 ECTS)		
All 4TU-CME MSc-courses offered by TU/e, TUD, UT	15	
Graduation CME incl. Research proposal (40 ECTS)	**40**	**1,2,3,4**

Internship USRE/CME Relevant Work Experience	
Responsible lecturer:	Ir. A.W.J. Borgers
Course code:	7ZRWE0
Period:	**1, 2, 3, 4**
ECTS:	**5**

Course description:
The internship Relevant Work Experience can be one of the electives in the student's personal study plan. It allows the student to acquire some experience in one of the fields related to the built environment.

Internship USRE/CME Academic Work Experience	
Responsible lecturer:	Ir. A.W.J. Borgers
Course code:	7ZAWE0
Period:	**1, 2, 3, 4**
ECTS:	**15**

Course description:
To be specified in the Internship Plan. The learning objectives must be described on MSc-level and must lead to an academic attitude.
The learning objectives must:
be relevant for the development as a starting professional in the field of the Built Environment.
fit into the personal study plan of the student.

To establish the contents a choice must be made for:

- a type of internship and
- a connection with the unit's research program and/or
- a connection with one of the university's strategic areas and/or
- a connection with one of the themes of the department.

See the scheme below:

Possible characteristics of the Internship			
Type of internship	Design	Research	Combination
Research Program (Unit)	Design and Decision Support Systems		
Strategic Area (TU/e)	Energy	Smart Mobility	Health
Theme (Department BE)	Quality of Life	Smart Living Environments	Sustainable Transformation

Case Study Process Modelling	
Responsible lecturer:	Dr. Q. Han
Course code:	7ZM3M0
Period:	1
ECTS:	2.5

Course description:
The course focuses on executing analysis for the process of a complex development project in the context of Construction Management and Engineering.
At first a real complex development project challenge is identified. This projects can be an international well known project, e.g., an Olympic stadium. Students are required to search all the necessary information online and use appropriate methods for analysis. The case study focuses more on the soft side of the process in terms of understanding the nature of interaction between involved stakeholders and decision making on projects within an uncertain and dynamic social, political and physical environment.

Project Management	
Responsible lecturer:	Dr. ir. R.A.C.M. Broekmeulen
Course code:	1CM900
Period:	2
ECTS:	2.5

Course description:
The course comprises the following topics: Planning work activities, costs and budgets, activity scheduling (PERT/CPM), resource allocation, and project execution (information requirements and control).
After the course, students are able to:
- characterize a project aiming at the realization of a physical product in terms of the dynamics, the variability and the stochasticity of the project targets, the activities be performed and their precedence relationships. The available resources and the time cost budget constraints.
- analyse the possible result of a project as function of its targets, its activities and the deployment of resources over time.
- evaluate the possible contribution of advanced decision making methods to improvements in project performance

System Dynamics	
Responsible lecturer:	Dr.ir. B. Walrave
Course code:	1ZM65
Period:	3
ECTS:	5

Course description:
In the first part, the course deals with a variety of subjects related to systems thinking, like: policy resistance, positive and negative feedback, bounded rationality, misperceptions of feedback, fundamental modes of dynamic behaviour (exponential growth, oscillation) and causal loop diagramming. In the second part, the course focuses on system dynamics modelling, by dealing with stocks and flows diagramming, the mathematical relation between stocks and flows (integration and differentiation), delays, modelling human behaviour and modelling supply chains. Also, students will perform a group assignment in which a system dynamics model is developed based on a case description of business processes. With this model, students will replicate the behaviour of the business processes, understand the causes of this behaviour, and simulate scenarios to improve the performance of these processes.

Systems Engineering	
Responsible lecturer:	Prof.dr.ir. B. de Vries
Course code:	7ZM9M0
Period:	1
ECTS:	2.5

Course description:
Systems Engineering principles are learned in the context of the building sector and by practicing Systems Engineering (SE) and Building Information Modelling (BIM) tools.

At first an introduction is presented on the theoretical principles of Systems Engineering. Following a student will work on assignments with different SE/BIM tools. These tools are state-of-the-art, but not yet well established in the building sector. Finally a report is written containing the output of the assignments and a reflection on how to improve SE in the building sector.

