TUHH
Hamburg
University of
Technology

Module Manual

Master of Science (M.Sc.)

Civil Engineering
Dual study program

Cohort: Winter Term 2024

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Program description

Content

Civil engineering deals with the erection of buildings of all kind, in particular of structures like bridges and tunnels, structures in hydraulic engineering, water supply, waste and waste water disposal, harbour construction, streets, hall construction, as well as industrial and housing construction, including refurbishment. The master program civil engineering gives graduates the qualification to process difficult projects in the construction practice, including the necessary competences in business and management. Buildings arise by the cooperation of owners, planning offices, contractors, environment, politicians and society. Civil engineering is located in the field between technical and economic constraint, political will and legal conditions. The master program prepares for that. The master program also opens the way to doctoral studies and successful research activities, assuming a sufficient diploma.

The master program civil engineering is associated with the bachelor program "Bau- und Umweltingenieurwesen" and "Allgemeine Ingenieurwissenschaften Vertiefung Bauingenieurwesen" of the University of Technology Hamburg in the sense of a consecutive course of studies. Possible entries from other bachelor programs are based on a catalog of requirements, described in the document "Specific Requirements for the Master Program Civil Engineering".

In addition to the foundational curriculum taught at TUHH, seminars on developing personal skills are integrated into the dual study programme, in the context of transfer between theory and practice. These seminars correspond to the modern professional requirements expected of an engineer, as well as promoting the link between the two places of learning.

The intensive dual courses at TUHH integrating practical experience consist of an academic-oriented and a practice-oriented element, which are completed at two places of learning. The academic-oriented element comprises study at TUHH. The practice-oriented element is coordinated with the study programme in terms of content and time, and consists of practical modules and phases spent in an affiliate company during periods when there are no lectures.

Career prospects

The graduates of the master program civil engineering are prepared for a leading professional activity in planning offices, at building contractors, building authorities, owners of major immovables and infrastructure, producers of building products, material testing institutions and in research facilities. It aims at activities in extensive and difficult projects, or in research and development. In Germany a great demand exists at this time for civil engineers in particular with good knowledge in structural engineering. The master program is based on this demand.

In addition, students acquire basic professional and personal skills as part of the dual study programme that enable them to enter professional practice at an early stage and to go on to further study. Students also gain practical work experience through the integrated practical modules. Graduates of the dual course have broad foundational knowledge, fundamental skills for academic work and relevant personal competences.

Learning target

The graduates of the master program civil engineering gain the specialist knowledge and the methods, to plan and erect new buildings, in particular concrete structures, steel structures, structures in water engineering, in foundation engineering, in water supply, waste and waste water disposal, including refurbishment of existing structures. This incorporates the realization of necessary preliminary investigations, the design of structural elements, the development of all necessary proofs and the project management.

The graduates of the master program are able to transfer the acquired knowledge in engineering, mathematics and natural sciences to practical applications and to analyze and solve problems on a scientific basis, even if these are unusual or incompletely defined and comprise complex specifications. The graduates are able to successfully work on research projects in the field of civil engineering. Therefore a comprehensive understanding of the underlying processes and the ability to model and calculate such processes, e.g. with Finite Elements Methods, are necessary.

The graduates for this purpose gain the skills to experimentally determine the necessary properties of soil, materials and components and to deal with construction-specific program systems to calculate mechanical behavior, the hydraulics of systems as well as other physical-chemical processes. They are enabled to work on problems of civil engineering and related disciplines on one´s own. They are able to use methods needed for the solution of technical problems and planning procedures. They are able to use new findings in a critical way and to improve methods and new developments.

The graduates can communicate on advanced contents and problems of civil engineering with specialists and the laity. They are able to present their methods and the results of their work in writing and verbally in a comprehensive way. The graduates in addition learn to work on problems in a team in a purposeful way, and to document and present their methods and results understandably with up-to-date presentation methods to other persons. They learn to take the leadership for parts of a project or the whole. They are able to familiarize themselves with a topic and to select suitable methods to solve questions and problems. They are able to acquire the necessary information about a topic on one´s own and to put the new information in the context of their knowledge.

The graduates are further qualified to develop concept designs for difficult projects in structural engineering, foundation engineering, bridge design and hydraulic engineering and to plan such constructions under consideration of the available information and restrictions. They can:

- successfully cooperate with expert und inexpert partners from the public administration, the economy and science,
- autonomously define, plan and conduct scientific tasks and to theoretically or experimentally investigate constructions, ground, materials, infrastructure as well as management duties,
- responsibly evaluate and consider the interests of building partners, people concerned and the society as a whole.

By continually switching places of learnings throughout the dual study programme, it is possible for theory and practice to be interlinked. Students reflect theoretically on their individual professional practical experience, and apply the results of their reflection to new forms of practice. They also test theoretical elements of the course in a practical setting, and use their findings as a stimulus for theoretical debate.

Program structure

The master program consists of modules which 6 credit points according to ECTS (CP) except for the master thesis. It is divided into a "Core Qualification", into the five alternative specializations "Coastal Engineering", "Geotechnical Engineering", "Structural Engineering", "Water and Traffic" and "Computational Engineering", as well as the master thesis. The core qualification covers 54 CP, each specialization covers 66 CP and the master thesis covers 30 CP. The program covers 150 CP in 2 years with 4 terms in total.

The core qualification contains a module "Finite Elements Methods" as well as a module “Sustainability and Risk Management” in the 1st term. In addition an open module during the 1st, 2nd or 3rd term from the field “Business and Management” as well as a module from the “Non-technical Courses for Master” are incorporated. The lectures of these open modules are selected from catalogs that are independend from the specific master program.

Each specialization covers 42 CP in the compulsory modules, that are indispensable for the specialization, and 24 CP in the mandatory electives. They contain also an open module and a project work with 6 CP in each case. The compulsory modules excepting the project work are located in the 1st and 2nd term.

The 4th term covers the master thesis. In addition lectures of the open module of the specialization can still be attended in the 4th term. The students must select a specialization and they have the choice to elect different options in the field of “Business and Management”, in the field of the “Non-technical Courses for Master” and in the mandatory electives of the specialization.

A term abroad is possible. In particular the 3rd semester is used by the students to go abroad, because in the 3rd term there are no compulsory modules, but only mandatory electives.

The structural model of the dual study programme follows a module-differentiating approach. Given the practice-oriented element, the curriculum of the dual study programme is different compared to a standard Bachelor’s course. Five practical modules are completed at the dual students’ partner company as part of corresponding practical terms during lecture-free periods.

Core Qualification

Module M0523: Business & Management

Module Responsible	Prof. Matthias Meyer
Admission Requirements	None
Recommended Previous Knowledge	None
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students are able to find their way around selected special areas of management within the scope of business management. • Students are able to explain basic theories, categories, and models in selected special areas of business management. • Students are able to interrelate technical and management knowledge.
Skills	• Students are able to apply basic methods in selected areas of business management. • Students are able to explain and give reasons for decision proposals on practical issues in areas of business management.
Personal Competence	
Social Competence	• Students are able to communicate in small interdisciplinary groups and to jointly develop solutions for complex problems
Autonomy	• Students are capable of acquiring necessary knowledge independently by means of research and preparation of material.
Workload in Hours	Depends on choice of courses
Credit points	6

Courses
Information regarding lectures and courses can be found in the corresponding module handbook published separately.

Module M1759: Linking theory and practice (dual study program, Master's degree)

Module Responsible	Dr. Henning Haschke
Admission Requirements	None
Recommended Previous Knowledge	• Successful completion of practical modules as part of the dual Bachelor’s course • Module "interlinking theory and practice as part of the dual Master’s course"
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Dual students ... ... can describe and classify selected classic and current theories, concepts and methods • related to project management and • change and transformation management ... and apply them to specific situations, processes and plans in a personal, professional context.
Skills	Dual students ... • ... anticipate typical difficulties, positive and negative effects, as well as success and failure factors in the engineering sector, evaluate them and consider promising strategies and courses of action. • ... develop specialised technical and conceptual skills to solve complex tasks and problems in their professional field of activity/work.
Personal Competence	
Social Competence	Dual students ... • ... can responsibly lead interdisciplinary teams within the framework of complex tasks and problems. • ... engage in sector-specific and cross-sectoral discussions with experts, stakeholders and staff, representing their approaches, points of view and work results.
Autonomy	Dual students ... • ... define, reflect and evaluate goals and measures for complex application-oriented projects and change processes. • ... shape their professional area of responsibility independently and sustainably. • ... take responsibility for their actions and for the results of their work.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Studienbegleitende und semesterübergreifende Dokumentation: Die Leistungspunkte für das Modul werden durch die Anfertigung eines digitalen Lern- und Entwicklungsberichtes (E-Portfolio) erworben. Dabei handelt es sich um eine fortlaufende Dokumentation und Reflexion der Lernerfahrungen und der Kompetenzentwicklung im Bereich der Personalen Kompetenz.

Course L2890: Responsible Project Management in Engineering (for Dual Study Program)

Typ	Seminar
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Dr. Henning Haschke, Heiko Sieben
Language	DE
Cycle	WiSe/SoSe
Content	• Theories and methods of project management • Innovation management • Agile project management • Fundamentals of classic and agile methods • Hybrid use of classic and agile methods • Roles, perspectives and stakeholders throughout the project • Initiating and coordinating complex engineering projects • Principles of moderation, team management, team leadership, conflict management • Communication structures: in-house, cross-company • Public information policy • Promoting commitment and empowerment • Sharing experience with specialists and managers from the engineering sector • Documenting and reflecting on learning experiences
Literature	Seminarapparat

Course L2891: Responsible Change and Transformation Management in Engineering (for Dual Study Program)	
Typ	Seminar
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Dr. Henning Haschke, Heiko Sieben
Language	DE
Cycle	WiSe/SoSe
Content	• Basic concepts, opportunities and limits of organisational change • Models and methods of organisational design and development • Strategic orientation and change, and their short-, medium- and long-term consequences for individuals, organisations and society as a whole • Roles, perspectives and stakeholders in change processes • Initiating and coordinating change measures in engineering • Phase models of organisational change (Lewin, Kotter, etc.) • Change-oriented information policy and dealing with resistance and uncertainty • Promoting commitment and empowerment • Successfully handling change and transformation: personally, as an employee, as a manager (personal, professional, organisational) • Company-level and globally (systemic) • Sharing experience with specialists and managers from the engineering sector • Documenting and reflecting on learning experiences
Literature	Seminarapparat

Module M1756: Practical module 1 (dual study program, Master's degree)

Courses

Title	Typ	Hrs/wk	CP
Practical term 1 (dual study program, Master's degree) (L2887)		0	10

Module Responsible	Dr. Henning Haschke
Admission Requirements	None
Recommended Previous Knowledge	• Successful completion of a compatible dual B.Sc. at TU Hamburg or comparable practical work experience and competences in the area of interlinking theory and practice • Course D from the module on interlinking theory and practice as part of the dual Master’s course
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Dual students ... • ... combine their knowledge of facts, principles, theories and methods gained from previous study content with acquired practical knowledge - in particular their knowledge of practical professional procedures and approaches, in the current field of activity in engineering. • ... have a critical understanding of the practical applications of their engineering subject.
Skills	Dual students ... • ... apply technical theoretical knowledge to complex, interdisciplinary problems within the company, and evaluate the associated work processes and results, taking into account different possible courses of action. • ... implement the university’s application recommendations with regard to their current tasks. • ... develop solutions as well as procedures and approaches in their field of activity and area of responsibility.
Personal Competence	
Social Competence	Dual students ... • ... work responsibly in project teams within their working area and proactively deal with problems within their team. • ... represent complex engineering viewpoints, facts, problems and solution approaches in discussions with internal and external stakeholders.
Autonomy	Dual students ... • ... define goals for their own learning and working processes as engineers. • ... reflect on learning and work processes in their area of responsibility. • ... reflect on the relevance of subject modules specialisations and specialisation for work as an engineer, and also implement the university’s application recommendations and the associated challenges to positively transfer knowledge between theory and practice.
Workload in Hours	Independent Study Time 300, Study Time in Lecture 0
Credit points	10
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Documentation accompanying studies and across semesters: Module credit points are earned by completing a digital learning and development report (e-portfolio). This documents and reflects individual learning experiences and skills development relating to interlinking theory and practice, as well as professional practice. In addition, the partner company provides proof to the dual@TUHH Coordination Office that the dual student has completed the practical phase.
Assignment for the Following Curricula	Civil Engineering: Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Computer Science: Core Qualification: Compulsory Data Science: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Compulsory Environmental Engineering: Core Qualification: Compulsory Aircraft Systems Engineering: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Information and Communication Systems: Core Qualification: Compulsory International Management and Engineering: Core Qualification: Compulsory Logistics, Infrastructure and Mobility: Core Qualification: Compulsory Aeronautics: Core Qualification: Compulsory Materials Science and Engineering: Core Qualification: Compulsory Materials Science: Core Qualification: Compulsory Mechanical Engineering and Management: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Core Qualification: Compulsory Microelectronics and Microsystems: Core Qualification: Compulsory Product Development, Materials and Production: Core Qualification: Compulsory Renewable Energies: Core Qualification: Compulsory

	Naval Architecture and Ocean Engineering: Core Qualification: Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory Water and Environmental Engineering: Core Qualification: Compulsory

Course L2887: Practical term 1 (dual study program, Master's degree)	
Typ	
Hrs/wk	0
CP	10
Workload in Hours	Independent Study Time 300, Study Time in Lecture 0
Lecturer	Dr. Henning Haschke
Language	DE
Cycle	WiSe/SoSe
Content	**Company onboarding process** • Assigning a professional field of activity as an engineer (B.Sc.) and associated fields of work • Establishing responsibilities and authorisation of the dual student within the company as an engineer (B.Sc.) • Working independently in a team and on selected projects - across departments and, if applicable, across companies • Scheduling the current practical module with a clear correlation to work structures • Scheduling the examination phase/subsequent study semester **Operational knowledge and skills** • Company-specific: Responsibility as an engineer (B.Sc.) in their own area of work, coordinating team and project work, dealing with complex contexts and unsolved problems, developing and implementing innovative solutions • Subject specialisation (corresponding to the chosen course [M.Sc.]) in the field of activity • Systemic skills • Implementing the university’s application recommendations (theory-practice transfer) in corresponding work and task areas across the company **Sharing/reflecting on learning** • Creating an e-portfolio • Importance of course contents (M.Sc.) when working as an engineer • Importance of development and innovation when working as an engineer
Literature	• Studierendenhandbuch • Betriebliche Dokumente • Hochschulseitige Handlungsempfehlungen zum Theorie-Praxis-Transfer

Module M2004: Sustainable Circular Economy

Courses

Title	Typ	Hrs/wk	CP
Circular Economy (L3264)	Seminar	2	3
Environment and Sustainability (L0319)	Lecture	2	3

Module Responsible	Prof. Kerstin Kuchta
Admission Requirements	None
Recommended Previous Knowledge	none
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to describe single techniques and to give an overview for the field of safety and risk assessment, Circular Economy as well as environmental and sustainable engineering, in detail: • basics in safety and reliability of technical facilities • risk assessment and reliability analysis methods • Circularity of material • Identification and evaluation of material flows • energy production and supply • sustainable product design
Skills	Students are able apply interdisciplinary system-oriented methods for Circularity and risk assessment as well as sustainability reporting. They can evaluate the effort and costs for processes and select economically feasible treatment concepts.
Personal Competence	
Social Competence	
Autonomy	Students can gain knowledge of the subject area from given sources and transform it to new questions. Furthermore, they can define targets for new application or research-oriented duties in for risk management and sustainability concepts accordance with the potential social, economic and cultural impact.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Elaboration and presentation (45 minutes in groups)
Assignment for the Following Curricula	Civil Engineering: Core Qualification: Compulsory Bioprocess Engineering: Specialisation C - Bioeconomic Process Engineering, Focus Management and Controlling: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Water and Environmental Engineering: Core Qualification: Compulsory

Course L3264: Circular Economy

Typ	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Marco Ritzkowski
Language	EN
Cycle	WiSe
Content	
Literature	

Course L0319: Environment and Sustainability	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	WiSe
Content	This course presents actual methodologies and examples of environmental relevant, sustainable technologies, concepts and strategies in the field of energy supply, product design, water supply, waste water treatment or mobility. The following list shows examples: • Production and use of biochar • Energy production with algae • Environmentally friendly product design • Clean development mechanisms • Democracy and energy • Alternative mobility
Literature	Wird in der Veranstaltung bekannt gegeben.

Module M2024: Finite elements

Courses

Title	Typ	Hrs/wk	CP
Finite elements (L3279)	Lecture	3	3
Finite elements (L3280)	Recitation Section (large)	2	3

Module Responsible	Prof. Bastian Oesterle
Admission Requirements	None
Recommended Previous Knowledge	Mechanics I/II, Mathematics I/II, Differential Equations I, Structural Analysis I, Structural Analysis II, Structural Analysis III
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of this module, students can express theoretical, methodological and practical aspects of the finite element method.
Skills	After successfully completing this module, students are able to derive, implement and appropriately apply finite element formulations.
Personal Competence	
Social Competence	Students can participate in subject-specific and interdisciplinary discussions, defend their own work results in front of others and promote the scientific development of colleagues. Furthermore, they can give and accept professional constructive criticism.
Autonomy	Students are able to gain knowledge of the subject area from given and other sources and apply it to new problems. Furthermore, they are able to structure the solution process for problems in the area of the finite element method.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Core Qualification: Compulsory

Course L3279: Finite elements

Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Bastian Oesterle
Language	DE
Cycle	WiSe
Content	Direct stiffness method, variational formulation of finite elements, requirements for the approaches, convergence conditions, isoparametric concept finite elements for trusses, beams, disks and plates, locking and alternative FE formulations, basics of model building, mathematical and numerical model, assessment and interpretation of calculation results, Singularities, influence of approximation errors, interactions between mathematical and numerical models
Literature	Vorlesungsskript

Course L3280: Finite elements

Typ	Recitation Section (large)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	DE
Cycle	WiSe
Content	Direct stiffness method, variational formulation of finite elements, requirements for the approaches, convergence conditions, isoparametric concept finite elements for trusses, beams, disks and plates, locking and alternative FE formulations, basics of model building, mathematical and numerical model, assessment and interpretation of calculation results, Singularities, influence of approximation errors, interactions between mathematical and numerical models
Literature	Vorlesungsskript

Module M1757: Practical module 2 (dual study program, Master's degree)

Courses

Title	Typ	Hrs/wk	CP
Practical term 2 (dual study program, Master's degree) (L2888)		0	10

Module Responsible	Dr. Henning Haschke
Admission Requirements	None
Recommended Previous Knowledge	• Successful completion of practical module 1 as part of the dual Master’s course • course D from the module on interlinking theory and practice as part of the dual Master’s course
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Dual students ... • ... combine their knowledge of facts, principles, theories and methods gained from previous study content with acquired practical knowledge - in particular their knowledge of practical professional procedures and approaches, in the current field of activity in engineering. • ... have a critical understanding of the practical applications of their engineering subject.
Skills	Dual students ... • ... apply technical theoretical knowledge to complex, interdisciplinary problems within the company, and evaluate the associated work processes and results, taking into account different possible courses of action. • ... implement the university’s application recommendations with regard to their current tasks. • ... develop (new) solutions as well as procedures and approaches in their field of activity and area of responsibility - including in the case of frequently changing requirements (systemic skills).
Personal Competence	
Social Competence	Dual students ... • ... work responsibly in cross-departmental and interdisciplinary project teams and proactively deal with problems within their team. • ... represent complex engineering viewpoints, facts, problems and solution approaches in discussions with internal and external stakeholders and develop these further together.
Autonomy	Dual students ... • ... define goals for their own learning and working processes as engineers. • ... reflect on learning and work processes in their area of responsibility. • ... reflect on the relevance of subject modules specialisations and specialisation for work as an engineer, and also implement the university’s application recommendations and the associated challenges to positively transfer knowledge between theory and practice.
Workload in Hours	Independent Study Time 300, Study Time in Lecture 0
Credit points	10
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Documentation accompanying studies and across semesters: Module credit points are earned by completing a digital learning and development report (e-portfolio). This documents and reflects individual learning experiences and skills development relating to interlinking theory and practice, as well as professional practice. In addition, the partner company provides proof to the dual@TUHH Coordination Office that the dual student has completed the practical phase.
Assignment for the Following Curricula	Civil Engineering: Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Computer Science: Core Qualification: Compulsory Data Science: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Compulsory Environmental Engineering: Core Qualification: Compulsory Aircraft Systems Engineering: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Information and Communication Systems: Core Qualification: Compulsory International Management and Engineering: Core Qualification: Compulsory Logistics, Infrastructure and Mobility: Core Qualification: Compulsory Aeronautics: Core Qualification: Compulsory Materials Science and Engineering: Core Qualification: Compulsory Materials Science: Core Qualification: Compulsory Mechanical Engineering and Management: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Core Qualification: Compulsory Microelectronics and Microsystems: Core Qualification: Compulsory Product Development, Materials and Production: Core Qualification: Compulsory

	Renewable Energies: Core Qualification: Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory Water and Environmental Engineering: Core Qualification: Compulsory

Course L2888: Practical term 2 (dual study program, Master's degree)	
Typ	
Hrs/wk	0
CP	10
Workload in Hours	Independent Study Time 300, Study Time in Lecture 0
Lecturer	Dr. Henning Haschke
Language	DE
Cycle	WiSe/SoSe
Content	**Company onboarding process** • Assigning a professional field of activity as an engineer (B.Sc.) and associated fields of work • Establishing responsibilities and authorisation of the dual student within the company as an engineer (B.Sc.) • Taking personal responsibility within a team and on selected projects - across departments and, if applicable, across companies • Scheduling the current practical module with a clear correlation to work structures • Scheduling the examination phase/subsequent study semester **Operational knowledge and skills** • Company-specific: Responsibility as an engineer (B.Sc.) in their own area of work, coordinating team and project work, dealing with complex contexts and unsolved problems, developing and implementing innovative solutions • Subject specialisation (corresponding to the chosen course [M.Sc.]) in the field of activity • Systemic skills • Implementing the university’s application recommendations (theory-practice transfer) in corresponding work and task areas across the company **Sharing/reflecting on learning** • Updating their e-portfolio • Importance of course contents (M.Sc.) when working as an engineer • Importance of development and innovation when working as an engineer
Literature	• Studierendenhandbuch • Betriebliche Dokumente • Hochschulseitige Anwendungsempfehlungen zum Theorie-Praxis-Transfer

Module M1758: Practical module 3 (dual study program, Master's degree)

Courses

Title	Typ	Hrs/wk	CP
Practical term 3 (dual study program, Master's degree) (L2889)		0	10

Module Responsible	Dr. Henning Haschke
Admission Requirements	None
Recommended Previous Knowledge	• Successful completion of practical module 2 as part of the dual Master's course • course E from the module on interlinking theory and practice as part of the dual Master's course
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Dual students ... • ... combine their comprehensive and specialised engineering knowledge acquired from previous study contents with the strategy-oriented practical knowledge gained from their current field of work and area of responsibility. • ... have a critical understanding of the practical applications of their engineering subject, as well as related fields when implementing innovations.
Skills	Dual students ... • ... apply specialised and conceptual skills to solve complex, sometimes interdisciplinary problems within the company, and evaluate the associated work processes and results, taking into account different possible courses of action. • ... implement the university's application recommendations with regard to their current tasks. • ... develop new solutions as well as procedures and approaches to implement operational projects and assignments - even when facing frequently changing requirements and unpredictable changes (systemic skills). • ... can use academic methods to develop new ideas and procedures for operational problems and issues, and to assess these with regard to their usability.
Personal Competence	
Social Competence	Dual students ... • ... work responsibly in cross-departmental and interdisciplinary project teams and proactively deal with problems within their team. • ... can promote the professional development of others in a targeted manner. • ... represent complex and interdisciplinary engineering viewpoints, facts, problems and solution approaches in discussions with internal and external stakeholders and develop these further together.
Autonomy	Dual students ... • ... reflect on learning and work processes in their area of responsibility. • ... define goals for new application-oriented tasks, projects and innovation plans while reflecting on potential effects on the company and the public. • ... reflect on the relevance of areas of specialisation and research for work as an engineer, and also implement the university's application recommendations and the associated challenges to positively transfer knowledge between theory and practice.
Workload in Hours	Independent Study Time 300, Study Time in Lecture 0
Credit points	10
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Documentation accompanying studies and across semesters: Module credit points are earned by completing a digital learning and development report (e-portfolio). This documents and reflects individual learning experiences and skills development relating to interlinking theory and practice, as well as professional practice. In addition, the partner company provides proof to the dual@TUHH Coordination Office that the dual student has completed the practical phase.
Assignment for the Following Curricula	Civil Engineering: Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Computer Science: Core Qualification: Compulsory Data Science: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Compulsory Environmental Engineering: Core Qualification: Compulsory Aircraft Systems Engineering: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Information and Communication Systems: Core Qualification: Compulsory International Management and Engineering: Core Qualification: Compulsory Logistics, Infrastructure and Mobility: Core Qualification: Compulsory Aeronautics: Core Qualification: Compulsory Materials Science and Engineering: Core Qualification: Compulsory

	Materials Science: Core Qualification: Compulsory Mechanical Engineering and Management: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Core Qualification: Compulsory Microelectronics and Microsystems: Core Qualification: Compulsory Product Development, Materials and Production: Core Qualification: Compulsory Renewable Energies: Core Qualification: Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory Water and Environmental Engineering: Core Qualification: Compulsory

Course L2889: Practical term 3 (dual study program, Master's degree)	
Typ	
Hrs/wk	0
CP	10
Workload in Hours	Independent Study Time 300, Study Time in Lecture 0
Lecturer	Dr. Henning Haschke
Language	DE
Cycle	WiSe/SoSe
Content	**Company onboarding process** • Assigning a future professional field of activity as an engineer (M.Sc.) and associated fields of work • Extending responsibilities and authorisation of the dual student within the company up to the intended first assignment after completing their studies • Working responsibly in a team; project responsibility within own area - as well as across divisions and companies if necessary • Scheduling the final practical module with a clear correlation to work structures • Internal agreement on a potential topic or innovation project for the Master’s dissertation • Planning the Master’s dissertation within the company in cooperation with TU Hamburg • Scheduling the examination phase/subsequent study semester **Operational knowledge and skills** • Company-specific: dealing with change, project and team development, responsibility as an engineer in their future field of work (M.Sc.), dealing with complex contexts, frequent and unpredictable changes, developing and implementing innovative solutions • Specialising in one field of work (final dissertation) • Systemic skills • Implementing the university’s application recommendations (theory-practice transfer) in corresponding work and task areas across the company **Sharing/reflecting on learning** • E-portfolio • Relevance of study content and personal specialisation when working as an engineer • Relevance of research and innovation when working as an engineer
Literature	• Studierendenhandbuch • betriebliche Dokumente • Hochschulseitige Anwendungsempfehlungen zum Theorie-Praxis-Transfer

Specialization Coastal Engineering

Module M0699: Geotechnics III

Courses

Title	Typ	Hrs/wk	CP
Numerical Methods in Geotechnics (L0375)	Lecture	3	3
Advanced Foundation Engineering (L0497)	Lecture	2	2
Advanced Foundation Engineering (L0498)	Recitation Section (large)	1	1

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	Geotechnics I and II, Mathematics I-III
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successfully completing the module, students will be able to • describe individual procedures for the geotechnical monitoring of civil engineering measures, • reproduce exploration and investigation methods of the subsoil, • select suitable types of field and laboratory tests for subsoil investigation and evaluate their results, • state the differences between various stress and deformation states and the physical significance of invariants of the stress and distortion tensor, • outline the standard and special soil mechanics tests used to determine the stress-strain behavior of soil, • describe continuum models and the resulting boundary value problems, • as well as define boundary value problems from the field of geotechnical engineering in such a way that they can be solved unambiguously.
Skills	Students will be able to • dimension vertical drains for soil improvement of soft soils, • calculate depth compaction using various appropriate methods, • apply principles of horizontal bearing capacity of piles, • verify the internal and external stability of fluid-supported diaphragm walls, • evaluate the boundary conditions for the design of a deep excavation and design the individual components of the excavation, • perform, evaluate and interpret tests for the description and classification of soils according to applicable standards, • computationally implement numerical algorithms to solve boundary value problems, • select and apply the types of analyses depending on the degree of saturation, the impact, and the material behavior • determine appropriate model parameters for different possibilities and limitations of material models for the grain structure of soils.
Personal Competence	
Social Competence	Students can work in groups and support each other in finding solutions.
Autonomy	Students are able to assess their own strengths and weaknesses and, based on this, organize their time and learning management and think in terms of processes.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L0375: Numerical Methods in Geotechnics	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Dr. Hans Mathäus Stanford
Language	DE
Cycle	WiSe
Content	Topics: • Introduction to numerical soil mechanics • Introduction to numerical mathematics • Finite Element Method (analysis procedures, algorithms) • Finite Element Method (application in geotechnical engineering)
Literature	• Wriggers P. (2001): Nichtlineare Finite-Elemente-Methoden. Springer • Wriggers P. (2008): Nonlinear Finite Element Methods. Springer • Deutsche Gesellschaft für Geotechnik e.V. (Hrsg., 2014): Empfehlungen des Arbeitskreises "Numerik in der Geotechnik". Ernst & Sohn

Course L0497: Advanced Foundation Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	WiSe
Content	• Vertical drains • Piles • Ground improvement (Deep Compaction, Soil mixing) • Vibration driving • Jet grouting • Slurry wall • Deep excavation
Literature	• EAK (2002): Empfehlungen für Küstenschutzbauwerke • EAU (2004): Empfehlungen des Arbeitsausschusses Uferbauwerke • EAB (1988): Empfehlungen des Arbeitskreises Baugruben • Grundbau-Taschenbuch, Teil 1-3, (1997), Ernst & Sohn Verlag

Course L0498: Advanced Foundation Engineering	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0964: Underground Constructions

Courses

Title	Typ	Hrs/wk	CP
Applied Tunnel Constructions (L2407)	Lecture	2	3
Introduction to tunnel construction (L0707)	Lecture	1	2
Introduction to tunnel construction (L1811)	Recitation Section (large)	1	1

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	Modules from Bachelor studies Civil and environmental engineering: • Geotechnics I-II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Knowledge of different tunnel construction types as well as special methods and techniques of subsoil construction.
Skills	Basic knowledge of tunnel design as well as practical skills in structural tunnel analysis.
Personal Competence	
Social Competence	Capacity for teamwork concerning project management and design of tunnels.
Autonomy	Promotion of independent and creative work flow in the framework of a design exercise.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory** No; **Bonus** 5 %; **Form** Excercises; **Description**
Examination	Written exam
Examination duration and scale	120 minutes
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L2407: Applied Tunnel Constructions

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Jürgen Grabe, Tim Babendererde
Language	DE
Cycle	WiSe
Content	
Literature	

Course L0707: Introduction to tunnel construction	
Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dr. Julian Bubel
Language	DE
Cycle	WiSe
Content	• Definitions • Historical development in tunneling • Geology for tunneling • Hard rock tunneling (construction composite and machines) • Tunnelung in temporarly stable soil with conventional construction methods • Tunneling in soft soils (form of supports, shield types, compressed air application) • Pipe jacking • Tunnel Lining, tunnel supporting structures • Calculation approaches for supporting structures in shield-driven tunnels • Surveying for tunneling • Safety requirements • Construction Contract • Literature and sources
Literature	• Vorlesung/Übung s. www.tu-harburg.de/gbt

Course L1811: Introduction to tunnel construction	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Julian Bubel
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1748: Construction Robotics

Courses

Title	Typ	Hrs/wk	CP
Construction Robotics (L2867)	Project-/problem-based Learning	6	6

Module Responsible	Prof. Kay Smarsly
Admission Requirements	None
Recommended Previous Knowledge	Basics of project-oriented programming
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Basics of robotics Applications in civil engineering Kinematics
Skills	Use of specific hardware Development of software routines Python programming language Image processing Basics of localization (LIDAR, SLAM)
Personal Competence	
Social Competence	Teamwork Communication skills
Autonomy	Independent work Independent decisions
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	ca. 10 Seiten
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Course L2867: Construction Robotics	
Typ	Project-/problem-based Learning
Hrs/wk	6
CP	6
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Lecturer	Prof. Kay Smarsly, Jan Stührenberg
Language	EN
Cycle	WiSe

Content	1. Introduction: Robotics in civil engineering
	2. Presentation of potential topics
	3. Programming of algorithms in Python
	4. Application of software systems: LINUX distribution, ROS, CloudCompare, ...
	5. Application of hardware systems: Petoi Bittle Dog, Raspberry Pi, Arduino, sensing ...
	6. Topics considered for robotics using the Petoi Bittle Dog:
	    1. Movement
	    2. Use of sensors (camera, infrared, ...)
	    3. Data structures/data acquisition
	    4. Programming
	7. Topics technically relevant to building inspection:
	    1. Geodetic evaluations
	    2. Image processing
	    3. Localization

Literature	Bock/Linner: Construction Robotics Verl et al.: Soft Robotics Pasquale: New Laws of robotics

Module M1895: Digital Twinning in Civil Engineering

Courses

Title	Typ	Hrs/wk	CP
Digital Twinning in Civil Engineering (L3136)	Lecture	2	2
Digital Twinning in Civil Engineering (L3137)	Seminar	2	4

Module Responsible	Alexander Chmelnizkij
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	
Skills	
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Presentation
Examination duration and scale	20 min presentation and 5 pages handout
Assignment for the Following Curricula	Civil Engineering: Specialisation Computational Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory

Course L3136: Digital Twinning in Civil Engineering

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Alexander Chmelnizkij, Prof. Bastian Oesterle, Prof. Kay Smarsly
Language	DE
Cycle	SoSe
Content	
Literature	

Course L3137: Digital Twinning in Civil Engineering

Typ	Seminar
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Alexander Chmelnizkij, Prof. Bastian Oesterle, Prof. Kay Smarsly
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0593: Building Materials and Building Preservation

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Repair of Structures (L0255)	Lecture	1	1
Mineral Building Materials (L0253)	Lecture	2	2
Technology of mineral Building Materials (L0256)	Project-/problem-based Learning	1	2
Transport Processes in Building Materials and Damage Processes (L0254)	Lecture	1	1

Module Responsible	Prof. Frank Schmidt-Döhl
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge about building materials, building physics and building chemistry, for example by the modules Principles of Building Materials and Building Physics and Building Materials and Building Chemistry.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe the components of mineral building materials and their function in detail and to use them for the manufacture of special mineral building materials. They are able to show the characteristics of mineral building materials. They are able to describe the manufacture, properties and fields of application of special mortars and special concretes and the correlations of their material parameters. They are able to show the principles of anchor technology and design.
Skills	The students are able to perform an optimization of granulometry of a mineral building material. They are able to design a special mineral mortar and to manufacture this mortar. The students are able to manufacture post installed rebar connections. They are able to recognize damages, to assess possible causes, to use the fundamentals of construction preservation and to select repair and strengthening measures.
Personal Competence	
Social Competence	The students are able to develop in small grous the mixture of a special mortar. They present their results to the lecturer and the other students. In a critical discussion they defend and adjust their results. The students are able to manufacture their special building material on the basis of this feedback.
Autonomy	The students are able to responsibly use the resources of materials and lab equipment for their project and to investigate and to get missing components.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** Yes / 20 % / Subject theoretical and practical work /
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory

Course L0255: Repair of Structures

Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	SoSe
Content	Maintenance of structures, repair and strengthening, subsequent waterproofing of structures
Literature	BetonMarketing Deutschland (Hrsg.): Stahlbetonoberflächen - schützen, erhalten, instandsetzen

Course L0253: Mineral Building Materials	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	SoSe
Content	Components of mineral building materials and their function, binding materials, concrete and mortar, special mortars, special concretes
Literature	Taylor, H.F.W.: Cement Chemistry Springenschmid, R.: Betontechnologie für die Praxis

Course L0256: Technology of mineral Building Materials	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	SoSe
Content	Design and production of a special mineral building material
Literature	Taylor, H.F.W.: Cement Chemistry Springenschmid, R.: Betontechnologie für die Praxis

Course L0254: Transport Processes in Building Materials and Damage Processes	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	SoSe
Content	Transport Processes in Building Materials and Damage Processes
Literature	Blaich, J.: Bauschäden, Analyse und Vermeidung

Module M0723: Design of Prestressed Structures and Concrete Bridges

Courses

Title	Typ	Hrs/wk	CP
Design of Prestressed Structures and Concreet Bridges (L0603)	Lecture	3	4
Design of Prestressed Structures and Concreet Bridges (L0604)	Recitation Section (large)	2	2

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	Detailed knowledge on the design of concrete structures. Modules: Reinforced Concrete Structures I+II, Structural Analysis I+II, Mechanics I+II, Concrete Structures
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students know the main bridge types, their applications and the various loads. They can explain the basic design methods. They can explain the design of a prestressed bridge.
Skills	The students are able to design reinforced or prestressed concrete bridges.
Personal Competence	
Social Competence	The students can design in teamwork a real concrete bridge.
Autonomy	The students are able to design a prestressed concrete bridge and discuss the problems and results with other students.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	180 minutes
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L0603: Design of Prestressed Structures and Concreet Bridges	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	NN
Language	DE
Cycle	SoSe
Content	prestressed structures • basis of prestressed structures, field of application • differences between reinforced and prestressed concrete structures • history of prestressing • construction materials: concrete, tendons, ducts, anchorage systems • construction: prestressing methods • prestressing forces and member forces (friction, elongation) • tendon layout • time dependant prestressing losses • design of prestressed structures • design of anchorage region • non-bonded prestressing • prestressed flat slabs Concrete bridges • history of bridges • design of bridges • loads on bridges • member forces for slab, T-beam, hollow box, frame and arch bridges • precast bridges - precast segmental bridges • bearings • abutments, columns • construction methods • damages - checking of bridges
Literature	• Vorlesungsumdruckim STUDiP • Rombach, G. (2003): Spannbetonbau. Ernst & Sohn, Berlin • Wicke, M. (2002): Anwendung des Spannbetons. Betonkalender 2002, Teil II, S. 113-180, Verlag Ernst & Sohn, Berlin • Leonhardt, F. (1980): Vorlesungen über Massivbau. Teil 5: Spannbeton. Berlin • Mehlhorn, G. (2007): Handbuch Brücken, Springer Verlag • Schäfer, H.; Kaufeld, K. (1997): Massivbrücken. Betonkalender Teil II, S. 443ff, Ernst & Sohn, Berlin • Menn, Ch. (1986): Stahlbetonbrücken. Springer Verlag, Wien

Course L0604: Design of Prestressed Structures and Concreet Bridges	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	NN
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0756: Soil Mechanics and -Dynamics

Courses

Title	Typ	Hrs/wk	CP
Soil Mechanics - Selected Topics (L0374)	Lecture	2	2
Soil Dynamics (L0452)	Lecture	2	2
Experimental Researches in Geotechnics (L0706)	Practical Course	2	2

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	Modules: Mathematics I-III, Mechanics I-II, Geotechnics I Courses: Soil laboratory course, (Applied structural dynamics)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will be able to, • describe wave propagation in the ground under dynamic excitation and define the relevant parameters, • to measure vibrations and to interpret the data obtained with regard to their effect on people and structures, • justify when elastodynamic methods are sufficient and when plastodynamic effects must be taken into account, • to reproduce the collapse theorems of plasticity theory, • describe the viscous behavior of cohesive soils and computationally account for creep deformation and rate-dependent shear strengths • as well as to determine the effect of partial saturation on the seepage flow and the shear strength.
Skills	After the successful completion of the module the students should be able to: • to derive and apply the basic equation of a simple mass oscillator, • to understand the wave propagation in the soil under dynamic excitation and to detect the relevant parameters, • to know the essential laboratory and field tests to determine soil dynamic characteristics and to evaluate them, • to design machine foundations to dynamic load, • to measure shocks to perform vibration forecast, • to evaluate shocks in terms of their effect on people and buildings, • to evaluate possibilities of isolation, • to understand mechanisms that cause earthquakes and evaluate earthquakes in terms of their magnitude and intensity, • to know methods to determine axial pile capacity, integrity, and the dynamic bedding modulus, • to know the mechanisms that lead to a deformation accumulation due to cyclic loading and to estimate these deformations mathematically, • to distinguish the area of application of the method of elastodynamics and plastodynamics, • to detect the undrained shear strength as a function of a number of state variables, • to capture the visous behaviour of cohesive soils and to consider the effects of creep and rate-dependent shear strength in calculations, • to consider the impact of the partly saturated of a seepage and shear strength.
Personal Competence	
Social Competence	Students will be able to work in teams to achieve results on measurement and experimental principles and present their results together at the end of the semester.
Autonomy	Students are able to assess their own strengths and weaknesses and organize their time and learning management based on this.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** Yes / None / Subject theoretical and practical work /
Examination	Written exam
Examination duration and scale	135 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory

Course L0374: Soil Mechanics - Selected Topics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Hans Mathäus Stanford
Language	DE
Cycle	SoSe
Content	selected topis: • Stress-strain behaviour (experiments, observations, models) • Hydraulic behaviour (experiments, observations, models) • Physical modelling (similarity theory, 1g model tests, ng model tests) • Limit and safety analysis (collapse theorems of plasticity theory, upper and lower bound analysis, limit equilibrium analysis, numerical analysis) • Heat transport (heat conduction, convective heat transport, freezing/thawing)
Literature	• Kolymbas D. (2019): Geotechnik - Bodenmechanik, Grundbau und Tunnelbau. Springer Verlag, 5. Auflage • Muir Wood D. (2004). Geotechnical modelling. CRC Press Nova, R. (2010). Soil mechanics. Wiley Verruijt, A. (2012). Soil mechanics. u r l: https://geo.verruijt.net Verrujit A. (2018). An introduction to soil mechanics. Vol. 30, Springer Series Theory and Applications of Transport in Porous Media

Course L0452: Soil Dynamics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Anne Hagemann
Language	DE
Cycle	SoSe
Content	• mass-spring-damper systems, • wave propagation in soils, • dynamic soil parameters, • Determination of dynamic soil parameters, • machine foundations, • in-situ measurement of ground motion, ground motion prediction, evaluation of ground motion, • ground motion shielding, • introduction into earthquake engineering, • dynamic pile tests, • cyclic accumulation, • plastodynamics
Literature	• Das B.M.: Fundamentals of Soil Dynamics, Elsevier • Empfehlungen des Arbeitskreises Baugrunddynamik. Hrsg. Deutsche Gesellschaft für Geotechnik (DGGT) • Haupt W.: Bodendynamik. Vieweg und Teubner • Meskouris K. und Hinzen K.-G.: Bauwerke und Erdbeben. Vieweg Verlag • Studer J.A., Koller M.G. und Laue J.: Bodendynamik, Springer Verlag

Course L0706: Experimental Researches in Geotechnics	
Typ	Practical Course
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Hans Mathäus Stanford, Göta Bürkner
Language	DE
Cycle	SoSe
Content	The students are supposed to: • become acquainted with geotechnical model tests, field tests and laboratory tests as well as corresponding measurement techniques. These compromise amongst others inclinometer measurements and geophone measurements as well as high-grade laboratory tests on the stress-strain relationship of soil specimens, e. g. triaxial tests, simple shear tests and resonant column tests. • gain insight into current soil mechanical research. • plan, coordinate, perform and evaluate soil mechanical tests in a team. • discuss, reflect, review and present the obtained results in a group. An important learning target is the introduction to scientific work for students who plan a scientific career, and for those who will work in practice with the responsibility to order corresponding tests and evaluate the results. The practical laboratory work is based on annualy changing problems, which are however related to the experience and results of the preceding year's course group.
Literature	- Grabe, J. (2004): Bodenmechanik und Grundbau, Band 3 der Veröffentlichungsreihe des Instituts für Geotechnik und Baubetrieb, Technische Universität Hamburg-Harburg. - Kolymbas, D. (2007): Geotechnik - Bodenmechanik, Grundbau und Tunnelbau. 2., korrigierte und ergänzte Auflage, Springer Verlag. - Normen zu geotechnischen Versuchsgeräten und Versuchsverfahren: - DIN 18135:2012-04: Baugrund, Untersuchung von Bodenproben - Eindimensionaler Kompressionsversuch, Deutsches Institut für Normung, e. V. - DIN 18137-2:2011-04: Baugrund, Untersuchung von Bodenproben - Bestimmung der Scherfestigkeit - Teil 2: Triaxialversuch, Deutsches Institut für Normung e. V.

Module M0827: Modeling in Water Management

Courses

Title	Typ	Hrs/wk	CP
Groundwater Modeling using Modflow (L0543)	Lecture	1	1
Groundwater Modeling using Modflow (L0544)	Recitation Section (small)	2	2
Modeling of Water Supply Network (L0875)	Project-/problem-based Learning	2	3

Module Responsible	Dr. Klaus Johannsen
Admission Requirements	None
Recommended Previous Knowledge	Groundwater • groundwater hydraulics and transport of substances Pipe Systems • Knowledge on urban water infrastructures, in particular drinking water systemsand urban drainage systems including special structures • Hydraulics of drinking water supply systems and sewer systems • Basic knowledge on water management
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe the modelling of groundwater flow and transport as well as urban water infrastructures. They can carry out systems analyses and can detect technical and conceptual weak points within the systems in case studies. Besides they are able to analyse interdependencies of hydraulic and toxic phenomena in soil and water.
Skills	The students are able to construct and apply scientific groundwater models indipendently. They can work on different scenarios and can compare or assess different solutions for existing problems by application of selected software products. The students are able to use different software solutions (e.g. EPANET, EPA-SWMM).
Personal Competence	
Social Competence	Wird nicht vermittelt.
Autonomy	Wird nicht vermittelt.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L0543: Groundwater Modeling using Modflow

Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Sonja Götz
Language	DE/EN
Cycle	SoSe
Content	Introduction and application of the groundwater model MODFLOW (PMWIN); theoretical backround of the modell, students do work with the model PMWIN for practical case studies.
Literature	MODFLOW-Handbuch Chiang, Wen Hsien: PMWIN

Course L0544: Groundwater Modeling using Modflow	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Sonja Götz
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0875: Modeling of Water Supply Network	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Klaus Johannsen
Language	DE
Cycle	SoSe
Content	
Literature	Mutschmann/Stimmelmayr: Taschenbuch der Wasserversorgung, 16. Auflage. Springer Vieweg - Verlag. Wiesbaden 2014.