Process Modelling & Information Management	
Responsible lecturer:	Dr. Q. Han
Course code:	7ZM5M0
Period:	4
ECTS:	5

Course description:
During this course, students will learn how to construct mathematic models to model and analyse the problems in the development projects, and optimize the process and manage the information flow. Students learn to understand and apply the analysis method for process modelling and information management in the context of urban development. The course deals with Process management, Process modelling, Agent based models, Qualitative methods, Linear optimization models, Discrete optimization models, Network optimization models and Measuring Stakeholders' Interests and Actions.

Legal & Governance	
Responsible lecturer:	Prof.dr.ir. B. de Vries
Course code:	7ZM6M0
Period:	1
ECTS:	7.5

Course description:

The course consists of a legal & governance part:

- The legal part is divided into a private and public law part. The public law part concentrates on principles of spatial regulation on national, provincial and municipal level. The private law part concentrates on procurement proceedings, contracting and responsibility and assurance matters in the field of the construction industry.
- The governance part concentrates on describing and analysing markets, hierarchies and networks as governance modes in the construction sector. Special attention is given to the relations between governmental actors and the actors in the construction sector.

Collaborative Design	
Responsible lecturer:	Prof.dr.ir. B. de Vries
Course code:	7ZM8M0
Period:	3
ECTS:	5

Course description:

The objective of this course is to gain insight in the problem domain of Collaborative Design with special attention to Systems Engineering (SE) and Building Information Models (BIM).

A consortium of companies will work on a design assignment for one semester. A student is member on one of the following companies: Architects, Urban designers, and Engineers. A company consists of 4 persons with one person as Chief Executive Officer (CEO), one Systems Engineering Officer (SEO) and the other two as domain experts. The consortium management consist of all CEOs and SEOs from all companies. CEO and SEO will swap roles with the two other persons halfway the project. The project starts with writing a project management plan. Following the design is created between the companies while monitoring and evaluating the progress. In this process the application of SE and BIM techniques and tools is compulsory. Consortium management is tutored by the teachers in weekly sessions. Finally the design is presented and reports are written about the design product and process.

Specialisation Electives in Eindhoven

Urban Research Methods	
Responsible lecturer:	Prof.dr. T.A. Arentze
Course code:	7ZW7M0
Period:	3
ECTS:	5

Course description:
In this course students learn core research and evaluation methods for urban planning/management. The focus is on quantitative methods and evaluation techniques. Research methods are relevant in the first stages of the decision process where the aim is to generate knowledge about a problem or possible actions. Evaluation techniques are relevant in the last stage where the aim is to determine a preference ranking of action alternatives. The techniques are explicitly positioned in a decision process model.
The course consists of a series of lectures and literature study. Each lecture is complementary to the literature studied and accompanied by a practical exercise where the students apply the theory to a case.

Technology Entrepreneurship	
Responsible lecturer:	Dr. A.S.A. Bobelyn
Course code:	1ZM20
Period:	2
ECTS:	5

Course description:
The aim of this course is to develop your awareness, understanding and application of flexible and adaptive decision-making approaches along with more familiar prediction and planning-based methods for decision making in the face of uncertainty in new business development based on new technology.
The main deliverables in the course are focused on identifying and testing the key factors that help you decide if a (technology based) idea is a real opportunity and validate and adjust the idea in the market. Therefore, identifying, defining, and understanding the market and all relevant stakeholders is a cornerstone of the course. Equally important, however, is investigating whether the idea is an opportunity for you. To answer that, you need to understand who you are and what you want, particularly in relation to the idea and the decision making process needed to further develop this idea. This course is designed to help you do that through a thoughtful and active exploration of the decisions you will make and the experiences you will encounter in pursuing an idea to its fulfillment.

Entrepreneurial Marketing	
Responsible lecturer:	Dr.ing. J.P.M. Wouters
Course code:	1ZM120
Period:	2
ECTS:	5

Course description:
This course:
- Provides knowledge of how to bridge the marketing discipline and the entrepreneurial field
- Provides guidelines and tools to deal with entrepreneurial side of marketing
- Provides guidelines and tools to deal with the marketing side of entrepreneurship

Topics in this course are the introduction to marketing-entrepreneurship interface, the technology adoption life cycle (TALC), and the entrepreneurial marketing plan.

Built Environment and Smart Mobility	
Responsible lecturer:	Dr. S. Rasouli
Course code:	7ZW4M0
Period:	4
ECTS:	5

Course description:
This course deals with analysing the interdependencies between transportation and various aspects and components of urban systems. Application of models to support transport-related design and decision processes in urban design, planning, real estate and transportation, considering:
- The complex interdependencies involved
- Effects on the environment, functioning of the system and quality of life
- Uncertainties in model applications, data and scenarios.

Research and Development Project	
Responsible lecturer:	Dr. G.Z. Dane
Course code:	7ZM1M0
Period:	1,2,3,4
ECTS:	10

Course description:
Executing a Research and Development project for a specific case in the context of Construction Management and Engineering and/or Design Systems. To reach the goal, research and development methods/techniques are selected that are not yet known by the student, but are relevant for the student's education. These methods/techniques are state-of-the-art in DDSS research. Design Systems Lab facilities are available to support experiments. With support from the staff these new methods/techniques are learned by doing. The results are tested against the predefined criteria. Finally a scientific report is written that reflects upon the achieved results.

Smart Urban Environments	
Responsible lecturer:	Dr.ir. A.D.A.M. Kemperman
Course code:	7ZW5M0
Period:	2
ECTS:	5

Course description:
Cities are booming and constitute the heart of economic and cultural developments. At the same time, threats of the quality of living environments ask for smart solutions in areas such as mobility, health and energy. In this course, new perspectives offered by emerging technologies and research are addressed. The course considers current issues in urban development (smart cities, healthy cities, smart grids) and links these issues to new approaches in urban analysis and decision support (big data).

Project Big Data and Experiments for Urban Analysis	
Responsible lecturer:	Dr.ir. A.D.A.M. Kemperman
Course code:	7ZW1M0
Period:	3,4
ECTS:	10

Course description:
To find good solutions one need to have a good understanding of the problem. This holds true also for the problems urban planners are facing in areas such as mobility (congestion and accessibility), health (air pollution, passive life styles), energy (smart grids and transformation to renewable sources of energy) and ageing (social exclusion, social satisfaction).
In this project students consider a planning problem of their choice and apply an approach to better understand the problem and evaluate scenarios.
- The first method (A) is the stated preference/choice approach and can be used for measuring individuals' preference and choice behaviour for new, not yet existing, alternatives.
- The second approach (B) uses information from a big database such as GPS data or one of the large national surveys, such as OVIN and WOON.

Fundamentals of BIM	
Responsible lecturer:	Ir. J.J. Heinen
Course code:	7M900
Period:	2
ECTS:	5

Course description:
This course is of importance to everyone applying building information technologies in practice, developing novel ways to address current and future challenges in ICT-supported collaboration in building and construction and doing fundamental research in the field. In order to model such information, the student learns to model using tools like the visual modelling language UML (Unified Modelling Language). UML is used as the "stepping stone" to translate data models created by other diagram techniques. The student learns to read and to interpret such models created with different diagraming techniques. The student also learns to read and created models as a basis for new insights.

Urban Planning II	
Responsible lecturer:	Ir. A.W.J. Borgers
Course code:	7ZW3M0
Period:	1
ECTS:	5

Course description:

This course is about planning of retail and public facilities in urban areas. It also deals with population and housing demand forecasting and predicting the development of urban areas.

The course starts with a short introduction into spatial planning in the Netherlands and Europe. The next part deals with planning retail facilities and public facilities, both in terms of supply and demand. Retail facilities will be discussed at the level of urban areas and at the level of shopping centres. Small groups of students compare and assess facilities in different urban areas. The last part of the course is about predicting the development of urban areas. Methods to predict the size and composition of the future population and the corresponding housing demand, as well as so called land use models are introduced. Students will gain experience with such methods and models.

Graduation in Eindhoven

Graduation Project	
Responsible lecturer:	Prof.dr.ir. B. de Vries
Course code:	7CC40
Period:	1,2,3,4
ECTS:	40

Course description:

The MSc. Education program `Construction Management & Engineering (CME) at TU/e is a joint international Master-program of the three Dutch Universities of Technology. At TU/e the graduation specialization of CME consists of `Construction Management & Urban Development' (CMUD). The final graduation project has a clear scientific signature, and is grounded in actual CMUD challenges. CME graduation projects are often executed in collaboration with industry partners, engineering offices or government institutes. CMUD borrows from two scientific domains: (i) urban science and systems and (ii) management and innovation sciences.