Module M0828: Urban Environmental Management

Courses

Title	Typ	Hrs/wk	CP
Noise Protection (L1109)	Lecture	2	2
Urban Infrastructures (L0874)	Project-/problem-based Learning	2	4

Module Responsible	Dr. Dorothea Rechtenbach
Admission Requirements	None
Recommended Previous Knowledge	• Knowledge on Urban planning • Knowledge on measures for climate protection • General knowledge of scientific writing/working
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can describe urban development corridors as well as current and future urban environmental problems. They are able to explain the causes of environmental problems (like noise). Students can specify applications for various technical innovations and explain why these contribute to the improvement of urban life. They can, for example, derive and discuss measures for effective noise abatement.
Skills	Students are able to develop specific solutions for correcting existing or future environment-related problems of urban development. They can define a range of conceptual and technical solutions for environmental problems for different development paths. To solve specific urban environmental problems they can select technical innovations and integrate them into the urban context.
Personal Competence	
Social Competence	The students can work together in international groups.
Autonomy	Students are able to organize their work flow to prepare themselves for presentations and contributions to the discussions. They can acquire appropriate knowledge by making enquiries independently.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Written Report plus oral Presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L1109: Noise Protection

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Martin Jäschke
Language	EN
Cycle	SoSe
Content	
Literature	1) Müller & Möser (2013): Handbook of Engineering Acoustics (also available in German) 2) WHO (1999): Guidelines for Community Noise 3) Environmental Noise Directive 2002/49/EG 4) ISO 9613-2 (1996): Acoustics, Attenuation of sound during propagation outdoors, Part 2: General method of calculation

Course L0874: Urban Infrastructures	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Dr. Dorothea Rechtenbach
Language	EN
Cycle	SoSe
Content	Problem Based Learning Main topics are: • Central vs. Decentral Wastewater Treatment. • Compaction of Cities. • Car Free Cities. • Multifunctional Places in Cities. • The Sustainability of Freight Transport in Cities.
Literature	Depends on chosen topic.

Module M0860: Harbour Engineering and Harbour Planning

Courses

Title	Typ	Hrs/wk	CP
Harbour Engineering (L0809)	Lecture	2	2
Harbour Engineering (L1414)	Project-/problem-based Learning	1	2
Port Planning and Port Construction (L0378)	Lecture	2	2

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Basics of coastal engineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to define in details and to choose design approaches for the functional design of a port and apply them to design tasks. They can design the fundamental elements of a port.
Skills	The students are able to select and apply appropriate approaches for the functional design of ports.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in applied problems such as the functional design of ports. Additionaly, they will be able to work in team with engineers of other disciplines.
Autonomy	The students will be able to independently extend their knowledge and apply it to new problems.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	The duration of the examination is 150 min. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L0809: Harbour Engineering

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Peter Fröhle
Language	DE
Cycle	SoSe
Content	• Fundamentals of harbor engineering ◦ Maritime transportation and waterways engineering ◦ Ships • Elements of harbors ◦ Harbor approaches and water-side harbor areas ◦ Terminal design and handling of cargo ◦ Quay-walls and piers ◦ Equipment of harbors ◦ Sluices and other special constructions • Connection to inland transportation / inland waterway transportation • Protection of harbors ◦ Breakwaters and Jetties ◦ Wave protection of harbors • Fishery and other small harbors
Literature	Brinkmann, B.: Seehäfen, Springer 2005

Course L1414: Harbour Engineering	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0378: Port Planning and Port Construction	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Frank Feindt
Language	DE
Cycle	SoSe
Content	• Planning and implementation of major projects • Market analysis and traffic relations • Planning process and plan • Port planning in urban neighborhood • Development of the logistics center "Port of Hamburg" in the metropolis • Quays and waterfront structure • Special planning Law Harbor - securing of a flexible use of the port • Dimensioning of quays • Flood protection structures • Port of Hamburg - Infrastructure and development • Preparation of areas • Scour formation in front of shore structures
Literature	Vorlesungsumdruck, s. www.tu-harburg.de/gbt

Module M0861: Modelling of Hydraulic Engineering

Courses

Title	Typ	Hrs/wk	CP
Hydraulic Models (L0813)	Project-/problem-based Learning	1	1
Modelling of Waves (L0812)	Project-/problem-based Learning	1	1
Modelling of Flow in Rivers and Estuaries (L0810)	Lecture	3	4

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Coastal Hydraulic Engineering I
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to define in detail the basic processes that are related to the modelling of flows in hydraulic engineering. Besides, they can describe the basic aspects of numerical modelling and actual numerical models for the simulation of flows and waves.
Skills	Students are able to apply hydrodynamic-numerical models to practical hydraulic engineering tasks.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in simple applied problems. Additionaly, they will be able to work in team with others.
Autonomy	The students will be able to independently extend their knowledge and apply it to new problems.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	The duration of the examination is 3 hours. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Compulsory

Course L0813: Hydraulic Models

Typ	Project-/problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	• Fundamentals of hydraulic models • Model laws • Pi theorem of Buckingham • Practical examples of hydraulic models
Literature	Strobl, Zunic: Wasserbau, Kap. 11 Hydraulische Modelle, Springer

Course L0812: Modelling of Waves	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	• Waves, interactions with shallow water and constructions • Wave theories • Sea state and surges • Development of waves • Wave spectra • Modelling of Waves / phase averaged and phase resolved models • Application of a phase averaged model for wave prediction (SWAN) • · Application of phase resolved wave models (Mike)
Literature	Vorlesungsumdruck

<table>
<tr><th colspan="2">Course L0810: Modelling of Flow in Rivers and Estuaries</th></tr>
<tr><td>Typ</td><td>Lecture</td></tr>
<tr><td>Hrs/wk</td><td>3</td></tr>
<tr><td>CP</td><td>4</td></tr>
<tr><td>Workload in Hours</td><td>Independent Study Time 78, Study Time in Lecture 42</td></tr>
<tr><td>Lecturer</td><td>Prof. Edgar Nehlsen, Prof. Peter Fröhle</td></tr>
<tr><td>Language</td><td>EN</td></tr>
<tr><td>Cycle</td><td>SoSe</td></tr>
<tr><td>Content</td><td>Introduction to numerical flow modelling
Processes affecting tht flow
Examples and applications of numerical models
Procedure of numerical modelling
Model concept
Basic equations of hydrodynamics
Saint-Venant equations
Euler Equations
Navier-Stokes equations
Reynolds-averaged Navier-Stokes equations
Shallow water equations
Solving schemes
Numerical discretization
Solution algorithms
Convergence</td></tr>
<tr><td>Literature</td><td>Vorlesungsskript

Literaturempfehlungen

Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau (1997): Hydraulische Berechnung von naturnahen Fließgewässern. Düsseldorf: BWK (BWK-Merkblatt).

Chow, Ven-te (1959): Open-channel Hydraulics. New York usw.: McGraw-Hill (McGraw-Hill Civil Engineering Series).

Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019a): Merkblatt DWA-M 543-2 Geodaten in der Fließgewässermodellierung Teil 1: Geodaten in der Fließgewässermodellierung. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-1).

Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019b): Merkblatt DWA-M 543-2 Geodaten in der Fließgewässermodellierung Teil 2: Bedarfsgerechte Datenerfassung und -aufbereitung. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-2).

Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019c): Merkblatt DWA-M 543-3 Geodaten in der Fließgewässermodellierung - Teil 3: Aspekte der Strömungsmodellierung und Fallbeispiele. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-3).

Hervouet, Jean-Michel (2007): Hydrodynamics of free surface flows. Modelling with the finite element method. Chichester: Wiley. Online verfügbar unter http://www.loc.gov/catdir/enhancements/fy0741/2007296953-b.html.

IAHR (2015): Professional Specifications for Physical and Numerical Studies in Environmental Hydraulics. In: Hydrolink (3/2015), S. 90-92.

Olsen, Nils Reidar B. (2012): Numerical Modelling and Hydraulics. 3. Aufl. Department of Hydraulic and Environmental Engineering, The Norwegian University of Science and Technology.

Szymkiewicz, Romuald (2010): Numerical modeling in open channel hydraulics. Dordrecht: Springer (Water science and technology library, 83).

van Waveren, Harold (1999-): Good modelling practice handbook. [Utrecht], Lelystad, Den Haag: STOWA; Rijkswaterstaat-RIZA; SDU, afd. SEO/RIZA [etc. distr.] (Nota, nr. 99.036).

Zielke, Werner (Hg.) (1999): Numerische Modelle von Flüssen, Seen und Küstengewässern. Deutscher Verband für Wasserwirtschaft und Kulturbau. Bonn: Wirtschafts- und Verl.-Ges. Gas und Wasser (Schriftenreihe des Deutschen Verbandes für Wasserwirtschaft und Kulturbau, 127).</td></tr>
</table>

Module M0874: Wastewater Systems

Courses

Title	Typ	Hrs/wk	CP
Biological Wastewater Treatment (L0517)	Lecture	2	2
Biological Wastewater Treatment (L3122)	Recitation Section (large)	1	1
Advanced Wastewater Treatment (L0357)	Lecture	2	2
Advanced Wastewater Treatment (L0358)	Recitation Section (large)	1	1

Module Responsible	Dr. Joachim Behrendt
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of wastewater management and the key processes involved in wastewater treatment.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to outline key areas of the full range of treatment systems in waste water management, as well as their mutual dependence for sustainable water protection. They can describe relevant economic, environmental and social factors.
Skills	Students are able to pre-design and explain the available wastewater treatment processes and the scope of their application in municipal and for some industrial treatment plants.
Personal Competence	
Social Competence	Social skills are not targeted in this module.
Autonomy	Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L0517: Biological Wastewater Treatment

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Joachim Behrendt
Language	DE/EN
Cycle	SoSe
Content	Charaterisation of Wastewater Metobolism of Microorganisms Kinetic of mirobiotic processes Calculation of bioreactor for wastewater treatment Concepts of Wastewater treatment Design of WWTP Excursion to a WWTP Biofilms Biofim Reactors Anaerobic Wastewater and sldge treatment resources oriented sanitation technology Future challenges of wastewater treatment
Literature	**Gujer, Willi** Siedlungswasserwirtschaft : mit 84 Tabellen

	ISBN: 3540343296 (Gb.) URL: http://www.gbv.de/dms/bs/toc/516261924.pdf URL: http://deposit.d-nb.de/cgi-bin/dokserv?id=2842122&prov=M&dok_var=1&dok_ext=htm Berlin [u.a.] : Springer, 2007 TUB_HH_Katalog **Henze, Mogens** Wastewater treatment : biological and chemical processes ISBN: 3540422285 (Pp.) Berlin [u.a.] : Springer, 2002 TUB_HH_Katalog **Imhoff, Karl** (Imhoff, Klaus R.;) Taschenbuch der Stadtentwässerung : mit 10 Tafeln ISBN: 3486263331 ((Gb.)) München [u.a.] : Oldenbourg, 1999 TUB_HH_Katalog **Lange, Jörg** (Otterpohl, Ralf; Steger-Hartmann, Thomas;) Abwasser : Handbuch zu einer zukunftsfähigen Wasserwirtschaft ISBN: 3980350215 (kart.) URL: http://www.gbv.de/du/services/agi/52567E5D44DA0809C12570220050BF25/000000700334 Donaueschingen-Pfohren : Mall-Beton-Verl., 2000 TUB_HH_Katalog **Mudrack, Klaus** (Kunst, Sabine;) Biologie der Abwasserreinigung : 18 Tabellen ISBN: 382741427X URL: http://www.gbv.de/du/services/agi/94B581161B6EC747C1256E3F005A8143/420000114903 Heidelberg [u.a.] : Spektrum, Akad. Verl., 2003 TUB_HH_Katalog **Tchobanoglous, George** (Metcalf & Eddy, Inc., ;) Wastewater engineering : treatment and reuse ISBN: 0070418780 (alk. paper) ISBN: 0071122508 (ISE (*pbk)) Boston [u.a.] : McGraw-Hill, 2003 TUB_HH_Katalog **Henze, Mogens** Activated sludge models ASM1, ASM2, ASM2d and ASM3 ISBN: 1900222248 London : IWA Publ., 2002 TUB_HH_Katalog **Kunz, Peter** Umwelt-Bioverfahrenstechnik Vieweg, 1992 **Bauhaus-Universität., Arbeitsgruppe Weiterbildendes Studium Wasser und Umwelt** (Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall, ;) Abwasserbehandlung : Gewässerbelastung, Bemessungsgrundlagen, Mechanische Verfahren, Biologische Verfahren, Reststoffe aus der Abwasserbehandlung, Kleinkläranlagen ISBN: 3860682725 URL: http://www.gbv.de/dms/weimar/toc/513989765_toc.pdf URL: http://www.gbv.de/dms/weimar/abs/513989765_abs.pdf Weimar : Universitätsverl, 2006 TUB_HH_Katalog **Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall** DWA-Regelwerk Hennef : DWA, 2004 TUB_HH_Katalog **Wiesmann, Udo** (Choi, In Su; Dombrowski, Eva-Maria;) Fundamentals of biological wastewater treatment ISBN: 3527312196 (Gb.) URL: http://deposit.ddb.de/cgi-bin/dokserv?id=2774611&prov=M&dok_var=1&dok_ext=htm Weinheim : WILEY-VCH, 2007 TUB_HH_Katalog

Course L3122: Biological Wastewater Treatment	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Joachim Behrendt
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0357: Advanced Wastewater Treatment	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Joachim Behrendt
Language	EN
Cycle	SoSe
Content	Survey on advanced wastewater treatment reuse of reclaimed municipal wastewater Precipitation Flocculation Depth filtration Membrane Processes Activated carbon adsorption Ozonation "Advanced Oxidation Processes" Disinfection
Literature	Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003 Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987 Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007 Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003

Course L0358: Advanced Wastewater Treatment	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Joachim Behrendt
Language	EN
Cycle	SoSe
Content	Aggregate organic compounds (sum parameters) Industrial wastewater Processes for industrial wastewater treatment Precipitation Flocculation Activated carbon adsorption Recalcitrant organic compounds
Literature	Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003 Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987 Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007 Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003

Module M0922: City Planning

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
City Planning (L1066)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Carsten Gertz
Admission Requirements	None
Recommended Previous Knowledge	for "Principles of Urban Planning": none for "Designing Urban Streetscapes": some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineering“
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • use technical terms of urban planning. • describe the main determinants of urban development. • explain and compare different possibilities of how urban development can be influenced. • discuss requirements for public streetscapes. • explain the importance of street design.
Skills	Students are able to: • read and analyze urban development concepts and designs for streetscapes • appraise such concepts in the context of competing requirements. • design, justify and reflect their own solutions for concrete examples.
Personal Competence	
Social Competence	Students are able to: • discuss intermediate results with each other. • constructively accept feedback on their own work. • provide constructive feedback to others.
Autonomy	Students are able to: • independently complete a written report including drawings following a broadly pre-defined process. • assess the consequences of their proposed solutions. • independently acquire knowledge and apply this to new issues or problem areas.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	written assignment, designwork during the semester
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L1066: City Planning	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Carsten Gertz
Language	DE
Cycle	SoSe
Content	„Principles of Urban Planning“ deals with the determinants of urban development and their interactions. Topics include: • legal framework, • instruments and methods of planning, • functional requirements, • stakeholders and actors • basic design requirements • different planning levels and • historical contexts. The objective of the course is for students to acquire a basic understanding of urban development problems and approaches for solving them. They will also be able to comprehend the process of urban planning. The course also covers the various functional and aesthetic requirements for designing streetscape as the most important elements of public space. The project work deals with a real life scenario and includes drawing up a development plan, an urban design concept, a building masterplan and a street redesign.
Literature	Albers, Gerd; Wekel, Julian (2021) Stadtplanung: Eine illustrierte Einführung. 4. überarbeitete Auflage. Primus Verlag. Darmstadt. Frick, Dieter (2011) Theorie des Städtebaus: Zur baulich-räumlichen Organisation von Stadt. 3. veränderte Auflage. Wasmuth-Verlag. Tübingen Jonas, Carsten (2009) Die Stadt und ihr Grundriss. Wasmuth-Verlag. Tübingen Kostof, Spiro; Castillo, Greg (1998) Die Anatomie der Stadt. Geschichte städtischer Strukturen. Campus-Verlag. Frankfurt/New York.

Module M0977: Construction Logistics and Project Management

Courses

Title	Typ	Hrs/wk	CP
Construction Logistics (L1163)	Lecture	1	2
Construction Logistics (L1164)	Recitation Section (small)	1	2
Project Development and Management (L1161)	Lecture	1	1
Project Development and Management (L1162)	Project-/problem-based Learning	1	1

Module Responsible	Prof. Heike Flämig
Admission Requirements	None
Recommended Previous Knowledge	none
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can... • give definitions of the main terms of construction logistics and project development and management • name advantages and disadvantages of internal or external construction logistics • explain characteristics of products, demand and production of construction objects and their consequences for construction specific supply chains • differentiate constructions logistics from other logistics systems
Skills	Students can... • carry out project life cycle assessments • apply methods and instruments of construction logistics • apply methods and instruments of project development and management • apply methods and instruments of conflict management • design supply and waste removal concepts for a construction project
Personal Competence	
Social Competence	Students can... • hold presentations in and for groups • apply methods of conflict solving skills in group work and case studies
Autonomy	Students can... • solve problems by holistic, systemic and flow oriented thinking • improve their creativity, negotiation skills, conflict and crises solution skills by applying methods of moderation in case studies
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Two written papers with presentations
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory

Course L1163: Construction Logistics	
Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Heike Flämig
Language	DE
Cycle	SoSe
Content	The lecture gives deeper insight how important logistics are as a competetive factor for construction projects and which issues are to be adressed. The following toppics are covered: • competetive factor logistics • the concept of systems, planning and coordination of logistics • material, equipment and reverse logistics • IT in construction logistics • elements of the planning model of construction logistics and their connections • flow oriented logistics systems for construction projects • logistics concepts for ready to use construction projects (especially procurement and waste removel logistics) • best practice examples (construction logistics Potsdamer Platz, recent case study of the region) Contents of the lecture are deepened in special exercises.
Literature	Flämig, Heike: Produktionslogistik in Stadtregionen. In: Forschungsverbund Ökologische Mobilität (Hrsg.) Forschungsbericht Bd. 15.2. Wuppertal 2000. Krauss, Siri: Die Baulogistik in der schlüsselfertigen Ausführung, Bauwerk Verlag GmbH Berlin 2005. Lipsmeier, Klaus: Abfallkennzahlen für Neubauleistungen im Hochbau : Verlag Forum für Abfallwirtschaft und Altlasten, 2004. Schmidt, Norbert: Wettbewerbsfaktor Baulogistik. Neue Wertschöpfungspotenziale in der Baustoffversorgung. In: Klaus, Peter: Edition Logistik. Band 6. Deutscher Verkehrs-Verlag. Hamburg 2003. Seemann, Y.F. (2007): Logistikkoordination als Organisationseinheit bei der Bauausführung Wissenschaftsverlag Mainz in Aachen, Aachen. (Mitteilungen aus dem Fachgebiet Baubetrieb und Bauwirtschaft (Hrsg. Kuhne, V.): Heft 20)

Course L1164: Construction Logistics	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Heike Flämig
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1161: Project Development and Management	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Heike Flämig, Dr. Anton Worobei
Language	DE
Cycle	SoSe
Content	Within the lecture, the main aspects of project development and management are tought: • Terms and definitions of project management • Advantages and disadvantages of different ways of project handling • organization, information, coordination and documentation • cost and fincance management in projects • time- and capacity management in projects • specific methods and instruments for successful team work Contents of the lecture are deepened in special exercises.
Literature	Projektmanagement-Fachmann. Band 1 und Band 2. RKW-Verlag, Eschborn, 2004.

Course L1162: Project Development and Management	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Heike Flämig, Dr. Anton Worobei
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0998: Statics and Dynamics of Structures

Courses

Title	Typ	Hrs/wk	CP
Structural Dynamics (L1202)	Lecture	2	2
Structural Dynamics (L1203)	Recitation Section (large)	2	2
Fracture mechanics and fatigue in steel structures (L0564)	Lecture	1	1
Fracture mechanics and fatigue in steel structures (L0565)	Recitation Section (large)	1	1

Module Responsible	Prof. Bastian Oesterle
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of linear structural analysis of statically determinate and indeterminate structures; Mechanics I/II, Mathematics I/II, Differential equations I
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of this module, the student can explain the basic aspects of dynamic effects on structures and the respective methods.
Skills	After successful completion of this module, the students will be able to predict the response of material and structures to dynamics loading using the appropriate computational approaches and methods.
Personal Competence	
Social Competence	Students can • participate in subject-specific and interdisciplinary discussions, • defend their own work results in front of others • promote the scientific development of colleagues • Furthermore, they can give and accept professional constructive criticism
Autonomy	Students are able to gain knowledge of the subject area from given and other sources and apply it to new problems. Furthermore, they are able to structure the solution process for problems in the area of Structural Analysis.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	150 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L1202: Structural Dynamics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	DE
Cycle	SoSe
Content	• mechanical background of dynamics • harmonic vibrations, damped and undamped free and forced vibrations • frequency and time domain • modelling aspects • principle of d'Alembert • systems with multiple degrees of freedom • consistent and lumped mass matrices • finite elements for dynamics problems • impact problems • eigenvalue problems and modal analysis • direct time integration schemes, transient analyses
Literature	• Vorlesungsmanuskript • Clough, R.W., Penzien, J.: Dynamics of Structures. 2. Aufl., McGraw-Hill, New York, 1993.

Course L1203: Structural Dynamics	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0564: Fracture mechanics and fatigue in steel structures	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Jürgen Priebe
Language	DE
Cycle	SoSe
Content	• basics of fatigue stress and fatigue resistance and determination of fatigue strength, • determination anduse of S-N-curves and classification of notch effects, • set up of determination of fatigue strength under dynamic load using the accumulation formula by Palmgren-Miner, • set up of determination of fatigue strength in different examples, • basics of construction and design regarding the problem of material fatigue, • basics of linear elastic fracture mechanics under static and dynamic load, • determination of lifetime of steel construction based on linear elastic fracture mechanics in different examples.
Literature	• Seeßelberg, C.; Kranbahnen - Bemessung und konstruktive Gestaltung; 3. Auflage; Bauwerk-Verlag; Berlin 2009 • Kuhlmann, Dürr, Günther; Kranbahnen und Betriebsfestigkeit; in Stahlbau Kalender 2003; Verlag Ernst & Sohn; Berlin 2003 • Deutscher Stahlbau-Verband (Hrsg.); Stahlbau Handbuch Band 1 Teil B; 3. Auflage; Stahlbau-Verlagsgesellschaft; Köln 1996 • Petersen, C.; Stahlbau; 3. überarb. und erw. Auflage; Vieweg-Verlag; Braunschweig 1993 • DIN V ENV 1993-1-1: Eurocode 3; Bemessung und Konstruktion von Stahlbauwerken; Teil 1-1: Allgemeine Bemessungsregeln, Bemessungsregeln für den Hochbau; 1993 • DIN V ENV 1993-6: Eurocode 3; Bemessung und Konstruktion von Stahlbauwerken; Teil 6: Kranbahnen; 2001 • DIN-Fachbericht 126. Richtlinie zur Anwendung von DIN V ENV 1993-6; Nationales Anwendungsdokument (NAD); Berlin 2002

Course L0565: Fracture mechanics and fatigue in steel structures	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Jürgen Priebe
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0999: Steel Construction Project

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Steel Construction Project (L1206)	Project Seminar	4	6

Module Responsible	Prof. Marcus Rutner
Admission Requirements	None
Recommended Previous Knowledge	Steel and Composite Structures
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to prepare a part of the whole project and explain it to the others.
Skills	Students can produce sketches and calculations of their part of the project. They are able to adjust their work in reaction to changing conditions resulting from other participants of the project.
Personal Competence	
Social Competence	Students can present their results to other members of the group. They have the ability to work for a broad agreement with respect to intergroup dependencies. They can distribute and process tasks independently.
Autonomy	Students can handle their part of the project on their own resposibility-
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	approx. 15-20 pages (without appendix)
Assignment for the Following Curricula	Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory

Course L1206: Steel Construction Project

Typ	Project Seminar
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Marcus Rutner
Language	DE
Cycle	SoSe
Content	Design of a big construction project (i.e skyscraper, large bridge, roof of a stadiuim) in small groups
Literature	Wird je nach Projekt individuell angegeben.

Module M0663: Marine Geotechnics

Courses

Title	Typ	Hrs/wk	CP
Marine Geotechnics (L0548)	Lecture	1	2
Marine Geotechnics (L0549)	Recitation Section (large)	2	2
Steel Structures in Foundation and Hydraulic Engineering (L1146)	Lecture	2	2

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	Complete modules: Geotechnics I-III, Mathematics I-III Courses: Soil laboratory course
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students get a deeper knowledge of steel and ground engineering as well as constructions knowledge concerning quay walls. Furthermore, the students get all the necessary knowledge to design singular construction elements for sheet pile walls and they know how to choose the right construction elements depending on the influencing conditions.
Skills	Furthermore, the students are able to dimension sheet pile wall construction regarding all construction elements, to choose the suitable construction elements with respect to the influencing conditions, to design all kinds of sheet pile walls (wave sheet pile walls and combined sheet pile walls) and to dimension all construction elements and connections.
Personal Competence	
Social Competence	
Autonomy	Students are able to assess their own strengths and weaknesses and organize their time and learning management based on this.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory

Course L0548: Marine Geotechnics

Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	SoSe
Content	• Geotechnical investigation an description of the seabed • Foundations of Offshore-Constructions • cCliff erosion • Sea dikes • Port structures • Flood protection structures
Literature	• EAK (2002): Empfehlungen für Küstenschutzbauwerke • EAU (2004): Empfehlungen des Arbeitsausschusses Uferbauwerke • Poulos H.G. (1988): Marine Geotechnics. Unwin Hyman, London • Wagner P. (1990): Meerestechnik: Eine Einführung für Bauingenieure. Ernst & Sohn, Berlin

Course L0549: Marine Geotechnics	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1146: Steel Structures in Foundation and Hydraulic Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Frank Feindt
Language	DE
Cycle	SoSe
Content	Design of a sheet pile wall, design of a combined sheet pile wall, piles, walings, connections, fatigue
Literature	EAU 2012, EA-Pfähle, EAB

Module M1721: Water and Environment: Theory and Application

Courses

Title	Typ	Hrs/wk	CP
Water and Environment (L2754)	Project-/problem-based Learning	3	3
Water and Environment (L2753)	Lecture	3	3

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in water and environmental research, Hydrology
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Common research tools and techniques together with the fundamental knowledge relevant to multi-scale and multi-phase challenges present in water and environmental research will be discussed in this module. Both theory and application will be considered.
Skills	In addition to the fundamental knowledge, the students will be exposed to several analytical, experimental and numerical tools and techniques relevant to water and environmental research at different scales. This will provide the students with an excellent opportunity to improve their skills on multiple fronts which will be useful in their future career.
Personal Competence	
Social Competence	Developing teamwork and problem solving skills through Research-Based Teaching approaches will be at the core of this module.
Autonomy	The students will be involved in writing individual reports and presentation. This will contribute to the students' ability and willingness to work independently and responsibly.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	Report and Presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory

Course L2754: Water and Environment

Typ	Project-/problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Dr. Salome Shokri-Kuehni
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L2753: Water and Environment

Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	Research based learning: The students will be engaged in active research focused on water and environmental related challenges. The required knowledge and tools will be discussed during the semester.
Literature	NA

Module M1133: Port Logistics

Courses

Title	Typ	Hrs/wk	CP
Port Logistics (L0686)	Lecture	2	3
Port Logistics (L1473)	Recitation Section (small)	2	3

Module Responsible	Prof. Carlos Jahn
Admission Requirements	None
Recommended Previous Knowledge	none
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Th After completing the module, students can... • reflect on the development of seaports (in terms of the functions of the ports and the corresponding terminals, as well as the relevant operator models) and place them in their historical context; • explain and evaluate different types of seaport terminals and their specific characteristics (cargo, transhipment technologies, logistic functional areas); • analyze common planning tasks (e.g. berth planning, stowage planning, yard planning) at seaport terminals and develop suitable approaches (in terms of methods and tools) to solve these planning tasks; • identify future developments and trends regarding the planning and control of innovative seaport terminals and discuss them in a problem-oriented manner.
Skills	After completing the module, students will be able to... • recognize functional areas in ports and seaport terminals; • define and evaluate suitable operating systems for container terminals; • perform static calculations with regard to given boundary conditions, e.g. required capacity (parking spaces, equipment requirements, quay wall length, port access) on selected terminal types; • reliably estimate which boundary conditions influence common logistics indicators in the static planning of selected terminal types and to what extent.
Personal Competence	
Social Competence	After completing the module, students can... • transfer the acquired knowledge to further questions of port logistics; • discuss and successfully organize extensive task packages in small groups; • in small groups, document work results in writing in an understandable form and present them to an appropriate extent.
Autonomy	After completing the module, the students are able to... • research and select specialist literature, including standards, guidelines and journal papers, and to develop the contents independently; • submit own parts in an extensive written elaboration in small groups in due time and to present them jointly within a fixed time frame.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** No / 15 % / Written elaboration
Examination	Written exam
Examination duration and scale	120 minutes
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory

Course L0686: Port Logistics	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Carlos Jahn
Language	DE
Cycle	SoSe
Content	Port Logistics deals with the planning, control, execution and monitoring of material flows and the associated information flows in the port system and its interfaces to numerous actors inside and outside the port area. The extraordinary role of maritime transport in international trade requires very efficient ports. These must meet numerous requirements in terms of economy, speed, safety and the environment. Against this background, the lecture Port Logistics deals with the planning, control, execution and monitoring of material flows and the associated information flows in the port system and its interfaces to numerous actors inside and outside the port area. The aim of the lecture Port Logistics is to convey an understanding of structures and processes in ports. The focus will be on different types of terminals, their characteristical layouts and the technical equipment used as well as the ongoing digitization and interaction of the players involved. In addition, renowned guest speakers from science and practice will be regularly invited to discuss some lecture-relevant topics from alternative perspectives. The following contents will be conveyed in the lectures: • Instruction of structures and processes in the port • Planning, control, implementation and monitoring of material and information flows in the port • Fundamentals of different terminals, characteristical layouts and the technical equipment used • Handling of current issues in port logistics
Literature	• Alderton, Patrick (2013). Port Management and Operations. • Biebig, Peter and Althof, Wolfgang and Wagener, Norbert (2017). Seeverkehrswirtschaft: Kompendium. • Brinkmann, Birgitt. Seehäfen: Planung und Entwurf. Berlin Heidelberg: Springer-Verlag, 2005. • Büter, Clemens (2013). Außenhandel: Grundlagen internationaler Handelsbeziehungen. • Gleissner, Harald and Femerling, J. Christian (2012). Logistik: Grundlagen, Übungen, Fallbeispiele. • Jahn, Carlos; Saxe, Sebastian (Hg.). Digitalization of Seaports - Visions of the Future, Stuttgart: Fraunhofer Verlag, 2017. • Kummer, Sebastian (2019). Einführung in die Verkehrswirtschaft • Lun, Y.H.V. and Lai, K.-H. and Cheng, T.C.E. (2010). Shipping and Logistics Management. • Woitschützke, Claus-Peter (2013). Verkehrsgeografie.

Course L1473: Port Logistics	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Carlos Jahn
Language	DE
Cycle	SoSe
Content	The content of the exercise is the independent preparation of a scientific paper plus an accompanying presentation on a current topic of port logistics. The paper deals with current topics of port logistics. For example, the future challenges in sustainability and productivity of ports, the digital transformation of terminals and ports or the introduction of new regulations by the International Maritime Organization regarding the verified gross weight of containers. Due to the international orientation of the event, the paper is to be prepared in English.
Literature	• Alderton, Patrick (2013). Port Management and Operations. • Biebig, Peter and Althof, Wolfgang and Wagener, Norbert (2017). Seeverkehrswirtschaft: Kompendium. • Brinkmann, Birgitt. Seehäfen: Planung und Entwurf. (2005) Berlin Heidelberg: Springer-Verlag. • Büter, Clemens (2013). Außenhandel: Grundlagen internationaler Handelsbeziehungen. • Gleissner, Harald and Femerling, J. Christian (2012). Logistik: Grundlagen, Übungen, Fallbeispiele. • Jahn, Carlos; Saxe, Sebastian (Hg.) (2017) Digitalization of Seaports - Visions of the Future, Stuttgart: Fraunhofer Verlag. • Kummer, Sebastian (2019). Einführung in die Verkehrswirtschaft • Lun, Y.H.V. and Lai, K.-H. and Cheng, T.C.E. (2010). Shipping and Logistics Management. • Woitschützke, Claus-Peter (2013). Verkehrsgeografie.

Module M1845: Thin-walled structures

Courses

Title	Typ	Hrs/wk	CP
Thin-walled structures (L1199)	Lecture	2	3
Thin-walled structures (L3045)	Recitation Section (large)	2	3

Module Responsible	Prof. Bastian Oesterle
Admission Requirements	None
Recommended Previous Knowledge	• Structural Analysis I • Structural Analysis II • Finite Element Methods
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of this module, the students can express the basic aspects of the load-carrying behaviour of thin-walled structures.
Skills	After successful completion of this module, the students will be able to predict load-carrying behaviour of thin-walled structures using appropriate analytical and coputational methods.
Personal Competence	
Social Competence	Students can • participate in subject-specific and interdisciplinary discussions, • defend their own work results in front of others • promote the scientific development of colleagues • Furthermore, they can give and accept professional constructive criticism
Autonomy	Students are able to gain knowledge of the subject area from given and other sources and apply it to new problems. Furthermore, they are able to structure the solution process for problems in the area of modelling and analysis of thin-walled structures.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L1199: Thin-walled structures	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	DE
Cycle	SoSe
Content	Plates loaded in-plane • Governing equations (equilibrium, kinematics, constitutive law) • Differential equation • Airy stress function • Plane stress / plane strain • Structural behaviour of plates loaded in-plane • finite elements for plates loaded in-plane, modelling apsects, interpretation and critical assessment of results Plates in bending • Governing equations (equilibrium, kinematics, constitutive law) • Differential equation • Navier solution / Fourier series expansion • Approximation procedures • Circular and rectangular plates • Structural behaviour of plates in bending • finite elements for plates in bending, modelling apsects, interpretation and critical assessment of results Shells • Phenomenona of the structural behaviour of shells • Membrane and bending theory • Equilibrium equations of shells of revolution • Stress resultants and deformations of the spherical shell, the half spherical shell, and the cylindrical shell • finite elements for shells Stability problems (overview) • Plate buckling • Shell buckling
Literature	• Vorlesungsmanuskript • Basar, Y.: Krätzig, W.B. (1985): Mechanik der Flächentragwerke. Vieweg-Verlag, Braunschweig, Wiesbaden • Girkmann, K. (1963): Flächentragwerke, Springer Verlag, Wien, 1963, unveränderter Nachdruck 1986 • Zienkiewicz, O.C. (1977): The Finite Element Method in Enginieering Science. McGraw-Hill, London

Course L3045: Thin-walled structures	
Typ	Recitation Section (large)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1132: Maritime Transport

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Maritime Transport (L0063)	Lecture	2	3
Maritime Transport (L0064)	Recitation Section (small)	2	3

Module Responsible	Prof. Carlos Jahn
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to... • present the actors involved in the maritime transport chain with regard to their typical tasks; • name common cargo types in shipping and classify cargo to the corresponding categories; • explain operating forms in maritime shipping, transport options and management in transport networks; • weigh the advantages and disadvantages of the various modes of hinterland transport and apply them in practice; • estimate the potential of digitisation in maritime shipping.
Skills	The students are able to... • determine the mode of transport, actors and functions of the actors in the maritime supply chain; • identify possible cost drivers in a transport chain and recommend appropriate proposals for cost reduction; • record, map and systematically analyse material and information flows of a maritime logistics chain, identify possible problems and recommend solutions; • perform risk assessments of human disruptions to the supply chain; • analyse accidents in the field of maritime logistics and evaluating their relevance in everyday life; • deal with current research topics in the field of maritime logistics in a differentiated way; • plan the deployment of a fleet based on scenarios; • apply different process modelling methods in a hitherto unknown field of activity and to work out the respective advantages.
Personal Competence	
Social Competence	The students are able to... • discuss and organise extensive work packages in groups; • document and present the elaborated results.
Autonomy	The students are capable to... • research and select technical literature, including standards and guidelines; • submit own shares in an extensive written elaboration in small groups in due time.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** No / 15 % / Subject theoretical and practical work / Teilnahme an einem Planspiel und anschließende schriftliche Ausarbeitung
Examination	Written exam
Examination duration and scale	120 minutes
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory

Course L0063: Maritime Transport	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Carlos Jahn
Language	DE
Cycle	SoSe
Content	The general tasks of maritime logistics include the planning, design, implementation and control of material and information flows in the logistics chain ship - port - hinterland. The aim of the course is to provide students with knowledge of maritime transport and the actors involved in the maritime transport chain. Typical problem areas and tasks will be dealt with, taking into account the economic development. Thus, classical problems as well as current developments and trends in the field of maritime logistics are considered. In the lecture, the components of the maritime logistics chain and the actors involved will be examined and risk assessments of human disturbances on the supply chain will be developed. In addition, students learn to estimate the potential of digitisation in maritime shipping, especially with regard to the monitoring of ships. In addition, students are able to design operational planning for fleets of container or tramp vessels. Further content of the lecture is the different modes of transport in the hinterland, which students can evaluate after completion of the course regarding their advantages and disadvantages.
Literature	• Clausen, Uwe and Geiger, Christiane. Verkehrs- und Transportlogistik. Berlin Heidelberg: Springer-Verlag, 2013. • Schönknecht, Axel. Maritime Containerlogistik: Leistungsvergleich von Containerschiffen in intermodalen Transportketten. Berlin Heidelberg: Springer-Verlag, 2009. • Rodrigue, Jean-Paul. Geography of Transport Systems. London New York: Routledge, 2020. • Stopford, Martin. Maritime Economics Routledge, 2009.

Course L0064: Maritime Transport	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Carlos Jahn
Language	DE
Cycle	SoSe
Content	The exercise lesson bases on the haptic management game MARITIME. MARITIME focuses on providing knowledge about structures and processes in a maritime transport network. Furthermore, the management game systematically provides process management methodology and also promotes personal skills of the participants.
Literature	• Brinkmann, Birgitt. Seehäfen: Planung und Entwurf. Berlin Heidelberg: Springer-Verlag, 2005. • Koch Susanne. Methoden des Prozessmanagements. In: Einführung in das Management von Geschäftsprozessen. Springer, Berlin, Heidelberg, 2011. • Liebetruth, Thomas. Prozessmanagement in Einkauf und Logistik, Springer Gabler: Wiesbaden, 2020. • Schönknecht, Axel. Maritime Containerlogistik: Leistungsvergleich von Containerschiffen in intermodalen Transportketten. Berlin Heidelberg: Springer-Verlag, 2009. • Stopford, Martin. Maritime Economics Routledge, 2009

Module M1724: Smart Monitoring

Courses

Title	Typ	Hrs/wk	CP
Smart Monitoring (L2762)	Integrated Lecture	2	2
Smart Monitoring (L2763)	Recitation Section (small)	2	4

Module Responsible	Prof. Kay Smarsly
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge or interest in object-oriented modeling, programming, and sensor technologies are helpful. Interest in modern research and teaching areas, such as Internet of Things, Industry 4.0 and cyber-physical systems, as well as the will to deepen skills of scientific working, are required. Basic knowledge in scientific writing and good English skills.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students will become familiar with the principles and practices of smart monitoring. The students will be able to design decentralized smart systems to be applied for continuous (remote) monitoring of systems in the built and in the natural environment. In addition, the students will learn to design and to implement intelligent sensor systems using state-of-the-art data analysis techniques, modern software design concepts, and embedded computing methodologies. Besides lectures, project work is also part of this module, which will be conducted throughout the semester and will contribute to the grade. In small groups, the students will design smart monitoring systems that integrate a number of “intelligent” sensors to be implemented by the students. Specific focus will be put on the application of machine learning techniques. The smart monitoring systems will be mounted on real-world (built or natural) systems, such as bridges or slopes, or on scaled lab structures for validation purposes. The outcome of every group will be documented in a paper. All students of this module will “automatically” participate with their smart monitoring system in the annual "Smart Monitoring" competition. The written papers and oral examinations form the final grades. The module will be taught in English. Limited enrollment.
Skills	The students will gain insights into operating state-of-the-art smart sensor systems, used for monitoring a wide range of physical processes relevant to engineering, such as environmental, structural, or comfort monitoring. The students will be capable of devising monitoring strategies of physical processes as part of group projects, tailored to their knowledge backgrounds, and to implement the strategies in smart wireless sensor nodes, using embedded computing and programming. Finally, the students will be able to document the findings of their projects in short reports.
Personal Competence	
Social Competence	The students will be able to work in groups, share parts of the work for their projects, and develop communication skills, towards achieving the common project goals.
Autonomy	The students will be able to gain a solid basis on approaching and solving problems in engineering, as well as on documenting results, through their involvement in their monitoring group projects.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	10 pages of work with 15-minute oral presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2762: Smart Monitoring	
Typ	Integrated Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Kay Smarsly
Language	EN
Cycle	SoSe
Content	In this course, principles of smart monitoring will be taught, focusing on modern concepts of data acquisition, data storage, and data analysis. Also, fundamentals of intelligent sensors and embedded computing will be illuminated. Autonomous software and decentralized data processing are further crucial parts of the course, including concepts of the Internet of Things, Industry 4.0 and cyber-physical systems. Furthermore, measuring principles, data acquisition systems, data management and data analysis algorithms will be discussed. Besides the theoretical background, numerous practical examples will be shown to demonstrate how smart monitoring may advantageously be used for assessing the condition of systems in the built or natural environment.
Literature	The course contents couples different fields, such as signal processing, sensing technologies, data analytics, environmental engineering, civil engineering, artificial intelligence, database systems, and many more. The basics will be taught in this course. However, specific literature that covers all these topics does not exist. Instead, literature will be referenced in the lectures, all of which are papers that are freely available online.

Course L2763: Smart Monitoring	
Typ	Recitation Section (small)
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Kay Smarsly
Language	EN
Cycle	SoSe
Content	The contents of the exercises are based on the lecture contents. In addition to the exercises, project work will be conducted throughout the semester, which will consume the majority of the workload. As part of the project work, students will design smart monitoring systems that will be tested in the laboratory or in the field. As mentioned in the module description, the students will participate in the “Smart Monitoring” competition, hosted annually by the Institute of Digital and Autonomous Construction. Students are encouraged to contribute their own ideas. The tools required to implement the smart monitoring systems will be taught in the group exercises as well as through external sources, such as video tutorials and literature.
Literature	The course contents couples different fields, such as signal processing, sensing technologies, data analytics, environmental engineering, civil engineering, artificial intelligence, database systems, and many more. The basics will be taught in this course. However, specific literature that covers all these topics does not exist. Instead, literature will be referenced in the lectures, all of which are papers that are freely available online.

Module M1878: Sustainable energy from wind and water

Courses

Title	Typ	Hrs/wk	CP
Offshore Geotechnical Engineering (L0067)	Lecture	1	1
Hydro Power Use (L0013)	Lecture	1	1
Wind Turbine Plants (L0011)	Lecture	2	3
Wind Energy Use - Focus Offshore (L0012)	Lecture	1	1

Module Responsible	Dr. Marvin Scherzinger
Admission Requirements	None
Recommended Previous Knowledge	Module: Technical Thermodynamics I, Module: Technical Thermodynamics II, Module: Fundamentals of Fluid Mechanics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	By ending this module students can explain in detail knowledge of wind turbines with a particular focus of wind energy use in offshore conditions and can critical comment these aspects in consideration of current developments. Furthermore, they are able to describe fundamentally the use of water power to generate electricity. The students reproduce and explain the basic procedure in the implementation of renewable energy projects in countries outside Europe. Through active discussions of various topics within the seminar of the module, students improve their understanding and the application of the theoretical background and are thus able to transfer what they have learned in practice.
Skills	Students are able to apply the acquired theoretical foundations on exemplary water or wind power systems and evaluate and assess technically the resulting relationships in the context of dimensioning and operation of these energy systems. They can in compare critically the special procedure for the implementation of renewable energy projects in countries outside Europe with the in principle applied approach in Europe and can apply this procedure on exemplary theoretical projects.
Personal Competence	
Social Competence	Students can discuss scientific tasks subjet-specificly and multidisciplinary within a seminar.
Autonomy	Students can independently exploit sources in the context of the emphasis of the lecture material to clear the contents of the lecture and to acquire the particular knowledge about the subject area.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	180 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Renewable Energies: Core Qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L0067: Offshore Geotechnical Engineering	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Jan Dührkop
Language	DE
Cycle	SoSe
Content	• Overview and Introduction Offshore Geotechnics • Introduction to Soil Mechanics • Offshore soil investigation • Focus on cyclical effects • Geotechnical design of offshore foundations • Monopiles • Jackets • Heavyweight foundations • Geotechnical preliminary exploration for the use of lift boats and platforms
Literature	• Randolph, M. and Gourvenec, S (2011): Offshore Geotechnical Engineering. Spon Press. • Poulos H.G. (1988): Marine Geotechnics. Unwin Hyman, London • BSH-Standard Baugrunderkundung für Offshore-Windenergieparks • Lesny K. (2010): Foundations for Offshore Wind Turbines. VGE Verlag, Essen. • EA-Pfähle (2012): Empfehlungen des Arbeitskreises Pfähle der DGGT. Ernst & Sohn, Berlin.