Graduation options

The graduation project is executed across of the two aforementioned scientific domains. Within this cross section students can choose from a list of subjects that are strongly related to on-going projects in the TU/e departments Built Environment (BE), and Industrial Engineering and Innovation Sciences (IE&IS). All subjects are clustered into the following research areas:

- Process engineering:
  When cities or urban districts are to be developed or redeveloped, complex decision-making and information processes are needed in order to bring shareholders and stakeholders together. Developing models for negotiation, data management, simulation of expected results and process governance are the focus of these graduation projects.
- Business engineering:
  Cities and urban districts are considered and approached in terms of entrepreneurial entities: profit and non-profit companies. In the individual graduation projects, the subjects are value features, exploitation possibilities, management and financing concepts.

For both research areas the following relevant societal and engineering topics, regarding smart city development are in focus:

- Energy management
- Urban management
- Information management

During the graduation project students will learn to make scientific analyses for complex technical and/or managerial problems. They can model these problems using state-of-the-art modelling techniques and their knowledge on technical systems, urban environment and management theories. The students are skilled in scientific publication of the problem analyses and model outcome and they can present of the results to a wide audience.

OVERVIEW OF THE COURSES IN TWENTE

PROGRAMME OVERVIEW

Profile: Markets and Organization in Construction	**Profile: Digital Technologies in Construction**
Profile courses minimum 30 EC	**Profile courses minimum 30 EC**
- Research Methodology & Academic Skills - Planning and Process Management - Legal & Governance Aspects - Planning and Process management - Sustainability and Circularity in Civil Engineering - Construction Industry Dynamics - Construction Process Management - Systems Engineering in Construction - Infrastructure Asset Management	- Research Methodology & Academic Skills - Planning and Process Management - Legal & Governance Aspects - Planning and Process management - Construction Industry Dynamics - Construction Process Management - Systems Engineering in Construction - Digital Technologies for Civil Engineering - Technology and Innovation in Road Construction
Elective profile courses	**Elective profile courses**
- Construction Supply Chains and Digitization - Experiments in Water Infrastructure - Procurement Strategies and Tendering - Infrastructure Maintenance Machines - Urban Governance and Resilience for Smarter Cities (2019-2020) - Value Management - Culture in Construction (2019-2020) - Innovation in Construction (2019-2020) - Decision Engineering in Construction (2019-2020) - Innovation in Construction (2019-2020) - Decision Engineering in Construction (2019-2020) - Governing Product development (IDE) - Maintenance Engineering and Management (ME) 201200146 - Product Life Cycle (IDE) 192850740 - Scenario based product design (IDE) 192850810 - Cost Management and Engineering (IEM) 194110140 - Product Life Cycle Management (IDE) 192850750 - Reliability Engineering & Maintenance Mgmt. (IEM) 191852630 - Design for Maintenance Operations (IDE) 201500235 - Advanced 3D Modelling (IDE) 201500518 - Supply Chain Finance (IEM) - Virtual Reality (IDE) 201000201	- Sustainability and Circularity in Civil Engineering - Construction Supply Chains and Digitization - BIM and 5D Planning - Experiments in Water Infrastructure - Simulation and Optimization of Construction Processes - Value Management - Subsurface Infrastructure Engineering - Infrastructure Maintenance Machines - Infrastructure Asset Management - Innovation in Construction (2019-2020) - Decision Engineering in Construction (2019-2020) - Simulation (IEM; follow-up of Module 8 CiT/TBK) 191820210 - Maintenance Engineering and Management (ME) 201200146 - Product Life Cycle (IDE) 192850740 - Scenario based product design (IDE) 192850810 - Cost Management and Engineering (IEM) 194110140 - Product Life Cycle Management (IDE) 192850750 - Reliability Engineering & Maintenance Mgmt. (IEM) 191852630 - Design for Maintenance Operations (IDE) 201500235 - Advanced 3D Modelling (IDE) 201500518 - Supply Chain Finance (IEM) - Virtual Reality (IDE) 201000201
Electives (maximum 15 EC) - Any course from UT or approved other university*	

Thesis (35 EC)

- Preparation MSc-thesis (5 EC)
- MSc-Thesis Project (30 EC)

* an "approved university" is any university in The Netherlands (not HBO-schools), or any international university that is partner of the UT or of the faculty of Engineering Technology
For a list of partner universities, see: https://www.utwente.nl/ctw/student-mobility/partners/
For courses from other universities: contact your track-coordinator.
The Free Electives should be at MSc-level and should have no overlap with other courses in your programme.