Course L0013: Hydro Power Use	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Stefan Achleitner
Language	DE
Cycle	SoSe
Content	• Introduction, importance of water power in the national and global context • Physical basics: Bernoulli's equation, usable height of fall, hydrological measures, loss mechanisms, efficiencies • Classification of Hydropower: Flow and Storage hydropower, low and high pressure systems • Construction of hydroelectric power plants: description of the individual components and their technical system interaction • Structural engineering components; representation of dams, weirs, dams, power houses, computer systems, etc. • Energy Technical Components: Illustration of the different types of hydraulic machinery, generators and grid connection • Hydropower and the Environment • Examples from practice
Literature	• Schröder, W.; Euler, G.; Schneider, K.: Grundlagen des Wasserbaus; Werner, Düsseldorf, 1999, 4. Auflage • Quaschning, V.: Regenerative Energiesysteme: Technologie - Berechnung - Simulation; Carl Hanser, München, 2011, 7. Auflage • Giesecke, J.; Heimerl, S.; Mosony, E.: Wasserkraftanlagen - Planung, Bau und Betrieb; Springer, Berlin, Heidelberg, 2009, 5. Auflage • von König, F.; Jehle, C.: Bau von Wasserkraftanlagen - Praxisbezogene Planungsunterlagen; C. F. Müller, Heidelberg, 2005, 4. Auflage • Strobl, T.; Zunic, F.: Wasserbau: Aktuelle Grundlagen - Neue Entwicklungen; Springer, Berlin, Heidelberg, 2006

Course L0011: Wind Turbine Plants	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Rudolf Zellermann
Language	DE
Cycle	SoSe
Content	• Historical development • Wind: origins, geographic and temporal distribution, locations • Power coefficient, rotor thrust • Aerodynamics of the rotor • Operating performance • Power limitation, partial load, pitch and stall control • Plant selection, yield prediction, economy • Excursion
Literature	Gasch, R., Windkraftanlagen, 4. Auflage, Teubner-Verlag, 2005

Course L0012: Wind Energy Use - Focus Offshore	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Martin Skiba
Language	DE
Cycle	SoSe
Content	• Introduction, importance of offshore wind power generation, Specific requirements for offshore engineering • Physical fundamentals for utilization of wind energy • Design and operation of offshore wind turbines, presentation of different concepts of offshore wind turbines, representation of the individual system components and their system-technical relationships • Foundation engineering, offshore site investigation, presentation of different concepts of offshore foundation structures, planning and fabrication of foundation structures • Electrical infrastructure of an offshore wind farm, Inner Park cabling, offshore substation, grid connection • Installation of offshore wind farms, installation techniques and auxiliary devices, construction logistics • Development and planning of offshore wind farms • Operation and optimization of offshore wind farms • Day excursion
Literature	• Gasch, R.; Twele, J.: Windkraftanlagen - Grundlagen, Entwurf, Planung und Betrieb; Vieweg + Teubner, Stuttgart, 2007, 7. Auflage • Molly, J. P.: Windenergie - Theorie, Anwendung, Messung; C. F. Müller, Heidel-berg, 1997, 3. Auflage • Hau, E.: Windkraftanalagen; Springer, Berlin, Heidelberg, 2008, 4.Auflage • Heier, S.: Windkraftanlagen - Systemauslegung, Integration und Regelung; Vieweg + Teubner, Stuttgart, 2009, 5. Auflage • Jarass, L.; Obermair, G.M.; Voigt, W.: Windenergie: Zuverlässige Integration in die Energieversorgung; Springer, Berlin, Heidelberg, 2009, 2. Auflage

Module M0858: Coastal Hydraulic Engineering I

Courses

Title	Typ	Hrs/wk	CP
Basics of Coastal Engineering (L0807)	Lecture	3	4
Basics of Coastal Engineering (L1413)	Project-/problem-based Learning	1	2

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Basics of hydraulic engineering, hydrology and hydromechanics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to define and explain the basic concepts of coastal engineering and port engineering. They are able to apply the concepts to selected practical problems of coastal engineering. Students can define and determine the basics for design and dimensioning of coastal engineering constructions.
Skills	The students are capable to apply basic design approaches to selected and pre-defined design tasks in coastal engineering.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in applied problems such as the design of coastal protection structures. Additionaly, they will be able to work in team with engineers of other disciplines, for instance designing of coastal breakwaters.
Autonomy	The students will be able to independently extend their knowledge and applyit to new problems.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	The duration of the examination is 2 hours. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L0807: Basics of Coastal Engineering

Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Peter Fröhle
Language	EN
Cycle	SoSe

Content	• Basics of planning and design
	  ◦ Water levels
	  ◦ Currents
	  ◦ Waves
	  ◦ Ice
	• Planning and Design in Coastal Engineering
	  ◦ Functional and constructional design
	  ◦ Determination of design parameters
	  ◦ Design-approaches
	    ▪ Filter
	    ▪ Rubble mound constructions
	    ▪ Piles
	    ▪ Vertical constructions

Literature	Coastal Engineering Manual, CEM Vorlesungsumdruck

Course L1413: Basics of Coastal Engineering	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0581: Water Protection

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Water Protection and Wastewater Management (L0226)	Lecture	3	3
Water Protection and Wastewater Management (L2008)	Project Seminar	3	3

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	• Basic knowledge in water management; • Good knowledge in urban drainage; • Good knowledge of wastewater treatment techniques; • Good knowledge of pollutants (e.g. COD, BOD, TS, N, P) and their properties;
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can describe the basic principles of the regulatory framework related to the international and European water sector. They can explain limnological processes, substance cycles and water morphology in detail. They are able to assess complex problems related to water protection, such as ecosystem service and wastewater treatment with a special focus on innovative solutions, remediation measures as well as conceptual approaches.
Skills	Students can accurately assess current problems and situations in a country-specific or local context. They can suggest concrete actions to contribute to the planning of tomorrow's urban water cycle. Furthermore, they can suggest appropriate technical, administrative and legislative solutions to solve these problems.
Personal Competence	
Social Competence	The students can work together in international groups.
Autonomy	Students are able to organize their work flow to prepare presentations and discussions. They can acquire appropriate knowledge by making enquiries independently.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Presentation
Examination duration and scale	Term paper plus presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory

Course L0226: Water Protection and Wastewater Management	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	The lecture focusses on: • Regulatory Framework (e.g. WFD) • Main instruments for the water management and protection • In depth knowledge of relevant measures of water pollution control • Urban drainage, treatment options in different regions on the world • Rainwater management, improved management of heavy rainfalls, downpours, rainwater harvesting, rainwater infiltration • Case Studies and Field Trips
Literature	The literature listed below is available in the library of the TUHH. • Water and wastewater technology Hammer, M. J. 1., & . (2012). (7. ed., internat. ed.). Boston [u.a.]: Pearson Education International. • Water and wastewater engineering : design principles and practice: Davis, M. L. 1. (2011). . New York, NY: McGraw-Hill. • Biological wastewater treatment: (2011). C. P. Leslie Grady, Jr. (3. ed.). London, Boca Raton, Fla. [u.a.]: IWA Publ.

Course L2008: Water Protection and Wastewater Management	
Typ	Project Seminar
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	
Literature	

Module M0595: Examination of Materials, Structural Condition and Damages

Courses

Title	Typ	Hrs/wk	CP
Examination of Materials, Structural Condition and Damages (L0260)	Lecture	3	4
Examination of Materials, Structural Condition and Damages (L0261)	Recitation Section (small)	1	2

Module Responsible	Prof. Frank Schmidt-Döhl
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge about building materials or material science, for example by the module Building Materials and Building Chemistry.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe the rules for trading, use and marking of construction products in Germany. They know which methods for the testing of building material properties are usable and know the limitations and characterics of the most important testing methods.
Skills	The students are able to responsibly discover the rules for trading and using of building products in Germany. They are able to chose suitable methods for the testing and inspection of construction products, the examination of damages and the examination of the structural conditions of buildings. They are able to conclude from symptons to the cause of damages. They are able to describe an examination in form of a test report or expert opinion.
Personal Competence	
Social Competence	The students can describe the different roles of manufacturers as well as testing, supervisory and certification bodies within the framework of material testing. They can describe the different roles of the participants in legal proceedings.
Autonomy	The students are able to make the timing and the operation steps to learn the specialist knowledge of a very extensive field.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Materials Science and Engineering: Specialisation Engineering Materials: Elective Compulsory Materials Science: Specialisation Engineering Materials: Elective Compulsory

Course L0260: Examination of Materials, Structural Condition and Damages

Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	WiSe
Content	Materials testing and marking process of construction products, testing methods for building materials and structures, testing reports and expert opinions, describing the condition of a structure, from symptons to the cause of damages
Literature	Frank Schmidt-Döhl: Materialprüfung im Bauwesen. Fraunhofer irb-Verlag, Stuttgart, 2013.

Course L0261: Examination of Materials, Structural Condition and Damages

Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0713: Concrete Structures

Courses

Title	Typ	Hrs/wk	CP
Concrete Structures (L0579)	Seminar	1	1
Structural Concrete Members (L0577)	Lecture	2	3
Structural Concrete Members (L0578)	Recitation Section (large)	2	2

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	Basics of structural analysis, conception and dimensioning of structural concrete Modules: Reinforced Concrete Structures I+II, Structural Analysis I+II, Mechanics I+II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students broaden their skills in structural engineering, especially in the field of buildings (houses, roofs, halls). They dispose of the knowledge for the conception and design of concrete buildings and structural members that are often used.
Skills	The students are able to apply procedures of the conception and dimensioning to to practical problems of structural engineering. They are capable to draft concrete buildings and to design them for general action effects and to plan their detailing and execution. Moreover, they can make design and construction sketches and draw up technical descriptions.
Personal Competence	
Social Competence	The students are able to obtain results of high quality in teamwork.
Autonomy	The students are able to carry out complex conception and dimensioning tasks of structures under the guidance of tutors.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory**: No; **Bonus**: None; **Form**: Presentation; **Description**: Es werden 2 Referate ausgegeben
Examination	Written exam
Examination duration and scale	120 minutes
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L0579: Concrete Structures

Typ	Seminar
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	NN
Language	DE
Cycle	WiSe
Content	With help of a project teamwork the subjects of the course "Concrete Structures" is practiced, discussed and presented.
Literature	- Projektbezogene Unterlagen werden abgegeben.

Course L0577: Structural Concrete Members	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	NN
Language	DE
Cycle	WiSe
Content	• skyscrapers: structural elements • actions on structrues • bracing systems • design orf slabs (line and point supported plates and floor slabs) • membranes and deep beams • folded plates and shells • truss models • reinforced and prestressed members
Literature	Vorlesungsunterlagen können im STUDiP heruntergeladen werden • Zilch K., Zehetmaier G.: Bemessung im konstruktiven Ingenieurbau. Springer, Heidelberg 2010 • König, G., Liphardt S.: Hochhäuser aus Stahlbeton, Betonkalender 2003, Teil II, Seite 1-69, Verlag Ernst & Sohn, Berlin 2003 • Phocas, Marios C.: Hochhäuser : Tragwerk und Konstruktion, Stuttgart, Teubner, 2005 • Deutscher Ausschuss für Stahlbeton: Heft 600: Erläuterungen zu DIN EN 1992-1-1, Beuth Verlag, Berlin 2012 • Deutscher Ausschuss für Stahlbeton: Heft 240: Hilfsmittel zur Berechnung der Schnittgrößen und Formänderungen von Stahlbetontragwerken, Verlag Ernst & Sohn, Berlin 1978 • Stiglat, K., Wippel, H.: Massive Platten - Ausgewählte Kapitel der Schnittkraftermittlung und Bemessung, Betonkalender 1992, Teil I, 287-366, Verlag Ernst & Sohn, Berlin 1992 • Stiglat/Wippel: Platten. Verlag Ernst & Sohn, Berlin,1973 • Schlaich J.; Schäfer K.: Konstruieren im Stahlbetonbau. Betonkalender 1998, Teil II, S. 721ff, Verlag Ernst & Sohn, Berlin, 1998 • Dames K.-H.: Rohbauzeichnungen Bewehrungszeichnungen. Bauverlag, Wiesbaden 1997

Course L0578: Structural Concrete Members	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	NN
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0923: Integrated Transportation Planning

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Integrated Transportation Planning (L1068)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Carsten Gertz
Admission Requirements	None
Recommended Previous Knowledge	some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineerin
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • describe interdependencies between land-use/location choice and transportation/mobility behaviour • explain and evaluate the social, ecological and economic effects of transport and land-use policy measures. • relate current issues in the area of integrated transport planning and formulate an opinion on them.
Skills	Students are able to: • quantify important parameters, which influence travel demand or are influenced by it. • comprehensively examine a pre-defined or self-selected topic from a transportation studies perspective and document the results in accordance with scientific conventions.
Personal Competence	
Social Competence	Students are able to: • provide feedback on topical contents and their teaching. • constructively handle feedback on their own work. • produce results in group work and document these.
Autonomy	Students are able to: • assess potential consequences of their future professional activities • independently plan working on a pre-defined project topic, acquire the necessary knowledge and use appropriate means for its execution.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	written assignment with presentation during the semester
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L1068: Integrated Transportation Planning	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Carsten Gertz, Dr. Philine Gaffron, Jacqueline Bianca Maaß
Language	DE
Cycle	WiSe
Content	The course will provide students with an understanding of interdependencies between land-use and transportation. Specific topics include a.o.: • interactions between transport and the environment and consequent limitations • characteristics of integrated planning • complex planning processes • interdependencies of location choice and mobility behaviour • transport and land-use policies • project on current issues in transportation studies
Literature	Kutter, Eckhard (2019) Stadtstruktur und Erreichbarkeit in der postfossilen Zukunft. Erich Schmidt Verlag. Berlin. Gies, Huber u. a. (Hrsg.) (93. Ergänzung 2022) Handbuch der kommunalen Verkehrsplanung. Herbert Wichmann Verlag. Berlin, Offenbach. (Loseblattsammlung mit kontinuierlichen Ergänzungen)

Module M0963: Steel and Composite Structures

Courses

Title	Typ	Hrs/wk	CP
Steel and Composite Structures (L1204)	Lecture	2	2
Steel and Composite Structures (L1205)	Recitation Section (large)	2	2
Steel Bridges (L1097)	Lecture	2	2

Module Responsible	Prof. Marcus Rutner
Admission Requirements	None
Recommended Previous Knowledge	Basics of steel construction (i.e. Steel Structures I and II, BUBC)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completition, students can • describe the phenomenon of local buckling • explain warping torsion • illustrate the behaviour of composite structures • specify the principles in design of composite sttructures • sketch the contructions of steel and composite bridges
Skills	After successful participation students are able to • check stiffened and unstiffened plated structures • recognize and verify warping tosion in strucures • design composite structures • design bridges and o perform the detailing
Personal Competence	
Social Competence	--
Autonomy	--
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	180 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L1204: Steel and Composite Structures

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Marcus Rutner
Language	DE
Cycle	WiSe
Content	• Local-buckling of plated structures • Warping torsion • Composite-girders, -columns, -slabs, -bridges • Principles in composite constructions • Bridge-design and -construction
Literature	Petersen, C.: Stahlbau, 4.Auflage 2013, Springer-Vieweg Verlag Minnert, J. Wagenknecht, G.: Verbundbau-Praxis - Berechnung und Konstruktion nach Eurocode 4, 2.Auflage 2013, Bauwerk Beuth Verlag

Course L1205: Steel and Composite Structures	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Marcus Rutner
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1097: Steel Bridges	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Yves Freundt
Language	DE
Cycle	WiSe
Content	**Lecture Contents ‚Steel Bridge Construction'** **Dr.-Ing. Jörg Ahlgrimm** - From tendering and contracting to completion - the development of a steel bridge - Contents of a bridge static - structural details, examples of analysis in detail: -> effective width in regard to the longitudinal stiffeners -> Bearing point, bearing stiffener -> Crossbeam breakthrough, crossbeam reinforcement -> Analysis of the Rib-to-Floorbeam (RF) connection (web-tooth of the floorbeam between trapezoidal shaped Ribs) - Steel grades, -designation, testing methods and approval certificates - Nondestructive weld inspecting - Corrosion protection - Bridge bearing - types, format, function, dimensioning, installation - Expansion Joints - Oscillation of bridge hangers and cables - oscillation damper - Opening bridges- Detailed reviews to different assembling procedures and - implements - Selective damage events Requirements: Basic knowledge in the calculation, dimensioning, and construction of structural elements and joints of constructional steelwork
Literature	• Herbert Schmidt, Ulrich Schulte, Rainer Zwätz, Lothar Bär: Ausführung von Stahlbauten • Petersen, Christian: Stahlbau, Abschnitt Brückenbau • Ahlgrimm, J., Lohrer, I.: Erneuerung der Eisenbahnüberführung in Fulda-Horas über die Fulda, Stahlbau 74 (2005), Heft 2, S. 114

Module M0969: Selected Topics in Civil Engineering

Courses

Title	Typ	Hrs/wk	CP
Design of Composite Bridges (L3092)	Integrated Lecture	2	3
Analysis of Offshore Structures (L1867)	Lecture	1	1
Energy Geotechnics (L3227)	Lecture	3	3
Solid Matter Process Technology for Biomass (L0052)	Lecture	2	3
Forum I - Geotechnics and Construction Management (L1634)	Seminar	1	1
Forum II - Geotechnics and Construction Management (L1635)	Seminar	1	1
Timber Structures (L1151)	Seminar	2	2
Innovative Timber Construction (L2666)	Lecture	2	4
Glass Structures (L1152)	Lecture	2	2
Glass Structures (L1447)	Recitation Section (large)	1	1
Sustainable landfill design and operation (L3270)	Integrated Lecture	3	3
Special Topics in Steel Design (L3091)	Integrated Lecture	2	3
Special topics of civil engineering 1CP (L2378)		1	1
Special topics of civil engineering 2 LP (L2379)		2	2
Special topics of civil engineering 3 LP (L2380)		3	3
Structural Design (L2789)	Seminar	2	2

Module Responsible	Prof. Frank Schmidt-Döhl
Admission Requirements	None
Recommended Previous Knowledge	none
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students are able to find their way through selected special areas within civil and structural engineering. • Students are able to explain basic models and procedures in selected special areas of civil and structural engineering. • Students are able to interrelate scientific and technical knowledge.
Skills	• Students are able to apply basic methods in selected areas of civil and structural engineering.
Personal Competence	
Social Competence	---
Autonomy	• Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses.
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory

Course L3092: Design of Composite Bridges

Typ	Integrated Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Marcus Rutner
Language	DE
Cycle	SoSe
Content	
Literature	

Course L1867: Analysis of Offshore Structures	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Said Fawad Mohammadi
Language	DE/EN
Cycle	SoSe
Content	Topic 1: Types of Offshore Structures, Fixed and floating structures for Oil & Gas and Offshore Wind industry Topic 2: Wave Forces, Morisons equation Topic 3: Irregular Seastates, Power spectrum and application of FFT Topic 4: Additional Environmental Forces, wind spectra, current forces Topic 5: Linear-Time-Invariant Systems, response of an LTI-system in frequency domain Topic 6: Tubular Welded Connections, stress concentration factors, weld geometry Topic 7: Introduction to Fracture Mechanics, criteria for fracture initiation and crack growth Topic 8: Time and Frequency Domain Fatigue Analyses, rainflow counting, application of LTI-systems for frequency domain fatigue Topic 9: Offshore Installation and Exam, installation of structures, pile driving, pipe laying techniques
Literature	Chakrabarti, Handbook of Offshore Engineering, 2005 Sarpkaya, Wave Forces on Offshore Structures, 2010 Faltinsen, Sea Loads on Ships and Offshore Structures, 1998 Sorensen, Basic Coastal Engineering, 2006 Dowling, Mechanical Behavior of Materials, 2007 Haibach, Betriebsfestigkeit, 2006 Marshall, Design of Welded Tubular Connections, 1992 Newland, Random vibrations, spectral and wavelet analysis, 1993

Course L3227: Energy Geotechnics	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Schriftliche Ausarbeitung (laut FPrO)
Examination duration and scale	wird zu Beginn der Lehrveranstaltung festgelegt
Lecturer	Pauline Kaminski
Language	DE/EN
Cycle	WiSe
Content	Energy geotechnics is a young field in geotechnical engineering with the aim of developing sustainable geotechnical solutions for future-oriented issues relating to the production, transport, operation, decommissioning, and waste utilisation of various energy sources. Examples of possible fields of activity in energy geotechnics include geothermal energy and thermally activated foundation components, foundations for onshore and offshore wind turbines, the decommissioning of mining facilities and the handling of waste products from fossil fuels such as tailings and the geological storage of CO_2. Relevant soil mechanical processes in these applications include the thermo-hydro-mechanically coupled behaviour of soils, multiphase flow in porous media and partially saturated soils. The lecture gives an overview of various aspects of energy geotechnics and provides in-depth knowledge of the associated soil mechanical processes. In addition, CO_2-scarce geotechnical applications are discussed and emission estimates as well as the optimisation of geotechnical structures according to sustainability aspects are addressed.
Literature	

Course L0052: Solid Matter Process Technology for Biomass	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Prof. Werner Sitzmann
Language	DE
Cycle	SoSe
Content	The industrial application of unit operations as part of process engineering is explained by actual examples of solid biomass processes. Size reduction, transportation and dosing, drying and agglomeration of renewable resources are described as important unit operations when producing solid fuels and bioethanol, producing and refining edible oils, when making Btl - and WPC - products. Aspects of explosion protection and plant design complete the lecture.
Literature	Kaltschmitt M., Hartmann H. (Hrsg.): Energie aus Bioamsse, Springer Verlag, 2001, ISBN 3-540-64853-4 Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, Schriftenreihe Nachwachsende Rohstoffe, Fachagentur Nachwachsende Rohstoffe e.V. www.nachwachsende-rohstoffe.de Bockisch M.: Nahrungsfette und -öle, Ulmer Verlag, 1993, ISBN 380000158175

Course L1634: Forum I - Geotechnics and Construction Management	
Typ	Seminar
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	WiSe
Content	Lectures about projects and issues with practical and scientific relevance.
Literature	--

Course L1635: Forum II - Geotechnics and Construction Management	
Typ	Seminar
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	SoSe
Content	Lectures about projects and issues with practical and scientific relevance.
Literature	--

Course L1151: Timber Structures	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Referat
Examination duration and scale	90 min
Lecturer	Prof. Torsten Faber
Language	DE
Cycle	WiSe
Content	
Literature	

Course L2666: Innovative Timber Construction	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Schriftliche Ausarbeitung
Examination duration and scale	45 Minuten
Lecturer	Dr. Andreas Meisel
Language	DE
Cycle	WiSe
Content	
Literature	- Blass, J.: "Ingenieurholzbau" - Schickhofer, G.: "BSPhandbuch: Holz-Massivbauweise in Brettsperrholz" - Informationsdienst Holz: div. Merkblätter und Broschüren - Wallner-Novak M.: Brettsperrholz Bemessung, Band 1 und 2 - Gerner M.: "Fachwerk: Entwicklung, Instandsetzung, Neubau" - Meisel, A.: "Historische Dachwerke: Beurteilung, realitätsnahe statische Analyse und Instandsetzung" - Kempe K.: "Dokumentation Holzschädlinge" - Huckfeldt T.: "Hausfäule- und Bauholzpilze"

Course L1152: Glass Structures	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Marvin Matzik
Language	DE
Cycle	WiSe
Content	Glass structures - Introduction of the material glass (production, refinement, material characteristic) - design of facades - facade types - static calculation of glazing - static calculation of facades - load bearing behavior of glazing (plate or membrane stiffness) - vertical / horizontal glazing with safety-related requirements - glass structures - fire safety of glass facades - construction physics of facades and glazing
Literature	

Course L1447: Glass Structures	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Marvin Matzik
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L3270: Sustainable landfill design and operation	
Typ	Integrated Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Dr. Marco Ritzkowski
Language	EN
Cycle	SoSe
Content	The course introduces the development of modern waste resource management and demonstrates the importance of landfills in the context of recycling processes. Based on international (EU) and national legislation, the current landfill situation is presented and the future significance of landfills will be discussed. A central element of the course deals with the main transformation processes in the landfilled waste, the emission of gases and leachate, the long-term behaviour of landfills as well as aftercare and after-utilisation measures. Further focal points of the course are measures for the sustainable reduction of environmentally and climate-damaging emissions and aspects of landfill technology in an international context.
Literature	1) **Waste Management**. Bernd Bilitewski; Georg Härdtle; Klaus Marek (Eds.), ISBN: 9783540592105 , Springer Verlag Lehrbuchsammlung der TUB, Signatur USH-305 2) **Solid Waste Technology and Management.** Thomas Christensen (Ed.), ISBN: 978-1-4051-7517-3 , Wiley Verlag Lesesaal 2: US - Umweltschutz, Signatur USH-332 3) **Solid Waste Landfilling - Concepts, Processes, Technologies.** Cossu, R. and Stegmann, R. (Eds.), ISBN: 978-0-12-818336-6 PDF (Volltext) über TUB

Course L3091: Special Topics in Steel Design	
Typ	Integrated Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Marcus Rutner, Nikolay Lalkovski
Language	DE
Cycle	SoSe
Content	
Literature	

Course L2378: Special topics of civil engineering 1CP	
Typ	
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Fachtheoretisch-fachpraktische Arbeit
Examination duration and scale	wird zu Beginn der Lehrveranstaltung festgelegt
Lecturer	Dozenten des SD B
Language	DE
Cycle	WiSe/SoSe
Content	The course occurs only if required. The content is defined at short notice.
Literature	Die Literatur wird kurzfristig festgelegt.

Course L2379: Special topics of civil engineering 2 LP	
Typ	
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Fachtheoretisch-fachpraktische Arbeit
Examination duration and scale	wird zu Beginn der Lehrveranstaltung festgelegt
Lecturer	Dozenten des SD B
Language	DE
Cycle	WiSe/SoSe
Content	The course occurs only if required. The content is defined at short notice.
Literature	Die Literatur wird kurzfristig festgelegt.

Course L2380: Special topics of civil engineering 3 LP	
Typ	
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Fachtheoretisch-fachpraktische Arbeit
Examination duration and scale	wird zu Beginn der Lehrveranstaltung festgelegt
Lecturer	Dozenten des SD B
Language	DE
Cycle	WiSe/SoSe
Content	The course occurs only if required. The content is defined at short notice.
Literature	Die Literatur wird kurzfristig festgelegt.

Course L2789: Structural Design	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	20 min
Lecturer	Dr. Jan Mittelstädt
Language	DE/EN
Cycle	SoSe
Content	
Literature	[1] Structure Systems by Heino Engel, Hantje Cantz, 3rd edition (Feb 2007), ISBN-10: 3775718761 Form and Force, Designing Efficient, Expressive Structures by Allan, E., Zalewski, W. et al, John Wiley and Sons; 1st edition (Sept 2009), ISBN-10: 047017465X [2] Peter Rice: An Engineer Imagines, ISBN-10 : 1849944237 [3] Konrad Wachsmann and the Grapevine Structure by C. Sumi et al., Park Books (Oct 2018), ISBN-10: 9783038601104 [4] Manual of Multi-Story Timber Construction by Hermann Kaufmann, Stefan Krotsch, Stefan Winter, DETAIL, (June 2018), ISBN-10: 3955533948 [5] The Art of Structural Design: A Swiss Legacy by B. Billington, Princeton University Art Museum; First Edition edition (Mar 2003), ISBN-10: 0300097867 [6] Structured Lineages: Learning from Japanese Structural Design by G. Nordenson et al, The Museum of Modern Art (Jul 2019), ISBN-10: 1633450562 [7] The Structure: Works of Mahendra Raj by V. Mehta, R. Mehndiretta, A. Huber, Park Books (Oct 2015), ISBN-10: 3038600253

Module M0967: Study Work Harbour and Coastal Engineering

Courses			
Title	**Typ**	**Hrs/wk**	**CP**

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Subjects of the Port and Coastal Engineering specialisation.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to demonstrate their detailed knowledge in the field of port and coastal engineering. They can exemplify the state of technology and application and discuss critically in the context of actual problems and general conditions of science and society. The students can develop solving strategies and approaches for fundamental and practical problems in port and coastal engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view points of science and society. Scientific work techniques that are used can be described and critically reviewed.
Skills	The students are able to independently select methods for the project work and to justify this choice. They can explain how these methods relate to the field of work and how the context of application has to be adjusted. General findings and further developments may essentially be outlined.
Personal Competence	
Social Competence	The students are able to condense the relevance and the structure of the project work, the work steps and the sub-problems for the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to their colleagues.
Autonomy	The students are capable of independently planning and documenting the work steps and procedures while considering the given deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedback from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology.
Workload in Hours	Independent Study Time 180, Study Time in Lecture 0
Credit points	6
Course achievement	None
Examination	Study work
Examination duration and scale	The number of pages depends on the task.
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Compulsory

Module M0801: Water Resources and -Supply

Courses

Title	Typ	Hrs/wk	CP
Chemistry of Drinking Water Treatment (L0311)	Lecture	2	1
Chemistry of Drinking Water Treatment (L0312)	Recitation Section (large)	1	2
Water Resource Management (L0402)	Lecture	2	2
Water Resource Management (L0403)	Recitation Section (small)	1	1

Module Responsible	Prof. Mathias Ernst
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of water management and the key processes involved in water treatment.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will be able to outline key areas of conflict in water management, as well as their mutual dependence for sustainable water supply. They will understand relevant economic, environmental and social factors. Students will be able to explain and outline the organisational structures of water companies. They will be able to explain the available water treatment processes and the scope of their application.
Skills	Students will be able to assess complex problems in drinking water production and establish solutions involving water management and technical measures. They will be able to assess the evaluation methods that can be used for this. Students will be able to carry out chemical calculations for selected treatment processes and apply generally accepted technical rules and standards to these processes.
Personal Competence	
Social Competence	Working in a diverse group of specialists, students will be able to develop and document complex solutions for the management and treatment of drinking water. They will be able to take an appropriate professional position, for example representing user interests. They will be able to develop joint solutions in teams of diverse experts and present these solutions to others.
Autonomy	Students will be in a position to work on a subject independently and present on this subject.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	60 min (chemistry) + presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0311: Chemistry of Drinking Water Treatment	
Typ	Lecture
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Dr. Klaus Johannsen
Language	DE
Cycle	WiSe
Content	The topic of this course is water chemistry with respect to drinking water treatment and water distribution Major topics are solubility of gases, carbonic acid system and calcium carbonate, blending, softening, redox processes, materials and legal requirements on drinking water treatment. Focus is put on generally accepted rules of technology (DVGW- and DIN-standards). Special emphasis is put on calculations using realistic analysis data (e.g. calculation of pH or calcium carbonate dissolution potential) in exercises. Students can get a feedback and gain extra points for exam by solving problems for homework. Knowledge of drinking water treatment processes is vital for this lecture. Therefore the most important processes are explained coordinated with the course " Water resources management" in the beginning of the semester.
Literature	**MHW (rev. by Crittenden, J. et al.):** Water treatment principles and design. John Wiley & Sons, Hoboken, 2005. **Stumm, W., Morgan, J.J.**: Aquatic chemistry. John Wiley & Sons, New York, 1996. **DVGW (Hrsg.):** Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004. **Jensen, J. N.**: A Problem Solving Approach to Aquatic Chemistry. John Wiley & Sons, Inc., New York, 2003.

Course L0312: Chemistry of Drinking Water Treatment	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dr. Klaus Johannsen
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0402: Water Resource Management	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Mathias Ernst
Language	DE
Cycle	WiSe
Content	The lecture provides comprehensive knowledge on interaction of water ressource management and drinking water supply. Content overview: • Current situation of global water resources - User and Stakeholder conflicts - Wasserressourcenmanagement in urbane Gebieten - Rechtliche Aspekte, Organisationsformen Trinkwasserversorgungsunternehmen. - Ökobilanzierung, Benchmarking in der Wasserversorgung
Literature	• Aktuelle UN World Water Development Reports • Branchenbild der deutschen Wasserwirtschaft, VKU (2011) • Aktuelle Artikel wissenschaftlicher Zeitschriften • Ppt der Vorlesung

Course L0403: Water Resource Management	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Mathias Ernst
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1505: Adaptation to Climate Change in Hydraulic Engineering (AKWAS)

Courses

Title	Typ	Hrs/wk	CP
Adaptation to climate change in hydraulic engineering (L2291)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	• Hydrology, Hydraulic Engineering • Hydromechanic, Hydraulics • Fundamentals of Coastal Engineering, Coastal- and Flood Protection • Hydrological Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Climate protection and climate adaptation • Insights into climate change and its regional characteristics - fundamentals, climate modelling / climate models • Impacts of climate change on the components of the regional hydrological cycle • Fundamentals of analysis of climate data • Consequences of the impact of the climate change • Measures for climate adaptation • Assessment, prioritization and communication of adaptation measures • Fundamentals of the analysis of hydrometeorological and hydrological data
Skills	• Critical thinking: analysis of processes and relations, assessment of needs for action • Creative thinking: development of adaptation strategies and adaptation measures • Practical thinking: inclusion of restrictions, application of calculation approaches, methods, numerical models, planning methods • Consideration of complex tasks
Personal Competence	
Social Competence	• Working in heterogenous groups • Working with different scientific / non-scientific disciplines • Self reflection
Autonomy	• Application oriented use of knowledge and skills • Autonomous work on complex tasks
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Preparation of a written report and a presentation of a complex task.
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2291: Adaptation to climate change in hydraulic engineering	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Peter Fröhle
Language	DE
Cycle	WiSe
Content	• Climate protection and climate adaptation • Findings on climate change and its regional characteristics: fundamentals of climate change, climate modelling / climate models • Impacts of climate change on the components of the regional hydrological cycle(climate science view) • Fundamentals of the analysis of climate data • Concequences of the impacts of climate change (ingenieering science view) • Measures for climate change adaptation • Assessment, prioritization and communication of measures • Fundamentals of analysis of hydrometeorological and hydrological data
Literature	• Wird bereitgestellt über die HOOU - eLearning Plattform • abhängig von den jeweils schwerpunktmäßig behandelten Fragestellungen wird das Schrifttum (aktuelle Paper) in der Veranstaltung bzw. über StudIP zur Verfügung gestellt.

Module M1779: Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC)

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC) (L2926)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	• Hydraulic Engineering • Hydromechanics, Hydraulics • Fundamentals of Coastal Engineering, Coastal- and Flood Protection
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Climate and Climate Change • General Impacts of Climate Change on Wind Regime and Water Cycle • Consequences of Climate Change for Coastal Processes • Coastal Protection in Taiwan and Germany • Fundamentals of Climate Adaptation • Nature-based Solutions (NBS) for Coastal Protection
Skills	• Critical thinking: analysis of processes and relations, assessment of needs for action • Creative thinking: development of adaptation strategies and adaptation measures • Practical thinking: inclusion of restrictions, application of calculation approaches, methods, numerical models, planning methods • Consideration of complex tasks
Personal Competence	
Social Competence	• Working in heterogenous groups • Working in international groups • Working with different scientific / non-scientific disciplines • Self reflection
Autonomy	• Application oriented use of knowledge and skills • Autonomous work on complex tasks
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Preparation of a written report on a complex task with a presentation and subsequent discussion. The work on the complex task happens in the course of the lecture.
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2926: Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC)	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Peter Fröhle
Language	EN
Cycle	WiSe
Content	• Climate and Climate Change • General Impacts of Climate Change on Wind Regime and Water Cycle • Consequences of Climate Change for Coastal Processes • Coastal Protection in Taiwan and Germany • Fundamentals of Climate Adaptation • Nature-Based Solutions (NBS) for Coastal Protection
Literature	• Materials provided on eLearning Platform (HOOU Platform) • Depending on the main topics of the course in the respective year, the literature (recent papers) will be provided in the course-material or via StudIP.

Module M1844: Modern discretization methods in structural mechanics

Courses

Title	Typ	Hrs/wk	CP
Modern discretization methods in structural mechanics (L3043)	Lecture	2	3
Modern discretization methods in structural mechanics (L3044)	Recitation Section (small)	2	3

Module Responsible	Prof. Bastian Oesterle
Admission Requirements	None
Recommended Previous Knowledge	• Finite Element Methods • Flächentragwerke
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of this module, students can express the basic aspects of modern discretization methods in structural mechanics.
Skills	After successful completion of this module, the students will be able to use and further improve modern discretization methods for problems in structural mechanics.
Personal Competence	
Social Competence	Students can • participate in subject-specific and interdisciplinary discussions, • defend their own work results in front of others • promote the scientific development of colleagues • Furthermore, they can give and accept professional constructive criticism
Autonomy	Students are able to gain knowledge of the subject area from given and other sources and apply it to new problems. Furthermore, they are able to structure the solution process for problems in the area of modern discretization methods.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L3043: Modern discretization methods in structural mechanics

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	EN
Cycle	WiSe
Content	The course covers variational formulations, various locking phenomena and alternative formulations for finite elements and modern discretization schemes in the context of structural mechanics, like isogeometric analysis. • variational formulation of finite elements, mixed variational principles • geometrical and material locking effects in structural and solid mechanics • hybrid-mixed and enhanced assumed strain finite element formulations, reduced integration and stabilization, DSG method, u-p formulations • patch test, stability, convergence • linear and non-linear analyses • introduction to isogeometric analysis • isogeometric beam, plate and shell formulations • locking effects and their avoidance in modern, smooth discretization schemes, like isogeometric analysis
Literature	• lecture notes and selected scientific papers • O.C. Zienkiewicz, R.L. Taylor, and J.Z. Zhu: Finite Element Method: Its Basis and Fundamentals. Elsevier, 2013. • J. Austin Cottrell, Thomas J. R Hughes, Yuri Bazilevs: Isogeometric Analysis: Toward Integration of CAD and FEA. Wiley, 2009.

Course L3044: Modern discretization methods in structural mechanics	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1725: Scientific Working in Computational Engineering

Courses

Title	Typ	Hrs/wk	CP
Scientific Working in Computational Engineering (L2764)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Kay Smarsly
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in scientific writing. String interest in topics related to computing in civil engineering.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students will learn to apply concepts and methods of scientific working in computational engineering. In interaction with the course instructors and in collaboration with each other, the students will also learn to understand the complex process of scientific thinking, being able to accurately plan, implement and analyze scientific projects, such as prospective master theses. A project will be conducted throughout the semester, which will contribute to the grade. Since scientific writing is of particular importance in this course, a scientific paper will be developed based, which is a prerequisite for the final examination. The paper will be written based on the project conducted within this course. Project meetings in small groups, presentations, and critical discussions of scientific publications are further key activities.
Skills	The students will be capable (i) of solving a scientific problem following a scientific methodology, (ii) of documenting their work effectively in the form of a paper, and (iii) of sharing their work in a presentation.
Personal Competence	
Social Competence	The students will be able to work in a multidisciplinary team and develop communication skills necessary for problem solving.
Autonomy	The students will be able to extend their knowledge and apply it to solve scientific problems by working independently in a project.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	10 pages of work with 15-minute oral presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory

Course L2764: Scientific Working in Computational Engineering

Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Kay Smarsly
Language	EN
Cycle	WiSe/SoSe
Content	In the course, a scientific problem of practical relevance will first be defined, taking into account the interests of the students participating in the course. The scientific problem will then systematically be solved within the framework of a comprehensive project. The principles of scientific working will be taught based on the scientific problem defined previously. As an integral part of scientific working, fundamentals of scientific writing will be presented and applied to a scientific paper to be written during the course. Topics related to scientific writing include structuring in scientific writing (structuring the abstract, the introduction, the main part, the summary and conclusions, and the acknowledgments and references) and recommendations on effective scientific writing (principles of composition, use of English in scientific writing, useful tips, creating figures, writing in mathematics, referencing, and formal email correspondence). A final paper and a final presentation will be assembled by the students.
Literature	Smarsly, K. & Dragos, K., 2019. Scientific Writing in Engineering. Tredition, Hamburg, Germany.

Module M1956: Building and Excavation Law

Courses

Title	Typ	Hrs/wk	CP
Construction law BGB and VOB - law in (excavation) practice (L3182)	Lecture	2	3
Construction disputes from construction (excavation) practice (L3181)	Lecture	2	3

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	Complete modules: Geotechnics I-III
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will gain knowledge of • the history of civil engineering law, • basics of foundation and civil engineering law, • legal aspects of technical regulations in civil engineering (with case studies), • the civil engineering contract, • the liability of the designer and contractor in civil engineering, • the subsoil risk and the system risk, • the total debt in (civil) engineering law, • the (construction) conflict, dispute avoidance models and the construction process, • the systematics of construction contract law, • the BGB construction contract law, • responsibilities on the construction site, • remuneration and contract management, • liability for defects, • public procurement law • Disturbed construction processes: How much money am I entitled to? • Correct calculation of supplements.
Skills	Students learn to apply legal aspects in planning and construction in a legally balanced way. Students learn how to use legal and construction management aspects in practice (planning and construction) on the construction site in a targeted manner and how to manage the construction project optimally.
Personal Competence	
Social Competence	Students can work in groups and support each other in finding solutions.
Autonomy	Students are able to assess their own strengths and weaknesses and organize their time and learning management based on this.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory

Course L3182: Construction law BGB and VOB - law in (excavation) practice

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Günther Schalk
Language	DE
Cycle	WiSe
Content	
Literature	Literatur: - Folienskript (in der Vorlesung erhältlich) - Fuchs/Maurer/Schalk: Handbuch Tiefbaurecht

Course L3181: Construction disputes from construction (excavation) practice	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Ingo Junker
Language	DE
Cycle	WiSe
Content	
Literature	

Module M0859: Coastal Hydraulic Engineering II

Courses

Title	Typ	Hrs/wk	CP
Coastal- and Flood Protection (L0808)	Lecture	2	3
Coastal- and Flood Protection (L1415)	Project-/problem-based Learning	1	1
Maintenance and Defence of Flood Protection Structures (L1411)	Lecture	2	2

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Coastal Engineering I
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students have the capability to define and explain in detail the important aspects of erosion protection and flood protection and are able to apply the aspects to practical coastal protection problems. They are able to design and dimension important coastal protection measures from the functional and from the constructional point of view.
Skills	The students are able to select design approaches for the functional and constructional design of erosion and flood protection measures and apply these approaches to practical design tasks.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in applied problems such as the functional and constructive design of coastal and flood protection structures. Additionaly, they will be able to work in team with engineers of other disciplines.
Autonomy	The students will be able to independently extend their knowledge and apply it to new problems.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	The duration of the examination is 130 min. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L0808: Coastal- and Flood Protection	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Peter Fröhle
Language	EN
Cycle	WiSe

Content	Protection of sandy coasts
	• Sediment transport
	• Morphology
	• Technical solution for the protection of sandy coasts
	  ◦ Construction in direction of the coast
	  ◦ Constructions perpendicular to the coast
	  ◦ Other Concepst
	• Calculation approaches and numerical models
	
	Flood Protection
	• Classification of constructions / measures
	• Dikes
	• Dunes
	• Foreland - constructions
	• Flood-Protection Walls
	• Drainage of the hinterland

Literature	Vorlesungsumdruck Coastal Engineering Manual CEM

Course L1415: Coastal- and Flood Protection	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1411: Maintenance and Defence of Flood Protection Structures	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Olaf Müller
Language	EN
Cycle	WiSe
Content	• Dike protection • Maintennance of flood protection measures
Literature	Vorlesungsumdruck

Module M2003: Biological Waste Treatment

Courses

Title	Typ	Hrs/wk	CP
Waste and Environmental Chemistry (L0328)	Practical Course	2	2
Biological Waste Treatment (L0318)	Project-/problem-based Learning	3	4

Module Responsible	Prof. Kerstin Kuchta
Admission Requirements	None
Recommended Previous Knowledge	chemical and biological basics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The module aims possess knowledge concerning the planning of biological waste treatment plants. Students are able to explain the design and layout of anaerobic and aerobic waste treatment plants in detail, describe different techniques for waste gas treatment plants for biological waste treatment plants and explain different methods for waste analytics.
Skills	The students are able to discuss the compilation of design and layout of plants. They can critically evaluate techniques and quality control measurements. The students can recherché and evaluate literature and date connected to the tasks given in der module and plan additional tests. They are capable of reflecting and evaluating findings in the group.
Personal Competence	
Social Competence	Students can participate in subject-specific and interdisciplinary discussions, develop cooperated solutions and defend their own work results in front of others and promote the scientific development in front of colleagues. Furthermore, they can give and accept professional constructive criticism.
Autonomy	Students can independently tap knowledge from literature, business or test reports and transform it to the course projects. They are capable, in consultation with supervisors as well as in the interim presentation, to assess their learning level and define further steps on this basis. Furthermore, they can define targets for new application-or research-oriented duties in accordance with the potential social, economic and cultural impact.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** Yes; **Bonus** None; **Form** Subject theoretical and practical work; **Description**
Examination	Presentation
Examination duration and scale	Elaboration and Presentation (15-25 minutes in groups)
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Environmental Engineering: Core Qualification: Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory

Course L0328: Waste and Environmental Chemistry	
Typ	Practical Course
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	WiSe
Content	The participants are divided into groups. Each group prepares a transcript on the experiment performed, which is then used as basis for discussing the results and to evaluate the performance of the group and the individual student. In some experiments the test procedure and the results are presented in seminar form, accompanied by discussion and results evaluation. Experiments ar e.g. Screening and particle size determination Fos/Tac AAS Chalorific value
Literature	Scripte

Course L0318: Biological Waste Treatment	
Typ	Project-/problem-based Learning
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	WiSe
Content	1. Introduction 2. biological basics 3. determination process specific material characterization 4. aerobic degradation (Composting, stabilization) 5. anaerobic degradation (Biogas production, fermentation) 6. Technical layout and process design 7. Flue gas treatment 8. Plant design practical phase
Literature	

Module M2025: Finite element modeling of structures

Courses

Title	Typ	Hrs/wk	CP
Finite element modeling of structures (L3046)	Lecture	2	3
Finite element modeling of structures (L3047)	Recitation Section (small)	2	3

Module Responsible	Prof. Bastian Oesterle
Admission Requirements	None
Recommended Previous Knowledge	• Finite Element Methods • Thin-walled structures
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of this module, students can express the basic aspects of modelling of structures with finite elements.
Skills	After successful completion of this module, the students will be able to model structures with finite elements and to analyse structures using appropriate computational methods.
Personal Competence	
Social Competence	Students can • participate in subject-specific and interdisciplinary discussions, • defend their own work results in front of others • promote the scientific development of colleagues • Furthermore, they can give and accept professional constructive criticism
Autonomy	Students are able to gain knowledge of the subject area from given and other sources and apply it to new problems. Furthermore, they are able to structure the solution process for problems in the area of finite element modelling of structures.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	written elaboration of a project work (10-15 pages)
Assignment for the Following Curricula	Civil Engineering: Specialisation Computational Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L3046: Finite element modeling of structures

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	EN
Cycle	WiSe
Content	Basic phenomena and aspects of the finite element modelling of structures are discussed. Besides theoretical decription of the phenomena and methods, a strong focus is on the practical use a commercial finite element software within computer-based exercises. The covered topics are: • finite element modeling of trusses/beams/frames, plates subject to in-plane/out-of-plane loading and shells • convergence properties of displacements and stresses • singularities • locking effects • critical assessment, interpretation and check of results • mixed-dimensional coupling of finite elements • geometrically linear and non-linear, and material linear and non-linear analyses • stability: bifurcation and snap-through problems • dynamic problems, modal analyses
Literature	Vorlesungsmanuskript, Vorlesungsfolien

Course L3047: Finite element modeling of structures	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M2033: Subsurface Processes

Courses

Title	Typ	Hrs/wk	CP
Modeling of Subsurface Processes (L2731)	Recitation Section (small)	3	3
Subsurface Solute Transport (L2728)	Lecture	2	2
Subsurface Solute Transport (L2729)	Recitation Section (large)	1	1

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	Basic Mathematics, Hydrology
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Upon completion of this module, the students will understand the mechanisms controlling solute transport in soil and natural porous media and will be able to work with the equations that govern the fate and transport of solutes in porous media. Analytical, numerical and experimental tools and techniques will be used in this module.
Skills	In addition to the physical insights, the students will be exposed to analytical, experimental and numerical tools and techniques in this module. This provides them with an excellent opportunity to improve their skills on multiple fronts which will be useful in their future career.
Personal Competence	
Social Competence	Teamwork & problem solving
Autonomy	The students will be involved in writing individual reports and presentation. This will contribute to the students' ability and willingness to work independently and responsibly.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	Report
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Environmental Engineering: Core Qualification: Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory

Course L2731: Modeling of Subsurface Processes

Typ	Recitation Section (small)
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Dr. Milad Aminzadeh
Language	EN
Cycle	WiSe
Content	Basic usage and background of chosen computer software to calculate flow and transport in the saturated and unsaturated zone and to analyze field data like pumping test data
Literature	

Course L2728: Subsurface Solute Transport	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	WiSe
Content	Basic physical properties of soil: Definition and quantification; Liquid flow in soils (Darcy's law); Solute transport in soils; Practical analysis to measure dispersion coefficient in soil under different boundary conditions; Advanced topics (e.g. Application of Artificial Intelligence to predict soil salinization)
Literature	- Environmental Soil Physics, by Daniel Hillel - Soil Physics, Sixth Edition, by William A. Jury and Robert Horton

Course L2729: Subsurface Solute Transport	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Hannes Nevermann
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Specialization Geotechnical Engineering

Module M0699: Geotechnics III

Courses

Title	Typ	Hrs/wk	CP
Numerical Methods in Geotechnics (L0375)	Lecture	3	3
Advanced Foundation Engineering (L0497)	Lecture	2	2
Advanced Foundation Engineering (L0498)	Recitation Section (large)	1	1

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	Geotechnics I and II, Mathematics I-III
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successfully completing the module, students will be able to • describe individual procedures for the geotechnical monitoring of civil engineering measures, • reproduce exploration and investigation methods of the subsoil, • select suitable types of field and laboratory tests for subsoil investigation and evaluate their results, • state the differences between various stress and deformation states and the physical significance of invariants of the stress and distortion tensor, • outline the standard and special soil mechanics tests used to determine the stress-strain behavior of soil, • describe continuum models and the resulting boundary value problems, • as well as define boundary value problems from the field of geotechnical engineering in such a way that they can be solved unambiguously.
Skills	Students will be able to • dimension vertical drains for soil improvement of soft soils, • calculate depth compaction using various appropriate methods, • apply principles of horizontal bearing capacity of piles, • verify the internal and external stability of fluid-supported diaphragm walls, • evaluate the boundary conditions for the design of a deep excavation and design the individual components of the excavation, • perform, evaluate and interpret tests for the description and classification of soils according to applicable standards, • computationally implement numerical algorithms to solve boundary value problems, • select and apply the types of analyses depending on the degree of saturation, the impact, and the material behavior • determine appropriate model parameters for different possibilities and limitations of material models for the grain structure of soils.
Personal Competence	
Social Competence	Students can work in groups and support each other in finding solutions.
Autonomy	Students are able to assess their own strengths and weaknesses and, based on this, organize their time and learning management and think in terms of processes.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L0375: Numerical Methods in Geotechnics	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Dr. Hans Mathäus Stanford
Language	DE
Cycle	WiSe
Content	Topics: • Introduction to numerical soil mechanics • Introduction to numerical mathematics • Finite Element Method (analysis procedures, algorithms) • Finite Element Method (application in geotechnical engineering)
Literature	• Wriggers P. (2001): Nichtlineare Finite-Elemente-Methoden. Springer • Wriggers P. (2008): Nonlinear Finite Element Methods. Springer • Deutsche Gesellschaft für Geotechnik e.V. (Hrsg., 2014): Empfehlungen des Arbeitskreises "Numerik in der Geotechnik". Ernst & Sohn

Course L0497: Advanced Foundation Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	WiSe
Content	• Vertical drains • Piles • Ground improvement (Deep Compaction, Soil mixing) • Vibration driving • Jet grouting • Slurry wall • Deep excavation
Literature	• EAK (2002): Empfehlungen für Küstenschutzbauwerke • EAU (2004): Empfehlungen des Arbeitsausschusses Uferbauwerke • EAB (1988): Empfehlungen des Arbeitskreises Baugruben • Grundbau-Taschenbuch, Teil 1-3, (1997), Ernst & Sohn Verlag

Course L0498: Advanced Foundation Engineering	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0964: Underground Constructions

Courses

Title	Typ	Hrs/wk	CP
Applied Tunnel Constructions (L2407)	Lecture	2	3
Introduction to tunnel construction (L0707)	Lecture	1	2
Introduction to tunnel construction (L1811)	Recitation Section (large)	1	1

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	Modules from Bachelor studies Civil and environmental engineering: • Geotechnics I-II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Knowledge of different tunnel construction types as well as special methods and techniques of subsoil construction.
Skills	Basic knowledge of tunnel design as well as practical skills in structural tunnel analysis.
Personal Competence	
Social Competence	Capacity for teamwork concerning project management and design of tunnels.
Autonomy	Promotion of independent and creative work flow in the framework of a design exercise.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** No / 5 % / Excercises /
Examination	Written exam
Examination duration and scale	120 minutes
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L2407: Applied Tunnel Constructions

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Jürgen Grabe, Tim Babendererde
Language	DE
Cycle	WiSe
Content	
Literature	

Course L0707: Introduction to tunnel construction	
Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dr. Julian Bubel
Language	DE
Cycle	WiSe
Content	• Definitions • Historical development in tunneling • Geology for tunneling • Hard rock tunneling (construction composite and machines) • Tunnelung in temporarly stable soil with conventional construction methods • Tunneling in soft soils (form of supports, shield types, compressed air application) • Pipe jacking • Tunnel Lining, tunnel supporting structures • Calculation approaches for supporting structures in shield-driven tunnels • Surveying for tunneling • Safety requirements • Construction Contract • Literature and sources
Literature	• Vorlesung/Übung s. www.tu-harburg.de/gbt

Course L1811: Introduction to tunnel construction	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Julian Bubel
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1748: Construction Robotics

Courses

Title	Typ	Hrs/wk	CP
Construction Robotics (L2867)	Project-/problem-based Learning	6	6

Module Responsible	Prof. Kay Smarsly
Admission Requirements	None
Recommended Previous Knowledge	Basics of project-oriented programming
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Basics of robotics Applications in civil engineering Kinematics
Skills	Use of specific hardware Development of software routines Python programming language Image processing Basics of localization (LIDAR, SLAM)
Personal Competence	
Social Competence	Teamwork Communication skills
Autonomy	Independent work Independent decisions
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	ca. 10 Seiten
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Course L2867: Construction Robotics	
Typ	Project-/problem-based Learning
Hrs/wk	6
CP	6
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Lecturer	Prof. Kay Smarsly, Jan Stührenberg
Language	EN
Cycle	WiSe

Content	1. Introduction: Robotics in civil engineering
	2. Presentation of potential topics
	3. Programming of algorithms in Python
	4. Application of software systems: LINUX distribution, ROS, CloudCompare, ...
	5. Application of hardware systems: Petoi Bittle Dog, Raspberry Pi, Arduino, sensing ...
	6. Topics considered for robotics using the Petoi Bittle Dog:
	    1. Movement
	    2. Use of sensors (camera, infrared, ...)
	    3. Data structures/data acquisition
	    4. Programming
	7. Topics technically relevant to building inspection:
	    1. Geodetic evaluations
	    2. Image processing
	    3. Localization

Literature	Bock/Linner: Construction Robotics Verl et al.: Soft Robotics Pasquale: New Laws of robotics

Module M1895: Digital Twinning in Civil Engineering

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Digital Twinning in Civil Engineering (L3136)	Lecture	2	2
Digital Twinning in Civil Engineering (L3137)	Seminar	2	4

Module Responsible	Alexander Chmelnizkij
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	
Skills	
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Presentation
Examination duration and scale	20 min presentation and 5 pages handout
Assignment for the Following Curricula	Civil Engineering: Specialisation Computational Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory

Course L3136: Digital Twinning in Civil Engineering

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Alexander Chmelnizkij, Prof. Bastian Oesterle, Prof. Kay Smarsly
Language	DE
Cycle	SoSe
Content	
Literature	

Course L3137: Digital Twinning in Civil Engineering

Typ	Seminar
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Alexander Chmelnizkij, Prof. Bastian Oesterle, Prof. Kay Smarsly
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0593: Building Materials and Building Preservation

Courses

Title	Typ	Hrs/wk	CP
Repair of Structures (L0255)	Lecture	1	1
Mineral Building Materials (L0253)	Lecture	2	2
Technology of mineral Building Materials (L0256)	Project-/problem-based Learning	1	2
Transport Processes in Building Materials and Damage Processes (L0254)	Lecture	1	1

Module Responsible	Prof. Frank Schmidt-Döhl
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge about building materials, building physics and building chemistry, for example by the modules Principles of Building Materials and Building Physics and Building Materials and Building Chemistry.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe the components of mineral building materials and their function in detail and to use them for the manufacture of special mineral building materials. They are able to show the characteristics of mineral building materials. They are able to describe the manufacture, properties and fields of application of special mortars and special concretes and the correlations of their material parameters. They are able to show the principles of anchor technology and design.
Skills	The students are able to perform an optimization of granulometry of a mineral building material. They are able to design a special mineral mortar and to manufacture this mortar. The students are able to manufacture post installed rebar connections. They are able to recognize damages, to assess possible causes, to use the fundamentals of construction preservation and to select repair and strengthening measures.
Personal Competence	
Social Competence	The students are able to develop in small grous the mixture of a special mortar. They present their results to the lecturer and the other students. In a critical discussion they defend and adjust their results. The students are able to manufacture their special building material on the basis of this feedback.
Autonomy	The students are able to responsibly use the resources of materials and lab equipment for their project and to investigate and to get missing components.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** Yes / 20 % / Subject theoretical and practical work /
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory

Course L0255: Repair of Structures

Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	SoSe
Content	Maintenance of structures, repair and strengthening, subsequent waterproofing of structures
Literature	BetonMarketing Deutschland (Hrsg.): Stahlbetonoberflächen - schützen, erhalten, instandsetzen

Course L0253: Mineral Building Materials	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	SoSe
Content	Components of mineral building materials and their function, binding materials, concrete and mortar, special mortars, special concretes
Literature	Taylor, H.F.W.: Cement Chemistry Springenschmid, R.: Betontechnologie für die Praxis

Course L0256: Technology of mineral Building Materials	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	SoSe
Content	Design and production of a special mineral building material
Literature	Taylor, H.F.W.: Cement Chemistry Springenschmid, R.: Betontechnologie für die Praxis

Course L0254: Transport Processes in Building Materials and Damage Processes	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	SoSe
Content	Transport Processes in Building Materials and Damage Processes
Literature	Blaich, J.: Bauschäden, Analyse und Vermeidung

Module M0723: Design of Prestressed Structures and Concrete Bridges

Courses

Title	Typ	Hrs/wk	CP
Design of Prestressed Structures and Concreet Bridges (L0603)	Lecture	3	4
Design of Prestressed Structures and Concreet Bridges (L0604)	Recitation Section (large)	2	2

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	Detailed knowledge on the design of concrete structures. Modules: Reinforced Concrete Structures I+II, Structural Analysis I+II, Mechanics I+II, Concrete Structures
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students know the main bridge types, their applications and the various loads. They can explain the basic design methods. They can explain the design of a prestressed bridge.
Skills	The students are able to design reinforced or prestressed concrete bridges.
Personal Competence	
Social Competence	The students can design in teamwork a real concrete bridge.
Autonomy	The students are able to design a prestressed concrete bridge and discuss the problems and results with other students.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	180 minutes
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L0603: Design of Prestressed Structures and Concreet Bridges	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	NN
Language	DE
Cycle	SoSe
Content	prestressed structures • basis of prestressed structures, field of application • differences between reinforced and prestressed concrete structures • history of prestressing • construction materials: concrete, tendons, ducts, anchorage systems • construction: prestressing methods • prestressing forces and member forces (friction, elongation) • tendon layout • time dependant prestressing losses • design of prestressed structures • design of anchorage region • non-bonded prestressing • prestressed flat slabs Concrete bridges • history of bridges • design of bridges • loads on bridges • member forces for slab, T-beam, hollow box, frame and arch bridges • precast bridges - precast segmental bridges • bearings • abutments, columns • construction methods • damages - checking of bridges
Literature	• Vorlesungsumdruckim STUDiP • Rombach, G. (2003): Spannbetonbau. Ernst & Sohn, Berlin • Wicke, M. (2002): Anwendung des Spannbetons. Betonkalender 2002, Teil II, S. 113-180, Verlag Ernst & Sohn, Berlin • Leonhardt, F. (1980): Vorlesungen über Massivbau. Teil 5: Spannbeton. Berlin • Mehlhorn, G. (2007): Handbuch Brücken, Springer Verlag • Schäfer, H.; Kaufeld, K. (1997): Massivbrücken. Betonkalender Teil II, S. 443ff, Ernst & Sohn, Berlin • Menn, Ch. (1986): Stahlbetonbrücken. Springer Verlag, Wien

Course L0604: Design of Prestressed Structures and Concreet Bridges	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	NN
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0756: Soil Mechanics and -Dynamics

Courses

Title	Typ	Hrs/wk	CP
Soil Mechanics - Selected Topics (L0374)	Lecture	2	2
Soil Dynamics (L0452)	Lecture	2	2
Experimental Researches in Geotechnics (L0706)	Practical Course	2	2

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	Modules: Mathematics I-III, Mechanics I-II, Geotechnics I Courses: Soil laboratory course, (Applied structural dynamics)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will be able to, • describe wave propagation in the ground under dynamic excitation and define the relevant parameters, • to measure vibrations and to interpret the data obtained with regard to their effect on people and structures, • justify when elastodynamic methods are sufficient and when plastodynamic effects must be taken into account, • to reproduce the collapse theorems of plasticity theory, • describe the viscous behavior of cohesive soils and computationally account for creep deformation and rate-dependent shear strengths • as well as to determine the effect of partial saturation on the seepage flow and the shear strength.
Skills	After the successful completion of the module the students should be able to: • to derive and apply the basic equation of a simple mass oscillator, • to understand the wave propagation in the soil under dynamic excitation and to detect the relevant parameters, • to know the essential laboratory and field tests to determine soil dynamic characteristics and to evaluate them, • to design machine foundations to dynamic load, • to measure shocks to perform vibration forecast, • to evaluate shocks in terms of their effect on people and buildings, • to evaluate possibilities of isolation, • to understand mechanisms that cause earthquakes and evaluate earthquakes in terms of their magnitude and intensity, • to know methods to determine axial pile capacity, integrity, and the dynamic bedding modulus, • to know the mechanisms that lead to a deformation accumulation due to cyclic loading and to estimate these deformations mathematically, • to distinguish the area of application of the method of elastodynamics and plastodynamics, • to detect the undrained shear strength as a function of a number of state variables, • to capture the visous behaviour of cohesive soils and to consider the effects of creep and rate-dependent shear strength in calculations, • to consider the impact of the partly saturated of a seepage and shear strength.
Personal Competence	
Social Competence	Students will be able to work in teams to achieve results on measurement and experimental principles and present their results together at the end of the semester.
Autonomy	Students are able to assess their own strengths and weaknesses and organize their time and learning management based on this.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** Yes / None / Subject theoretical and practical work /
Examination	Written exam
Examination duration and scale	135 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory

Course L0374: Soil Mechanics - Selected Topics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Hans Mathäus Stanford
Language	DE
Cycle	SoSe
Content	selected topis: • Stress-strain behaviour (experiments, observations, models) • Hydraulic behaviour (experiments, observations, models) • Physical modelling (similarity theory, 1g model tests, ng model tests) • Limit and safety analysis (collapse theorems of plasticity theory, upper and lower bound analysis, limit equilibrium analysis, numerical analysis) • Heat transport (heat conduction, convective heat transport, freezing/thawing)
Literature	• Kolymbas D. (2019): Geotechnik - Bodenmechanik, Grundbau und Tunnelbau. Springer Verlag, 5. Auflage • Muir Wood D. (2004). Geotechnical modelling. CRC Press Nova, R. (2010). Soil mechanics. Wiley Verruijt, A. (2012). Soil mechanics. u r l: https://geo.verruijt.net Verrujit A. (2018). An introduction to soil mechanics. Vol. 30, Springer Series Theory and Applications of Transport in Porous Media

Course L0452: Soil Dynamics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Anne Hagemann
Language	DE
Cycle	SoSe
Content	• mass-spring-damper systems, • wave propagation in soils, • dynamic soil parameters, • Determination of dynamic soil parameters, • machine foundations, • in-situ measurement of ground motion, ground motion prediction, evaluation of ground motion, • ground motion shielding, • introduction into earthquake engineering, • dynamic pile tests, • cyclic accumulation, • plastodynamics
Literature	• Das B.M.: Fundamentals of Soil Dynamics, Elsevier • Empfehlungen des Arbeitskreises Baugrunddynamik. Hrsg. Deutsche Gesellschaft für Geotechnik (DGGT) • Haupt W.: Bodendynamik. Vieweg und Teubner • Meskouris K. und Hinzen K.-G.: Bauwerke und Erdbeben. Vieweg Verlag • Studer J.A., Koller M.G. und Laue J.: Bodendynamik, Springer Verlag

Course L0706: Experimental Researches in Geotechnics	
Typ	Practical Course
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Hans Mathäus Stanford, Göta Bürkner
Language	DE
Cycle	SoSe
Content	The students are supposed to: • become acquainted with geotechnical model tests, field tests and laboratory tests as well as corresponding measurement techniques. These compromise amongst others inclinometer measurements and geophone measurements as well as high-grade laboratory tests on the stress-strain relationship of soil specimens, e. g. triaxial tests, simple shear tests and resonant column tests. • gain insight into current soil mechanical research. • plan, coordinate, perform and evaluate soil mechanical tests in a team. • discuss, reflect, review and present the obtained results in a group. An important learning target is the introduction to scientific work for students who plan a scientific career, and for those who will work in practice with the responsibility to order corresponding tests and evaluate the results. The practical laboratory work is based on annualy changing problems, which are however related to the experience and results of the preceding year's course group.
Literature	- Grabe, J. (2004): Bodenmechanik und Grundbau, Band 3 der Veröffentlichungsreihe des Instituts für Geotechnik und Baubetrieb, Technische Universität Hamburg-Harburg. - Kolymbas, D. (2007): Geotechnik - Bodenmechanik, Grundbau und Tunnelbau. 2., korrigierte und ergänzte Auflage, Springer Verlag. - Normen zu geotechnischen Versuchsgeräten und Versuchsverfahren: - DIN 18135:2012-04: Baugrund, Untersuchung von Bodenproben - Eindimensionaler Kompressionsversuch, Deutsches Institut für Normung, e. V. - DIN 18137-2:2011-04: Baugrund, Untersuchung von Bodenproben - Bestimmung der Scherfestigkeit - Teil 2: Triaxialversuch, Deutsches Institut für Normung e. V.

Module M0827: Modeling in Water Management

Courses

Title	Typ	Hrs/wk	CP
Groundwater Modeling using Modflow (L0543)	Lecture	1	1
Groundwater Modeling using Modflow (L0544)	Recitation Section (small)	2	2
Modeling of Water Supply Network (L0875)	Project-/problem-based Learning	2	3

Module Responsible	Dr. Klaus Johannsen
Admission Requirements	None
Recommended Previous Knowledge	Groundwater • groundwater hydraulics and transport of substances Pipe Systems • Knowledge on urban water infrastructures, in particular drinking water systemsand urban drainage systems including special structures • Hydraulics of drinking water supply systems and sewer systems • Basic knowledge on water management
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe the modelling of groundwater flow and transport as well as urban water infrastructures. They can carry out systems analyses and can detect technical and conceptual weak points within the systems in case studies. Besides they are able to analyse interdependencies of hydraulic and toxic phenomena in soil and water.
Skills	The students are able to construct and apply scientific groundwater models indipendently. They can work on different scenarios and can compare or assess different solutions for existing problems by application of selected software products. The students are able to use different software solutions (e.g. EPANET, EPA-SWMM).
Personal Competence	
Social Competence	Wird nicht vermittelt.
Autonomy	Wird nicht vermittelt.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L0543: Groundwater Modeling using Modflow

Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Sonja Götz
Language	DE/EN
Cycle	SoSe
Content	Introduction and application of the groundwater model MODFLOW (PMWIN); theoretical backround of the modell, students do work with the model PMWIN for practical case studies.
Literature	MODFLOW-Handbuch Chiang, Wen Hsien: PMWIN

Course L0544: Groundwater Modeling using Modflow	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Sonja Götz
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0875: Modeling of Water Supply Network	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Klaus Johannsen
Language	DE
Cycle	SoSe
Content	
Literature	Mutschmann/Stimmelmayr: Taschenbuch der Wasserversorgung, 16. Auflage. Springer Vieweg - Verlag. Wiesbaden 2014.

Module M0828: Urban Environmental Management

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Noise Protection (L1109)	Lecture	2	2
Urban Infrastructures (L0874)	Project-/problem-based Learning	2	4

Module Responsible	Dr. Dorothea Rechtenbach
Admission Requirements	None
Recommended Previous Knowledge	• Knowledge on Urban planning • Knowledge on measures for climate protection • General knowledge of scientific writing/working
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can describe urban development corridors as well as current and future urban environmental problems. They are able to explain the causes of environmental problems (like noise). Students can specify applications for various technical innovations and explain why these contribute to the improvement of urban life. They can, for example, derive and discuss measures for effective noise abatement.
Skills	Students are able to develop specific solutions for correcting existing or future environment-related problems of urban development. They can define a range of conceptual and technical solutions for environmental problems for different development paths. To solve specific urban environmental problems they can select technical innovations and integrate them into the urban context.
Personal Competence	
Social Competence	The students can work together in international groups.
Autonomy	Students are able to organize their work flow to prepare themselves for presentations and contributions to the discussions. They can acquire appropriate knowledge by making enquiries independently.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Written Report plus oral Presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L1109: Noise Protection

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Martin Jäschke
Language	EN
Cycle	SoSe
Content	
Literature	1) Müller & Möser (2013): Handbook of Engineering Acoustics (also available in German) 2) WHO (1999): Guidelines for Community Noise 3) Environmental Noise Directive 2002/49/EG 4) ISO 9613-2 (1996): Acoustics, Attenuation of sound during propagation outdoors, Part 2: General method of calculation

Course L0874: Urban Infrastructures	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Dr. Dorothea Rechtenbach
Language	EN
Cycle	SoSe
Content	Problem Based Learning Main topics are: • Central vs. Decentral Wastewater Treatment. • Compaction of Cities. • Car Free Cities. • Multifunctional Places in Cities. • The Sustainability of Freight Transport in Cities.
Literature	Depends on chosen topic.

Module M0860: Harbour Engineering and Harbour Planning

Courses

Title	Typ	Hrs/wk	CP
Harbour Engineering (L0809)	Lecture	2	2
Harbour Engineering (L1414)	Project-/problem-based Learning	1	2
Port Planning and Port Construction (L0378)	Lecture	2	2

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Basics of coastal engineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to define in details and to choose design approaches for the functional design of a port and apply them to design tasks. They can design the fundamental elements of a port.
Skills	The students are able to select and apply appropriate approaches for the functional design of ports.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in applied problems such as the functional design of ports. Additionaly, they will be able to work in team with engineers of other disciplines.
Autonomy	The students will be able to independently extend their knowledge and apply it to new problems.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	The duration of the examination is 150 min. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L0809: Harbour Engineering

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Peter Fröhle
Language	DE
Cycle	SoSe

Content	• Fundamentals of harbor engineering
	  ◦ Maritime transportation and waterways engineering
	  ◦ Ships
	• Elements of harbors
	  ◦ Harbor approaches and water-side harbor areas
	  ◦ Terminal design and handling of cargo
	  ◦ Quay-walls and piers
	  ◦ Equipment of harbors
	  ◦ Sluices and other special constructions
	• Connection to inland transportation / inland waterway transportation
	• Protection of harbors
	  ◦ Breakwaters and Jetties
	  ◦ Wave protection of harbors
	• Fishery and other small harbors

Literature	Brinkmann, B.: Seehäfen, Springer 2005

Course L1414: Harbour Engineering	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0378: Port Planning and Port Construction	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Frank Feindt
Language	DE
Cycle	SoSe
Content	• Planning and implementation of major projects • Market analysis and traffic relations • Planning process and plan • Port planning in urban neighborhood • Development of the logistics center "Port of Hamburg" in the metropolis • Quays and waterfront structure • Special planning Law Harbor - securing of a flexible use of the port • Dimensioning of quays • Flood protection structures • Port of Hamburg - Infrastructure and development • Preparation of areas • Scour formation in front of shore structures
Literature	Vorlesungsumdruck, s. www.tu-harburg.de/gbt

Module M0861: Modelling of Hydraulic Engineering

Courses

Title	Typ	Hrs/wk	CP
Hydraulic Models (L0813)	Project-/problem-based Learning	1	1
Modelling of Waves (L0812)	Project-/problem-based Learning	1	1
Modelling of Flow in Rivers and Estuaries (L0810)	Lecture	3	4

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Coastal Hydraulic Engineering I
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to define in detail the basic processes that are related to the modelling of flows in hydraulic engineering. Besides, they can describe the basic aspects of numerical modelling and actual numerical models for the simulation of flows and waves.
Skills	Students are able to apply hydrodynamic-numerical models to practical hydraulic engineering tasks.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in simple applied problems. Additionaly, they will be able to work in team with others.
Autonomy	The students will be able to independently extend their knowledge and apply it to new problems.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	The duration of the examination is 3 hours. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Compulsory

Course L0813: Hydraulic Models

Typ	Project-/problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	• Fundamentals of hydraulic models • Model laws • Pi theorem of Buckingham • Practical examples of hydraulic models
Literature	Strobl, Zunic: Wasserbau, Kap. 11 Hydraulische Modelle, Springer

Course L0812: Modelling of Waves	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	• Waves, interactions with shallow water and constructions • Wave theories • Sea state and surges • Development of waves • Wave spectra • Modelling of Waves / phase averaged and phase resolved models • Application of a phase averaged model for wave prediction (SWAN) • · Application of phase resolved wave models (Mike)
Literature	Vorlesungsumdruck

Course L0810: Modelling of Flow in Rivers and Estuaries	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Edgar Nehlsen, Prof. Peter Fröhle
Language	EN
Cycle	SoSe
Content	Introduction to numerical flow modelling • Processes affecting tht flow • Examples and applications of numerical models • Procedure of numerical modelling • Model concept Basic equations of hydrodynamics • Saint-Venant equations • Euler Equations • Navier-Stokes equations • Reynolds-averaged Navier-Stokes equations • Shallow water equations Solving schemes • Numerical discretization • Solution algorithms • Convergence
Literature	Vorlesungsskript Literaturempfehlungen Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau (1997): Hydraulische Berechnung von naturnahen Fließgewässern. Düsseldorf: BWK (BWK-Merkblatt). Chow, Ven-te (1959): Open-channel Hydraulics. New York usw.: McGraw-Hill (McGraw-Hill Civil Engineering Series). Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019a): Merkblatt DWA-M 543-2 Geodaten in der Fließgewässermodellierung Teil 1: Geodaten in der Fließgewässermodellierung. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-1). Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019b): Merkblatt DWA-M 543-2 Geodaten in der Fließgewässermodellierung Teil 2: Bedarfsgerechte Datenerfassung und -aufbereitung. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-2). Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019c): Merkblatt DWA-M 543-3 Geodaten in der Fließgewässermodellierung - Teil 3: Aspekte der Strömungsmodellierung und Fallbeispiele. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-3). Hervouet, Jean-Michel (2007): Hydrodynamics of free surface flows. Modelling with the finite element method. Chichester: Wiley. Online verfügbar unter http://www.loc.gov/catdir/enhancements/fy0741/2007296953-b.html. IAHR (2015): Professional Specifications for Physical and Numerical Studies in Environmental Hydraulics. In: Hydrolink (3/2015), S. 90-92. Olsen, Nils Reidar B. (2012): Numerical Modelling and Hydraulics. 3. Aufl. Department of Hydraulic and Environmental Engineering, The Norwegian University of Science and Technology. Szymkiewicz, Romuald (2010): Numerical modeling in open channel hydraulics. Dordrecht: Springer (Water science and technology library, 83). van Waveren, Harold (1999-): Good modelling practice handbook. [Utrecht], Lelystad, Den Haag: STOWA; Rijkswaterstaat-RIZA; SDU, afd. SEO/RIZA [etc. distr.] (Nota, nr. 99.036). Zielke, Werner (Hg.) (1999): Numerische Modelle von Flüssen, Seen und Küstengewässern. Deutscher Verband für Wasserwirtschaft und Kulturbau. Bonn: Wirtschafts- und Verl.-Ges. Gas und Wasser (Schriftenreihe des Deutschen Verbandes für Wasserwirtschaft und Kulturbau, 127).

Module M0874: Wastewater Systems

Courses

Title	Typ	Hrs/wk	CP
Biological Wastewater Treatment (L0517)	Lecture	2	2
Biological Wastewater Treatment (L3122)	Recitation Section (large)	1	1
Advanced Wastewater Treatment (L0357)	Lecture	2	2
Advanced Wastewater Treatment (L0358)	Recitation Section (large)	1	1

Module Responsible	Dr. Joachim Behrendt
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of wastewater management and the key processes involved in wastewater treatment.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to outline key areas of the full range of treatment systems in waste water management, as well as their mutual dependence for sustainable water protection. They can describe relevant economic, environmental and social factors.
Skills	Students are able to pre-design and explain the available wastewater treatment processes and the scope of their application in municipal and for some industrial treatment plants.
Personal Competence	
Social Competence	Social skills are not targeted in this module.
Autonomy	Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L0517: Biological Wastewater Treatment

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Joachim Behrendt
Language	DE/EN
Cycle	SoSe
Content	Charaterisation of Wastewater Metobolism of Microorganisms Kinetic of mirobiotic processes Calculation of bioreactor for wastewater treatment Concepts of Wastewater treatment Design of WWTP Excursion to a WWTP Biofilms Biofim Reactors Anaerobic Wastewater and sldge treatment resources oriented sanitation technology Future challenges of wastewater treatment
Literature	**Gujer, Willi** Siedlungswasserwirtschaft : mit 84 Tabellen

ISBN: 3540343296 (Gb.) URL: http://www.gbv.de/dms/bs/toc/516261924.pdf URL: http://deposit.d-nb.de/cgi-bin/dokserv?id=2842122&prov=M&dok_var=1&dok_ext=htm
Berlin [u.a.] : Springer, 2007
TUB_HH_Katalog
Henze, Mogens
Wastewater treatment : biological and chemical processes
ISBN: 3540422285 (Pp.)
Berlin [u.a.] : Springer, 2002
TUB_HH_Katalog
Imhoff, Karl (Imhoff, Klaus R.;)
Taschenbuch der Stadtentwässerung : mit 10 Tafeln
ISBN: 3486263331 ((Gb.))
München [u.a.] : Oldenbourg, 1999
TUB_HH_Katalog
Lange, Jörg (Otterpohl, Ralf; Steger-Hartmann, Thomas;)
Abwasser : Handbuch zu einer zukunftsfähigen Wasserwirtschaft
ISBN: 3980350215 (kart.) URL: http://www.gbv.de/du/services/agi/52567E5D44DA0809C12570220050BF25/000000700334
Donaueschingen-Pfohren : Mall-Beton-Verl., 2000
TUB_HH_Katalog
Mudrack, Klaus (Kunst, Sabine;)
Biologie der Abwasserreinigung : 18 Tabellen
ISBN: 382741427X URL: http://www.gbv.de/du/services/agi/94B581161B6EC747C1256E3F005A8143/420000114903
Heidelberg [u.a.] : Spektrum, Akad. Verl., 2003
TUB_HH_Katalog
Tchobanoglous, George (Metcalf & Eddy, Inc., ;)
Wastewater engineering : treatment and reuse
ISBN: 0070418780 (alk. paper) ISBN: 0071122508 (ISE (*pbk))
Boston [u.a.] : McGraw-Hill, 2003
TUB_HH_Katalog
Henze, Mogens
Activated sludge models ASM1, ASM2, ASM2d and ASM3
ISBN: 1900222248
London : IWA Publ., 2002
TUB_HH_Katalog
Kunz, Peter
Umwelt-Bioverfahrenstechnik
Vieweg, 1992
Bauhaus-Universität., Arbeitsgruppe Weiterbildendes Studium Wasser und Umwelt (Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall, ;)
Abwasserbehandlung : Gewässerbelastung, Bemessungsgrundlagen, Mechanische Verfahren, Biologische Verfahren, Reststoffe aus der Abwasserbehandlung, Kleinkläranlagen
ISBN: 3860682725 URL: http://www.gbv.de/dms/weimar/toc/513989765_toc.pdf URL: http://www.gbv.de/dms/weimar/abs/513989765_abs.pdf
Weimar : Universitätsverl, 2006
TUB_HH_Katalog
Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall
DWA-Regelwerk
Hennef : DWA, 2004
TUB_HH_Katalog
Wiesmann, Udo (Choi, In Su; Dombrowski, Eva-Maria;)
Fundamentals of biological wastewater treatment
ISBN: 3527312196 (Gb.) URL: http://deposit.ddb.de/cgi-bin/dokserv?id=2774611&prov=M&dok_var=1&dok_ext=htm
Weinheim : WILEY-VCH, 2007
TUB_HH_Katalog

Course L3122: Biological Wastewater Treatment	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Joachim Behrendt
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0357: Advanced Wastewater Treatment	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Joachim Behrendt
Language	EN
Cycle	SoSe
Content	Survey on advanced wastewater treatment reuse of reclaimed municipal wastewater Precipitation Flocculation Depth filtration Membrane Processes Activated carbon adsorption Ozonation "Advanced Oxidation Processes" Disinfection
Literature	Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003 Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987 Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007 Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003

Course L0358: Advanced Wastewater Treatment	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Joachim Behrendt
Language	EN
Cycle	SoSe
Content	Aggregate organic compounds (sum parameters) Industrial wastewater Processes for industrial wastewater treatment Precipitation Flocculation Activated carbon adsorption Recalcitrant organic compounds
Literature	Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003 Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987 Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007 Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003

Module M0922: City Planning

Courses

Title	Typ	Hrs/wk	CP
City Planning (L1066)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Carsten Gertz
Admission Requirements	None
Recommended Previous Knowledge	for "Principles of Urban Planning": none for "Designing Urban Streetscapes": some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineering“
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • use technical terms of urban planning. • describe the main determinants of urban development. • explain and compare different possibilities of how urban development can be influenced. • discuss requirements for public streetscapes. • explain the importance of street design.
Skills	Students are able to: • read and analyze urban development concepts and designs for streetscapes • appraise such concepts in the context of competing requirements. • design, justify and reflect their own solutions for concrete examples.
Personal Competence	
Social Competence	Students are able to: • discuss intermediate results with each other. • constructively accept feedback on their own work. • provide constructive feedback to others.
Autonomy	Students are able to: • independently complete a written report including drawings following a broadly pre-defined process. • assess the consequences of their proposed solutions. • independently acquire knowledge and apply this to new issues or problem areas.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	written assignment, designwork during the semester
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L1066: City Planning	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Carsten Gertz
Language	DE
Cycle	SoSe
Content	„Principles of Urban Planning“ deals with the determinants of urban development and their interactions. Topics include: • legal framework, • instruments and methods of planning, • functional requirements, • stakeholders and actors • basic design requirements • different planning levels and • historical contexts. The objective of the course is for students to acquire a basic understanding of urban development problems and approaches for solving them. They will also be able to comprehend the process of urban planning. The course also covers the various functional and aesthetic requirements for designing streetscape as the most important elements of public space. The project work deals with a real life scenario and includes drawing up a development plan, an urban design concept, a building masterplan and a street redesign.
Literature	Albers, Gerd; Wekel, Julian (2021) Stadtplanung: Eine illustrierte Einführung. 4. überarbeitete Auflage. Primus Verlag. Darmstadt. Frick, Dieter (2011) Theorie des Städtebaus: Zur baulich-räumlichen Organisation von Stadt. 3. veränderte Auflage. Wasmuth-Verlag. Tübingen Jonas, Carsten (2009) Die Stadt und ihr Grundriss. Wasmuth-Verlag. Tübingen Kostof, Spiro; Castillo, Greg (1998) Die Anatomie der Stadt. Geschichte städtischer Strukturen. Campus-Verlag. Frankfurt/New York.

Module M0977: Construction Logistics and Project Management

Courses

Title	Typ	Hrs/wk	CP
Construction Logistics (L1163)	Lecture	1	2
Construction Logistics (L1164)	Recitation Section (small)	1	2
Project Development and Management (L1161)	Lecture	1	1
Project Development and Management (L1162)	Project-/problem-based Learning	1	1

Module Responsible	Prof. Heike Flämig
Admission Requirements	None
Recommended Previous Knowledge	none
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can... • give definitions of the main terms of construction logistics and project development and management • name advantages and disadvantages of internal or external construction logistics • explain characteristics of products, demand and production of construction objects and their consequences for construction specific supply chains • differentiate constructions logistics from other logistics systems
Skills	Students can... • carry out project life cycle assessments • apply methods and instruments of construction logistics • apply methods and instruments of project development and management • apply methods and instruments of conflict management • design supply and waste removal concepts for a construction project
Personal Competence	
Social Competence	Students can... • hold presentations in and for groups • apply methods of conflict solving skills in group work and case studies
Autonomy	Students can... • solve problems by holistic, systemic and flow oriented thinking • improve their creativity, negotiation skills, conflict and crises solution skills by applying methods of moderation in case studies
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Two written papers with presentations
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory

Course L1163: Construction Logistics	
Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Heike Flämig
Language	DE
Cycle	SoSe
Content	The lecture gives deeper insight how important logistics are as a competetive factor for construction projects and which issues are to be adressed. The following toppics are covered: • competetive factor logistics • the concept of systems, planning and coordination of logistics • material, equipment and reverse logistics • IT in construction logistics • elements of the planning model of construction logistics and their connections • flow oriented logistics systems for construction projects • logistics concepts for ready to use construction projects (especially procurement and waste removel logistics) • best practice examples (construction logistics Potsdamer Platz, recent case study of the region) Contents of the lecture are deepened in special exercises.
Literature	Flämig, Heike: Produktionslogistik in Stadtregionen. In: Forschungsverbund Ökologische Mobilität (Hrsg.) Forschungsbericht Bd. 15.2. Wuppertal 2000. Krauss, Siri: Die Baulogistik in der schlüsselfertigen Ausführung, Bauwerk Verlag GmbH Berlin 2005. Lipsmeier, Klaus: Abfallkennzahlen für Neubauleistungen im Hochbau : Verlag Forum für Abfallwirtschaft und Altlasten, 2004. Schmidt, Norbert: Wettbewerbsfaktor Baulogistik. Neue Wertschöpfungspotenziale in der Baustoffversorgung. In: Klaus, Peter: Edition Logistik. Band 6. Deutscher Verkehrs-Verlag. Hamburg 2003. Seemann, Y.F. (2007): Logistikkoordination als Organisationseinheit bei der Bauausführung Wissenschaftsverlag Mainz in Aachen, Aachen. (Mitteilungen aus dem Fachgebiet Baubetrieb und Bauwirtschaft (Hrsg. Kuhne, V.): Heft 20)

Course L1164: Construction Logistics	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Heike Flämig
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1161: Project Development and Management	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Heike Flämig, Dr. Anton Worobei
Language	DE
Cycle	SoSe
Content	Within the lecture, the main aspects of project development and management are tought: • Terms and definitions of project management • Advantages and disadvantages of different ways of project handling • organization, information, coordination and documentation • cost and fincance management in projects • time- and capacity management in projects • specific methods and instruments for successful team work Contents of the lecture are deepened in special exercises.
Literature	Projektmanagement-Fachmann. Band 1 und Band 2. RKW-Verlag, Eschborn, 2004.

Course L1162: Project Development and Management	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Heike Flämig, Dr. Anton Worobei
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0998: Statics and Dynamics of Structures

Courses

Title	Typ	Hrs/wk	CP
Structural Dynamics (L1202)	Lecture	2	2
Structural Dynamics (L1203)	Recitation Section (large)	2	2
Fracture mechanics and fatigue in steel structures (L0564)	Lecture	1	1
Fracture mechanics and fatigue in steel structures (L0565)	Recitation Section (large)	1	1

Module Responsible	Prof. Bastian Oesterle
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of linear structural analysis of statically determinate and indeterminate structures; Mechanics I/II, Mathematics I/II, Differential equations I
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of this module, the student can explain the basic aspects of dynamic effects on structures and the respective methods.
Skills	After successful completion of this module, the students will be able to predict the response of material and structures to dynamics loading using the appropriate computational approaches and methods.
Personal Competence	
Social Competence	Students can • participate in subject-specific and interdisciplinary discussions, • defend their own work results in front of others • promote the scientific development of colleagues • Furthermore, they can give and accept professional constructive criticism
Autonomy	Students are able to gain knowledge of the subject area from given and other sources and apply it to new problems. Furthermore, they are able to structure the solution process for problems in the area of Structural Analysis.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	150 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L1202: Structural Dynamics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	DE
Cycle	SoSe
Content	• mechanical background of dynamics • harmonic vibrations, damped and undamped free and forced vibrations • frequency and time domain • modelling aspects • principle of d'Alembert • systems with multiple degrees of freedom • consistent and lumped mass matrices • finite elements for dynamics problems • impact problems • eigenvalue problems and modal analysis • direct time integration schemes, transient analyses
Literature	• Vorlesungsmanuskript • Clough, R.W., Penzien, J.: Dynamics of Structures. 2. Aufl., McGraw-Hill, New York, 1993.

Course L1203: Structural Dynamics	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0564: Fracture mechanics and fatigue in steel structures	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Jürgen Priebe
Language	DE
Cycle	SoSe
Content	• basics of fatigue stress and fatigue resistance and determination of fatigue strength, • determination anduse of S-N-curves and classification of notch effects, • set up of determination of fatigue strength under dynamic load using the accumulation formula by Palmgren-Miner, • set up of determination of fatigue strength in different examples, • basics of construction and design regarding the problem of material fatigue, • basics of linear elastic fracture mechanics under static and dynamic load, • determination of lifetime of steel construction based on linear elastic fracture mechanics in different examples.
Literature	• Seeßelberg, C.; Kranbahnen - Bemessung und konstruktive Gestaltung; 3. Auflage; Bauwerk-Verlag; Berlin 2009 • Kuhlmann, Dürr, Günther; Kranbahnen und Betriebsfestigkeit; in Stahlbau Kalender 2003; Verlag Ernst & Sohn; Berlin 2003 • Deutscher Stahlbau-Verband (Hrsg.); Stahlbau Handbuch Band 1 Teil B; 3. Auflage; Stahlbau-Verlagsgesellschaft; Köln 1996 • Petersen, C.; Stahlbau; 3. überarb. und erw. Auflage; Vieweg-Verlag; Braunschweig 1993 • DIN V ENV 1993-1-1: Eurocode 3; Bemessung und Konstruktion von Stahlbauwerken; Teil 1-1: Allgemeine Bemessungsregeln, Bemessungsregeln für den Hochbau; 1993 • DIN V ENV 1993-6: Eurocode 3; Bemessung und Konstruktion von Stahlbauwerken; Teil 6: Kranbahnen; 2001 • DIN-Fachbericht 126. Richtlinie zur Anwendung von DIN V ENV 1993-6; Nationales Anwendungsdokument (NAD); Berlin 2002

Course L0565: Fracture mechanics and fatigue in steel structures	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Jürgen Priebe
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0999: Steel Construction Project

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Steel Construction Project (L1206)	Project Seminar	4	6

Module Responsible	Prof. Marcus Rutner
Admission Requirements	None
Recommended Previous Knowledge	Steel and Composite Structures
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to prepare a part of the whole project and explain it to the others.
Skills	Students can produce sketches and calculations of their part of the project. They are able to adjust their work in reaction to changing conditions resulting from other participants of the project.
Personal Competence	
Social Competence	Students can present their results to other members of the group. They have the ability to work for a broad agreement with respect to intergroup dependencies. They can distribute and process tasks independently.
Autonomy	Students can handle their part of the project on their own resposibility-
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	approx. 15-20 pages (without appendix)
Assignment for the Following Curricula	Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory

Course L1206: Steel Construction Project

Typ	Project Seminar
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Marcus Rutner
Language	DE
Cycle	SoSe
Content	Design of a big construction project (i.e skyscraper, large bridge, roof of a stadiuim) in small groups
Literature	Wird je nach Projekt individuell angegeben.