COMPULSORY COURSES IN BOTH DOMAINS

Research Methodology & Academic Skills	
Responsible lecturer:	Dr. A. Hartmann
Course code:	195820400
Period:	2
ECTS:	7,5/5

Course description:
While working on assignments/projects or their master thesis many students face the challenge to define a research problem, design a research strategy, and execute the research plan. In these assignments the students often have to relate a real world problem to theory and literature from the field of construction management and engineering to come up with valid conclusions and practical recommendations.
The main aim of the course is to prepare the students for tasks/jobs where (research) reports need to be assessed or produced (in a wider sense). It is all about arguments, data, theory and proof, requires skills and competences in reasoning, research, data gathering, analysis and formulation of problems and account of results.

PROFILE COURSES

Legal & Governance Aspects	
Responsible lecturer:	dr. P.J. Klok
Course code:	195800100
Period:	1
ECTS:	5

Course description:
This course is about legal & governance aspects of the construction process, especially the institutional legal & framework settings concerning the major players and the main interests concerned. The main course topics will deal with both public and private law. The place and position of the future graduate in the construction process will serve as a guideline in the selection of these topics.

The course consist of a legal & governance part. The legal part is divided into a private and public law part. The public law part concentrates on principles of spatial regulation on national, provincial and municipal level. The private law part concentrates on procurement proceedings, contracting and responsibility and assurance matters in the field of the construction industry.
The governance part concentrates on describing and analysing markets, hierarchies and networks as governance modes in the construction sector. Special attention is given to the relations between governmental actors and the actors in the construction sector.

Planning & Process Management	
Responsible lecturer:	Prof.dr.ing. K.T. Geurs
Course code:	201500097
Period:	1
ECTS:	5

Course description:

This course focuses on (transport) infrastructure planning and process management of major infrastructure projects and area developments. Current developments in cities realities force authorities to plan, manage and monitor their transport and infrastructure systems more accurately, for example to take into account the requirements of a growing number of complex and sometimes conflicting interests like congestion relief, pollution reduction, efficient resource use, equity and accessibility.

This course has two main elements:

1. Strategic Transport Infrastructure Planning: students review and discuss the strengths, limitations and weaknesses of state of the practice strategic transport policy and transport planning frameworks.
2. Process Management: this part aims at providing students with basic concepts, skills, and insights needed to understand the nature of interaction between actors regarding the initiation and development of complex large-scale construction projects.

Sustainability and Circularity in Civil Engineering	
Responsible lecturer:	dr. S. Bhochhibhoya
Course code:	201800043
Period:	1
ECTS:	5

Course description:

This course addresses sustainability of the civil infrastructure and built environment in a broad sense with attention for economic, environmental and social aspects as well as for resilience and circularity. Sustainability is achieved when the whole society has the capacity and opportunity to maintain and improve its quality of life without degrading the quantity, quality and availability of economic, environmental and social capital.

Resilience and circularity play an important role in achieving sustainability. Resilience can be defined as the ability of a system to preserve and sustain the operation of critical functions under conditions of chronic stress or shocks. Resilience is under pressure as human-based modifications to the natural system have led to an increase of the frequency and magnitude of stressors and shocks, such as, sea level rise, extreme weather events or landslides, whereas urbanization has led to the clustering of infrastructure, population and capital.

With the increasing evidence of global warming due to greenhouse gas emissions and the reduced availability of natural resources, the pressure to create regenerative systems where waste, emission and energy leakage is minimized has become increasingly important. Circular economy models are therefore important elements to consider as well. In this context, civil engineers need to be armed with skills than enable them to develop and apply ways, means, and methods to study and analyze the construction and management processes of civil engineering infrastructure towards improving their sustainability, resilience and circularity.