Module M0663: Marine Geotechnics

Courses

Title	Typ	Hrs/wk	CP
Marine Geotechnics (L0548)	Lecture	1	2
Marine Geotechnics (L0549)	Recitation Section (large)	2	2
Steel Structures in Foundation and Hydraulic Engineering (L1146)	Lecture	2	2

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	Complete modules: Geotechnics I-III, Mathematics I-III Courses: Soil laboratory course
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students get a deeper knowledge of steel and ground engineering as well as constructions knowledge concerning quay walls. Furthermore, the students get all the necessary knowledge to design singular construction elements for sheet pile walls and they know how to choose the right construction elements depending on the influencing conditions.
Skills	Furthermore, the students are able to dimension sheet pile wall construction regarding all construction elements, to choose the suitable construction elements with respect to the influencing conditions, to design all kinds of sheet pile walls (wave sheet pile walls and combined sheet pile walls) and to dimension all construction elements and connections.
Personal Competence	
Social Competence	
Autonomy	Students are able to assess their own strengths and weaknesses and organize their time and learning management based on this.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory

Course L0548: Marine Geotechnics

Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	SoSe
Content	• Geotechnical investigation an description of the seabed • Foundations of Offshore-Constructions • cCliff erosion • Sea dikes • Port structures • Flood protection structures
Literature	• EAK (2002): Empfehlungen für Küstenschutzbauwerke • EAU (2004): Empfehlungen des Arbeitsausschusses Uferbauwerke • Poulos H.G. (1988): Marine Geotechnics. Unwin Hyman, London • Wagner P. (1990): Meerestechnik: Eine Einführung für Bauingenieure. Ernst & Sohn, Berlin

Course L0549: Marine Geotechnics	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1146: Steel Structures in Foundation and Hydraulic Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Frank Feindt
Language	DE
Cycle	SoSe
Content	Design of a sheet pile wall, design of a combined sheet pile wall, piles, walings, connections, fatigue
Literature	EAU 2012, EA-Pfähle, EAB

Module M1724: Smart Monitoring

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Smart Monitoring (L2762)	Integrated Lecture	2	2
Smart Monitoring (L2763)	Recitation Section (small)	2	4

Module Responsible	Prof. Kay Smarsly
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge or interest in object-oriented modeling, programming, and sensor technologies are helpful. Interest in modern research and teaching areas, such as Internet of Things, Industry 4.0 and cyber-physical systems, as well as the will to deepen skills of scientific working, are required. Basic knowledge in scientific writing and good English skills.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students will become familiar with the principles and practices of smart monitoring. The students will be able to design decentralized smart systems to be applied for continuous (remote) monitoring of systems in the built and in the natural environment. In addition, the students will learn to design and to implement intelligent sensor systems using state-of-the-art data analysis techniques, modern software design concepts, and embedded computing methodologies. Besides lectures, project work is also part of this module, which will be conducted throughout the semester and will contribute to the grade. In small groups, the students will design smart monitoring systems that integrate a number of “intelligent” sensors to be implemented by the students. Specific focus will be put on the application of machine learning techniques. The smart monitoring systems will be mounted on real-world (built or natural) systems, such as bridges or slopes, or on scaled lab structures for validation purposes. The outcome of every group will be documented in a paper. All students of this module will “automatically” participate with their smart monitoring system in the annual "Smart Monitoring" competition. The written papers and oral examinations form the final grades. The module will be taught in English. Limited enrollment.
Skills	The students will gain insights into operating state-of-the-art smart sensor systems, used for monitoring a wide range of physical processes relevant to engineering, such as environmental, structural, or comfort monitoring. The students will be capable of devising monitoring strategies of physical processes as part of group projects, tailored to their knowledge backgrounds, and to implement the strategies in smart wireless sensor nodes, using embedded computing and programming. Finally, the students will be able to document the findings of their projects in short reports.
Personal Competence	
Social Competence	The students will be able to work in groups, share parts of the work for their projects, and develop communication skills, towards achieving the common project goals.
Autonomy	The students will be able to gain a solid basis on approaching and solving problems in engineering, as well as on documenting results, through their involvement in their monitoring group projects.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	10 pages of work with 15-minute oral presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2762: Smart Monitoring	
Typ	Integrated Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Kay Smarsly
Language	EN
Cycle	SoSe
Content	In this course, principles of smart monitoring will be taught, focusing on modern concepts of data acquisition, data storage, and data analysis. Also, fundamentals of intelligent sensors and embedded computing will be illuminated. Autonomous software and decentralized data processing are further crucial parts of the course, including concepts of the Internet of Things, Industry 4.0 and cyber-physical systems. Furthermore, measuring principles, data acquisition systems, data management and data analysis algorithms will be discussed. Besides the theoretical background, numerous practical examples will be shown to demonstrate how smart monitoring may advantageously be used for assessing the condition of systems in the built or natural environment.
Literature	The course contents couples different fields, such as signal processing, sensing technologies, data analytics, environmental engineering, civil engineering, artificial intelligence, database systems, and many more. The basics will be taught in this course. However, specific literature that covers all these topics does not exist. Instead, literature will be referenced in the lectures, all of which are papers that are freely available online.

Course L2763: Smart Monitoring	
Typ	Recitation Section (small)
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Kay Smarsly
Language	EN
Cycle	SoSe
Content	The contents of the exercises are based on the lecture contents. In addition to the exercises, project work will be conducted throughout the semester, which will consume the majority of the workload. As part of the project work, students will design smart monitoring systems that will be tested in the laboratory or in the field. As mentioned in the module description, the students will participate in the “Smart Monitoring” competition, hosted annually by the Institute of Digital and Autonomous Construction. Students are encouraged to contribute their own ideas. The tools required to implement the smart monitoring systems will be taught in the group exercises as well as through external sources, such as video tutorials and literature.
Literature	The course contents couples different fields, such as signal processing, sensing technologies, data analytics, environmental engineering, civil engineering, artificial intelligence, database systems, and many more. The basics will be taught in this course. However, specific literature that covers all these topics does not exist. Instead, literature will be referenced in the lectures, all of which are papers that are freely available online.

Module M1845: Thin-walled structures

Courses

Title	Typ	Hrs/wk	CP
Thin-walled structures (L1199)	Lecture	2	3
Thin-walled structures (L3045)	Recitation Section (large)	2	3

Module Responsible	Prof. Bastian Oesterle
Admission Requirements	None
Recommended Previous Knowledge	• Structural Analysis I • Structural Analysis II • Finite Element Methods
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of this module, the students can express the basic aspects of the load-carrying behaviour of thin-walled structures.
Skills	After successful completion of this module, the students will be able to predict load-carrying behaviour of thin-walled structures using appropriate analytical and coputational methods.
Personal Competence	
Social Competence	Students can • participate in subject-specific and interdisciplinary discussions, • defend their own work results in front of others • promote the scientific development of colleagues • Furthermore, they can give and accept professional constructive criticism
Autonomy	Students are able to gain knowledge of the subject area from given and other sources and apply it to new problems. Furthermore, they are able to structure the solution process for problems in the area of modelling and analysis of thin-walled structures.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L1199: Thin-walled structures	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	DE
Cycle	SoSe
Content	Plates loaded in-plane • Governing equations (equilibrium, kinematics, constitutive law) • Differential equation • Airy stress function • Plane stress / plane strain • Structural behaviour of plates loaded in-plane • finite elements for plates loaded in-plane, modelling apsects, interpretation and critical assessment of results Plates in bending • Governing equations (equilibrium, kinematics, constitutive law) • Differential equation • Navier solution / Fourier series expansion • Approximation procedures • Circular and rectangular plates • Structural behaviour of plates in bending • finite elements for plates in bending, modelling apsects, interpretation and critical assessment of results Shells • Phenomenona of the structural behaviour of shells • Membrane and bending theory • Equilibrium equations of shells of revolution • Stress resultants and deformations of the spherical shell, the half spherical shell, and the cylindrical shell • finite elements for shells Stability problems (overview) • Plate buckling • Shell buckling
Literature	• Vorlesungsmanuskript • Basar, Y.: Krätzig, W.B. (1985): Mechanik der Flächentragwerke. Vieweg-Verlag, Braunschweig, Wiesbaden • Girkmann, K. (1963): Flächentragwerke, Springer Verlag, Wien, 1963, unveränderter Nachdruck 1986 • Zienkiewicz, O.C. (1977): The Finite Element Method in Enginieering Science. McGraw-Hill, London

Course L3045: Thin-walled structures	
Typ	Recitation Section (large)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1878: Sustainable energy from wind and water

Courses

Title	Typ	Hrs/wk	CP
Offshore Geotechnical Engineering (L0067)	Lecture	1	1
Hydro Power Use (L0013)	Lecture	1	1
Wind Turbine Plants (L0011)	Lecture	2	3
Wind Energy Use - Focus Offshore (L0012)	Lecture	1	1

Module Responsible	Dr. Marvin Scherzinger
Admission Requirements	None
Recommended Previous Knowledge	Module: Technical Thermodynamics I, Module: Technical Thermodynamics II, Module: Fundamentals of Fluid Mechanics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	By ending this module students can explain in detail knowledge of wind turbines with a particular focus of wind energy use in offshore conditions and can critical comment these aspects in consideration of current developments. Furthermore, they are able to describe fundamentally the use of water power to generate electricity. The students reproduce and explain the basic procedure in the implementation of renewable energy projects in countries outside Europe. Through active discussions of various topics within the seminar of the module, students improve their understanding and the application of the theoretical background and are thus able to transfer what they have learned in practice.
Skills	Students are able to apply the acquired theoretical foundations on exemplary water or wind power systems and evaluate and assess technically the resulting relationships in the context of dimensioning and operation of these energy systems. They can in compare critically the special procedure for the implementation of renewable energy projects in countries outside Europe with the in principle applied approach in Europe and can apply this procedure on exemplary theoretical projects.
Personal Competence	
Social Competence	Students can discuss scientific tasks subjet-specificly and multidisciplinary within a seminar.
Autonomy	Students can independently exploit sources in the context of the emphasis of the lecture material to clear the contents of the lecture and to acquire the particular knowledge about the subject area.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	180 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Renewable Energies: Core Qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L0067: Offshore Geotechnical Engineering	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Jan Dührkop
Language	DE
Cycle	SoSe
Content	• Overview and Introduction Offshore Geotechnics • Introduction to Soil Mechanics • Offshore soil investigation • Focus on cyclical effects • Geotechnical design of offshore foundations • Monopiles • Jackets • Heavyweight foundations • Geotechnical preliminary exploration for the use of lift boats and platforms
Literature	• Randolph, M. and Gourvenec, S (2011): Offshore Geotechnical Engineering. Spon Press. • Poulos H.G. (1988): Marine Geotechnics. Unwin Hyman, London • BSH-Standard Baugrunderkundung für Offshore-Windenergieparks • Lesny K. (2010): Foundations for Offshore Wind Turbines. VGE Verlag, Essen. • EA-Pfähle (2012): Empfehlungen des Arbeitskreises Pfähle der DGGT. Ernst & Sohn, Berlin.

Course L0013: Hydro Power Use	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Stefan Achleitner
Language	DE
Cycle	SoSe
Content	• Introduction, importance of water power in the national and global context • Physical basics: Bernoulli's equation, usable height of fall, hydrological measures, loss mechanisms, efficiencies • Classification of Hydropower: Flow and Storage hydropower, low and high pressure systems • Construction of hydroelectric power plants: description of the individual components and their technical system interaction • Structural engineering components; representation of dams, weirs, dams, power houses, computer systems, etc. • Energy Technical Components: Illustration of the different types of hydraulic machinery, generators and grid connection • Hydropower and the Environment • Examples from practice
Literature	• Schröder, W.; Euler, G.; Schneider, K.: Grundlagen des Wasserbaus; Werner, Düsseldorf, 1999, 4. Auflage • Quaschning, V.: Regenerative Energiesysteme: Technologie - Berechnung - Simulation; Carl Hanser, München, 2011, 7. Auflage • Giesecke, J.; Heimerl, S.; Mosony, E.: Wasserkraftanlagen - Planung, Bau und Betrieb; Springer, Berlin, Heidelberg, 2009, 5. Auflage • von König, F.; Jehle, C.: Bau von Wasserkraftanlagen - Praxisbezogene Planungsunterlagen; C. F. Müller, Heidelberg, 2005, 4. Auflage • Strobl, T.; Zunic, F.: Wasserbau: Aktuelle Grundlagen - Neue Entwicklungen; Springer, Berlin, Heidelberg, 2006

Course L0011: Wind Turbine Plants	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Rudolf Zellermann
Language	DE
Cycle	SoSe
Content	• Historical development • Wind: origins, geographic and temporal distribution, locations • Power coefficient, rotor thrust • Aerodynamics of the rotor • Operating performance • Power limitation, partial load, pitch and stall control • Plant selection, yield prediction, economy • Excursion
Literature	Gasch, R., Windkraftanlagen, 4. Auflage, Teubner-Verlag, 2005

Course L0012: Wind Energy Use - Focus Offshore	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Martin Skiba
Language	DE
Cycle	SoSe
Content	• Introduction, importance of offshore wind power generation, Specific requirements for offshore engineering • Physical fundamentals for utilization of wind energy • Design and operation of offshore wind turbines, presentation of different concepts of offshore wind turbines, representation of the individual system components and their system-technical relationships • Foundation engineering, offshore site investigation, presentation of different concepts of offshore foundation structures, planning and fabrication of foundation structures • Electrical infrastructure of an offshore wind farm, Inner Park cabling, offshore substation, grid connection • Installation of offshore wind farms, installation techniques and auxiliary devices, construction logistics • Development and planning of offshore wind farms • Operation and optimization of offshore wind farms • Day excursion
Literature	• Gasch, R.; Twele, J.: Windkraftanlagen - Grundlagen, Entwurf, Planung und Betrieb; Vieweg + Teubner, Stuttgart, 2007, 7. Auflage • Molly, J. P.: Windenergie - Theorie, Anwendung, Messung; C. F. Müller, Heidel-berg, 1997, 3. Auflage • Hau, E.: Windkraftanalagen; Springer, Berlin, Heidelberg, 2008, 4.Auflage • Heier, S.: Windkraftanlagen - Systemauslegung, Integration und Regelung; Vieweg + Teubner, Stuttgart, 2009, 5. Auflage • Jarass, L.; Obermair, G.M.; Voigt, W.: Windenergie: Zuverlässige Integration in die Energieversorgung; Springer, Berlin, Heidelberg, 2009, 2. Auflage

Module M0858: Coastal Hydraulic Engineering I

Courses

Title	Typ	Hrs/wk	CP
Basics of Coastal Engineering (L0807)	Lecture	3	4
Basics of Coastal Engineering (L1413)	Project-/problem-based Learning	1	2

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Basics of hydraulic engineering, hydrology and hydromechanics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to define and explain the basic concepts of coastal engineering and port engineering. They are able to apply the concepts to selected practical problems of coastal engineering. Students can define and determine the basics for design and dimensioning of coastal engineering constructions.
Skills	The students are capable to apply basic design approaches to selected and pre-defined design tasks in coastal engineering.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in applied problems such as the design of coastal protection structures. Additionaly, they will be able to work in team with engineers of other disciplines, for instance designing of coastal breakwaters.
Autonomy	The students will be able to independently extend their knowledge and applyit to new problems.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	The duration of the examination is 2 hours. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L0807: Basics of Coastal Engineering

Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Peter Fröhle
Language	EN
Cycle	SoSe

Content	• Basics of planning and design
	  ◦ Water levels
	  ◦ Currents
	  ◦ Waves
	  ◦ Ice
	• Planning and Design in Coastal Engineering
	  ◦ Functional and constructional design
	  ◦ Determination of design parameters
	  ◦ Design-approaches
	    ▪ Filter
	    ▪ Rubble mound constructions
	    ▪ Piles
	    ▪ Vertical constructions

Literature	Coastal Engineering Manual, CEM Vorlesungsumdruck

Course L1413: Basics of Coastal Engineering	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0581: Water Protection

Courses

Title	Typ	Hrs/wk	CP
Water Protection and Wastewater Management (L0226)	Lecture	3	3
Water Protection and Wastewater Management (L2008)	Project Seminar	3	3

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	• Basic knowledge in water management; • Good knowledge in urban drainage; • Good knowledge of wastewater treatment techniques; • Good knowledge of pollutants (e.g. COD, BOD, TS, N, P) and their properties;
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can describe the basic principles of the regulatory framework related to the international and European water sector. They can explain limnological processes, substance cycles and water morphology in detail. They are able to assess complex problems related to water protection, such as ecosystem service and wastewater treatment with a special focus on innovative solutions, remediation measures as well as conceptual approaches.
Skills	Students can accurately assess current problems and situations in a country-specific or local context. They can suggest concrete actions to contribute to the planning of tomorrow's urban water cycle. Furthermore, they can suggest appropriate technical, administrative and legislative solutions to solve these problems.
Personal Competence	
Social Competence	The students can work together in international groups.
Autonomy	Students are able to organize their work flow to prepare presentations and discussions. They can acquire appropriate knowledge by making enquiries independently.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Presentation
Examination duration and scale	Term paper plus presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory

Course L0226: Water Protection and Wastewater Management	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	The lecture focusses on: • Regulatory Framework (e.g. WFD) • Main instruments for the water management and protection • In depth knowledge of relevant measures of water pollution control • Urban drainage, treatment options in different regions on the world • Rainwater management, improved management of heavy rainfalls, downpours, rainwater harvesting, rainwater infiltration • Case Studies and Field Trips
Literature	The literature listed below is available in the library of the TUHH. • Water and wastewater technology Hammer, M. J. 1., & . (2012). (7. ed., internat. ed.). Boston [u.a.]: Pearson Education International. • Water and wastewater engineering : design principles and practice: Davis, M. L. 1. (2011). . New York, NY: McGraw-Hill. • Biological wastewater treatment: (2011). C. P. Leslie Grady, Jr. (3. ed.). London, Boca Raton, Fla. [u.a.]: IWA Publ.

Course L2008: Water Protection and Wastewater Management	
Typ	Project Seminar
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	
Literature	

Module M0595: Examination of Materials, Structural Condition and Damages

Courses

Title	Typ	Hrs/wk	CP
Examination of Materials, Structural Condition and Damages (L0260)	Lecture	3	4
Examination of Materials, Structural Condition and Damages (L0261)	Recitation Section (small)	1	2

Module Responsible	Prof. Frank Schmidt-Döhl
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge about building materials or material science, for example by the module Building Materials and Building Chemistry.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe the rules for trading, use and marking of construction products in Germany. They know which methods for the testing of building material properties are usable and know the limitations and characterics of the most important testing methods.
Skills	The students are able to responsibly discover the rules for trading and using of building products in Germany. They are able to chose suitable methods for the testing and inspection of construction products, the examination of damages and the examination of the structural conditions of buildings. They are able to conclude from symptons to the cause of damages. They are able to describe an examination in form of a test report or expert opinion.
Personal Competence	
Social Competence	The students can describe the different roles of manufacturers as well as testing, supervisory and certification bodies within the framework of material testing. They can describe the different roles of the participants in legal proceedings.
Autonomy	The students are able to make the timing and the operation steps to learn the specialist knowledge of a very extensive field.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Materials Science and Engineering: Specialisation Engineering Materials: Elective Compulsory Materials Science: Specialisation Engineering Materials: Elective Compulsory

Course L0260: Examination of Materials, Structural Condition and Damages

Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	WiSe
Content	Materials testing and marking process of construction products, testing methods for building materials and structures, testing reports and expert opinions, describing the condition of a structure, from symptons to the cause of damages
Literature	Frank Schmidt-Döhl: Materialprüfung im Bauwesen. Fraunhofer irb-Verlag, Stuttgart, 2013.

Course L0261: Examination of Materials, Structural Condition and Damages

Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0713: Concrete Structures

Courses

Title	Typ	Hrs/wk	CP
Concrete Structures (L0579)	Seminar	1	1
Structural Concrete Members (L0577)	Lecture	2	3
Structural Concrete Members (L0578)	Recitation Section (large)	2	2

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	Basics of structural analysis, conception and dimensioning of structural concrete Modules: Reinforced Concrete Structures I+II, Structural Analysis I+II, Mechanics I+II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students broaden their skills in structural engineering, especially in the field of buildings (houses, roofs, halls). They dispose of the knowledge for the conception and design of concrete buildings and structural members that are often used.
Skills	The students are able to apply procedures of the conception and dimensioning to to practical problems of structural engineering. They are capable to draft concrete buildings and to design them for general action effects and to plan their detailing and execution. Moreover, they can make design and construction sketches and draw up technical descriptions.
Personal Competence	
Social Competence	The students are able to obtain results of high quality in teamwork.
Autonomy	The students are able to carry out complex conception and dimensioning tasks of structures under the guidance of tutors.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory**: No; **Bonus**: None; **Form**: Presentation; **Description**: Es werden 2 Referate ausgegeben
Examination	Written exam
Examination duration and scale	120 minutes
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L0579: Concrete Structures

Typ	Seminar
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	NN
Language	DE
Cycle	WiSe
Content	With help of a project teamwork the subjects of the course "Concrete Structures" is practiced, discussed and presented.
Literature	- Projektbezogene Unterlagen werden abgegeben.

Course L0577: Structural Concrete Members	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	NN
Language	DE
Cycle	WiSe
Content	• skyscrapers: structural elements • actions on structrues • bracing systems • design orf slabs (line and point supported plates and floor slabs) • membranes and deep beams • folded plates and shells • truss models • reinforced and prestressed members
Literature	Vorlesungsunterlagen können im STUDiP heruntergeladen werden • Zilch K., Zehetmaier G.: Bemessung im konstruktiven Ingenieurbau. Springer, Heidelberg 2010 • König, G., Liphardt S.: Hochhäuser aus Stahlbeton, Betonkalender 2003, Teil II, Seite 1-69, Verlag Ernst & Sohn, Berlin 2003 • Phocas, Marios C.: Hochhäuser : Tragwerk und Konstruktion, Stuttgart, Teubner, 2005 • Deutscher Ausschuss für Stahlbeton: Heft 600: Erläuterungen zu DIN EN 1992-1-1, Beuth Verlag, Berlin 2012 • Deutscher Ausschuss für Stahlbeton: Heft 240: Hilfsmittel zur Berechnung der Schnittgrößen und Formänderungen von Stahlbetontragwerken, Verlag Ernst & Sohn, Berlin 1978 • Stiglat, K., Wippel, H.: Massive Platten - Ausgewählte Kapitel der Schnittkraftermittlung und Bemessung, Betonkalender 1992, Teil I, 287-366, Verlag Ernst & Sohn, Berlin 1992 • Stiglat/Wippel: Platten. Verlag Ernst & Sohn, Berlin,1973 • Schlaich J.; Schäfer K.: Konstruieren im Stahlbetonbau. Betonkalender 1998, Teil II, S. 721ff, Verlag Ernst & Sohn, Berlin, 1998 • Dames K.-H.: Rohbauzeichnungen Bewehrungszeichnungen. Bauverlag, Wiesbaden 1997

Course L0578: Structural Concrete Members	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	NN
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0801: Water Resources and -Supply

Courses

Title	Typ	Hrs/wk	CP
Chemistry of Drinking Water Treatment (L0311)	Lecture	2	1
Chemistry of Drinking Water Treatment (L0312)	Recitation Section (large)	1	2
Water Resource Management (L0402)	Lecture	2	2
Water Resource Management (L0403)	Recitation Section (small)	1	1

Module Responsible	Prof. Mathias Ernst
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of water management and the key processes involved in water treatment.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will be able to outline key areas of conflict in water management, as well as their mutual dependence for sustainable water supply. They will understand relevant economic, environmental and social factors. Students will be able to explain and outline the organisational structures of water companies. They will be able to explain the available water treatment processes and the scope of their application.
Skills	Students will be able to assess complex problems in drinking water production and establish solutions involving water management and technical measures. They will be able to assess the evaluation methods that can be used for this. Students will be able to carry out chemical calculations for selected treatment processes and apply generally accepted technical rules and standards to these processes.
Personal Competence	
Social Competence	Working in a diverse group of specialists, students will be able to develop and document complex solutions for the management and treatment of drinking water. They will be able to take an appropriate professional position, for example representing user interests. They will be able to develop joint solutions in teams of diverse experts and present these solutions to others.
Autonomy	Students will be in a position to work on a subject independently and present on this subject.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	60 min (chemistry) + presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0311: Chemistry of Drinking Water Treatment	
Typ	Lecture
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Dr. Klaus Johannsen
Language	DE
Cycle	WiSe
Content	The topic of this course is water chemistry with respect to drinking water treatment and water distribution Major topics are solubility of gases, carbonic acid system and calcium carbonate, blending, softening, redox processes, materials and legal requirements on drinking water treatment. Focus is put on generally accepted rules of technology (DVGW- and DIN-standards). Special emphasis is put on calculations using realistic analysis data (e.g. calculation of pH or calcium carbonate dissolution potential) in exercises. Students can get a feedback and gain extra points for exam by solving problems for homework. Knowledge of drinking water treatment processes is vital for this lecture. Therefore the most important processes are explained coordinated with the course " Water resources management" in the beginning of the semester.
Literature	**MHW (rev. by Crittenden, J. et al.):** Water treatment principles and design. John Wiley & Sons, Hoboken, 2005. **Stumm, W., Morgan, J.J.**: Aquatic chemistry. John Wiley & Sons, New York, 1996. **DVGW (Hrsg.):** Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004. **Jensen, J. N.**: A Problem Solving Approach to Aquatic Chemistry. John Wiley & Sons, Inc., New York, 2003.

Course L0312: Chemistry of Drinking Water Treatment	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dr. Klaus Johannsen
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0402: Water Resource Management	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Mathias Ernst
Language	DE
Cycle	WiSe
Content	The lecture provides comprehensive knowledge on interaction of water ressource management and drinking water supply. Content overview: • Current situation of global water resources - User and Stakeholder conflicts - Wasserressourcenmanagement in urbane Gebieten - Rechtliche Aspekte, Organisationsformen Trinkwasserversorgungsunternehmen. - Ökobilanzierung, Benchmarking in der Wasserversorgung
Literature	• Aktuelle UN World Water Development Reports • Branchenbild der deutschen Wasserwirtschaft, VKU (2011) • Aktuelle Artikel wissenschaftlicher Zeitschriften • Ppt der Vorlesung

Course L0403: Water Resource Management	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Mathias Ernst
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0923: Integrated Transportation Planning

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Integrated Transportation Planning (L1068)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Carsten Gertz
Admission Requirements	None
Recommended Previous Knowledge	some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineerin
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • describe interdependencies between land-use/location choice and transportation/mobility behaviour • explain and evaluate the social, ecological and economic effects of transport and land-use policy measures. • relate current issues in the area of integrated transport planning and formulate an opinion on them.
Skills	Students are able to: • quantify important parameters, which influence travel demand or are influenced by it. • comprehensively examine a pre-defined or self-selected topic from a transportation studies perspective and document the results in accordance with scientific conventions.
Personal Competence	
Social Competence	Students are able to: • provide feedback on topical contents and their teaching. • constructively handle feedback on their own work. • produce results in group work and document these.
Autonomy	Students are able to: • assess potential consequences of their future professional activities • independently plan working on a pre-defined project topic, acquire the necessary knowledge and use appropriate means for its execution.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	written assignment with presentation during the semester
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L1068: Integrated Transportation Planning	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Carsten Gertz, Dr. Philine Gaffron, Jacqueline Bianca Maaß
Language	DE
Cycle	WiSe
Content	The course will provide students with an understanding of interdependencies between land-use and transportation. Specific topics include a.o.: • interactions between transport and the environment and consequent limitations • characteristics of integrated planning • complex planning processes • interdependencies of location choice and mobility behaviour • transport and land-use policies • project on current issues in transportation studies
Literature	Kutter, Eckhard (2019) Stadtstruktur und Erreichbarkeit in der postfossilen Zukunft. Erich Schmidt Verlag. Berlin. Gies, Huber u. a. (Hrsg.) (93. Ergänzung 2022) Handbuch der kommunalen Verkehrsplanung. Herbert Wichmann Verlag. Berlin, Offenbach. (Loseblattsammlung mit kontinuierlichen Ergänzungen)

Module M0963: Steel and Composite Structures

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Steel and Composite Structures (L1204)	Lecture	2	2
Steel and Composite Structures (L1205)	Recitation Section (large)	2	2
Steel Bridges (L1097)	Lecture	2	2

Module Responsible	Prof. Marcus Rutner
Admission Requirements	None
Recommended Previous Knowledge	Basics of steel construction (i.e. Steel Structures I and II, BUBC)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completition, students can • describe the phenomenon of local buckling • explain warping torsion • illustrate the behaviour of composite structures • specify the principles in design of composite sttructures • sketch the contructions of steel and composite bridges
Skills	After successful participation students are able to • check stiffened and unstiffened plated structures • recognize and verify warping tosion in strucures • design composite structures • design bridges and o perform the detailing
Personal Competence	
Social Competence	--
Autonomy	--
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	180 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L1204: Steel and Composite Structures

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Marcus Rutner
Language	DE
Cycle	WiSe
Content	• Local-buckling of plated structures • Warping torsion • Composite-girders, -columns, -slabs, -bridges • Principles in composite constructions • Bridge-design and -construction
Literature	Petersen, C.: Stahlbau, 4.Auflage 2013, Springer-Vieweg Verlag Minnert, J. Wagenknecht, G.: Verbundbau-Praxis - Berechnung und Konstruktion nach Eurocode 4, 2.Auflage 2013, Bauwerk Beuth Verlag

Course L1205: Steel and Composite Structures	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Marcus Rutner
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1097: Steel Bridges	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Yves Freundt
Language	DE
Cycle	WiSe
Content	**Lecture Contents ‚Steel Bridge Construction'** **Dr.-Ing. Jörg Ahlgrimm** - From tendering and contracting to completion - the development of a steel bridge - Contents of a bridge static - structural details, examples of analysis in detail: -> effective width in regard to the longitudinal stiffeners -> Bearing point, bearing stiffener -> Crossbeam breakthrough, crossbeam reinforcement -> Analysis of the Rib-to-Floorbeam (RF) connection (web-tooth of the floorbeam between trapezoidal shaped Ribs) - Steel grades, -designation, testing methods and approval certificates - Nondestructive weld inspecting - Corrosion protection - Bridge bearing - types, format, function, dimensioning, installation - Expansion Joints - Oscillation of bridge hangers and cables - oscillation damper - Opening bridges- Detailed reviews to different assembling procedures and - implements - Selective damage events Requirements: Basic knowledge in the calculation, dimensioning, and construction of structural elements and joints of constructional steelwork
Literature	• Herbert Schmidt, Ulrich Schulte, Rainer Zwätz, Lothar Bär: Ausführung von Stahlbauten • Petersen, Christian: Stahlbau, Abschnitt Brückenbau • Ahlgrimm, J., Lohrer, I.: Erneuerung der Eisenbahnüberführung in Fulda-Horas über die Fulda, Stahlbau 74 (2005), Heft 2, S. 114

Module M0966: Study Work Foundation Engineering

Courses			
Title	**Typ**	**Hrs/wk**	**CP**

Module Responsible	Dozenten des SD B
Admission Requirements	None
Recommended Previous Knowledge	Subjects of the Foundation Engineering specialisation.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to demonstrate their detailed knowledge in the field of geotechnical and foundation engineering. They can exemplify the state of technology and application and discuss critically in the context of actual problems and general conditions of science and society. The students can develop solving strategies and approaches for fundamental and practical problems in geotechnical and foundation engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view points of science and society. Scientific work techniques that are used can be described and critically reviewed.
Skills	The students are able to independently select methods for the project work and to justify this choice. They can explain how these methods relate to the field of work and how the context of application has to be adjusted. General findings and further developments may essentially be outlined.
Personal Competence	
Social Competence	The students are able to condense the relevance and the structure of the project work, the work steps and the sub-problems for the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to their colleagues.
Autonomy	The students are capable of independently planning and documenting the work steps and procedures while considering the given deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedback from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology.
Workload in Hours	Independent Study Time 180, Study Time in Lecture 0
Credit points	6
Course achievement	None
Examination	Study work
Examination duration and scale	see FSPO
Assignment for the Following Curricula	Civil Engineering: Specialisation Geotechnical Engineering: Compulsory

Module M0969: Selected Topics in Civil Engineering

Courses

Title	Typ	Hrs/wk	CP
Design of Composite Bridges (L3092)	Integrated Lecture	2	3
Analysis of Offshore Structures (L1867)	Lecture	1	1
Energy Geotechnics (L3227)	Lecture	3	3
Solid Matter Process Technology for Biomass (L0052)	Lecture	2	3
Forum I - Geotechnics and Construction Management (L1634)	Seminar	1	1
Forum II - Geotechnics and Construction Management (L1635)	Seminar	1	1
Timber Structures (L1151)	Seminar	2	2
Innovative Timber Construction (L2666)	Lecture	2	4
Glass Structures (L1152)	Lecture	2	2
Glass Structures (L1447)	Recitation Section (large)	1	1
Sustainable landfill design and operation (L3270)	Integrated Lecture	3	3
Special Topics in Steel Design (L3091)	Integrated Lecture	2	3
Special topics of civil engineering 1CP (L2378)		1	1
Special topics of civil engineering 2 LP (L2379)		2	2
Special topics of civil engineering 3 LP (L2380)		3	3
Structural Design (L2789)	Seminar	2	2

Module Responsible	Prof. Frank Schmidt-Döhl
Admission Requirements	None
Recommended Previous Knowledge	none
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students are able to find their way through selected special areas within civil and structural engineering. • Students are able to explain basic models and procedures in selected special areas of civil and structural engineering. • Students are able to interrelate scientific and technical knowledge.
Skills	• Students are able to apply basic methods in selected areas of civil and structural engineering.
Personal Competence	
Social Competence	---
Autonomy	• Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses.
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory

Course L3092: Design of Composite Bridges

Typ	Integrated Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Marcus Rutner
Language	DE
Cycle	SoSe
Content	
Literature	

Course L1867: Analysis of Offshore Structures	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Said Fawad Mohammadi
Language	DE/EN
Cycle	SoSe
Content	Topic 1: Types of Offshore Structures, Fixed and floating structures for Oil & Gas and Offshore Wind industry Topic 2: Wave Forces, Morisons equation Topic 3: Irregular Seastates, Power spectrum and application of FFT Topic 4: Additional Environmental Forces, wind spectra, current forces Topic 5: Linear-Time-Invariant Systems, response of an LTI-system in frequency domain Topic 6: Tubular Welded Connections, stress concentration factors, weld geometry Topic 7: Introduction to Fracture Mechanics, criteria for fracture initiation and crack growth Topic 8: Time and Frequency Domain Fatigue Analyses, rainflow counting, application of LTI-systems for frequency domain fatigue Topic 9: Offshore Installation and Exam, installation of structures, pile driving, pipe laying techniques
Literature	Chakrabarti, Handbook of Offshore Engineering, 2005 Sarpkaya, Wave Forces on Offshore Structures, 2010 Faltinsen, Sea Loads on Ships and Offshore Structures, 1998 Sorensen, Basic Coastal Engineering, 2006 Dowling, Mechanical Behavior of Materials, 2007 Haibach, Betriebsfestigkeit, 2006 Marshall, Design of Welded Tubular Connections, 1992 Newland, Random vibrations, spectral and wavelet analysis, 1993

Course L3227: Energy Geotechnics	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Schriftliche Ausarbeitung (laut FPrO)
Examination duration and scale	wird zu Beginn der Lehrveranstaltung festgelegt
Lecturer	Pauline Kaminski
Language	DE/EN
Cycle	WiSe
Content	Energy geotechnics is a young field in geotechnical engineering with the aim of developing sustainable geotechnical solutions for future-oriented issues relating to the production, transport, operation, decommissioning, and waste utilisation of various energy sources. Examples of possible fields of activity in energy geotechnics include geothermal energy and thermally activated foundation components, foundations for onshore and offshore wind turbines, the decommissioning of mining facilities and the handling of waste products from fossil fuels such as tailings and the geological storage of CO2. Relevant soil mechanical processes in these applications include the thermo-hydro-mechanically coupled behaviour of soils, multiphase flow in porous media and partially saturated soils. The lecture gives an overview of various aspects of energy geotechnics and provides in-depth knowledge of the associated soil mechanical processes. In addition, CO2-scarce geotechnical applications are discussed and emission estimates as well as the optimisation of geotechnical structures according to sustainability aspects are addressed.
Literature	

Course L0052: Solid Matter Process Technology for Biomass	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Prof. Werner Sitzmann
Language	DE
Cycle	SoSe
Content	The industrial application of unit operations as part of process engineering is explained by actual examples of solid biomass processes. Size reduction, transportation and dosing, drying and agglomeration of renewable resources are described as important unit operations when producing solid fuels and bioethanol, producing and refining edible oils, when making Btl - and WPC - products. Aspects of explosion protection and plant design complete the lecture.
Literature	Kaltschmitt M., Hartmann H. (Hrsg.): Energie aus Bioamsse, Springer Verlag, 2001, ISBN 3-540-64853-4 Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, Schriftenreihe Nachwachsende Rohstoffe, Fachagentur Nachwachsende Rohstoffe e.V. www.nachwachsende-rohstoffe.de Bockisch M.: Nahrungsfette und -öle, Ulmer Verlag, 1993, ISBN 380000158175

Course L1634: Forum I - Geotechnics and Construction Management	
Typ	Seminar
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	WiSe
Content	Lectures about projects and issues with practical and scientific relevance.
Literature	--

Course L1635: Forum II - Geotechnics and Construction Management	
Typ	Seminar
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	SoSe
Content	Lectures about projects and issues with practical and scientific relevance.
Literature	--

Course L1151: Timber Structures	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Referat
Examination duration and scale	90 min
Lecturer	Prof. Torsten Faber
Language	DE
Cycle	WiSe
Content	
Literature	

Course L2666: Innovative Timber Construction	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Schriftliche Ausarbeitung
Examination duration and scale	45 Minuten
Lecturer	Dr. Andreas Meisel
Language	DE
Cycle	WiSe
Content	
Literature	- Blass, J.: "Ingenieurholzbau" - Schickhofer, G.: "BSPhandbuch: Holz-Massivbauweise in Brettsperrholz" - Informationsdienst Holz: div. Merkblätter und Broschüren - Wallner-Novak M.: Brettsperrholz Bemessung, Band 1 und 2 - Gerner M.: "Fachwerk: Entwicklung, Instandsetzung, Neubau" - Meisel, A.: "Historische Dachwerke: Beurteilung, realitätsnahe statische Analyse und Instandsetzung" - Kempe K.: "Dokumentation Holzschädlinge" - Huckfeldt T.: "Hausfäule- und Bauholzpilze"

Course L1152: Glass Structures	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Marvin Matzik
Language	DE
Cycle	WiSe
Content	Glass structures - Introduction of the material glass (production, refinement, material characteristic) - design of facades - facade types - static calculation of glazing - static calculation of facades - load bearing behavior of glazing (plate or membrane stiffness) - vertical / horizontal glazing with safety-related requirements - glass structures - fire safety of glass facades - construction physics of facades and glazing
Literature	

Course L1447: Glass Structures	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Marvin Matzik
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L3270: Sustainable landfill design and operation	
Typ	Integrated Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Dr. Marco Ritzkowski
Language	EN
Cycle	SoSe
Content	The course introduces the development of modern waste resource management and demonstrates the importance of landfills in the context of recycling processes. Based on international (EU) and national legislation, the current landfill situation is presented and the future significance of landfills will be discussed. A central element of the course deals with the main transformation processes in the landfilled waste, the emission of gases and leachate, the long-term behaviour of landfills as well as aftercare and after-utilisation measures. Further focal points of the course are measures for the sustainable reduction of environmentally and climate-damaging emissions and aspects of landfill technology in an international context.
Literature	1) **Waste Management**. Bernd Bilitewski; Georg Härdtle; Klaus Marek (Eds.), ISBN: 9783540592105 , Springer Verlag Lehrbuchsammlung der TUB, Signatur USH-305 2) **Solid Waste Technology and Management.** Thomas Christensen (Ed.), ISBN: 978-1-4051-7517-3 , Wiley Verlag Lesesaal 2: US - Umweltschutz, Signatur USH-332 3) **Solid Waste Landfilling - Concepts, Processes, Technologies.** Cossu, R. and Stegmann, R. (Eds.), ISBN: 978-0-12-818336-6 PDF (Volltext) über TUB

Course L3091: Special Topics in Steel Design	
Typ	Integrated Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Marcus Rutner, Nikolay Lalkovski
Language	DE
Cycle	SoSe
Content	
Literature	

Course L2378: Special topics of civil engineering 1CP	
Typ	
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Fachtheoretisch-fachpraktische Arbeit
Examination duration and scale	wird zu Beginn der Lehrveranstaltung festgelegt
Lecturer	Dozenten des SD B
Language	DE
Cycle	WiSe/SoSe
Content	The course occurs only if required. The content is defined at short notice.
Literature	Die Literatur wird kurzfristig festgelegt.

Course L2379: Special topics of civil engineering 2 LP	
Typ	
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Fachtheoretisch-fachpraktische Arbeit
Examination duration and scale	wird zu Beginn der Lehrveranstaltung festgelegt
Lecturer	Dozenten des SD B
Language	DE
Cycle	WiSe/SoSe
Content	The course occurs only if required. The content is defined at short notice.
Literature	Die Literatur wird kurzfristig festgelegt.

Course L2380: Special topics of civil engineering 3 LP	
Typ	
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Fachtheoretisch-fachpraktische Arbeit
Examination duration and scale	wird zu Beginn der Lehrveranstaltung festgelegt
Lecturer	Dozenten des SD B
Language	DE
Cycle	WiSe/SoSe
Content	The course occurs only if required. The content is defined at short notice.
Literature	Die Literatur wird kurzfristig festgelegt.

Course L2789: Structural Design	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	20 min
Lecturer	Dr. Jan Mittelstädt
Language	DE/EN
Cycle	SoSe
Content	
Literature	[1] Structure Systems by Heino Engel, Hantje Cantz, 3rd edition (Feb 2007), ISBN-10: 3775718761 Form and Force, Designing Efficient, Expressive Structures by Allan, E., Zalewski, W. et al, John Wiley and Sons; 1st edition (Sept 2009), ISBN-10: 047017465X [2] Peter Rice: An Engineer Imagines, ISBN-10 : 1849944237 [3] Konrad Wachsmann and the Grapevine Structure by C. Sumi et al., Park Books (Oct 2018), ISBN-10: 9783038601104 [4] Manual of Multi-Story Timber Construction by Hermann Kaufmann, Stefan Krotsch, Stefan Winter, DETAIL, (June 2018), ISBN-10: 3955533948 [5] The Art of Structural Design: A Swiss Legacy by B. Billington, Princeton University Art Museum; First Edition edition (Mar 2003), ISBN-10: 0300097867 [6] Structured Lineages: Learning from Japanese Structural Design by G. Nordenson et al, The Museum of Modern Art (Jul 2019), ISBN-10: 1633450562 [7] The Structure: Works of Mahendra Raj by V. Mehta, R. Mehndiretta, A. Huber, Park Books (Oct 2015), ISBN-10: 3038600253

Module M1505: Adaptation to Climate Change in Hydraulic Engineering (AKWAS)

Courses

Title	Typ	Hrs/wk	CP
Adaptation to climate change in hydraulic engineering (L2291)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	• Hydrology, Hydraulic Engineering • Hydromechanic, Hydraulics • Fundamentals of Coastal Engineering, Coastal- and Flood Protection • Hydrological Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Climate protection and climate adaptation • Insights into climate change and its regional characteristics - fundamentals, climate modelling / climate models • Impacts of climate change on the components of the regional hydrological cycle • Fundamentals of analysis of climate data • Consequences of the impact of the climate change • Measures for climate adaptation • Assessment, prioritization and communication of adaptation measures • Fundamentals of the analysis of hydrometeorological and hydrological data
Skills	• Critical thinking: analysis of processes and relations, assessment of needs for action • Creative thinking: development of adaptation strategies and adaptation measures • Practical thinking: inclusion of restrictions, application of calculation approaches, methods, numerical models, planning methods • Consideration of complex tasks
Personal Competence	
Social Competence	• Working in heterogenous groups • Working with different scientific / non-scientific disciplines • Self reflection
Autonomy	• Application oriented use of knowledge and skills • Autonomous work on complex tasks
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Preparation of a written report and a presentation of a complex task.
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2291: Adaptation to climate change in hydraulic engineering	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Peter Fröhle
Language	DE
Cycle	WiSe
Content	• Climate protection and climate adaptation • Findings on climate change and its regional characteristics: fundamentals of climate change, climate modelling / climate models • Impacts of climate change on the components of the regional hydrological cycle(climate science view) • Fundamentals of the analysis of climate data • Concequences of the impacts of climate change (ingenieering science view) • Measures for climate change adaptation • Assessment, prioritization and communication of measures • Fundamentals of analysis of hydrometeorological and hydrological data
Literature	• Wird bereitgestellt über die HOOU - eLearning Plattform • abhängig von den jeweils schwerpunktmäßig behandelten Fragestellungen wird das Schrifttum (aktuelle Paper) in der Veranstaltung bzw. über StudIP zur Verfügung gestellt.

Module M1779: Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC)

Courses

Title	Typ	Hrs/wk	CP
Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC) (L2926)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	• Hydraulic Engineering • Hydromechanics, Hydraulics • Fundamentals of Coastal Engineering, Coastal- and Flood Protection
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Climate and Climate Change • General Impacts of Climate Change on Wind Regime and Water Cycle • Consequences of Climate Change for Coastal Processes • Coastal Protection in Taiwan and Germany • Fundamentals of Climate Adaptation • Nature-based Solutions (NBS) for Coastal Protection
Skills	• Critical thinking: analysis of processes and relations, assessment of needs for action • Creative thinking: development of adaptation strategies and adaptation measures • Practical thinking: inclusion of restrictions, application of calculation approaches, methods, numerical models, planning methods • Consideration of complex tasks
Personal Competence	
Social Competence	• Working in heterogenous groups • Working in international groups • Working with different scientific / non-scientific disciplines • Self reflection
Autonomy	• Application oriented use of knowledge and skills • Autonomous work on complex tasks
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Preparation of a written report on a complex task with a presentation and subsequent discussion. The work on the complex task happens in the course of the lecture.
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2926: Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC)	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Peter Fröhle
Language	EN
Cycle	WiSe
Content	• Climate and Climate Change • General Impacts of Climate Change on Wind Regime and Water Cycle • Consequences of Climate Change for Coastal Processes • Coastal Protection in Taiwan and Germany • Fundamentals of Climate Adaptation • Nature-Based Solutions (NBS) for Coastal Protection
Literature	• Materials provided on eLearning Platform (HOOU Platform) • Depending on the main topics of the course in the respective year, the literature (recent papers) will be provided in the course-material or via StudIP.

Module M1725: Scientific Working in Computational Engineering

Courses

Title	Typ	Hrs/wk	CP
Scientific Working in Computational Engineering (L2764)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Kay Smarsly
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in scientific writing. String interest in topics related to computing in civil engineering.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students will learn to apply concepts and methods of scientific working in computational engineering. In interaction with the course instructors and in collaboration with each other, the students will also learn to understand the complex process of scientific thinking, being able to accurately plan, implement and analyze scientific projects, such as prospective master theses. A project will be conducted throughout the semester, which will contribute to the grade. Since scientific writing is of particular importance in this course, a scientific paper will be developed based, which is a prerequisite for the final examination. The paper will be written based on the project conducted within this course. Project meetings in small groups, presentations, and critical discussions of scientific publications are further key activities.
Skills	The students will be capable (i) of solving a scientific problem following a scientific methodology, (ii) of documenting their work effectively in the form of a paper, and (iii) of sharing their work in a presentation.
Personal Competence	
Social Competence	The students will be able to work in a multidisciplinary team and develop communication skills necessary for problem solving.
Autonomy	The students will be able to extend their knowledge and apply it to solve scientific problems by working independently in a project.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	10 pages of work with 15-minute oral presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory

Course L2764: Scientific Working in Computational Engineering

Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Kay Smarsly
Language	EN
Cycle	WiSe/SoSe
Content	In the course, a scientific problem of practical relevance will first be defined, taking into account the interests of the students participating in the course. The scientific problem will then systematically be solved within the framework of a comprehensive project. The principles of scientific working will be taught based on the scientific problem defined previously. As an integral part of scientific working, fundamentals of scientific writing will be presented and applied to a scientific paper to be written during the course. Topics related to scientific writing include structuring in scientific writing (structuring the abstract, the introduction, the main part, the summary and conclusions, and the acknowledgments and references) and recommendations on effective scientific writing (principles of composition, use of English in scientific writing, useful tips, creating figures, writing in mathematics, referencing, and formal email correspondence). A final paper and a final presentation will be assembled by the students.
Literature	Smarsly, K. & Dragos, K., 2019. Scientific Writing in Engineering. Tredition, Hamburg, Germany.

Module M1844: Modern discretization methods in structural mechanics

Courses

Title	Typ	Hrs/wk	CP
Modern discretization methods in structural mechanics (L3043)	Lecture	2	3
Modern discretization methods in structural mechanics (L3044)	Recitation Section (small)	2	3

Module Responsible	Prof. Bastian Oesterle
Admission Requirements	None
Recommended Previous Knowledge	• Finite Element Methods • Flächentragwerke
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of this module, students can express the basic aspects of modern discretization methods in structural mechanics.
Skills	After successful completion of this module, the students will be able to use and further improve modern discretization methods for problems in structural mechanics.
Personal Competence	
Social Competence	Students can • participate in subject-specific and interdisciplinary discussions, • defend their own work results in front of others • promote the scientific development of colleagues • Furthermore, they can give and accept professional constructive criticism
Autonomy	Students are able to gain knowledge of the subject area from given and other sources and apply it to new problems. Furthermore, they are able to structure the solution process for problems in the area of modern discretization methods.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L3043: Modern discretization methods in structural mechanics

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	EN
Cycle	WiSe
Content	The course covers variational formulations, various locking phenomena and alternative formulations for finite elements and modern discretization schemes in the context of structural mechanics, like isogeometric analysis. • variational formulation of finite elements, mixed variational principles • geometrical and material locking effects in structural and solid mechanics • hybrid-mixed and enhanced assumed strain finite element formulations, reduced integration and stabilization, DSG method, u-p formulations • patch test, stability, convergence • linear and non-linear analyses • introduction to isogeometric analysis • isogeometric beam, plate and shell formulations • locking effects and their avoidance in modern, smooth discretization schemes, like isogeometric analysis
Literature	• lecture notes and selected scientific papers • O.C. Zienkiewicz, R.L. Taylor, and J.Z. Zhu: Finite Element Method: Its Basis and Fundamentals. Elsevier, 2013. • J. Austin Cottrell, Thomas J. R Hughes, Yuri Bazilevs: Isogeometric Analysis: Toward Integration of CAD and FEA. Wiley, 2009.

Course L3044: Modern discretization methods in structural mechanics	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1956: Building and Excavation Law

Courses

Title	Typ	Hrs/wk	CP
Construction law BGB and VOB - law in (excavation) practice (L3182)	Lecture	2	3
Construction disputes from construction (excavation) practice (L3181)	Lecture	2	3

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	Complete modules: Geotechnics I-III
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will gain knowledge of • the history of civil engineering law, • basics of foundation and civil engineering law, • legal aspects of technical regulations in civil engineering (with case studies), • the civil engineering contract, • the liability of the designer and contractor in civil engineering, • the subsoil risk and the system risk, • the total debt in (civil) engineering law, • the (construction) conflict, dispute avoidance models and the construction process, • the systematics of construction contract law, • the BGB construction contract law, • responsibilities on the construction site, • remuneration and contract management, • liability for defects, • public procurement law • Disturbed construction processes: How much money am I entitled to? • Correct calculation of supplements.
Skills	Students learn to apply legal aspects in planning and construction in a legally balanced way. Students learn how to use legal and construction management aspects in practice (planning and construction) on the construction site in a targeted manner and how to manage the construction project optimally.
Personal Competence	
Social Competence	Students can work in groups and support each other in finding solutions.
Autonomy	Students are able to assess their own strengths and weaknesses and organize their time and learning management based on this.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory

Course L3182: Construction law BGB and VOB - law in (excavation) practice

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Günther Schalk
Language	DE
Cycle	WiSe
Content	
Literature	Literatur: - Folienskript (in der Vorlesung erhältlich) - Fuchs/Maurer/Schalk: Handbuch Tiefbaurecht

Course L3181: Construction disputes from construction (excavation) practice	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Ingo Junker
Language	DE
Cycle	WiSe
Content	
Literature	

Module M0859: Coastal Hydraulic Engineering II

Courses

Title	Typ	Hrs/wk	CP
Coastal- and Flood Protection (L0808)	Lecture	2	3
Coastal- and Flood Protection (L1415)	Project-/problem-based Learning	1	1
Maintenance and Defence of Flood Protection Structures (L1411)	Lecture	2	2

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Coastal Engineering I
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students have the capability to define and explain in detail the important aspects of erosion protection and flood protection and are able to apply the aspects to practical coastal protection problems. They are able to design and dimension important coastal protection measures from the functional and from the constructional point of view.
Skills	The students are able to select design approaches for the functional and constructional design of erosion and flood protection measures and apply these approaches to practical design tasks.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in applied problems such as the functional and constructive design of coastal and flood protection structures. Additionaly, they will be able to work in team with engineers of other disciplines.
Autonomy	The students will be able to independently extend their knowledge and apply it to new problems.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	The duration of the examination is 130 min. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L0808: Coastal- and Flood Protection	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Peter Fröhle
Language	EN
Cycle	WiSe

Content	Protection of sandy coasts
	• Sediment transport
	• Morphology
	• Technical solution for the protection of sandy coasts
	    ◦ Construction in direction of the coast
	    ◦ Constructions perpendicular to the coast
	    ◦ Other Concepst
	• Calculation approaches and numerical models
	
	Flood Protection
	• Classification of constructions / measures
	• Dikes
	• Dunes
	• Foreland - constructions
	• Flood-Protection Walls
	• Drainage of the hinterland

Literature	Vorlesungsumdruck Coastal Engineering Manual CEM

Course L1415: Coastal- and Flood Protection	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1411: Maintenance and Defence of Flood Protection Structures	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Olaf Müller
Language	EN
Cycle	WiSe
Content	• Dike protection • Maintennance of flood protection measures
Literature	Vorlesungsumdruck

Module M2003: Biological Waste Treatment

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Waste and Environmental Chemistry (L0328)	Practical Course	2	2
Biological Waste Treatment (L0318)	Project-/problem-based Learning	3	4

Module Responsible	Prof. Kerstin Kuchta
Admission Requirements	None
Recommended Previous Knowledge	chemical and biological basics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The module aims possess knowledge concerning the planning of biological waste treatment plants. Students are able to explain the design and layout of anaerobic and aerobic waste treatment plants in detail, describe different techniques for waste gas treatment plants for biological waste treatment plants and explain different methods for waste analytics.
Skills	The students are able to discuss the compilation of design and layout of plants. They can critically evaluate techniques and quality control measurements. The students can recherché and evaluate literature and date connected to the tasks given in der module and plan additional tests. They are capable of reflecting and evaluating findings in the group.
Personal Competence	
Social Competence	Students can participate in subject-specific and interdisciplinary discussions, develop cooperated solutions and defend their own work results in front of others and promote the scientific development in front of colleagues. Furthermore, they can give and accept professional constructive criticism.
Autonomy	Students can independently tap knowledge from literature, business or test reports and transform it to the course projects. They are capable, in consultation with supervisors as well as in the interim presentation, to assess their learning level and define further steps on this basis. Furthermore, they can define targets for new application-or research-oriented duties in accordance with the potential social, economic and cultural impact.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** Yes / None / Subject theoretical and practical work
Examination	Presentation
Examination duration and scale	Elaboration and Presentation (15-25 minutes in groups)
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Environmental Engineering: Core Qualification: Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory

Course L0328: Waste and Environmental Chemistry	
Typ	Practical Course
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	WiSe
Content	The participants are divided into groups. Each group prepares a transcript on the experiment performed, which is then used as basis for discussing the results and to evaluate the performance of the group and the individual student. In some experiments the test procedure and the results are presented in seminar form, accompanied by discussion and results evaluation. Experiments ar e.g. Screening and particle size determination Fos/Tac AAS Chalorific value
Literature	Scripte

Course L0318: Biological Waste Treatment	
Typ	Project-/problem-based Learning
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	WiSe
Content	1. Introduction 2. biological basics 3. determination process specific material characterization 4. aerobic degradation (Composting, stabilization) 5. anaerobic degradation (Biogas production, fermentation) 6. Technical layout and process design 7. Flue gas treatment 8. Plant design practical phase
Literature	

Module M2025: Finite element modeling of structures

Courses

Title	Typ	Hrs/wk	CP
Finite element modeling of structures (L3046)	Lecture	2	3
Finite element modeling of structures (L3047)	Recitation Section (small)	2	3

Module Responsible	Prof. Bastian Oesterle
Admission Requirements	None
Recommended Previous Knowledge	• Finite Element Methods • Thin-walled structures
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of this module, students can express the basic aspects of modelling of structures with finite elements.
Skills	After successful completion of this module, the students will be able to model structures with finite elements and to analyse structures using appropriate computational methods.
Personal Competence	
Social Competence	Students can • participate in subject-specific and interdisciplinary discussions, • defend their own work results in front of others • promote the scientific development of colleagues • Furthermore, they can give and accept professional constructive criticism
Autonomy	Students are able to gain knowledge of the subject area from given and other sources and apply it to new problems. Furthermore, they are able to structure the solution process for problems in the area of finite element modelling of structures.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	written elaboration of a project work (10-15 pages)
Assignment for the Following Curricula	Civil Engineering: Specialisation Computational Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L3046: Finite element modeling of structures

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	EN
Cycle	WiSe
Content	Basic phenomena and aspects of the finite element modelling of structures are discussed. Besides theoretical decription of the phenomena and methods, a strong focus is on the practical use a commercial finite element software within computer-based exercises. The covered topics are: • finite element modeling of trusses/beams/frames, plates subject to in-plane/out-of-plane loading and shells • convergence properties of displacements and stresses • singularities • locking effects • critical assessment, interpretation and check of results • mixed-dimensional coupling of finite elements • geometrically linear and non-linear, and material linear and non-linear analyses • stability: bifurcation and snap-through problems • dynamic problems, modal analyses
Literature	Vorlesungsmanuskript, Vorlesungsfolien

Course L3047: Finite element modeling of structures	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M2033: Subsurface Processes

Courses

Title	Typ	Hrs/wk	CP
Modeling of Subsurface Processes (L2731)	Recitation Section (small)	3	3
Subsurface Solute Transport (L2728)	Lecture	2	2
Subsurface Solute Transport (L2729)	Recitation Section (large)	1	1

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	Basic Mathematics, Hydrology
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Upon completion of this module, the students will understand the mechanisms controlling solute transport in soil and natural porous media and will be able to work with the equations that govern the fate and transport of solutes in porous media. Analytical, numerical and experimental tools and techniques will be used in this module.
Skills	In addition to the physical insights, the students will be exposed to analytical, experimental and numerical tools and techniques in this module. This provides them with an excellent opportunity to improve their skills on multiple fronts which will be useful in their future career.
Personal Competence	
Social Competence	Teamwork & problem solving
Autonomy	The students will be involved in writing individual reports and presentation. This will contribute to the students' ability and willingness to work independently and responsibly.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	Report
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Environmental Engineering: Core Qualification: Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory

Course L2731: Modeling of Subsurface Processes

Typ	Recitation Section (small)
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Dr. Milad Aminzadeh
Language	EN
Cycle	WiSe
Content	Basic usage and background of chosen computer software to calculate flow and transport in the saturated and unsaturated zone and to analyze field data like pumping test data
Literature	

Course L2728: Subsurface Solute Transport	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	WiSe
Content	Basic physical properties of soil: Definition and quantification; Liquid flow in soils (Darcy's law); Solute transport in soils; Practical analysis to measure dispersion coefficient in soil under different boundary conditions; Advanced topics (e.g. Application of Artificial Intelligence to predict soil salinization)
Literature	- Environmental Soil Physics, by Daniel Hillel - Soil Physics, Sixth Edition, by William A. Jury and Robert Horton

Course L2729: Subsurface Solute Transport	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Hannes Nevermann
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Specialization Structural Engineering

Module M0713: Concrete Structures

Courses

Title	Typ	Hrs/wk	CP
Concrete Structures (L0579)	Seminar	1	1
Structural Concrete Members (L0577)	Lecture	2	3
Structural Concrete Members (L0578)	Recitation Section (large)	2	2

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	Basics of structural analysis, conception and dimensioning of structural concrete Modules: Reinforced Concrete Structures I+II, Structural Analysis I+II, Mechanics I+II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students broaden their skills in structural engineering, especially in the field of buildings (houses, roofs, halls). They dispose of the knowledge for the conception and design of concrete buildings and structural members that are often used.
Skills	The students are able to apply procedures of the conception and dimensioning to to practical problems of structural engineering. They are capable to draft concrete buildings and to design them for general action effects and to plan their detailing and execution. Moreover, they can make design and construction sketches and draw up technical descriptions.
Personal Competence	
Social Competence	The students are able to obtain results of high quality in teamwork.
Autonomy	The students are able to carry out complex conception and dimensioning tasks of structures under the guidance of tutors.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** No / **Bonus** None / **Form** Presentation / **Description** Es werden 2 Referate ausgegeben
Examination	Written exam
Examination duration and scale	120 minutes
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L0579: Concrete Structures

Typ	Seminar
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	NN
Language	DE
Cycle	WiSe
Content	With help of a project teamwork the subjects of the course "Concrete Structures" is practiced, discussed and presented.
Literature	- Projektbezogene Unterlagen werden abgegeben.

Course L0577: Structural Concrete Members	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	NN
Language	DE
Cycle	WiSe
Content	• skyscrapers: structural elements • actions on structrues • bracing systems • design orf slabs (line and point supported plates and floor slabs) • membranes and deep beams • folded plates and shells • truss models • reinforced and prestressed members
Literature	Vorlesungsunterlagen können im STUDiP heruntergeladen werden • Zilch K., Zehetmaier G.: Bemessung im konstruktiven Ingenieurbau. Springer, Heidelberg 2010 • König, G., Liphardt S.: Hochhäuser aus Stahlbeton, Betonkalender 2003, Teil II, Seite 1-69, Verlag Ernst & Sohn, Berlin 2003 • Phocas, Marios C.: Hochhäuser : Tragwerk und Konstruktion, Stuttgart, Teubner, 2005 • Deutscher Ausschuss für Stahlbeton: Heft 600: Erläuterungen zu DIN EN 1992-1-1, Beuth Verlag, Berlin 2012 • Deutscher Ausschuss für Stahlbeton: Heft 240: Hilfsmittel zur Berechnung der Schnittgrößen und Formänderungen von Stahlbetontragwerken, Verlag Ernst & Sohn, Berlin 1978 • Stiglat, K., Wippel, H.: Massive Platten - Ausgewählte Kapitel der Schnittkraftermittlung und Bemessung, Betonkalender 1992, Teil I, 287-366, Verlag Ernst & Sohn, Berlin 1992 • Stiglat/Wippel: Platten. Verlag Ernst & Sohn, Berlin,1973 • Schlaich J.; Schäfer K.: Konstruieren im Stahlbetonbau. Betonkalender 1998, Teil II, S. 721ff, Verlag Ernst & Sohn, Berlin, 1998 • Dames K.-H.: Rohbauzeichnungen Bewehrungszeichnungen. Bauverlag, Wiesbaden 1997

Course L0578: Structural Concrete Members	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	NN
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0699: Geotechnics III

Courses

Title	Typ	Hrs/wk	CP
Numerical Methods in Geotechnics (L0375)	Lecture	3	3
Advanced Foundation Engineering (L0497)	Lecture	2	2
Advanced Foundation Engineering (L0498)	Recitation Section (large)	1	1

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	Geotechnics I and II, Mathematics I-III
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successfully completing the module, students will be able to • describe individual procedures for the geotechnical monitoring of civil engineering measures, • reproduce exploration and investigation methods of the subsoil, • select suitable types of field and laboratory tests for subsoil investigation and evaluate their results, • state the differences between various stress and deformation states and the physical significance of invariants of the stress and distortion tensor, • outline the standard and special soil mechanics tests used to determine the stress-strain behavior of soil, • describe continuum models and the resulting boundary value problems, • as well as define boundary value problems from the field of geotechnical engineering in such a way that they can be solved unambiguously.
Skills	Students will be able to • dimension vertical drains for soil improvement of soft soils, • calculate depth compaction using various appropriate methods, • apply principles of horizontal bearing capacity of piles, • verify the internal and external stability of fluid-supported diaphragm walls, • evaluate the boundary conditions for the design of a deep excavation and design the individual components of the excavation, • perform, evaluate and interpret tests for the description and classification of soils according to applicable standards, • computationally implement numerical algorithms to solve boundary value problems, • select and apply the types of analyses depending on the degree of saturation, the impact, and the material behavior • determine appropriate model parameters for different possibilities and limitations of material models for the grain structure of soils.
Personal Competence	
Social Competence	Students can work in groups and support each other in finding solutions.
Autonomy	Students are able to assess their own strengths and weaknesses and, based on this, organize their time and learning management and think in terms of processes.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L0375: Numerical Methods in Geotechnics	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Dr. Hans Mathäus Stanford
Language	DE
Cycle	WiSe
Content	Topics: • Introduction to numerical soil mechanics • Introduction to numerical mathematics • Finite Element Method (analysis procedures, algorithms) • Finite Element Method (application in geotechnical engineering)
Literature	• Wriggers P. (2001): Nichtlineare Finite-Elemente-Methoden. Springer • Wriggers P. (2008): Nonlinear Finite Element Methods. Springer • Deutsche Gesellschaft für Geotechnik e.V. (Hrsg., 2014): Empfehlungen des Arbeitskreises "Numerik in der Geotechnik". Ernst & Sohn

Course L0497: Advanced Foundation Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	WiSe
Content	• Vertical drains • Piles • Ground improvement (Deep Compaction, Soil mixing) • Vibration driving • Jet grouting • Slurry wall • Deep excavation
Literature	• EAK (2002): Empfehlungen für Küstenschutzbauwerke • EAU (2004): Empfehlungen des Arbeitsausschusses Uferbauwerke • EAB (1988): Empfehlungen des Arbeitskreises Baugruben • Grundbau-Taschenbuch, Teil 1-3, (1997), Ernst & Sohn Verlag

Course L0498: Advanced Foundation Engineering	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0963: Steel and Composite Structures

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Steel and Composite Structures (L1204)	Lecture	2	2
Steel and Composite Structures (L1205)	Recitation Section (large)	2	2
Steel Bridges (L1097)	Lecture	2	2

Module Responsible	Prof. Marcus Rutner
Admission Requirements	None
Recommended Previous Knowledge	Basics of steel construction (i.e. Steel Structures I and II, BUBC)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completition, students can • describe the phenomenon of local buckling • explain warping torsion • illustrate the behaviour of composite structures • specify the principles in design of composite sttructures • sketch the contructions of steel and composite bridges
Skills	After successful participation students are able to • check stiffened and unstiffened plated structures • recognize and verify warping tosion in strucures • design composite structures • design bridges and o perform the detailing
Personal Competence	
Social Competence	--
Autonomy	--
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	180 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L1204: Steel and Composite Structures

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Marcus Rutner
Language	DE
Cycle	WiSe
Content	• Local-buckling of plated structures • Warping torsion • Composite-girders, -columns, -slabs, -bridges • Principles in composite constructions • Bridge-design and -construction
Literature	Petersen, C.: Stahlbau, 4.Auflage 2013, Springer-Vieweg Verlag Minnert, J. Wagenknecht, G.: Verbundbau-Praxis - Berechnung und Konstruktion nach Eurocode 4, 2.Auflage 2013, Bauwerk Beuth Verlag

Course L1205: Steel and Composite Structures	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Marcus Rutner
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1097: Steel Bridges	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Yves Freundt
Language	DE
Cycle	WiSe
Content	**Lecture Contents ‚Steel Bridge Construction'** **Dr.-Ing. Jörg Ahlgrimm** - From tendering and contracting to completion - the development of a steel bridge - Contents of a bridge static - structural details, examples of analysis in detail: -> effective width in regard to the longitudinal stiffeners -> Bearing point, bearing stiffener -> Crossbeam breakthrough, crossbeam reinforcement -> Analysis of the Rib-to-Floorbeam (RF) connection (web-tooth of the floorbeam between trapezoidal shaped Ribs) - Steel grades, -designation, testing methods and approval certificates - Nondestructive weld inspecting - Corrosion protection - Bridge bearing - types, format, function, dimensioning, installation - Expansion Joints - Oscillation of bridge hangers and cables - oscillation damper - Opening bridges- Detailed reviews to different assembling procedures and - implements - Selective damage events Requirements: Basic knowledge in the calculation, dimensioning, and construction of structural elements and joints of constructional steelwork
Literature	• Herbert Schmidt, Ulrich Schulte, Rainer Zwätz, Lothar Bär: Ausführung von Stahlbauten • Petersen, Christian: Stahlbau, Abschnitt Brückenbau • Ahlgrimm, J., Lohrer, I.: Erneuerung der Eisenbahnüberführung in Fulda-Horas über die Fulda, Stahlbau 74 (2005), Heft 2, S. 114

Module M1748: Construction Robotics

Courses

Title	Typ	Hrs/wk	CP
Construction Robotics (L2867)	Project-/problem-based Learning	6	6

Module Responsible	Prof. Kay Smarsly
Admission Requirements	None
Recommended Previous Knowledge	Basics of project-oriented programming
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Basics of robotics Applications in civil engineering Kinematics
Skills	Use of specific hardware Development of software routines Python programming language Image processing Basics of localization (LIDAR, SLAM)
Personal Competence	
Social Competence	Teamwork Communication skills
Autonomy	Independent work Independent decisions
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	ca. 10 Seiten
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Course L2867: Construction Robotics	
Typ	Project-/problem-based Learning
Hrs/wk	6
CP	6
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Lecturer	Prof. Kay Smarsly, Jan Stührenberg
Language	EN
Cycle	WiSe

Content	1. Introduction: Robotics in civil engineering
	2. Presentation of potential topics
	3. Programming of algorithms in Python
	4. Application of software systems: LINUX distribution, ROS, CloudCompare, ...
	5. Application of hardware systems: Petoi Bittle Dog, Raspberry Pi, Arduino, sensing ...
	6. Topics considered for robotics using the Petoi Bittle Dog:
	    1. Movement
	    2. Use of sensors (camera, infrared, ...)
	    3. Data structures/data acquisition
	    4. Programming
	7. Topics technically relevant to building inspection:
	    1. Geodetic evaluations
	    2. Image processing
	    3. Localization

Literature	Bock/Linner: Construction Robotics Verl et al.: Soft Robotics Pasquale: New Laws of robotics

Module M1895: Digital Twinning in Civil Engineering

Courses

Title	Typ	Hrs/wk	CP
Digital Twinning in Civil Engineering (L3136)	Lecture	2	2
Digital Twinning in Civil Engineering (L3137)	Seminar	2	4

Module Responsible	Alexander Chmelnizkij
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	
Skills	
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Presentation
Examination duration and scale	20 min presentation and 5 pages handout
Assignment for the Following Curricula	Civil Engineering: Specialisation Computational Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory

Course L3136: Digital Twinning in Civil Engineering

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Alexander Chmelnizkij, Prof. Bastian Oesterle, Prof. Kay Smarsly
Language	DE
Cycle	SoSe
Content	
Literature	

Course L3137: Digital Twinning in Civil Engineering

Typ	Seminar
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Alexander Chmelnizkij, Prof. Bastian Oesterle, Prof. Kay Smarsly
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0723: Design of Prestressed Structures and Concrete Bridges

Courses

Title	Typ	Hrs/wk	CP
Design of Prestressed Structures and Concreet Bridges (L0603)	Lecture	3	4
Design of Prestressed Structures and Concreet Bridges (L0604)	Recitation Section (large)	2	2

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	Detailed knowledge on the design of concrete structures. Modules: Reinforced Concrete Structures I+II, Structural Analysis I+II, Mechanics I+II, Concrete Structures
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students know the main bridge types, their applications and the various loads. They can explain the basic design methods. They can explain the design of a prestressed bridge.
Skills	The students are able to design reinforced or prestressed concrete bridges.
Personal Competence	
Social Competence	The students can design in teamwork a real concrete bridge.
Autonomy	The students are able to design a prestressed concrete bridge and discuss the problems and results with other students.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	180 minutes
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L0603: Design of Prestressed Structures and Concreet Bridges	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	NN
Language	DE
Cycle	SoSe
Content	prestressed structures • basis of prestressed structures, field of application • differences between reinforced and prestressed concrete structures • history of prestressing • construction materials: concrete, tendons, ducts, anchorage systems • construction: prestressing methods • prestressing forces and member forces (friction, elongation) • tendon layout • time dependant prestressing losses • design of prestressed structures • design of anchorage region • non-bonded prestressing • prestressed flat slabs Concrete bridges • history of bridges • design of bridges • loads on bridges • member forces for slab, T-beam, hollow box, frame and arch bridges • precast bridges - precast segmental bridges • bearings • abutments, columns • construction methods • damages - checking of bridges
Literature	• Vorlesungsumdruckim STUDiP • Rombach, G. (2003): Spannbetonbau. Ernst & Sohn, Berlin • Wicke, M. (2002): Anwendung des Spannbetons. Betonkalender 2002, Teil II, S. 113-180, Verlag Ernst & Sohn, Berlin • Leonhardt, F. (1980): Vorlesungen über Massivbau. Teil 5: Spannbeton. Berlin • Mehlhorn, G. (2007): Handbuch Brücken, Springer Verlag • Schäfer, H.; Kaufeld, K. (1997): Massivbrücken. Betonkalender Teil II, S. 443ff, Ernst & Sohn, Berlin • Menn, Ch. (1986): Stahlbetonbrücken. Springer Verlag, Wien

Course L0604: Design of Prestressed Structures and Concreet Bridges	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	NN
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0756: Soil Mechanics and -Dynamics

Courses

Title	Typ	Hrs/wk	CP
Soil Mechanics - Selected Topics (L0374)	Lecture	2	2
Soil Dynamics (L0452)	Lecture	2	2
Experimental Researches in Geotechnics (L0706)	Practical Course	2	2

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	Modules: Mathematics I-III, Mechanics I-II, Geotechnics I Courses: Soil laboratory course, (Applied structural dynamics)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will be able to, • describe wave propagation in the ground under dynamic excitation and define the relevant parameters, • to measure vibrations and to interpret the data obtained with regard to their effect on people and structures, • justify when elastodynamic methods are sufficient and when plastodynamic effects must be taken into account, • to reproduce the collapse theorems of plasticity theory, • describe the viscous behavior of cohesive soils and computationally account for creep deformation and rate-dependent shear strengths • as well as to determine the effect of partial saturation on the seepage flow and the shear strength.
Skills	After the successful completion of the module the students should be able to: • to derive and apply the basic equation of a simple mass oscillator, • to understand the wave propagation in the soil under dynamic excitation and to detect the relevant parameters, • to know the essential laboratory and field tests to determine soil dynamic characteristics and to evaluate them, • to design machine foundations to dynamic load, • to measure shocks to perform vibration forecast, • to evaluate shocks in terms of their effect on people and buildings, • to evaluate possibilities of isolation, • to understand mechanisms that cause earthquakes and evaluate earthquakes in terms of their magnitude and intensity, • to know methods to determine axial pile capacity, integrity, and the dynamic bedding modulus, • to know the mechanisms that lead to a deformation accumulation due to cyclic loading and to estimate these deformations mathematically, • to distinguish the area of application of the method of elastodynamics and plastodynamics, • to detect the undrained shear strength as a function of a number of state variables, • to capture the visous behaviour of cohesive soils and to consider the effects of creep and rate-dependent shear strength in calculations, • to consider the impact of the partly saturated of a seepage and shear strength.
Personal Competence	
Social Competence	Students will be able to work in teams to achieve results on measurement and experimental principles and present their results together at the end of the semester.
Autonomy	Students are able to assess their own strengths and weaknesses and organize their time and learning management based on this.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** Yes / None / Subject theoretical and practical work /
Examination	Written exam
Examination duration and scale	135 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory

Course L0374: Soil Mechanics - Selected Topics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Hans Mathäus Stanford
Language	DE
Cycle	SoSe
Content	selected topis: • Stress-strain behaviour (experiments, observations, models) • Hydraulic behaviour (experiments, observations, models) • Physical modelling (similarity theory, 1g model tests, ng model tests) • Limit and safety analysis (collapse theorems of plasticity theory, upper and lower bound analysis, limit equilibrium analysis, numerical analysis) • Heat transport (heat conduction, convective heat transport, freezing/thawing)
Literature	• Kolymbas D. (2019): Geotechnik - Bodenmechanik, Grundbau und Tunnelbau. Springer Verlag, 5. Auflage • Muir Wood D. (2004). Geotechnical modelling. CRC Press Nova, R. (2010). Soil mechanics. Wiley Verruijt, A. (2012). Soil mechanics. u r l: https://geo.verruijt.net Verrujit A. (2018). An introduction to soil mechanics. Vol. 30, Springer Series Theory and Applications of Transport in Porous Media

Course L0452: Soil Dynamics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Anne Hagemann
Language	DE
Cycle	SoSe
Content	• mass-spring-damper systems, • wave propagation in soils, • dynamic soil parameters, • Determination of dynamic soil parameters, • machine foundations, • in-situ measurement of ground motion, ground motion prediction, evaluation of ground motion, • ground motion shielding, • introduction into earthquake engineering, • dynamic pile tests, • cyclic accumulation, • plastodynamics
Literature	• Das B.M.: Fundamentals of Soil Dynamics, Elsevier • Empfehlungen des Arbeitskreises Baugrunddynamik. Hrsg. Deutsche Gesellschaft für Geotechnik (DGGT) • Haupt W.: Bodendynamik. Vieweg und Teubner • Meskouris K. und Hinzen K.-G.: Bauwerke und Erdbeben. Vieweg Verlag • Studer J.A., Koller M.G. und Laue J.: Bodendynamik, Springer Verlag

Course L0706: Experimental Researches in Geotechnics	
Typ	Practical Course
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Hans Mathäus Stanford, Göta Bürkner
Language	DE
Cycle	SoSe
Content	The students are supposed to: • become acquainted with geotechnical model tests, field tests and laboratory tests as well as corresponding measurement techniques. These compromise amongst others inclinometer measurements and geophone measurements as well as high-grade laboratory tests on the stress-strain relationship of soil specimens, e. g. triaxial tests, simple shear tests and resonant column tests. • gain insight into current soil mechanical research. • plan, coordinate, perform and evaluate soil mechanical tests in a team. • discuss, reflect, review and present the obtained results in a group. An important learning target is the introduction to scientific work for students who plan a scientific career, and for those who will work in practice with the responsibility to order corresponding tests and evaluate the results. The practical laboratory work is based on annualy changing problems, which are however related to the experience and results of the preceding year's course group.
Literature	- Grabe, J. (2004): Bodenmechanik und Grundbau, Band 3 der Veröffentlichungsreihe des Instituts für Geotechnik und Baubetrieb, Technische Universität Hamburg-Harburg. - Kolymbas, D. (2007): Geotechnik - Bodenmechanik, Grundbau und Tunnelbau. 2., korrigierte und ergänzte Auflage, Springer Verlag. - Normen zu geotechnischen Versuchsgeräten und Versuchsverfahren: - DIN 18135:2012-04: Baugrund, Untersuchung von Bodenproben - Eindimensionaler Kompressionsversuch, Deutsches Institut für Normung, e. V. - DIN 18137-2:2011-04: Baugrund, Untersuchung von Bodenproben - Bestimmung der Scherfestigkeit - Teil 2: Triaxialversuch, Deutsches Institut für Normung e. V.

Module M0827: Modeling in Water Management

Courses

Title	Typ	Hrs/wk	CP
Groundwater Modeling using Modflow (L0543)	Lecture	1	1
Groundwater Modeling using Modflow (L0544)	Recitation Section (small)	2	2
Modeling of Water Supply Network (L0875)	Project-/problem-based Learning	2	3

Module Responsible	Dr. Klaus Johannsen
Admission Requirements	None
Recommended Previous Knowledge	Groundwater • groundwater hydraulics and transport of substances Pipe Systems • Knowledge on urban water infrastructures, in particular drinking water systemsand urban drainage systems including special structures • Hydraulics of drinking water supply systems and sewer systems • Basic knowledge on water management
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe the modelling of groundwater flow and transport as well as urban water infrastructures. They can carry out systems analyses and can detect technical and conceptual weak points within the systems in case studies. Besides they are able to analyse interdependencies of hydraulic and toxic phenomena in soil and water.
Skills	The students are able to construct and apply scientific groundwater models indipendently. They can work on different scenarios and can compare or assess different solutions for existing problems by application of selected software products. The students are able to use different software solutions (e.g. EPANET, EPA-SWMM).
Personal Competence	
Social Competence	Wird nicht vermittelt.
Autonomy	Wird nicht vermittelt.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L0543: Groundwater Modeling using Modflow

Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Sonja Götz
Language	DE/EN
Cycle	SoSe
Content	Introduction and application of the groundwater model MODFLOW (PMWIN); theoretical backround of the modell, students do work with the model PMWIN for practical case studies.
Literature	MODFLOW-Handbuch Chiang, Wen Hsien: PMWIN

Course L0544: Groundwater Modeling using Modflow	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Sonja Götz
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0875: Modeling of Water Supply Network	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Klaus Johannsen
Language	DE
Cycle	SoSe
Content	
Literature	Mutschmann/Stimmelmayr: Taschenbuch der Wasserversorgung, 16. Auflage. Springer Vieweg - Verlag. Wiesbaden 2014.

Module M0828: Urban Environmental Management

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Noise Protection (L1109)	Lecture	2	2
Urban Infrastructures (L0874)	Project-/problem-based Learning	2	4

Module Responsible	Dr. Dorothea Rechtenbach
Admission Requirements	None
Recommended Previous Knowledge	• Knowledge on Urban planning • Knowledge on measures for climate protection • General knowledge of scientific writing/working
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can describe urban development corridors as well as current and future urban environmental problems. They are able to explain the causes of environmental problems (like noise). Students can specify applications for various technical innovations and explain why these contribute to the improvement of urban life. They can, for example, derive and discuss measures for effective noise abatement.
Skills	Students are able to develop specific solutions for correcting existing or future environment-related problems of urban development. They can define a range of conceptual and technical solutions for environmental problems for different development paths. To solve specific urban environmental problems they can select technical innovations and integrate them into the urban context.
Personal Competence	
Social Competence	The students can work together in international groups.
Autonomy	Students are able to organize their work flow to prepare themselves for presentations and contributions to the discussions. They can acquire appropriate knowledge by making enquiries independently.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Written Report plus oral Presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L1109: Noise Protection

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Martin Jäschke
Language	EN
Cycle	SoSe
Content	
Literature	1) Müller & Möser (2013): Handbook of Engineering Acoustics (also available in German) 2) WHO (1999): Guidelines for Community Noise 3) Environmental Noise Directive 2002/49/EG 4) ISO 9613-2 (1996): Acoustics, Attenuation of sound during propagation outdoors, Part 2: General method of calculation

Course L0874: Urban Infrastructures	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Dr. Dorothea Rechtenbach
Language	EN
Cycle	SoSe
Content	Problem Based Learning Main topics are: • Central vs. Decentral Wastewater Treatment. • Compaction of Cities. • Car Free Cities. • Multifunctional Places in Cities. • The Sustainability of Freight Transport in Cities.
Literature	Depends on chosen topic.

Module M0860: Harbour Engineering and Harbour Planning

Courses

Title	Typ	Hrs/wk	CP
Harbour Engineering (L0809)	Lecture	2	2
Harbour Engineering (L1414)	Project-/problem-based Learning	1	2
Port Planning and Port Construction (L0378)	Lecture	2	2

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Basics of coastal engineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to define in details and to choose design approaches for the functional design of a port and apply them to design tasks. They can design the fundamental elements of a port.
Skills	The students are able to select and apply appropriate approaches for the functional design of ports.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in applied problems such as the functional design of ports. Additionaly, they will be able to work in team with engineers of other disciplines.
Autonomy	The students will be able to independently extend their knowledge and apply it to new problems.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	The duration of the examination is 150 min. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L0809: Harbour Engineering

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Peter Fröhle
Language	DE
Cycle	SoSe

Content	• Fundamentals of harbor engineering
	  ◦ Maritime transportation and waterways engineering
	  ◦ Ships
	• Elements of harbors
	  ◦ Harbor approaches and water-side harbor areas
	  ◦ Terminal design and handling of cargo
	  ◦ Quay-walls and piers
	  ◦ Equipment of harbors
	  ◦ Sluices and other special constructions
	• Connection to inland transportation / inland waterway transportation
	• Protection of harbors
	  ◦ Breakwaters and Jetties
	  ◦ Wave protection of harbors
	• Fishery and other small harbors

Literature	Brinkmann, B.: Seehäfen, Springer 2005

Course L1414: Harbour Engineering	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0378: Port Planning and Port Construction	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Frank Feindt
Language	DE
Cycle	SoSe
Content	• Planning and implementation of major projects • Market analysis and traffic relations • Planning process and plan • Port planning in urban neighborhood • Development of the logistics center "Port of Hamburg" in the metropolis • Quays and waterfront structure • Special planning Law Harbor - securing of a flexible use of the port • Dimensioning of quays • Flood protection structures • Port of Hamburg - Infrastructure and development • Preparation of areas • Scour formation in front of shore structures
Literature	Vorlesungsumdruck, s. www.tu-harburg.de/gbt

Module M0861: Modelling of Hydraulic Engineering

Courses

Title	Typ	Hrs/wk	CP
Hydraulic Models (L0813)	Project-/problem-based Learning	1	1
Modelling of Waves (L0812)	Project-/problem-based Learning	1	1
Modelling of Flow in Rivers and Estuaries (L0810)	Lecture	3	4

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Coastal Hydraulic Engineering I
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to define in detail the basic processes that are related to the modelling of flows in hydraulic engineering. Besides, they can describe the basic aspects of numerical modelling and actual numerical models for the simulation of flows and waves.
Skills	Students are able to apply hydrodynamic-numerical models to practical hydraulic engineering tasks.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in simple applied problems. Additionaly, they will be able to work in team with others.
Autonomy	The students will be able to independently extend their knowledge and apply it to new problems.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	The duration of the examination is 3 hours. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Compulsory

Course L0813: Hydraulic Models

Typ	Project-/problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	• Fundamentals of hydraulic models • Model laws • Pi theorem of Buckingham • Practical examples of hydraulic models
Literature	Strobl, Zunic: Wasserbau, Kap. 11 Hydraulische Modelle, Springer

Course L0812: Modelling of Waves	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	• Waves, interactions with shallow water and constructions • Wave theories • Sea state and surges • Development of waves • Wave spectra • Modelling of Waves / phase averaged and phase resolved models • Application of a phase averaged model for wave prediction (SWAN) • · Application of phase resolved wave models (Mike)
Literature	Vorlesungsumdruck

Course L0810: Modelling of Flow in Rivers and Estuaries	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Edgar Nehlsen, Prof. Peter Fröhle
Language	EN
Cycle	SoSe
Content	Introduction to numerical flow modelling • Processes affecting tht flow • Examples and applications of numerical models • Procedure of numerical modelling • Model concept Basic equations of hydrodynamics • Saint-Venant equations • Euler Equations • Navier-Stokes equations • Reynolds-averaged Navier-Stokes equations • Shallow water equations Solving schemes • Numerical discretization • Solution algorithms • Convergence
Literature	Vorlesungsskript Literaturempfehlungen Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau (1997): Hydraulische Berechnung von naturnahen Fließgewässern. Düsseldorf: BWK (BWK-Merkblatt). Chow, Ven-te (1959): Open-channel Hydraulics. New York usw.: McGraw-Hill (McGraw-Hill Civil Engineering Series). Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019a): Merkblatt DWA-M 543-2 Geodaten in der Fließgewässermodellierung Teil 1: Geodaten in der Fließgewässermodellierung. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-1). Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019b): Merkblatt DWA-M 543-2 Geodaten in der Fließgewässermodellierung Teil 2: Bedarfsgerechte Datenerfassung und -aufbereitung. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-2). Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019c): Merkblatt DWA-M 543-3 Geodaten in der Fließgewässermodellierung - Teil 3: Aspekte der Strömungsmodellierung und Fallbeispiele. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-3). Hervouet, Jean-Michel (2007): Hydrodynamics of free surface flows. Modelling with the finite element method. Chichester: Wiley. Online verfügbar unter http://www.loc.gov/catdir/enhancements/fy0741/2007296953-b.html. IAHR (2015): Professional Specifications for Physical and Numerical Studies in Environmental Hydraulics. In: Hydrolink (3/2015), S. 90-92. Olsen, Nils Reidar B. (2012): Numerical Modelling and Hydraulics. 3. Aufl. Department of Hydraulic and Environmental Engineering, The Norwegian University of Science and Technology. Szymkiewicz, Romuald (2010): Numerical modeling in open channel hydraulics. Dordrecht: Springer (Water science and technology library, 83). van Waveren, Harold (1999-): Good modelling practice handbook. [Utrecht], Lelystad, Den Haag: STOWA; Rijkswaterstaat-RIZA; SDU, afd. SEO/RIZA [etc. distr.] (Nota, nr. 99.036). Zielke, Werner (Hg.) (1999): Numerische Modelle von Flüssen, Seen und Küstengewässern. Deutscher Verband für Wasserwirtschaft und Kulturbau. Bonn: Wirtschafts- und Verl.-Ges. Gas und Wasser (Schriftenreihe des Deutschen Verbandes für Wasserwirtschaft und Kulturbau, 127).

Module M0874: Wastewater Systems

Courses

Title	Typ	Hrs/wk	CP
Biological Wastewater Treatment (L0517)	Lecture	2	2
Biological Wastewater Treatment (L3122)	Recitation Section (large)	1	1
Advanced Wastewater Treatment (L0357)	Lecture	2	2
Advanced Wastewater Treatment (L0358)	Recitation Section (large)	1	1

Module Responsible	Dr. Joachim Behrendt
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of wastewater management and the key processes involved in wastewater treatment.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to outline key areas of the full range of treatment systems in waste water management, as well as their mutual dependence for sustainable water protection. They can describe relevant economic, environmental and social factors.
Skills	Students are able to pre-design and explain the available wastewater treatment processes and the scope of their application in municipal and for some industrial treatment plants.
Personal Competence	
Social Competence	Social skills are not targeted in this module.
Autonomy	Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L0517: Biological Wastewater Treatment

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Joachim Behrendt
Language	DE/EN
Cycle	SoSe
Content	Charaterisation of Wastewater Metobolism of Microorganisms Kinetic of mirobiotic processes Calculation of bioreactor for wastewater treatment Concepts of Wastewater treatment Design of WWTP Excursion to a WWTP Biofilms Biofim Reactors Anaerobic Wastewater and sldge treatment resources oriented sanitation technology Future challenges of wastewater treatment
Literature	**Gujer, Willi** Siedlungswasserwirtschaft : mit 84 Tabellen

	ISBN: 3540343296 (Gb.) URL: http://www.gbv.de/dms/bs/toc/516261924.pdf URL: http://deposit.d-nb.de/cgi-bin/dokserv?id=2842122&prov=M&dok_var=1&dok_ext=htm Berlin [u.a.] : Springer, 2007 TUB_HH_Katalog **Henze, Mogens** Wastewater treatment : biological and chemical processes ISBN: 3540422285 (Pp.) Berlin [u.a.] : Springer, 2002 TUB_HH_Katalog **Imhoff, Karl** (Imhoff, Klaus R.;) Taschenbuch der Stadtentwässerung : mit 10 Tafeln ISBN: 3486263331 ((Gb.)) München [u.a.] : Oldenbourg, 1999 TUB_HH_Katalog **Lange, Jörg** (Otterpohl, Ralf; Steger-Hartmann, Thomas;) Abwasser : Handbuch zu einer zukunftsfähigen Wasserwirtschaft ISBN: 3980350215 (kart.) URL: http://www.gbv.de/du/services/agi/52567E5D44DA0809C12570220050BF25/000000700334 Donaueschingen-Pfohren : Mall-Beton-Verl., 2000 TUB_HH_Katalog **Mudrack, Klaus** (Kunst, Sabine;) Biologie der Abwasserreinigung : 18 Tabellen ISBN: 382741427X URL: http://www.gbv.de/du/services/agi/94B581161B6EC747C1256E3F005A8143/420000114903 Heidelberg [u.a.] : Spektrum, Akad. Verl., 2003 TUB_HH_Katalog **Tchobanoglous, George** (Metcalf & Eddy, Inc., ;) Wastewater engineering : treatment and reuse ISBN: 0070418780 (alk. paper) ISBN: 0071122508 (ISE (*pbk)) Boston [u.a.] : McGraw-Hill, 2003 TUB_HH_Katalog **Henze, Mogens** Activated sludge models ASM1, ASM2, ASM2d and ASM3 ISBN: 1900222248 London : IWA Publ., 2002 TUB_HH_Katalog **Kunz, Peter** Umwelt-Bioverfahrenstechnik Vieweg, 1992 **Bauhaus-Universität., Arbeitsgruppe Weiterbildendes Studium Wasser und Umwelt** (Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall, ;) Abwasserbehandlung : Gewässerbelastung, Bemessungsgrundlagen, Mechanische Verfahren, Biologische Verfahren, Reststoffe aus der Abwasserbehandlung, Kleinkläranlagen ISBN: 3860682725 URL: http://www.gbv.de/dms/weimar/toc/513989765_toc.pdf URL: http://www.gbv.de/dms/weimar/abs/513989765_abs.pdf Weimar : Universitätsverl, 2006 TUB_HH_Katalog **Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall** DWA-Regelwerk Hennef : DWA, 2004 TUB_HH_Katalog **Wiesmann, Udo** (Choi, In Su; Dombrowski, Eva-Maria;) Fundamentals of biological wastewater treatment ISBN: 3527312196 (Gb.) URL: http://deposit.ddb.de/cgi-bin/dokserv?id=2774611&prov=M&dok_var=1&dok_ext=htm Weinheim : WILEY-VCH, 2007 TUB_HH_Katalog

Course L3122: Biological Wastewater Treatment	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Joachim Behrendt
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0357: Advanced Wastewater Treatment	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Joachim Behrendt
Language	EN
Cycle	SoSe
Content	Survey on advanced wastewater treatment reuse of reclaimed municipal wastewater Precipitation Flocculation Depth filtration Membrane Processes Activated carbon adsorption Ozonation "Advanced Oxidation Processes" Disinfection
Literature	Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003 Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987 Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007 Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003

Course L0358: Advanced Wastewater Treatment	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Joachim Behrendt
Language	EN
Cycle	SoSe
Content	Aggregate organic compounds (sum parameters) Industrial wastewater Processes for industrial wastewater treatment Precipitation Flocculation Activated carbon adsorption Recalcitrant organic compounds
Literature	Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003 Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987 Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007 Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003

Module M0922: City Planning

Courses

Title	Typ	Hrs/wk	CP
City Planning (L1066)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Carsten Gertz
Admission Requirements	None
Recommended Previous Knowledge	for "Principles of Urban Planning": none for "Designing Urban Streetscapes": some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineering"
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • use technical terms of urban planning. • describe the main determinants of urban development. • explain and compare different possibilities of how urban development can be influenced. • discuss requirements for public streetscapes. • explain the importance of street design.
Skills	Students are able to: • read and analyze urban development concepts and designs for streetscapes • appraise such concepts in the context of competing requirements. • design, justify and reflect their own solutions for concrete examples.
Personal Competence	
Social Competence	Students are able to: • discuss intermediate results with each other. • constructively accept feedback on their own work. • provide constructive feedback to others.
Autonomy	Students are able to: • independently complete a written report including drawings following a broadly pre-defined process. • assess the consequences of their proposed solutions. • independently acquire knowledge and apply this to new issues or problem areas.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	written assignment, designwork during the semester
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L1066: City Planning	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Carsten Gertz
Language	DE
Cycle	SoSe
Content	„Principles of Urban Planning“ deals with the determinants of urban development and their interactions. Topics include: • legal framework, • instruments and methods of planning, • functional requirements, • stakeholders and actors • basic design requirements • different planning levels and • historical contexts. The objective of the course is for students to acquire a basic understanding of urban development problems and approaches for solving them. They will also be able to comprehend the process of urban planning. The course also covers the various functional and aesthetic requirements for designing streetscape as the most important elements of public space. The project work deals with a real life scenario and includes drawing up a development plan, an urban design concept, a building masterplan and a street redesign.
Literature	Albers, Gerd; Wekel, Julian (2021) Stadtplanung: Eine illustrierte Einführung. 4. überarbeitete Auflage. Primus Verlag. Darmstadt. Frick, Dieter (2011) Theorie des Städtebaus: Zur baulich-räumlichen Organisation von Stadt. 3. veränderte Auflage. Wasmuth-Verlag. Tübingen Jonas, Carsten (2009) Die Stadt und ihr Grundriss. Wasmuth-Verlag. Tübingen Kostof, Spiro; Castillo, Greg (1998) Die Anatomie der Stadt. Geschichte städtischer Strukturen. Campus-Verlag. Frankfurt/New York.