Construction Industry Dynamics	
Responsible lecturer:	prof.dr.ir. A.G. Doree
Course code:	201800047
Period:	1
ECTS:	5

Course description:

The construction industry provides infrastructures crucial for our society as roads, canals, energy networks, sewage systems, flood protection). These infrastructures keep us safe, healthy and prosperous. The Industry has to respond to the challenges and need of our societies. Central in this course is the way and pace the stakeholders in the construction industry deal with competition, and develop and absorb new technologies (eg ICT, BIM, GIS) and new challenges (eg sustainability, social responsibility). This knowledge and understanding is put into the context of the strategic choices of the stakeholders, and the international initiatives undertaken to reform the construction industry. The course focuses on the issue of changes in contract types and procurement, and the effects on strategies and innovation in agencies and firms. It explains the relationships between market regulation, competition, market dynamics and innovation at the level of the industry and the organizations within. It also addresses the issue of business paradigms and strategic management for firms in the construction industry.

This Course addresses the following topics:
Outlook to the future: World Economic Forum's "Infrastructure and Urban Development Industry vision 2050")
A narrative of the changes in the construction industry over the past five decades (to provide context)
Theories and logics used to explain the relationships between industry characteristics, strategic choices and industry dynamics
Papers on markets, competition, regulation and industry dynamics (to provide insight into dynamics beyond change in the entrepreneurial environment)
Papers on obstacles for innovation due to structure and culture of the construction industry (particularly to provide insight into the systemic barriers to change and innovate due to fragmented supply chain, project wise production, procurement ad adversarial relationships)
Papers on Complex product industry and the "systems integrator" business model (to provide insight is to an integrated business model for construction industry)

Systems Engineering in Construction	
Responsible lecturer:	dr.ir. R.S. de Graaf
Course code:	201800032
Period:	2
ECTS:	5

Course description:

Most clients, designers, contractors and other relevant stakeholders in the civil engineering industry acknowledge that sustainability is important when designing and building civil engineering objects. However, in many projects, sustainability goals are often not achieved. Among others because people do not fully understand the concept of sustainability, but also because designers fail to incorporate sustainability in the design process. The main focus of this course is therefore to teach students how to design sustainable civil engineering objects with the use of Systems Engineering, a promising and proven design method, and able to incorporate sustainability.

Systems Engineering is a universal design method, which is prescribed by the main Dutch clients in the Civil Engineering Industry (ProRail and Rijkswaterstaat). The second core concept is Sustainable development. Sustainable development is defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The three main pillars of sustainable development include economic growth, environmental protection, and social equality.

Three main topics are covered in this course. First, the principles of Systems Engineering. Second, the principles of sustainability. Third, the combination of Systems Engineering principles and sustainability principles. These topics are tested by means of an individual exam (30%), an individual practical assignment (20%) and a group project (50%)

Infrastructure Asset Management	
Responsible lecturer:	dr. A. Hartmann
Course code:	201800034
Period:	2
ECTS:	5

Course description:

Infrastructure asset management (IAM) involves activities and decisions that reduce the expenditures over the life-cycle of an infrastructure asset while extending the period for which the asset provides its required performance. It focuses on three main questions: the why, when and what of activities and decisions.
The “why” concerns the objective or purpose of infrastructure. An infrastructure asset represents a resource used by an organization (e.g. public agency) to deliver services to its customers or run its production processes. By defining infrastructure objectives the importance of an asset for an organization and its role for the organization’s business can be determined.
The “when” addresses the performance of infrastructure. An infrastructure asset wears out over time and can reach a critical stage of undesired performance. By analyzing the development of functional and technical performance of infrastructure the point in time when the performance of an asset becomes critical can be identified.
The “what” deals with the kind of interventions throughout the life-cycle of an infrastructure asset. Interventions may include preventive and corrective maintenance, renovation or (re)building.
The focus of this course is on the management of infrastructure facilities and the maintenance and rehabilitation process in particular. The course provides the basic concepts and tools to procure and preserve infrastructure systems most cost-effectively. It shows how to prevent costly deterioration of infrastructure and to ensure an acceptable performance level of the infrastructural asset. The course covers the development of effective maintenance and rehabilitation strategies for portfolios of infrastructure facilities as well as the planning and procurement of single maintenance and rehabilitation projects. It particularly addresses the dynamic relationship of economical, organisational and quality issues during the life cycle of infrastructure facilities.