Module M0977: Construction Logistics and Project Management

Courses

Title	Typ	Hrs/wk	CP
Construction Logistics (L1163)	Lecture	1	2
Construction Logistics (L1164)	Recitation Section (small)	1	2
Project Development and Management (L1161)	Lecture	1	1
Project Development and Management (L1162)	Project-/problem-based Learning	1	1

Module Responsible	Prof. Heike Flämig
Admission Requirements	None
Recommended Previous Knowledge	none
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can... • give definitions of the main terms of construction logistics and project development and management • name advantages and disadvantages of internal or external construction logistics • explain characteristics of products, demand and production of construction objects and their consequences for construction specific supply chains • differentiate constructions logistics from other logistics systems
Skills	Students can... • carry out project life cycle assessments • apply methods and instruments of construction logistics • apply methods and instruments of project development and management • apply methods and instruments of conflict management • design supply and waste removal concepts for a construction project
Personal Competence	
Social Competence	Students can... • hold presentations in and for groups • apply methods of conflict solving skills in group work and case studies
Autonomy	Students can... • solve problems by holistic, systemic and flow oriented thinking • improve their creativity, negotiation skills, conflict and crises solution skills by applying methods of moderation in case studies
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Two written papers with presentations
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory

Course L1163: Construction Logistics	
Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Heike Flämig
Language	DE
Cycle	SoSe
Content	The lecture gives deeper insight how important logistics are as a competetive factor for construction projects and which issues are to be adressed. The following toppics are covered: • competetive factor logistics • the concept of systems, planning and coordination of logistics • material, equipment and reverse logistics • IT in construction logistics • elements of the planning model of construction logistics and their connections • flow oriented logistics systems for construction projects • logistics concepts for ready to use construction projects (especially procurement and waste removel logistics) • best practice examples (construction logistics Potsdamer Platz, recent case study of the region) Contents of the lecture are deepened in special exercises.
Literature	Flämig, Heike: Produktionslogistik in Stadtregionen. In: Forschungsverbund Ökologische Mobilität (Hrsg.) Forschungsbericht Bd. 15.2. Wuppertal 2000. Krauss, Siri: Die Baulogistik in der schlüsselfertigen Ausführung, Bauwerk Verlag GmbH Berlin 2005. Lipsmeier, Klaus: Abfallkennzahlen für Neubauleistungen im Hochbau : Verlag Forum für Abfallwirtschaft und Altlasten, 2004. Schmidt, Norbert: Wettbewerbsfaktor Baulogistik. Neue Wertschöpfungspotenziale in der Baustoffversorgung. In: Klaus, Peter: Edition Logistik. Band 6. Deutscher Verkehrs-Verlag. Hamburg 2003. Seemann, Y.F. (2007): Logistikkoordination als Organisationseinheit bei der Bauausführung Wissenschaftsverlag Mainz in Aachen, Aachen. (Mitteilungen aus dem Fachgebiet Baubetrieb und Bauwirtschaft (Hrsg. Kuhne, V.): Heft 20)

Course L1164: Construction Logistics	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Heike Flämig
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1161: Project Development and Management	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Heike Flämig, Dr. Anton Worobei
Language	DE
Cycle	SoSe
Content	Within the lecture, the main aspects of project development and management are tought: • Terms and definitions of project management • Advantages and disadvantages of different ways of project handling • organization, information, coordination and documentation • cost and fincance management in projects • time- and capacity management in projects • specific methods and instruments for successful team work Contents of the lecture are deepened in special exercises.
Literature	Projektmanagement-Fachmann. Band 1 und Band 2. RKW-Verlag, Eschborn, 2004.

Course L1162: Project Development and Management	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Heike Flämig, Dr. Anton Worobei
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0998: Statics and Dynamics of Structures

Courses

Title	Typ	Hrs/wk	CP
Structural Dynamics (L1202)	Lecture	2	2
Structural Dynamics (L1203)	Recitation Section (large)	2	2
Fracture mechanics and fatigue in steel structures (L0564)	Lecture	1	1
Fracture mechanics and fatigue in steel structures (L0565)	Recitation Section (large)	1	1

Module Responsible	Prof. Bastian Oesterle
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of linear structural analysis of statically determinate and indeterminate structures; Mechanics I/II, Mathematics I/II, Differential equations I
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of this module, the student can explain the basic aspects of dynamic effects on structures and the respective methods.
Skills	After successful completion of this module, the students will be able to predict the response of material and structures to dynamics loading using the appropriate computational approaches and methods.
Personal Competence	
Social Competence	Students can • participate in subject-specific and interdisciplinary discussions, • defend their own work results in front of others • promote the scientific development of colleagues • Furthermore, they can give and accept professional constructive criticism
Autonomy	Students are able to gain knowledge of the subject area from given and other sources and apply it to new problems. Furthermore, they are able to structure the solution process for problems in the area of Structural Analysis.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	150 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L1202: Structural Dynamics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	DE
Cycle	SoSe
Content	• mechanical background of dynamics • harmonic vibrations, damped and undamped free and forced vibrations • frequency and time domain • modelling aspects • principle of d'Alembert • systems with multiple degrees of freedom • consistent and lumped mass matrices • finite elements for dynamics problems • impact problems • eigenvalue problems and modal analysis • direct time integration schemes, transient analyses
Literature	• Vorlesungsmanuskript • Clough, R.W., Penzien, J.: Dynamics of Structures. 2. Aufl., McGraw-Hill, New York, 1993.

Course L1203: Structural Dynamics	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0564: Fracture mechanics and fatigue in steel structures	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Jürgen Priebe
Language	DE
Cycle	SoSe
Content	• basics of fatigue stress and fatigue resistance and determination of fatigue strength, • determination anduse of S-N-curves and classification of notch effects, • set up of determination of fatigue strength under dynamic load using the accumulation formula by Palmgren-Miner, • set up of determination of fatigue strength in different examples, • basics of construction and design regarding the problem of material fatigue, • basics of linear elastic fracture mechanics under static and dynamic load, • determination of lifetime of steel construction based on linear elastic fracture mechanics in different examples.
Literature	• Seeßelberg, C.; Kranbahnen - Bemessung und konstruktive Gestaltung; 3. Auflage; Bauwerk-Verlag; Berlin 2009 • Kuhlmann, Dürr, Günther; Kranbahnen und Betriebsfestigkeit; in Stahlbau Kalender 2003; Verlag Ernst & Sohn; Berlin 2003 • Deutscher Stahlbau-Verband (Hrsg.); Stahlbau Handbuch Band 1 Teil B; 3. Auflage; Stahlbau-Verlagsgesellschaft; Köln 1996 • Petersen, C.; Stahlbau; 3. überarb. und erw. Auflage; Vieweg-Verlag; Braunschweig 1993 • DIN V ENV 1993-1-1: Eurocode 3; Bemessung und Konstruktion von Stahlbauwerken; Teil 1-1: Allgemeine Bemessungsregeln, Bemessungsregeln für den Hochbau; 1993 • DIN V ENV 1993-6: Eurocode 3; Bemessung und Konstruktion von Stahlbauwerken; Teil 6: Kranbahnen; 2001 • DIN-Fachbericht 126. Richtlinie zur Anwendung von DIN V ENV 1993-6; Nationales Anwendungsdokument (NAD); Berlin 2002

Course L0565: Fracture mechanics and fatigue in steel structures	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Jürgen Priebe
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0593: Building Materials and Building Preservation

Courses

Title	Typ	Hrs/wk	CP
Repair of Structures (L0255)	Lecture	1	1
Mineral Building Materials (L0253)	Lecture	2	2
Technology of mineral Building Materials (L0256)	Project-/problem-based Learning	1	2
Transport Processes in Building Materials and Damage Processes (L0254)	Lecture	1	1

Module Responsible	Prof. Frank Schmidt-Döhl
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge about building materials, building physics and building chemistry, for example by the modules Principles of Building Materials and Building Physics and Building Materials and Building Chemistry.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe the components of mineral building materials and their function in detail and to use them for the manufacture of special mineral building materials. They are able to show the characteristics of mineral building materials. They are able to describe the manufacture, properties and fields of application of special mortars and special concretes and the correlations of their material parameters. They are able to show the principles of anchor technology and design.
Skills	The students are able to perform an optimization of granulometry of a mineral building material. They are able to design a special mineral mortar and to manufacture this mortar. The students are able to manufacture post installed rebar connections. They are able to recognize damages, to assess possible causes, to use the fundamentals of construction preservation and to select repair and strengthening measures.
Personal Competence	
Social Competence	The students are able to develop in small grous the mixture of a special mortar. They present their results to the lecturer and the other students. In a critical discussion they defend and adjust their results. The students are able to manufacture their special building material on the basis of this feedback.
Autonomy	The students are able to responsibly use the resources of materials and lab equipment for their project and to investigate and to get missing components.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** Yes; **Bonus** 20 %; **Form** Subject theoretical and practical work; **Description**
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory

Course L0255: Repair of Structures

Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	SoSe
Content	Maintenance of structures, repair and strengthening, subsequent waterproofing of structures
Literature	BetonMarketing Deutschland (Hrsg.): Stahlbetonoberflächen - schützen, erhalten, instandsetzen

Course L0253: Mineral Building Materials	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	SoSe
Content	Components of mineral building materials and their function, binding materials, concrete and mortar, special mortars, special concretes
Literature	Taylor, H.F.W.: Cement Chemistry Springenschmid, R.: Betontechnologie für die Praxis

Course L0256: Technology of mineral Building Materials	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	SoSe
Content	Design and production of a special mineral building material
Literature	Taylor, H.F.W.: Cement Chemistry Springenschmid, R.: Betontechnologie für die Praxis

Course L0254: Transport Processes in Building Materials and Damage Processes	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	SoSe
Content	Transport Processes in Building Materials and Damage Processes
Literature	Blaich, J.: Bauschäden, Analyse und Vermeidung

Module M0999: Steel Construction Project

Courses

Title	Typ	Hrs/wk	CP
Steel Construction Project (L1206)	Project Seminar	4	6

Module Responsible	Prof. Marcus Rutner
Admission Requirements	None
Recommended Previous Knowledge	Steel and Composite Structures
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to prepare a part of the whole project and explain it to the others.
Skills	Students can produce sketches and calculations of their part of the project. They are able to adjust their work in reaction to changing conditions resulting from other participants of the project.
Personal Competence	
Social Competence	Students can present their results to other members of the group. They have the ability to work for a broad agreement with respect to intergroup dependencies. They can distribute and process tasks independently.
Autonomy	Students can handle their part of the project on their own resposibility-
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	approx. 15-20 pages (without appendix)
Assignment for the Following Curricula	Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory

Course L1206: Steel Construction Project

Typ	Project Seminar
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Marcus Rutner
Language	DE
Cycle	SoSe
Content	Design of a big construction project (i.e skyscraper, large bridge, roof of a stadiuim) in small groups
Literature	Wird je nach Projekt individuell angegeben.

Module M0663: Marine Geotechnics

Courses

Title	Typ	Hrs/wk	CP
Marine Geotechnics (L0548)	Lecture	1	2
Marine Geotechnics (L0549)	Recitation Section (large)	2	2
Steel Structures in Foundation and Hydraulic Engineering (L1146)	Lecture	2	2

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	Complete modules: Geotechnics I-III, Mathematics I-III Courses: Soil laboratory course
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students get a deeper knowledge of steel and ground engineering as well as constructions knowledge concerning quay walls. Furthermore, the students get all the necessary knowledge to design singular construction elements for sheet pile walls and they know how to choose the right construction elements depending on the influencing conditions.
Skills	Furthermore, the students are able to dimension sheet pile wall construction regarding all construction elements, to choose the suitable construction elements with respect to the influencing conditions, to design all kinds of sheet pile walls (wave sheet pile walls and combined sheet pile walls) and to dimension all construction elements and connections.
Personal Competence	
Social Competence	
Autonomy	Students are able to assess their own strengths and weaknesses and organize their time and learning management based on this.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory

Course L0548: Marine Geotechnics

Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	SoSe
Content	• Geotechnical investigation an description of the seabed • Foundations of Offshore-Constructions • cCliff erosion • Sea dikes • Port structures • Flood protection structures
Literature	• EAK (2002): Empfehlungen für Küstenschutzbauwerke • EAU (2004): Empfehlungen des Arbeitsausschusses Uferbauwerke • Poulos H.G. (1988): Marine Geotechnics. Unwin Hyman, London • Wagner P. (1990): Meerestechnik: Eine Einführung für Bauingenieure. Ernst & Sohn, Berlin

Course L0549: Marine Geotechnics	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1146: Steel Structures in Foundation and Hydraulic Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Frank Feindt
Language	DE
Cycle	SoSe
Content	Design of a sheet pile wall, design of a combined sheet pile wall, piles, walings, connections, fatigue
Literature	EAU 2012, EA-Pfähle, EAB

Module M1724: Smart Monitoring

Courses

Title	Typ	Hrs/wk	CP
Smart Monitoring (L2762)	Integrated Lecture	2	2
Smart Monitoring (L2763)	Recitation Section (small)	2	4

Module Responsible	Prof. Kay Smarsly
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge or interest in object-oriented modeling, programming, and sensor technologies are helpful. Interest in modern research and teaching areas, such as Internet of Things, Industry 4.0 and cyber-physical systems, as well as the will to deepen skills of scientific working, are required. Basic knowledge in scientific writing and good English skills.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students will become familiar with the principles and practices of smart monitoring. The students will be able to design decentralized smart systems to be applied for continuous (remote) monitoring of systems in the built and in the natural environment. In addition, the students will learn to design and to implement intelligent sensor systems using state-of-the-art data analysis techniques, modern software design concepts, and embedded computing methodologies. Besides lectures, project work is also part of this module, which will be conducted throughout the semester and will contribute to the grade. In small groups, the students will design smart monitoring systems that integrate a number of “intelligent” sensors to be implemented by the students. Specific focus will be put on the application of machine learning techniques. The smart monitoring systems will be mounted on real-world (built or natural) systems, such as bridges or slopes, or on scaled lab structures for validation purposes. The outcome of every group will be documented in a paper. All students of this module will “automatically” participate with their smart monitoring system in the annual "Smart Monitoring" competition. The written papers and oral examinations form the final grades. The module will be taught in English. Limited enrollment.
Skills	The students will gain insights into operating state-of-the-art smart sensor systems, used for monitoring a wide range of physical processes relevant to engineering, such as environmental, structural, or comfort monitoring. The students will be capable of devising monitoring strategies of physical processes as part of group projects, tailored to their knowledge backgrounds, and to implement the strategies in smart wireless sensor nodes, using embedded computing and programming. Finally, the students will be able to document the findings of their projects in short reports.
Personal Competence	
Social Competence	The students will be able to work in groups, share parts of the work for their projects, and develop communication skills, towards achieving the common project goals.
Autonomy	The students will be able to gain a solid basis on approaching and solving problems in engineering, as well as on documenting results, through their involvement in their monitoring group projects.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	10 pages of work with 15-minute oral presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2762: Smart Monitoring	
Typ	Integrated Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Kay Smarsly
Language	EN
Cycle	SoSe
Content	In this course, principles of smart monitoring will be taught, focusing on modern concepts of data acquisition, data storage, and data analysis. Also, fundamentals of intelligent sensors and embedded computing will be illuminated. Autonomous software and decentralized data processing are further crucial parts of the course, including concepts of the Internet of Things, Industry 4.0 and cyber-physical systems. Furthermore, measuring principles, data acquisition systems, data management and data analysis algorithms will be discussed. Besides the theoretical background, numerous practical examples will be shown to demonstrate how smart monitoring may advantageously be used for assessing the condition of systems in the built or natural environment.
Literature	The course contents couples different fields, such as signal processing, sensing technologies, data analytics, environmental engineering, civil engineering, artificial intelligence, database systems, and many more. The basics will be taught in this course. However, specific literature that covers all these topics does not exist. Instead, literature will be referenced in the lectures, all of which are papers that are freely available online.

Course L2763: Smart Monitoring	
Typ	Recitation Section (small)
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Kay Smarsly
Language	EN
Cycle	SoSe
Content	The contents of the exercises are based on the lecture contents. In addition to the exercises, project work will be conducted throughout the semester, which will consume the majority of the workload. As part of the project work, students will design smart monitoring systems that will be tested in the laboratory or in the field. As mentioned in the module description, the students will participate in the “Smart Monitoring” competition, hosted annually by the Institute of Digital and Autonomous Construction. Students are encouraged to contribute their own ideas. The tools required to implement the smart monitoring systems will be taught in the group exercises as well as through external sources, such as video tutorials and literature.
Literature	The course contents couples different fields, such as signal processing, sensing technologies, data analytics, environmental engineering, civil engineering, artificial intelligence, database systems, and many more. The basics will be taught in this course. However, specific literature that covers all these topics does not exist. Instead, literature will be referenced in the lectures, all of which are papers that are freely available online.

Module M1878: Sustainable energy from wind and water

Courses

Title	Typ	Hrs/wk	CP
Offshore Geotechnical Engineering (L0067)	Lecture	1	1
Hydro Power Use (L0013)	Lecture	1	1
Wind Turbine Plants (L0011)	Lecture	2	3
Wind Energy Use - Focus Offshore (L0012)	Lecture	1	1

Module Responsible	Dr. Marvin Scherzinger
Admission Requirements	None
Recommended Previous Knowledge	Module: Technical Thermodynamics I, Module: Technical Thermodynamics II, Module: Fundamentals of Fluid Mechanics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	By ending this module students can explain in detail knowledge of wind turbines with a particular focus of wind energy use in offshore conditions and can critical comment these aspects in consideration of current developments. Furthermore, they are able to describe fundamentally the use of water power to generate electricity. The students reproduce and explain the basic procedure in the implementation of renewable energy projects in countries outside Europe. Through active discussions of various topics within the seminar of the module, students improve their understanding and the application of the theoretical background and are thus able to transfer what they have learned in practice.
Skills	Students are able to apply the acquired theoretical foundations on exemplary water or wind power systems and evaluate and assess technically the resulting relationships in the context of dimensioning and operation of these energy systems. They can in compare critically the special procedure for the implementation of renewable energy projects in countries outside Europe with the in principle applied approach in Europe and can apply this procedure on exemplary theoretical projects.
Personal Competence	
Social Competence	Students can discuss scientific tasks subjet-specificly and multidisciplinary within a seminar.
Autonomy	Students can independently exploit sources in the context of the emphasis of the lecture material to clear the contents of the lecture and to acquire the particular knowledge about the subject area.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	180 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Renewable Energies: Core Qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L0067: Offshore Geotechnical Engineering	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Jan Dührkop
Language	DE
Cycle	SoSe
Content	• Overview and Introduction Offshore Geotechnics • Introduction to Soil Mechanics • Offshore soil investigation • Focus on cyclical effects • Geotechnical design of offshore foundations • Monopiles • Jackets • Heavyweight foundations • Geotechnical preliminary exploration for the use of lift boats and platforms
Literature	• Randolph, M. and Gourvenec, S (2011): Offshore Geotechnical Engineering. Spon Press. • Poulos H.G. (1988): Marine Geotechnics. Unwin Hyman, London • BSH-Standard Baugrunderkundung für Offshore-Windenergieparks • Lesny K. (2010): Foundations for Offshore Wind Turbines. VGE Verlag, Essen. • EA-Pfähle (2012): Empfehlungen des Arbeitskreises Pfähle der DGGT. Ernst & Sohn, Berlin.

Course L0013: Hydro Power Use	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Stefan Achleitner
Language	DE
Cycle	SoSe
Content	• Introduction, importance of water power in the national and global context • Physical basics: Bernoulli's equation, usable height of fall, hydrological measures, loss mechanisms, efficiencies • Classification of Hydropower: Flow and Storage hydropower, low and high pressure systems • Construction of hydroelectric power plants: description of the individual components and their technical system interaction • Structural engineering components; representation of dams, weirs, dams, power houses, computer systems, etc. • Energy Technical Components: Illustration of the different types of hydraulic machinery, generators and grid connection • Hydropower and the Environment • Examples from practice
Literature	• Schröder, W.; Euler, G.; Schneider, K.: Grundlagen des Wasserbaus; Werner, Düsseldorf, 1999, 4. Auflage • Quaschning, V.: Regenerative Energiesysteme: Technologie - Berechnung - Simulation; Carl Hanser, München, 2011, 7. Auflage • Giesecke, J.; Heimerl, S.; Mosony, E.: Wasserkraftanlagen - Planung, Bau und Betrieb; Springer, Berlin, Heidelberg, 2009, 5. Auflage • von König, F.; Jehle, C.: Bau von Wasserkraftanlagen - Praxisbezogene Planungsunterlagen; C. F. Müller, Heidelberg, 2005, 4. Auflage • Strobl, T.; Zunic, F.: Wasserbau: Aktuelle Grundlagen - Neue Entwicklungen; Springer, Berlin, Heidelberg, 2006

Course L0011: Wind Turbine Plants	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Rudolf Zellermann
Language	DE
Cycle	SoSe
Content	• Historical development • Wind: origins, geographic and temporal distribution, locations • Power coefficient, rotor thrust • Aerodynamics of the rotor • Operating performance • Power limitation, partial load, pitch and stall control • Plant selection, yield prediction, economy • Excursion
Literature	Gasch, R., Windkraftanlagen, 4. Auflage, Teubner-Verlag, 2005

Course L0012: Wind Energy Use - Focus Offshore	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Martin Skiba
Language	DE
Cycle	SoSe
Content	• Introduction, importance of offshore wind power generation, Specific requirements for offshore engineering • Physical fundamentals for utilization of wind energy • Design and operation of offshore wind turbines, presentation of different concepts of offshore wind turbines, representation of the individual system components and their system-technical relationships • Foundation engineering, offshore site investigation, presentation of different concepts of offshore foundation structures, planning and fabrication of foundation structures • Electrical infrastructure of an offshore wind farm, Inner Park cabling, offshore substation, grid connection • Installation of offshore wind farms, installation techniques and auxiliary devices, construction logistics • Development and planning of offshore wind farms • Operation and optimization of offshore wind farms • Day excursion
Literature	• Gasch, R.; Twele, J.: Windkraftanlagen - Grundlagen, Entwurf, Planung und Betrieb; Vieweg + Teubner, Stuttgart, 2007, 7. Auflage • Molly, J. P.: Windenergie - Theorie, Anwendung, Messung; C. F. Müller, Heidel-berg, 1997, 3. Auflage • Hau, E.: Windkraftanalagen; Springer, Berlin, Heidelberg, 2008, 4.Auflage • Heier, S.: Windkraftanlagen - Systemauslegung, Integration und Regelung; Vieweg + Teubner, Stuttgart, 2009, 5. Auflage • Jarass, L.; Obermair, G.M.; Voigt, W.: Windenergie: Zuverlässige Integration in die Energieversorgung; Springer, Berlin, Heidelberg, 2009, 2. Auflage

Module M0858: Coastal Hydraulic Engineering I

Courses

Title	Typ	Hrs/wk	CP
Basics of Coastal Engineering (L0807)	Lecture	3	4
Basics of Coastal Engineering (L1413)	Project-/problem-based Learning	1	2

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Basics of hydraulic engineering, hydrology and hydromechanics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to define and explain the basic concepts of coastal engineering and port engineering. They are able to apply the concepts to selected practical problems of coastal engineering. Students can define and determine the basics for design and dimensioning of coastal engineering constructions.
Skills	The students are capable to apply basic design approaches to selected and pre-defined design tasks in coastal engineering.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in applied problems such as the design of coastal protection structures. Additionaly, they will be able to work in team with engineers of other disciplines, for instance designing of coastal breakwaters.
Autonomy	The students will be able to independently extend their knowledge and applyit to new problems.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	The duration of the examination is 2 hours. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L0807: Basics of Coastal Engineering

Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Peter Fröhle
Language	EN
Cycle	SoSe

Content	• Basics of planning and design
	  ◦ Water levels
	  ◦ Currents
	  ◦ Waves
	  ◦ Ice
	• Planning and Design in Coastal Engineering
	  ◦ Functional and constructional design
	  ◦ Determination of design parameters
	  ◦ Design-approaches
	    ▪ Filter
	    ▪ Rubble mound constructions
	    ▪ Piles
	    ▪ Vertical constructions

Literature	Coastal Engineering Manual, CEM Vorlesungsumdruck

Course L1413: Basics of Coastal Engineering	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1845: Thin-walled structures

Courses

Title	Typ	Hrs/wk	CP
Thin-walled structures (L1199)	Lecture	2	3
Thin-walled structures (L3045)	Recitation Section (large)	2	3

Module Responsible	Prof. Bastian Oesterle
Admission Requirements	None
Recommended Previous Knowledge	• Structural Analysis I • Structural Analysis II • Finite Element Methods
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of this module, the students can express the basic aspects of the load-carrying behaviour of thin-walled structures.
Skills	After successful completion of this module, the students will be able to predict load-carrying behaviour of thin-walled structures using appropriate analytical and coputational methods.
Personal Competence	
Social Competence	Students can • participate in subject-specific and interdisciplinary discussions, • defend their own work results in front of others • promote the scientific development of colleagues • Furthermore, they can give and accept professional constructive criticism
Autonomy	Students are able to gain knowledge of the subject area from given and other sources and apply it to new problems. Furthermore, they are able to structure the solution process for problems in the area of modelling and analysis of thin-walled structures.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L1199: Thin-walled structures	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	DE
Cycle	SoSe
Content	Plates loaded in-plane • Governing equations (equilibrium, kinematics, constitutive law) • Differential equation • Airy stress function • Plane stress / plane strain • Structural behaviour of plates loaded in-plane • finite elements for plates loaded in-plane, modelling apsects, interpretation and critical assessment of results Plates in bending • Governing equations (equilibrium, kinematics, constitutive law) • Differential equation • Navier solution / Fourier series expansion • Approximation procedures • Circular and rectangular plates • Structural behaviour of plates in bending • finite elements for plates in bending, modelling apsects, interpretation and critical assessment of results Shells • Phenomenona of the structural behaviour of shells • Membrane and bending theory • Equilibrium equations of shells of revolution • Stress resultants and deformations of the spherical shell, the half spherical shell, and the cylindrical shell • finite elements for shells Stability problems (overview) • Plate buckling • Shell buckling
Literature	• Vorlesungsmanuskript • Basar, Y.: Krätzig, W.B. (1985): Mechanik der Flächentragwerke. Vieweg-Verlag, Braunschweig, Wiesbaden • Girkmann, K. (1963): Flächentragwerke, Springer Verlag, Wien, 1963, unveränderter Nachdruck 1986 • Zienkiewicz, O.C. (1977): The Finite Element Method in Enginieering Science. McGraw-Hill, London

Course L3045: Thin-walled structures	
Typ	Recitation Section (large)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0581: Water Protection

Courses

Title	Typ	Hrs/wk	CP
Water Protection and Wastewater Management (L0226)	Lecture	3	3
Water Protection and Wastewater Management (L2008)	Project Seminar	3	3

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	• Basic knowledge in water management; • Good knowledge in urban drainage; • Good knowledge of wastewater treatment techniques; • Good knowledge of pollutants (e.g. COD, BOD, TS, N, P) and their properties;
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can describe the basic principles of the regulatory framework related to the international and European water sector. They can explain limnological processes, substance cycles and water morphology in detail. They are able to assess complex problems related to water protection, such as ecosystem service and wastewater treatment with a special focus on innovative solutions, remediation measures as well as conceptual approaches.
Skills	Students can accurately assess current problems and situations in a country-specific or local context. They can suggest concrete actions to contribute to the planning of tomorrow's urban water cycle. Furthermore, they can suggest appropriate technical, administrative and legislative solutions to solve these problems.
Personal Competence	
Social Competence	The students can work together in international groups.
Autonomy	Students are able to organize their work flow to prepare presentations and discussions. They can acquire appropriate knowledge by making enquiries independently.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Presentation
Examination duration and scale	Term paper plus presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory

Course L0226: Water Protection and Wastewater Management	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	The lecture focusses on: • Regulatory Framework (e.g. WFD) • Main instruments for the water management and protection • In depth knowledge of relevant measures of water pollution control • Urban drainage, treatment options in different regions on the world • Rainwater management, improved management of heavy rainfalls, downpours, rainwater harvesting, rainwater infiltration • Case Studies and Field Trips
Literature	The literature listed below is available in the library of the TUHH. • Water and wastewater technology Hammer, M. J. 1., & . (2012). (7. ed., internat. ed.). Boston [u.a.]: Pearson Education International. • Water and wastewater engineering : design principles and practice: Davis, M. L. 1. (2011). . New York, NY: McGraw-Hill. • Biological wastewater treatment: (2011). C. P. Leslie Grady, Jr. (3. ed.). London, Boca Raton, Fla. [u.a.]: IWA Publ.

Course L2008: Water Protection and Wastewater Management	
Typ	Project Seminar
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	
Literature	

Module M0595: Examination of Materials, Structural Condition and Damages

Courses

Title	Typ	Hrs/wk	CP
Examination of Materials, Structural Condition and Damages (L0260)	Lecture	3	4
Examination of Materials, Structural Condition and Damages (L0261)	Recitation Section (small)	1	2

Module Responsible	Prof. Frank Schmidt-Döhl
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge about building materials or material science, for example by the module Building Materials and Building Chemistry.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe the rules for trading, use and marking of construction products in Germany. They know which methods for the testing of building material properties are usable and know the limitations and characterics of the most important testing methods.
Skills	The students are able to responsibly discover the rules for trading and using of building products in Germany. They are able to chose suitable methods for the testing and inspection of construction products, the examination of damages and the examination of the structural conditions of buildings. They are able to conclude from symptons to the cause of damages. They are able to describe an examination in form of a test report or expert opinion.
Personal Competence	
Social Competence	The students can describe the different roles of manufacturers as well as testing, supervisory and certification bodies within the framework of material testing. They can describe the different roles of the participants in legal proceedings.
Autonomy	The students are able to make the timing and the operation steps to learn the specialist knowledge of a very extensive field.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Materials Science and Engineering: Specialisation Engineering Materials: Elective Compulsory Materials Science: Specialisation Engineering Materials: Elective Compulsory

Course L0260: Examination of Materials, Structural Condition and Damages

Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	WiSe
Content	Materials testing and marking process of construction products, testing methods for building materials and structures, testing reports and expert opinions, describing the condition of a structure, from symptons to the cause of damages
Literature	Frank Schmidt-Döhl: Materialprüfung im Bauwesen. Fraunhofer irb-Verlag, Stuttgart, 2013.

Course L0261: Examination of Materials, Structural Condition and Damages

Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1345: Metallic and Hybrid Light-weight Materials

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Joining of Polymer-Metal Lightweight Structures (L0500)	Lecture	2	2
Joining of Polymer-Metal Lightweight Structures (L0501)	Practical Course	1	1
Metallic Light-weight Materials (L1660)	Lecture	2	3

Module Responsible	Prof. Marcus Rutner
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	
Skills	
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	45 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Materials Science and Engineering: Specialisation Engineering Materials: Elective Compulsory Materials Science: Specialisation Engineering Materials: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory

Course L0500: Joining of Polymer-Metal Lightweight Structures

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Marcus Rutner
Language	EN
Cycle	WiSe

Content

Contents:

The lecture and the related laboratory exercises intend to provide an insight on advanced joining technologies for polymer-metal lightweight structures used in engineering applications. A general understanding of the principles of the consolidated and new technologies and its main fields of applications is to be accomplished through theoretical and practical lectures.

Theoretical Lectures:

- Review of the relevant properties of Lightweight Alloys, Engineering Plastics and Composites in Joining Technology
- Introduction to Welding of Lightweight Alloys, Thermoplastics and Fiber Reinforced Plastics
- Mechanical Fastening of Polymer-Metal Hybrid Structures
- Adhesive Bonding of Polymer-Metal Hybrid Structures
- Fusion and Solid State Joining Processes of Polymer-Metal Hybrid Structures
- Hybrid Joining Methods and Direct Assembly of Polymer-Metal Hybrid Structures

Laboratory Exercises:

- Joining Processes: Introduction to state-of-the-art joining technologies
- Introduction to metallographic specimen preparation, optical microscopy and mechanical testing of polymer-metal joints

Course Outcomes:

After successful completion of this unit, students should be able to understand the principles of welding and joining of polymer-metal lightweight structures as well as their application fields.

Literature

- S. T. Amancio-Filho, L.-A. Blaga, Joining of Polymer-Metal Hybrid Structures, Wiley, 2018
- J.F. Shackelford, Introduction to materials science for engineers, Prentice-Hall International
- J. Rotheiser, Joining of Plastics, Handbook for designers and engineers, Hanser Publishers
- D.A. Grewell, A. Benatar, J.B. Park, Plastics and Composites Welding Handbook
- D. Lohwasser, Z. Chen, Friction Stir Welding, From basics to applications, Woodhead Publishing Limited
- J. Friedrich, Metal-Polymer Systems: Interface Design and Chemical Bonding, Wiley, 2017

Course L0501: Joining of Polymer-Metal Lightweight Structures	
Typ	Practical Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Marcus Rutner
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1660: Metallic Light-weight Materials	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Domonkos Tolnai
Language	EN
Cycle	WiSe
Content	Lightweight construction - Structural lightweight construction - Material lightweight construction - Choice criteria for metallic lightweight construction materials Steel as lightweight construction materials - Introduction to the fundamentals of steels - Modern steels for the lightweight construction - Fine grain steels - High-strength low-alloyed steels - Multi-phase steels (dual phase, TRIP) - Weldability - Applications Aluminium alloys: Introduction to the fundamentals of aluminium materials Alloy systems Non age-hardenable Al alloys: Processing and microstructure, mechanical qualities and applications Age-hardenable Al alloys: Processing and microstructure, mechanical qualities and applications Magnesium alloys Introduction to the fundamental of magnesium materials Alloy systems Magnesium casting alloys, processing, microstructure and qualities Magnesium wrought alloys, processing, microstructure and qualities Examples of applications Titanium alloys Introduction to the fundamental of the titanium materials Alloy systems Processing, microstructure and properties Examples of applications

	Exercises and excursions
Literature	George Krauss, Steels: Processing, Structure, and Performance, 978-0-87170-817-5 , 2006, 613 S. Hans Berns, Werner Theisen, Ferrous Materials: Steel and Cast Iron, 2008. http://dx.doi.org/10.1007/978-3-540-71848-2 C. W. Wegst, Stahlschlüssel = Key to steel = La Clé des aciers = Chiave dell'acciaio = Liave del acero ISBN/ISSN: 3922599095 Bruno C., De Cooman / John G. Speer: Fundamentals of Steel Product Physical Metallurgy, 2011, 642 S. Harry Chandler, Steel Metallurgy for the Non-Metallurgist 0-87170-652-0 , 2006, 84 S. Catrin Kammer, Aluminium Taschenbuch 1, Grundlagen und Werkstoffe, Beuth, 16. Auflage 2009. 784 S., ISBN 978-3-410-22028-2 Günter Drossel, Susanne Friedrich, Catrin Kammer und Wolfgang Lehnert, Aluminium Taschenbuch 2, Umformung von Aluminium-Werkstoffen, Gießen von Aluminiumteilen, Oberflächenbehandlung von Aluminium, Recycling und Ökologie, Beuth, 16. Auflage 2009. 768 S., ISBN 978-3-410-22029-9 Catrin Kammer, Aluminium Taschenbuch 3, Weiterverarbeitung und Anwendung, Beuith,17. Auflage 2014. 892 S., ISBN 978-3-410-22311-5 G. Lütjering, J.C. Williams: Titanium, 2nd ed., Springer, Berlin, Heidelberg, 2007, ISBN 978-3-540-71397 Magnesium - Alloys and Technologies, K. U. Kainer (Hrsg.), Wiley-VCH, Weinheim 2003, ISBN 3-527-30570-x Mihriban O. Pekguleryuz, Karl U. Kainer and Ali Kaya “Fundamentals of Magnesium Alloy Metallurgy”, Woodhead Publishing Ltd, 2013,ISBN 10: 0857090887

Module M0603: Nonlinear Structural Analysis

Courses

Title	Typ	Hrs/wk	CP
Nonlinear Structural Analysis (L0277)	Lecture	3	4
Nonlinear Structural Analysis (L0279)	Recitation Section (small)	1	2

Module Responsible	Prof. Alexander Düster
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of partial differential equations is recommended.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to + give an overview of the different nonlinear phenomena in structural mechanics. + explain the mechanical background of nonlinear phenomena in structural mechanics. + to specify problems of nonlinear structural analysis, to identify them in a given situation and to explain their mathematical and mechanical background.
Skills	Students are able to + model nonlinear structural problems. + select for a given nonlinear structural problem a suitable computational procedure. + apply finite element procedures for nonlinear structural analysis. + critically verify and judge results of nonlinear finite elements. + to transfer their knowledge of nonlinear solution procedures to new problems.
Personal Competence	
Social Competence	Students are able to + solve problems in heterogeneous groups. + present and discuss their results in front of others. + give and accept professional constructive criticism.
Autonomy	Students are able to + assess their knowledge by means of exercises and E-Learning. + acquaint themselves with the necessary knowledge to solve research oriented tasks. + to transform the acquired knowledge to similar problems.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Materials Science: Specialisation Modeling: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory Ship and Offshore Technology: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L0277: Nonlinear Structural Analysis	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Alexander Düster
Language	EN
Cycle	WiSe
Content	1. Introduction 2. Nonlinear phenomena 3. Mathematical preliminaries 4. Basic equations of continuum mechanics 5. Spatial discretization with finite elements 6. Solution of nonlinear systems of equations 7. Solution of elastoplastic problems 8. Stability problems 9. Contact problems
Literature	[1] Alexander Düster, Nonlinear Structrual Analysis, Lecture Notes, Technische Universität Hamburg-Harburg, 2014. [2] Peter Wriggers, Nonlinear Finite Element Methods, Springer 2008. [3] Peter Wriggers, Nichtlineare Finite-Elemente-Methoden, Springer 2001. [4] Javier Bonet and Richard D. Wood, Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge University Press, 2008.

Course L0279: Nonlinear Structural Analysis	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Alexander Düster
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0801: Water Resources and -Supply

Courses

Title	Typ	Hrs/wk	CP
Chemistry of Drinking Water Treatment (L0311)	Lecture	2	1
Chemistry of Drinking Water Treatment (L0312)	Recitation Section (large)	1	2
Water Resource Management (L0402)	Lecture	2	2
Water Resource Management (L0403)	Recitation Section (small)	1	1

Module Responsible	Prof. Mathias Ernst
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of water management and the key processes involved in water treatment.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will be able to outline key areas of conflict in water management, as well as their mutual dependence for sustainable water supply. They will understand relevant economic, environmental and social factors. Students will be able to explain and outline the organisational structures of water companies. They will be able to explain the available water treatment processes and the scope of their application.
Skills	Students will be able to assess complex problems in drinking water production and establish solutions involving water management and technical measures. They will be able to assess the evaluation methods that can be used for this. Students will be able to carry out chemical calculations for selected treatment processes and apply generally accepted technical rules and standards to these processes.
Personal Competence	
Social Competence	Working in a diverse group of specialists, students will be able to develop and document complex solutions for the management and treatment of drinking water. They will be able to take an appropriate professional position, for example representing user interests. They will be able to develop joint solutions in teams of diverse experts and present these solutions to others.
Autonomy	Students will be in a position to work on a subject independently and present on this subject.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	60 min (chemistry) + presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0311: Chemistry of Drinking Water Treatment	
Typ	Lecture
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Dr. Klaus Johannsen
Language	DE
Cycle	WiSe
Content	The topic of this course is water chemistry with respect to drinking water treatment and water distribution Major topics are solubility of gases, carbonic acid system and calcium carbonate, blending, softening, redox processes, materials and legal requirements on drinking water treatment. Focus is put on generally accepted rules of technology (DVGW- and DIN-standards). Special emphasis is put on calculations using realistic analysis data (e.g. calculation of pH or calcium carbonate dissolution potential) in exercises. Students can get a feedback and gain extra points for exam by solving problems for homework. Knowledge of drinking water treatment processes is vital for this lecture. Therefore the most important processes are explained coordinated with the course " Water resources management" in the beginning of the semester.
Literature	**MHW (rev. by Crittenden, J. et al.):** Water treatment principles and design. John Wiley & Sons, Hoboken, 2005. **Stumm, W., Morgan, J.J.**: Aquatic chemistry. John Wiley & Sons, New York, 1996. **DVGW (Hrsg.):** Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004. **Jensen, J. N.**: A Problem Solving Approach to Aquatic Chemistry. John Wiley & Sons, Inc., New York, 2003.