Digital Technologies for Civil Engineering	
Responsible lecturer:	prof.dr.ir. A.M. Adriaanse
Course code:	201800044
Period:	2
ECTS:	5

Course description:

Arguably, digital technologies are changing the world around us with a fore and pace unmatched in the modern human history. Such technologies as laser scanning, drones, robotics, artificial intelligence, embedded sensors, ubiquitous computing, Internet of Things, and 3D printing have already reshaped and pushed the boundaries of productivity, safety, and quality in many industries.

For the fragmented construction industry, it remains a significant challenge to keep abreast with these new developments. Recently, construction companies have started to appreciate the exigency of harnessing the true potentials of digital technologies to remain competitive in the

fierce market. Many pilot projects with data-driven solutions are now developed to improve processes at different phases of construction projects' lifecycle. This strengthens the general notion that the development, adoption, and integration of tailor-made and customized digital technologies will be the future for construction industry.

This course reviews various types of design and data modelling applications (3D, 4D BIM, GIS), and sensors (e.g., GPS, inertial measurement unit, linescanner, laser scanner, infrared camera, accelerometers, etc.) and their applications in the construction industry. In doing so, this course will touch on topics such as wearable technologies, ubiquities computing, embedded sensors, Internet of Things, connected and smart construction site and real-time operator guidance systems.

Additionally, this course discusses how these sensor technologies support real-time and data-driven decision making throughout the lifecycle of infrastructure projects. This course will discuss various data analysis, simulation, visualization, and optimization methods that are used to address challenges in the construction industry. Finally, we discuss Building Information Modeling and as technology and process-support solutions that can integrate fragmented solutions into a harmonized system compatible with circular and lifecycle approach to infrastructure projects.

Technology and Innovation in Road Construction	
Responsible lecturer:	dr. S.R. Miller
Course code:	201800052
Period:	2
ECTS:	5

Course description:
Road construction processes are often described as being traditional where work methods are based on implicit knowledge and custom, leading to extensive variability in the final constructed road. Process control is defined as those activities involved in ensuring a process is predictable, stable, and consistently operating at the target level of performance with only normal variation. The goal therefore is to ensure that the process variability inherent in the asphalt construction process as a result of the custom-based work practices, is reduced to within acceptable limits. This requires that the construction process is explicit, meaning that key process parameters such as temperature homogeneity and compaction are measured, visualised and improved upon in a scientific manner.

This course focuses on how new sensor technologies and innovations can be integrated into construction processes in order to reduce process variability and improve overall quality. Using the case of asphalt construction, students are taught the fundamentals of process control with the main goal of reducing process variability.

The main topics covered in this course are:

- Fundamentals of process control
- Asphalt mix design to construction and maintenance – the need for science-based approaches
- Measuring variability in construction processes – a sensor-based approach
- Integrating sensors and innovative technologies to improve process control
- Visualization and Simulation tools for construction processes

- Using sensor data to apply Statistical Process Control techniques in Quality Control
- Integrating real-time systems into method-based operational strategies

Graduation in Twente

Preparation Master Thesis	
Responsible lecturer:	dr. S.R. Miller
Course code:	195889000
Period:	-
ECTS:	5

Course description:
The main objective of the course Preparation MSc-thesis project is to independently produce a research or design plan for his/her MSc-thesis project, based on state-of-the-art scientific knowledge of the sub-field and acquire additional knowledge to prepare for the MSc-thesis project. The MSc-thesis project is a large individual research or design project in one of the sub-fields of Civil Engineering and Management.
Based on a meeting with the thesis supervisor, the student will make a plan that contains the following information: outline of the thesis subject, knowledge to be gained (literature, software, and methodology), examination mode(s) and planning.
Based on this plan the student will deliver the following products:
- Research plan
- Proof of sufficient prior knowledge based on examination mode(s)

CME Master Thesis	
Responsible lecturer:	Dr.ir. R.S. de Graaf
Course code:	195899999
Period:	1,2,3,4
ECTS:	30

Course description:
The student will have to prove that he/she meets the objective of the programme which means academic knowledge, understanding and skills in the domain of civil engineering and certain sub-domains of business administration and public administration at a level which qualifies the graduate for independent professional practice and research in civil engineering.
It can either be a research project or a systematic design (of a model, object or procedure).
The assignment can be executed at one of the departments of CiT, for example a research project that contributes to a PhD dissertation. The assignment can also be executed externally at a company or an institution.