Course L0312: Chemistry of Drinking Water Treatment	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dr. Klaus Johannsen
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0402: Water Resource Management	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Mathias Ernst
Language	DE
Cycle	WiSe
Content	The lecture provides comprehensive knowledge on interaction of water ressource management and drinking water supply. Content overview: • Current situation of global water resources - User and Stakeholder conflicts - Wasserressourcenmanagement in urbane Gebieten - Rechtliche Aspekte, Organisationsformen Trinkwasserversorgungsunternehmen. - Ökobilanzierung, Benchmarking in der Wasserversorgung
Literature	• Aktuelle UN World Water Development Reports • Branchenbild der deutschen Wasserwirtschaft, VKU (2011) • Aktuelle Artikel wissenschaftlicher Zeitschriften • Ppt der Vorlesung

Course L0403: Water Resource Management	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Mathias Ernst
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0923: Integrated Transportation Planning

Courses

Title	Typ	Hrs/wk	CP
Integrated Transportation Planning (L1068)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Carsten Gertz
Admission Requirements	None
Recommended Previous Knowledge	some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineerin
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • describe interdependencies between land-use/location choice and transportation/mobility behaviour • explain and evaluate the social, ecological and economic effects of transport and land-use policy measures. • relate current issues in the area of integrated transport planning and formulate an opinion on them.
Skills	Students are able to: • quantify important parameters, which influence travel demand or are influenced by it. • comprehensively examine a pre-defined or self-selected topic from a transportation studies perspective and document the results in accordance with scientific conventions.
Personal Competence	
Social Competence	Students are able to: • provide feedback on topical contents and their teaching. • constructively handle feedback on their own work. • produce results in group work and document these.
Autonomy	Students are able to: • assess potential consequences of their future professional activities • independently plan working on a pre-defined project topic, acquire the necessary knowledge and use appropriate means for its execution.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	written assignment with presentation during the semester
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L1068: Integrated Transportation Planning	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Carsten Gertz, Dr. Philine Gaffron, Jacqueline Bianca Maaß
Language	DE
Cycle	WiSe
Content	The course will provide students with an understanding of interdependencies between land-use and transportation. Specific topics include a.o.: • interactions between transport and the environment and consequent limitations • characteristics of integrated planning • complex planning processes • interdependencies of location choice and mobility behaviour • transport and land-use policies • project on current issues in transportation studies
Literature	Kutter, Eckhard (2019) Stadtstruktur und Erreichbarkeit in der postfossilen Zukunft. Erich Schmidt Verlag. Berlin. Gies, Huber u. a. (Hrsg.) (93. Ergänzung 2022) Handbuch der kommunalen Verkehrsplanung. Herbert Wichmann Verlag. Berlin, Offenbach. (Loseblattsammlung mit kontinuierlichen Ergänzungen)

Module M0964: Underground Constructions

Courses

Title	Typ	Hrs/wk	CP
Applied Tunnel Constructions (L2407)	Lecture	2	3
Introduction to tunnel construction (L0707)	Lecture	1	2
Introduction to tunnel construction (L1811)	Recitation Section (large)	1	1

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	Modules from Bachelor studies Civil and environmental engineering: • Geotechnics I-II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Knowledge of different tunnel construction types as well as special methods and techniques of subsoil construction.
Skills	Basic knowledge of tunnel design as well as practical skills in structural tunnel analysis.
Personal Competence	
Social Competence	Capacity for teamwork concerning project management and design of tunnels.
Autonomy	Promotion of independent and creative work flow in the framework of a design exercise.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory** No, **Bonus** 5 %, **Form** Excercises, **Description**
Examination	Written exam
Examination duration and scale	120 minutes
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L2407: Applied Tunnel Constructions

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Jürgen Grabe, Tim Babendererde
Language	DE
Cycle	WiSe
Content	
Literature	

Course L0707: Introduction to tunnel construction	
Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dr. Julian Bubel
Language	DE
Cycle	WiSe
Content	• Definitions • Historical development in tunneling • Geology for tunneling • Hard rock tunneling (construction composite and machines) • Tunnelung in temporarly stable soil with conventional construction methods • Tunneling in soft soils (form of supports, shield types, compressed air application) • Pipe jacking • Tunnel Lining, tunnel supporting structures • Calculation approaches for supporting structures in shield-driven tunnels • Surveying for tunneling • Safety requirements • Construction Contract • Literature and sources
Literature	• Vorlesung/Übung s. www.tu-harburg.de/gbt

Course L1811: Introduction to tunnel construction	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Julian Bubel
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0965: Study Work Structural Engineering

Courses			
Title	**Typ**	**Hrs/wk**	**CP**

Module Responsible	Dozenten des SD B
Admission Requirements	None
Recommended Previous Knowledge	Subjects of the Structural Engineering specialisation.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to demonstrate their detailed knowledge in the field of structural and construction engineering. They can exemplify the state of technology and application and discuss critically in the context of actual problems and general conditions of science and society. The students can develop solving strategies and approaches for fundamental and practical problems in structural and construction engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view points of science and society. Scientific work techniques that are used can be described and critically reviewed.
Skills	The students are able to independently select methods for the project work and to justify this choice. They can explain how these methods relate to the field of work and how the context of application has to be adjusted. General findings and further developments may essentially be outlined.
Personal Competence	
Social Competence	The students are able to condense the relevance and the structure of the project work, the work steps and the sub-problems for the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to their colleagues.
Autonomy	The students are capable of independently planning and documenting the work steps and procedures while considering the given deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedback from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology.
Workload in Hours	Independent Study Time 180, Study Time in Lecture 0
Credit points	6
Course achievement	None
Examination	Study work
Examination duration and scale	see FSPO
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory

Module M0969: Selected Topics in Civil Engineering

Courses

Title	Typ	Hrs/wk	CP
Design of Composite Bridges (L3092)	Integrated Lecture	2	3
Analysis of Offshore Structures (L1867)	Lecture	1	1
Energy Geotechnics (L3227)	Lecture	3	3
Solid Matter Process Technology for Biomass (L0052)	Lecture	2	3
Forum I - Geotechnics and Construction Management (L1634)	Seminar	1	1
Forum II - Geotechnics and Construction Management (L1635)	Seminar	1	1
Timber Structures (L1151)	Seminar	2	2
Innovative Timber Construction (L2666)	Lecture	2	4
Glass Structures (L1152)	Lecture	2	2
Glass Structures (L1447)	Recitation Section (large)	1	1
Sustainable landfill design and operation (L3270)	Integrated Lecture	3	3
Special Topics in Steel Design (L3091)	Integrated Lecture	2	3
Special topics of civil engineering 1CP (L2378)		1	1
Special topics of civil engineering 2 LP (L2379)		2	2
Special topics of civil engineering 3 LP (L2380)		3	3
Structural Design (L2789)	Seminar	2	2

Module Responsible	Prof. Frank Schmidt-Döhl
Admission Requirements	None
Recommended Previous Knowledge	none
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students are able to find their way through selected special areas within civil and structural engineering. • Students are able to explain basic models and procedures in selected special areas of civil and structural engineering. • Students are able to interrelate scientific and technical knowledge.
Skills	• Students are able to apply basic methods in selected areas of civil and structural engineering.
Personal Competence	
Social Competence	---
Autonomy	• Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses.
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory

Course L3092: Design of Composite Bridges

Typ	Integrated Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Marcus Rutner
Language	DE
Cycle	SoSe
Content	
Literature	

Course L1867: Analysis of Offshore Structures	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Said Fawad Mohammadi
Language	DE/EN
Cycle	SoSe
Content	Topic 1: Types of Offshore Structures, Fixed and floating structures for Oil & Gas and Offshore Wind industry Topic 2: Wave Forces, Morisons equation Topic 3: Irregular Seastates, Power spectrum and application of FFT Topic 4: Additional Environmental Forces, wind spectra, current forces Topic 5: Linear-Time-Invariant Systems, response of an LTI-system in frequency domain Topic 6: Tubular Welded Connections, stress concentration factors, weld geometry Topic 7: Introduction to Fracture Mechanics, criteria for fracture initiation and crack growth Topic 8: Time and Frequency Domain Fatigue Analyses, rainflow counting, application of LTI-systems for frequency domain fatigue Topic 9: Offshore Installation and Exam, installation of structures, pile driving, pipe laying techniques
Literature	Chakrabarti, Handbook of Offshore Engineering, 2005 Sarpkaya, Wave Forces on Offshore Structures, 2010 Faltinsen, Sea Loads on Ships and Offshore Structures, 1998 Sorensen, Basic Coastal Engineering, 2006 Dowling, Mechanical Behavior of Materials, 2007 Haibach, Betriebsfestigkeit, 2006 Marshall, Design of Welded Tubular Connections, 1992 Newland, Random vibrations, spectral and wavelet analysis, 1993

Course L3227: Energy Geotechnics	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Schriftliche Ausarbeitung (laut FPrO)
Examination duration and scale	wird zu Beginn der Lehrveranstaltung festgelegt
Lecturer	Pauline Kaminski
Language	DE/EN
Cycle	WiSe
Content	Energy geotechnics is a young field in geotechnical engineering with the aim of developing sustainable geotechnical solutions for future-oriented issues relating to the production, transport, operation, decommissioning, and waste utilisation of various energy sources. Examples of possible fields of activity in energy geotechnics include geothermal energy and thermally activated foundation components, foundations for onshore and offshore wind turbines, the decommissioning of mining facilities and the handling of waste products from fossil fuels such as tailings and the geological storage of CO_2. Relevant soil mechanical processes in these applications include the thermo-hydro-mechanically coupled behaviour of soils, multiphase flow in porous media and partially saturated soils. The lecture gives an overview of various aspects of energy geotechnics and provides in-depth knowledge of the associated soil mechanical processes. In addition, CO_2-scarce geotechnical applications are discussed and emission estimates as well as the optimisation of geotechnical structures according to sustainability aspects are addressed.
Literature	

Course L0052: Solid Matter Process Technology for Biomass	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Prof. Werner Sitzmann
Language	DE
Cycle	SoSe
Content	The industrial application of unit operations as part of process engineering is explained by actual examples of solid biomass processes. Size reduction, transportation and dosing, drying and agglomeration of renewable resources are described as important unit operations when producing solid fuels and bioethanol, producing and refining edible oils, when making Btl - and WPC - products. Aspects of explosion protection and plant design complete the lecture.
Literature	Kaltschmitt M., Hartmann H. (Hrsg.): Energie aus Bioamsse, Springer Verlag, 2001, ISBN 3-540-64853-4 Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, Schriftenreihe Nachwachsende Rohstoffe, Fachagentur Nachwachsende Rohstoffe e.V. www.nachwachsende-rohstoffe.de Bockisch M.: Nahrungsfette und -öle, Ulmer Verlag, 1993, ISBN 380000158175

Course L1634: Forum I - Geotechnics and Construction Management	
Typ	Seminar
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	WiSe
Content	Lectures about projects and issues with practical and scientific relevance.
Literature	--

Course L1635: Forum II - Geotechnics and Construction Management	
Typ	Seminar
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	SoSe
Content	Lectures about projects and issues with practical and scientific relevance.
Literature	--

Course L1151: Timber Structures	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Referat
Examination duration and scale	90 min
Lecturer	Prof. Torsten Faber
Language	DE
Cycle	WiSe
Content	
Literature	

Course L2666: Innovative Timber Construction	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Schriftliche Ausarbeitung
Examination duration and scale	45 Minuten
Lecturer	Dr. Andreas Meisel
Language	DE
Cycle	WiSe
Content	
Literature	- Blass, J.: "Ingenieurholzbau" - Schickhofer, G.: "BSPhandbuch: Holz-Massivbauweise in Brettsperrholz" - Informationsdienst Holz: div. Merkblätter und Broschüren - Wallner-Novak M.: Brettsperrholz Bemessung, Band 1 und 2 - Gerner M.: "Fachwerk: Entwicklung, Instandsetzung, Neubau" - Meisel, A.: "Historische Dachwerke: Beurteilung, realitätsnahe statische Analyse und Instandsetzung" - Kempe K.: "Dokumentation Holzschädlinge" - Huckfeldt T.: "Hausfäule- und Bauholzpilze"

Course L1152: Glass Structures	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Marvin Matzik
Language	DE
Cycle	WiSe
Content	Glass structures - Introduction of the material glass (production, refinement, material characteristic) - design of facades - facade types - static calculation of glazing - static calculation of facades - load bearing behavior of glazing (plate or membrane stiffness) - vertical / horizontal glazing with safety-related requirements - glass structures - fire safety of glass facades - construction physics of facades and glazing
Literature	

Course L1447: Glass Structures	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Marvin Matzik
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L3270: Sustainable landfill design and operation	
Typ	Integrated Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Dr. Marco Ritzkowski
Language	EN
Cycle	SoSe
Content	The course introduces the development of modern waste resource management and demonstrates the importance of landfills in the context of recycling processes. Based on international (EU) and national legislation, the current landfill situation is presented and the future significance of landfills will be discussed. A central element of the course deals with the main transformation processes in the landfilled waste, the emission of gases and leachate, the long-term behaviour of landfills as well as aftercare and after-utilisation measures. Further focal points of the course are measures for the sustainable reduction of environmentally and climate-damaging emissions and aspects of landfill technology in an international context.
Literature	1) **Waste Management**. Bernd Bilitewski; Georg Härdtle; Klaus Marek (Eds.), ISBN: 9783540592105 , Springer Verlag Lehrbuchsammlung der TUB, Signatur USH-305 2) **Solid Waste Technology and Management.** Thomas Christensen (Ed.), ISBN: 978-1-4051-7517-3 , Wiley Verlag Lesesaal 2: US - Umweltschutz, Signatur USH-332 3) **Solid Waste Landfilling - Concepts, Processes, Technologies.** Cossu, R. and Stegmann, R. (Eds.), ISBN: 978-0-12-818336-6 PDF (Volltext) über TUB

Course L3091: Special Topics in Steel Design	
Typ	Integrated Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Marcus Rutner, Nikolay Lalkovski
Language	DE
Cycle	SoSe
Content	
Literature	

Course L2378: Special topics of civil engineering 1CP	
Typ	
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Fachtheoretisch-fachpraktische Arbeit
Examination duration and scale	wird zu Beginn der Lehrveranstaltung festgelegt
Lecturer	Dozenten des SD B
Language	DE
Cycle	WiSe/SoSe
Content	The course occurs only if required. The content is defined at short notice.
Literature	Die Literatur wird kurzfristig festgelegt.

Course L2379: Special topics of civil engineering 2 LP	
Typ	
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Fachtheoretisch-fachpraktische Arbeit
Examination duration and scale	wird zu Beginn der Lehrveranstaltung festgelegt
Lecturer	Dozenten des SD B
Language	DE
Cycle	WiSe/SoSe
Content	The course occurs only if required. The content is defined at short notice.
Literature	Die Literatur wird kurzfristig festgelegt.

Course L2380: Special topics of civil engineering 3 LP	
Typ	
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Fachtheoretisch-fachpraktische Arbeit
Examination duration and scale	wird zu Beginn der Lehrveranstaltung festgelegt
Lecturer	Dozenten des SD B
Language	DE
Cycle	WiSe/SoSe
Content	The course occurs only if required. The content is defined at short notice.
Literature	Die Literatur wird kurzfristig festgelegt.

Course L2789: Structural Design	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	20 min
Lecturer	Dr. Jan Mittelstädt
Language	DE/EN
Cycle	SoSe
Content	
Literature	[1] Structure Systems by Heino Engel, Hantje Cantz, 3rd edition (Feb 2007), ISBN-10: 3775718761 Form and Force, Designing Efficient, Expressive Structures by Allan, E., Zalewski, W. et al, John Wiley and Sons; 1st edition (Sept 2009), ISBN-10: 047017465X [2] Peter Rice: An Engineer Imagines, ISBN-10 : 1849944237 [3] Konrad Wachsmann and the Grapevine Structure by C. Sumi et al., Park Books (Oct 2018), ISBN-10: 9783038601104 [4] Manual of Multi-Story Timber Construction by Hermann Kaufmann, Stefan Krotsch, Stefan Winter, DETAIL, (June 2018), ISBN-10: 3955533948 [5] The Art of Structural Design: A Swiss Legacy by B. Billington, Princeton University Art Museum; First Edition edition (Mar 2003), ISBN-10: 0300097867 [6] Structured Lineages: Learning from Japanese Structural Design by G. Nordenson et al, The Museum of Modern Art (Jul 2019), ISBN-10: 1633450562 [7] The Structure: Works of Mahendra Raj by V. Mehta, R. Mehndiretta, A. Huber, Park Books (Oct 2015), ISBN-10: 3038600253

Module M1779: Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC)

Courses

Title	Typ	Hrs/wk	CP
Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC) (L2926)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	• Hydraulic Engineering • Hydromechanics, Hydraulics • Fundamentals of Coastal Engineering, Coastal- and Flood Protection
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Climate and Climate Change • General Impacts of Climate Change on Wind Regime and Water Cycle • Consequences of Climate Change for Coastal Processes • Coastal Protection in Taiwan and Germany • Fundamentals of Climate Adaptation • Nature-based Solutions (NBS) for Coastal Protection
Skills	• Critical thinking: analysis of processes and relations, assessment of needs for action • Creative thinking: development of adaptation strategies and adaptation measures • Practical thinking: inclusion of restrictions, application of calculation approaches, methods, numerical models, planning methods • Consideration of complex tasks
Personal Competence	
Social Competence	• Working in heterogenous groups • Working in international groups • Working with different scientific / non-scientific disciplines • Self reflection
Autonomy	• Application oriented use of knowledge and skills • Autonomous work on complex tasks
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Preparation of a written report on a complex task with a presentation and subsequent discussion. The work on the complex task happens in the course of the lecture.
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2926: Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC)	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Peter Fröhle
Language	EN
Cycle	WiSe
Content	• Climate and Climate Change • General Impacts of Climate Change on Wind Regime and Water Cycle • Consequences of Climate Change for Coastal Processes • Coastal Protection in Taiwan and Germany • Fundamentals of Climate Adaptation • Nature-Based Solutions (NBS) for Coastal Protection
Literature	• Materials provided on eLearning Platform (HOOU Platform) • Depending on the main topics of the course in the respective year, the literature (recent papers) will be provided in the course-material or via StudIP.

Module M1505: Adaptation to Climate Change in Hydraulic Engineering (AKWAS)

Courses

Title	Typ	Hrs/wk	CP
Adaptation to climate change in hydraulic engineering (L2291)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	• Hydrology, Hydraulic Engineering • Hydromechanic, Hydraulics • Fundamentals of Coastal Engineering, Coastal- and Flood Protection • Hydrological Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Climate protection and climate adaptation • Insights into climate change and its regional characteristics - fundamentals, climate modelling / climate models • Impacts of climate change on the components of the regional hydrological cycle • Fundamentals of analysis of climate data • Consequences of the impact of the climate change • Measures for climate adaptation • Assessment, prioritization and communication of adaptation measures • Fundamentals of the analysis of hydrometeorological and hydrological data
Skills	• Critical thinking: analysis of processes and relations, assessment of needs for action • Creative thinking: development of adaptation strategies and adaptation measures • Practical thinking: inclusion of restrictions, application of calculation approaches, methods, numerical models, planning methods • Consideration of complex tasks
Personal Competence	
Social Competence	• Working in heterogenous groups • Working with different scientific / non-scientific disciplines • Self reflection
Autonomy	• Application oriented use of knowledge and skills • Autonomous work on complex tasks
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Preparation of a written report and a presentation of a complex task.
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2291: Adaptation to climate change in hydraulic engineering	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Peter Fröhle
Language	DE
Cycle	WiSe
Content	• Climate protection and climate adaptation • Findings on climate change and its regional characteristics: fundamentals of climate change, climate modelling / climate models • Impacts of climate change on the components of the regional hydrological cycle(climate science view) • Fundamentals of the analysis of climate data • Concequences of the impacts of climate change (ingenieering science view) • Measures for climate change adaptation • Assessment, prioritization and communication of measures • Fundamentals of analysis of hydrometeorological and hydrological data
Literature	• Wird bereitgestellt über die HOOU - eLearning Plattform • abhängig von den jeweils schwerpunktmäßig behandelten Fragestellungen wird das Schrifttum (aktuelle Paper) in der Veranstaltung bzw. über StudIP zur Verfügung gestellt.

Module M1844: Modern discretization methods in structural mechanics

Courses

Title	Typ	Hrs/wk	CP
Modern discretization methods in structural mechanics (L3043)	Lecture	2	3
Modern discretization methods in structural mechanics (L3044)	Recitation Section (small)	2	3

Module Responsible	Prof. Bastian Oesterle
Admission Requirements	None
Recommended Previous Knowledge	• Finite Element Methods • Flächentragwerke
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of this module, students can express the basic aspects of modern discretization methods in structural mechanics.
Skills	After successful completion of this module, the students will be able to use and further improve modern discretization methods for problems in structural mechanics.
Personal Competence	
Social Competence	Students can • participate in subject-specific and interdisciplinary discussions, • defend their own work results in front of others • promote the scientific development of colleagues • Furthermore, they can give and accept professional constructive criticism
Autonomy	Students are able to gain knowledge of the subject area from given and other sources and apply it to new problems. Furthermore, they are able to structure the solution process for problems in the area of modern discretization methods.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L3043: Modern discretization methods in structural mechanics

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	EN
Cycle	WiSe
Content	The course covers variational formulations, various locking phenomena and alternative formulations for finite elements and modern discretization schemes in the context of structural mechanics, like isogeometric analysis. • variational formulation of finite elements, mixed variational principles • geometrical and material locking effects in structural and solid mechanics • hybrid-mixed and enhanced assumed strain finite element formulations, reduced integration and stabilization, DSG method, u-p formulations • patch test, stability, convergence • linear and non-linear analyses • introduction to isogeometric analysis • isogeometric beam, plate and shell formulations • locking effects and their avoidance in modern, smooth discretization schemes, like isogeometric analysis
Literature	• lecture notes and selected scientific papers • O.C. Zienkiewicz, R.L. Taylor, and J.Z. Zhu: Finite Element Method: Its Basis and Fundamentals. Elsevier, 2013. • J. Austin Cottrell, Thomas J. R Hughes, Yuri Bazilevs: Isogeometric Analysis: Toward Integration of CAD and FEA. Wiley, 2009.

Course L3044: Modern discretization methods in structural mechanics	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1725: Scientific Working in Computational Engineering

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Scientific Working in Computational Engineering (L2764)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Kay Smarsly
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in scientific writing. String interest in topics related to computing in civil engineering.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students will learn to apply concepts and methods of scientific working in computational engineering. In interaction with the course instructors and in collaboration with each other, the students will also learn to understand the complex process of scientific thinking, being able to accurately plan, implement and analyze scientific projects, such as prospective master theses. A project will be conducted throughout the semester, which will contribute to the grade. Since scientific writing is of particular importance in this course, a scientific paper will be developed based, which is a prerequisite for the final examination. The paper will be written based on the project conducted within this course. Project meetings in small groups, presentations, and critical discussions of scientific publications are further key activities.
Skills	The students will be capable (i) of solving a scientific problem following a scientific methodology, (ii) of documenting their work effectively in the form of a paper, and (iii) of sharing their work in a presentation.
Personal Competence	
Social Competence	The students will be able to work in a multidisciplinary team and develop communication skills necessary for problem solving.
Autonomy	The students will be able to extend their knowledge and apply it to solve scientific problems by working independently in a project.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	10 pages of work with 15-minute oral presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory

Course L2764: Scientific Working in Computational Engineering

Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Kay Smarsly
Language	EN
Cycle	WiSe/SoSe
Content	In the course, a scientific problem of practical relevance will first be defined, taking into account the interests of the students participating in the course. The scientific problem will then systematically be solved within the framework of a comprehensive project. The principles of scientific working will be taught based on the scientific problem defined previously. As an integral part of scientific working, fundamentals of scientific writing will be presented and applied to a scientific paper to be written during the course. Topics related to scientific writing include structuring in scientific writing (structuring the abstract, the introduction, the main part, the summary and conclusions, and the acknowledgments and references) and recommendations on effective scientific writing (principles of composition, use of English in scientific writing, useful tips, creating figures, writing in mathematics, referencing, and formal email correspondence). A final paper and a final presentation will be assembled by the students.
Literature	Smarsly, K. & Dragos, K., 2019. Scientific Writing in Engineering. Tredition, Hamburg, Germany.

Module M1956: Building and Excavation Law

Courses

Title	Typ	Hrs/wk	CP
Construction law BGB and VOB - law in (excavation) practice (L3182)	Lecture	2	3
Construction disputes from construction (excavation) practice (L3181)	Lecture	2	3

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	Complete modules: Geotechnics I-III
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will gain knowledge of • the history of civil engineering law, • basics of foundation and civil engineering law, • legal aspects of technical regulations in civil engineering (with case studies), • the civil engineering contract, • the liability of the designer and contractor in civil engineering, • the subsoil risk and the system risk, • the total debt in (civil) engineering law, • the (construction) conflict, dispute avoidance models and the construction process, • the systematics of construction contract law, • the BGB construction contract law, • responsibilities on the construction site, • remuneration and contract management, • liability for defects, • public procurement law • Disturbed construction processes: How much money am I entitled to? • Correct calculation of supplements.
Skills	Students learn to apply legal aspects in planning and construction in a legally balanced way. Students learn how to use legal and construction management aspects in practice (planning and construction) on the construction site in a targeted manner and how to manage the construction project optimally.
Personal Competence	
Social Competence	Students can work in groups and support each other in finding solutions.
Autonomy	Students are able to assess their own strengths and weaknesses and organize their time and learning management based on this.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory

Course L3182: Construction law BGB and VOB - law in (excavation) practice

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Günther Schalk
Language	DE
Cycle	WiSe
Content	
Literature	Literatur: - Folienskript (in der Vorlesung erhältlich) - Fuchs/Maurer/Schalk: Handbuch Tiefbaurecht

Course L3181: Construction disputes from construction (excavation) practice	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Ingo Junker
Language	DE
Cycle	WiSe
Content	
Literature	

Module M0859: Coastal Hydraulic Engineering II

Courses

Title	Typ	Hrs/wk	CP
Coastal- and Flood Protection (L0808)	Lecture	2	3
Coastal- and Flood Protection (L1415)	Project-/problem-based Learning	1	1
Maintenance and Defence of Flood Protection Structures (L1411)	Lecture	2	2

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Coastal Engineering I
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students have the capability to define and explain in detail the important aspects of erosion protection and flood protection and are able to apply the aspects to practical coastal protection problems. They are able to design and dimension important coastal protection measures from the functional and from the constructional point of view.
Skills	The students are able to select design approaches for the functional and constructional design of erosion and flood protection measures and apply these approaches to practical design tasks.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in applied problems such as the functional and constructive design of coastal and flood protection structures. Additionaly, they will be able to work in team with engineers of other disciplines.
Autonomy	The students will be able to independently extend their knowledge and apply it to new problems.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	The duration of the examination is 130 min. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L0808: Coastal- and Flood Protection	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Peter Fröhle
Language	EN
Cycle	WiSe

Content	Protection of sandy coasts
	• Sediment transport
	• Morphology
	• Technical solution for the protection of sandy coasts
	  ◦ Construction in direction of the coast
	  ◦ Constructions perpendicular to the coast
	  ◦ Other Concepst
	• Calculation approaches and numerical models
	
	Flood Protection
	• Classification of constructions / measures
	• Dikes
	• Dunes
	• Foreland - constructions
	• Flood-Protection Walls
	• Drainage of the hinterland

Literature	Vorlesungsumdruck Coastal Engineering Manual CEM

Course L1415: Coastal- and Flood Protection	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1411: Maintenance and Defence of Flood Protection Structures	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Olaf Müller
Language	EN
Cycle	WiSe
Content	• Dike protection • Maintennance of flood protection measures
Literature	Vorlesungsumdruck

Module M2003: Biological Waste Treatment

Courses

Title	Typ	Hrs/wk	CP
Waste and Environmental Chemistry (L0328)	Practical Course	2	2
Biological Waste Treatment (L0318)	Project-/problem-based Learning	3	4

Module Responsible	Prof. Kerstin Kuchta
Admission Requirements	None
Recommended Previous Knowledge	chemical and biological basics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The module aims possess knowledge concerning the planning of biological waste treatment plants. Students are able to explain the design and layout of anaerobic and aerobic waste treatment plants in detail, describe different techniques for waste gas treatment plants for biological waste treatment plants and explain different methods for waste analytics.
Skills	The students are able to discuss the compilation of design and layout of plants. They can critically evaluate techniques and quality control measurements. The students can recherché and evaluate literature and date connected to the tasks given in der module and plan additional tests. They are capable of reflecting and evaluating findings in the group.
Personal Competence	
Social Competence	Students can participate in subject-specific and interdisciplinary discussions, develop cooperated solutions and defend their own work results in front of others and promote the scientific development in front of colleagues. Furthermore, they can give and accept professional constructive criticism.
Autonomy	Students can independently tap knowledge from literature, business or test reports and transform it to the course projects. They are capable, in consultation with supervisors as well as in the interim presentation, to assess their learning level and define further steps on this basis. Furthermore, they can define targets for new application-or research-oriented duties in accordance with the potential social, economic and cultural impact.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** Yes / None / Subject theoretical and practical work /
Examination	Presentation
Examination duration and scale	Elaboration and Presentation (15-25 minutes in groups)
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Environmental Engineering: Core Qualification: Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory

Course L0328: Waste and Environmental Chemistry	
Typ	Practical Course
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	WiSe
Content	The participants are divided into groups. Each group prepares a transcript on the experiment performed, which is then used as basis for discussing the results and to evaluate the performance of the group and the individual student. In some experiments the test procedure and the results are presented in seminar form, accompanied by discussion and results evaluation. Experiments ar e.g. Screening and particle size determination Fos/Tac AAS Chalorific value
Literature	Scripte

Course L0318: Biological Waste Treatment	
Typ	Project-/problem-based Learning
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	WiSe
Content	1. Introduction 2. biological basics 3. determination process specific material characterization 4. aerobic degradation (Composting, stabilization) 5. anaerobic degradation (Biogas production, fermentation) 6. Technical layout and process design 7. Flue gas treatment 8. Plant design practical phase
Literature	

Module M2025: Finite element modeling of structures

Courses

Title	Typ	Hrs/wk	CP
Finite element modeling of structures (L3046)	Lecture	2	3
Finite element modeling of structures (L3047)	Recitation Section (small)	2	3

Module Responsible	Prof. Bastian Oesterle
Admission Requirements	None
Recommended Previous Knowledge	• Finite Element Methods • Thin-walled structures
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of this module, students can express the basic aspects of modelling of structures with finite elements.
Skills	After successful completion of this module, the students will be able to model structures with finite elements and to analyse structures using appropriate computational methods.
Personal Competence	
Social Competence	Students can • participate in subject-specific and interdisciplinary discussions, • defend their own work results in front of others • promote the scientific development of colleagues • Furthermore, they can give and accept professional constructive criticism
Autonomy	Students are able to gain knowledge of the subject area from given and other sources and apply it to new problems. Furthermore, they are able to structure the solution process for problems in the area of finite element modelling of structures.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	written elaboration of a project work (10-15 pages)
Assignment for the Following Curricula	Civil Engineering: Specialisation Computational Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L3046: Finite element modeling of structures

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	EN
Cycle	WiSe
Content	Basic phenomena and aspects of the finite element modelling of structures are discussed. Besides theoretical decription of the phenomena and methods, a strong focus is on the practical use a commercial finite element software within computer-based exercises. The covered topics are: • finite element modeling of trusses/beams/frames, plates subject to in-plane/out-of-plane loading and shells • convergence properties of displacements and stresses • singularities • locking effects • critical assessment, interpretation and check of results • mixed-dimensional coupling of finite elements • geometrically linear and non-linear, and material linear and non-linear analyses • stability: bifurcation and snap-through problems • dynamic problems, modal analyses
Literature	Vorlesungsmanuskript, Vorlesungsfolien

Course L3047: Finite element modeling of structures	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M2033: Subsurface Processes

Courses

Title	Typ	Hrs/wk	CP
Modeling of Subsurface Processes (L2731)	Recitation Section (small)	3	3
Subsurface Solute Transport (L2728)	Lecture	2	2
Subsurface Solute Transport (L2729)	Recitation Section (large)	1	1

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	Basic Mathematics, Hydrology
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Upon completion of this module, the students will understand the mechanisms controlling solute transport in soil and natural porous media and will be able to work with the equations that govern the fate and transport of solutes in porous media. Analytical, numerical and experimental tools and techniques will be used in this module.
Skills	In addition to the physical insights, the students will be exposed to analytical, experimental and numerical tools and techniques in this module. This provides them with an excellent opportunity to improve their skills on multiple fronts which will be useful in their future career.
Personal Competence	
Social Competence	Teamwork & problem solving
Autonomy	The students will be involved in writing individual reports and presentation. This will contribute to the students' ability and willingness to work independently and responsibly.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	Report
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Environmental Engineering: Core Qualification: Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory

Course L2731: Modeling of Subsurface Processes

Typ	Recitation Section (small)
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Dr. Milad Aminzadeh
Language	EN
Cycle	WiSe
Content	Basic usage and background of chosen computer software to calculate flow and transport in the saturated and unsaturated zone and to analyze field data like pumping test data
Literature	

Course L2728: Subsurface Solute Transport	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	WiSe
Content	Basic physical properties of soil: Definition and quantification; Liquid flow in soils (Darcy's law); Solute transport in soils; Practical analysis to measure dispersion coefficient in soil under different boundary conditions; Advanced topics (e.g. Application of Artificial Intelligence to predict soil salinization)
Literature	- Environmental Soil Physics, by Daniel Hillel - Soil Physics, Sixth Edition, by William A. Jury and Robert Horton

Course L2729: Subsurface Solute Transport	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Hannes Nevermann
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Specialization Computational Engineering

Module M0963: Steel and Composite Structures

Courses

Title	Typ	Hrs/wk	CP
Steel and Composite Structures (L1204)	Lecture	2	2
Steel and Composite Structures (L1205)	Recitation Section (large)	2	2
Steel Bridges (L1097)	Lecture	2	2

Module Responsible	Prof. Marcus Rutner
Admission Requirements	None
Recommended Previous Knowledge	Basics of steel construction (i.e. Steel Structures I and II, BUBC)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completition, students can • describe the phenomenon of local buckling • explain warping torsion • illustrate the behaviour of composite structures • specify the principles in design of composite sttructures • sketch the contructions of steel and composite bridges
Skills	After successful participation students are able to • check stiffened and unstiffened plated structures • recognize and verify warping tosion in strucures • design composite structures • design bridges and o perform the detailing
Personal Competence	
Social Competence	--
Autonomy	--
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	180 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L1204: Steel and Composite Structures

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Marcus Rutner
Language	DE
Cycle	WiSe
Content	• Local-buckling of plated structures • Warping torsion • Composite-girders, -columns, -slabs, -bridges • Principles in composite constructions • Bridge-design and -construction
Literature	Petersen, C.: Stahlbau, 4.Auflage 2013, Springer-Vieweg Verlag Minnert, J. Wagenknecht, G.: Verbundbau-Praxis - Berechnung und Konstruktion nach Eurocode 4, 2.Auflage 2013, Bauwerk Beuth Verlag

Course L1205: Steel and Composite Structures	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Marcus Rutner
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1097: Steel Bridges	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Yves Freundt
Language	DE
Cycle	WiSe
Content	**Lecture Contents ‚Steel Bridge Construction'** **Dr.-Ing. Jörg Ahlgrimm** - From tendering and contracting to completion - the development of a steel bridge - Contents of a bridge static - structural details, examples of analysis in detail: -> effective width in regard to the longitudinal stiffeners -> Bearing point, bearing stiffener -> Crossbeam breakthrough, crossbeam reinforcement -> Analysis of the Rib-to-Floorbeam (RF) connection (web-tooth of the floorbeam between trapezoidal shaped Ribs) - Steel grades, -designation, testing methods and approval certificates - Nondestructive weld inspecting - Corrosion protection - Bridge bearing - types, format, function, dimensioning, installation - Expansion Joints - Oscillation of bridge hangers and cables - oscillation damper - Opening bridges- Detailed reviews to different assembling procedures and - implements - Selective damage events Requirements: Basic knowledge in the calculation, dimensioning, and construction of structural elements and joints of constructional steelwork
Literature	• Herbert Schmidt, Ulrich Schulte, Rainer Zwätz, Lothar Bär: Ausführung von Stahlbauten • Petersen, Christian: Stahlbau, Abschnitt Brückenbau • Ahlgrimm, J., Lohrer, I.: Erneuerung der Eisenbahnüberführung in Fulda-Horas über die Fulda, Stahlbau 74 (2005), Heft 2, S. 114

Module M0699: Geotechnics III

Courses

Title	Typ	Hrs/wk	CP
Numerical Methods in Geotechnics (L0375)	Lecture	3	3
Advanced Foundation Engineering (L0497)	Lecture	2	2
Advanced Foundation Engineering (L0498)	Recitation Section (large)	1	1

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	Geotechnics I and II, Mathematics I-III
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successfully completing the module, students will be able to • describe individual procedures for the geotechnical monitoring of civil engineering measures, • reproduce exploration and investigation methods of the subsoil, • select suitable types of field and laboratory tests for subsoil investigation and evaluate their results, • state the differences between various stress and deformation states and the physical significance of invariants of the stress and distortion tensor, • outline the standard and special soil mechanics tests used to determine the stress-strain behavior of soil, • describe continuum models and the resulting boundary value problems, • as well as define boundary value problems from the field of geotechnical engineering in such a way that they can be solved unambiguously.
Skills	Students will be able to • dimension vertical drains for soil improvement of soft soils, • calculate depth compaction using various appropriate methods, • apply principles of horizontal bearing capacity of piles, • verify the internal and external stability of fluid-supported diaphragm walls, • evaluate the boundary conditions for the design of a deep excavation and design the individual components of the excavation, • perform, evaluate and interpret tests for the description and classification of soils according to applicable standards, • computationally implement numerical algorithms to solve boundary value problems, • select and apply the types of analyses depending on the degree of saturation, the impact, and the material behavior • determine appropriate model parameters for different possibilities and limitations of material models for the grain structure of soils.
Personal Competence	
Social Competence	Students can work in groups and support each other in finding solutions.
Autonomy	Students are able to assess their own strengths and weaknesses and, based on this, organize their time and learning management and think in terms of processes.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L0375: Numerical Methods in Geotechnics	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Dr. Hans Mathäus Stanford
Language	DE
Cycle	WiSe
Content	Topics: • Introduction to numerical soil mechanics • Introduction to numerical mathematics • Finite Element Method (analysis procedures, algorithms) • Finite Element Method (application in geotechnical engineering)
Literature	• Wriggers P. (2001): Nichtlineare Finite-Elemente-Methoden. Springer • Wriggers P. (2008): Nonlinear Finite Element Methods. Springer • Deutsche Gesellschaft für Geotechnik e.V. (Hrsg., 2014): Empfehlungen des Arbeitskreises "Numerik in der Geotechnik". Ernst & Sohn

Course L0497: Advanced Foundation Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	WiSe
Content	• Vertical drains • Piles • Ground improvement (Deep Compaction, Soil mixing) • Vibration driving • Jet grouting • Slurry wall • Deep excavation
Literature	• EAK (2002): Empfehlungen für Küstenschutzbauwerke • EAU (2004): Empfehlungen des Arbeitsausschusses Uferbauwerke • EAB (1988): Empfehlungen des Arbeitskreises Baugruben • Grundbau-Taschenbuch, Teil 1-3, (1997), Ernst & Sohn Verlag

Course L0498: Advanced Foundation Engineering	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0713: Concrete Structures

Courses

Title	Typ	Hrs/wk	CP
Concrete Structures (L0579)	Seminar	1	1
Structural Concrete Members (L0577)	Lecture	2	3
Structural Concrete Members (L0578)	Recitation Section (large)	2	2

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	Basics of structural analysis, conception and dimensioning of structural concrete Modules: Reinforced Concrete Structures I+II, Structural Analysis I+II, Mechanics I+II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students broaden their skills in structural engineering, especially in the field of buildings (houses, roofs, halls). They dispose of the knowledge for the conception and design of concrete buildings and structural members that are often used.
Skills	The students are able to apply procedures of the conception and dimensioning to to practical problems of structural engineering. They are capable to draft concrete buildings and to design them for general action effects and to plan their detailing and execution. Moreover, they can make design and construction sketches and draw up technical descriptions.
Personal Competence	
Social Competence	The students are able to obtain results of high quality in teamwork.
Autonomy	The students are able to carry out complex conception and dimensioning tasks of structures under the guidance of tutors.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** No; **Bonus** None; **Form** Presentation; **Description** Es werden 2 Referate ausgegeben
Examination	Written exam
Examination duration and scale	120 minutes
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L0579: Concrete Structures

Typ	Seminar
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	NN
Language	DE
Cycle	WiSe
Content	With help of a project teamwork the subjects of the course "Concrete Structures" is practiced, discussed and presented.
Literature	- Projektbezogene Unterlagen werden abgegeben.

Course L0577: Structural Concrete Members	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	NN
Language	DE
Cycle	WiSe
Content	• skyscrapers: structural elements • actions on structrues • bracing systems • design orf slabs (line and point supported plates and floor slabs) • membranes and deep beams • folded plates and shells • truss models • reinforced and prestressed members
Literature	Vorlesungsunterlagen können im STUDiP heruntergeladen werden • Zilch K., Zehetmaier G.: Bemessung im konstruktiven Ingenieurbau. Springer, Heidelberg 2010 • König, G., Liphardt S.: Hochhäuser aus Stahlbeton, Betonkalender 2003, Teil II, Seite 1-69, Verlag Ernst & Sohn, Berlin 2003 • Phocas, Marios C.: Hochhäuser : Tragwerk und Konstruktion, Stuttgart, Teubner, 2005 • Deutscher Ausschuss für Stahlbeton: Heft 600: Erläuterungen zu DIN EN 1992-1-1, Beuth Verlag, Berlin 2012 • Deutscher Ausschuss für Stahlbeton: Heft 240: Hilfsmittel zur Berechnung der Schnittgrößen und Formänderungen von Stahlbetontragwerken, Verlag Ernst & Sohn, Berlin 1978 • Stiglat, K., Wippel, H.: Massive Platten - Ausgewählte Kapitel der Schnittkraftermittlung und Bemessung, Betonkalender 1992, Teil I, 287-366, Verlag Ernst & Sohn, Berlin 1992 • Stiglat/Wippel: Platten. Verlag Ernst & Sohn, Berlin,1973 • Schlaich J.; Schäfer K.: Konstruieren im Stahlbetonbau. Betonkalender 1998, Teil II, S. 721ff, Verlag Ernst & Sohn, Berlin, 1998 • Dames K.-H.: Rohbauzeichnungen Bewehrungszeichnungen. Bauverlag, Wiesbaden 1997

Course L0578: Structural Concrete Members	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	NN
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1748: Construction Robotics

Courses

Title	Typ	Hrs/wk	CP
Construction Robotics (L2867)	Project-/problem-based Learning	6	6

Module Responsible	Prof. Kay Smarsly
Admission Requirements	None
Recommended Previous Knowledge	Basics of project-oriented programming
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Basics of robotics Applications in civil engineering Kinematics
Skills	Use of specific hardware Development of software routines Python programming language Image processing Basics of localization (LIDAR, SLAM)
Personal Competence	
Social Competence	Teamwork Communication skills
Autonomy	Independent work Independent decisions
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	ca. 10 Seiten
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Course L2867: Construction Robotics	
Typ	Project-/problem-based Learning
Hrs/wk	6
CP	6
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Lecturer	Prof. Kay Smarsly, Jan Stührenberg
Language	EN
Cycle	WiSe

Content	1. Introduction: Robotics in civil engineering
	2. Presentation of potential topics
	3. Programming of algorithms in Python
	4. Application of software systems: LINUX distribution, ROS, CloudCompare, ...
	5. Application of hardware systems: Petoi Bittle Dog, Raspberry Pi, Arduino, sensing ...
	6. Topics considered for robotics using the Petoi Bittle Dog:
	    1. Movement
	    2. Use of sensors (camera, infrared, ...)
	    3. Data structures/data acquisition
	    4. Programming
	7. Topics technically relevant to building inspection:
	    1. Geodetic evaluations
	    2. Image processing
	    3. Localization

Literature	Bock/Linner: Construction Robotics Verl et al.: Soft Robotics Pasquale: New Laws of robotics

Module M2033: Subsurface Processes

Courses

Title	Typ	Hrs/wk	CP
Modeling of Subsurface Processes (L2731)	Recitation Section (small)	3	3
Subsurface Solute Transport (L2728)	Lecture	2	2
Subsurface Solute Transport (L2729)	Recitation Section (large)	1	1

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	Basic Mathematics, Hydrology
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Upon completion of this module, the students will understand the mechanisms controlling solute transport in soil and natural porous media and will be able to work with the equations that govern the fate and transport of solutes in porous media. Analytical, numerical and experimental tools and techniques will be used in this module.
Skills	In addition to the physical insights, the students will be exposed to analytical, experimental and numerical tools and techniques in this module. This provides them with an excellent opportunity to improve their skills on multiple fronts which will be useful in their future career.
Personal Competence	
Social Competence	Teamwork & problem solving
Autonomy	The students will be involved in writing individual reports and presentation. This will contribute to the students' ability and willingness to work independently and responsibly.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	Report
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Environmental Engineering: Core Qualification: Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory

Course L2731: Modeling of Subsurface Processes

Typ	Recitation Section (small)
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Dr. Milad Aminzadeh
Language	EN
Cycle	WiSe
Content	Basic usage and background of chosen computer software to calculate flow and transport in the saturated and unsaturated zone and to analyze field data like pumping test data
Literature	

Course L2728: Subsurface Solute Transport	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	WiSe
Content	Basic physical properties of soil: Definition and quantification; Liquid flow in soils (Darcy’s law); Solute transport in soils; Practical analysis to measure dispersion coefficient in soil under different boundary conditions; Advanced topics (e.g. Application of Artificial Intelligence to predict soil salinization)
Literature	- Environmental Soil Physics, by Daniel Hillel - Soil Physics, Sixth Edition, by William A. Jury and Robert Horton

Course L2729: Subsurface Solute Transport	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Hannes Nevermann
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1845: Thin-walled structures

Courses

Title	Typ	Hrs/wk	CP
Thin-walled structures (L1199)	Lecture	2	3
Thin-walled structures (L3045)	Recitation Section (large)	2	3

Module Responsible	Prof. Bastian Oesterle
Admission Requirements	None
Recommended Previous Knowledge	• Structural Analysis I • Structural Analysis II • Finite Element Methods
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of this module, the students can express the basic aspects of the load-carrying behaviour of thin-walled structures.
Skills	After successful completion of this module, the students will be able to predict load-carrying behaviour of thin-walled structures using appropriate analytical and coputational methods.
Personal Competence	
Social Competence	Students can • participate in subject-specific and interdisciplinary discussions, • defend their own work results in front of others • promote the scientific development of colleagues • Furthermore, they can give and accept professional constructive criticism
Autonomy	Students are able to gain knowledge of the subject area from given and other sources and apply it to new problems. Furthermore, they are able to structure the solution process for problems in the area of modelling and analysis of thin-walled structures.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L1199: Thin-walled structures	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	DE
Cycle	SoSe
Content	Plates loaded in-plane • Governing equations (equilibrium, kinematics, constitutive law) • Differential equation • Airy stress function • Plane stress / plane strain • Structural behaviour of plates loaded in-plane • finite elements for plates loaded in-plane, modelling apsects, interpretation and critical assessment of results Plates in bending • Governing equations (equilibrium, kinematics, constitutive law) • Differential equation • Navier solution / Fourier series expansion • Approximation procedures • Circular and rectangular plates • Structural behaviour of plates in bending • finite elements for plates in bending, modelling apsects, interpretation and critical assessment of results Shells • Phenomenona of the structural behaviour of shells • Membrane and bending theory • Equilibrium equations of shells of revolution • Stress resultants and deformations of the spherical shell, the half spherical shell, and the cylindrical shell • finite elements for shells Stability problems (overview) • Plate buckling • Shell buckling
Literature	• Vorlesungsmanuskript • Basar, Y.: Krätzig, W.B. (1985): Mechanik der Flächentragwerke. Vieweg-Verlag, Braunschweig, Wiesbaden • Girkmann, K. (1963): Flächentragwerke, Springer Verlag, Wien, 1963, unveränderter Nachdruck 1986 • Zienkiewicz, O.C. (1977): The Finite Element Method in Enginieering Science. McGraw-Hill, London

Course L3045: Thin-walled structures	
Typ	Recitation Section (large)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0861: Modelling of Hydraulic Engineering

Courses

Title	Typ	Hrs/wk	CP
Hydraulic Models (L0813)	Project-/problem-based Learning	1	1
Modelling of Waves (L0812)	Project-/problem-based Learning	1	1
Modelling of Flow in Rivers and Estuaries (L0810)	Lecture	3	4

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Coastal Hydraulic Engineering I
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to define in detail the basic processes that are related to the modelling of flows in hydraulic engineering. Besides, they can describe the basic aspects of numerical modelling and actual numerical models for the simulation of flows and waves.
Skills	Students are able to apply hydrodynamic-numerical models to practical hydraulic engineering tasks.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in simple applied problems. Additionaly, they will be able to work in team with others.
Autonomy	The students will be able to independently extend their knowledge and apply it to new problems.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	The duration of the examination is 3 hours. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Compulsory

Course L0813: Hydraulic Models

Typ	Project-/problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	• Fundamentals of hydraulic models • Model laws • Pi theorem of Buckingham • Practical examples of hydraulic models
Literature	Strobl, Zunic: Wasserbau, Kap. 11 Hydraulische Modelle, Springer

Course L0812: Modelling of Waves	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	• Waves, interactions with shallow water and constructions • Wave theories • Sea state and surges • Development of waves • Wave spectra • Modelling of Waves / phase averaged and phase resolved models • Application of a phase averaged model for wave prediction (SWAN) • · Application of phase resolved wave models (Mike)
Literature	Vorlesungsumdruck

Course L0810: Modelling of Flow in Rivers and Estuaries	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Edgar Nehlsen, Prof. Peter Fröhle
Language	EN
Cycle	SoSe
Content	Introduction to numerical flow modelling • Processes affecting tht flow • Examples and applications of numerical models • Procedure of numerical modelling • Model concept Basic equations of hydrodynamics • Saint-Venant equations • Euler Equations • Navier-Stokes equations • Reynolds-averaged Navier-Stokes equations • Shallow water equations Solving schemes • Numerical discretization • Solution algorithms • Convergence
Literature	Vorlesungsskript Literaturempfehlungen Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau (1997): Hydraulische Berechnung von naturnahen Fließgewässern. Düsseldorf: BWK (BWK-Merkblatt). Chow, Ven-te (1959): Open-channel Hydraulics. New York usw.: McGraw-Hill (McGraw-Hill Civil Engineering Series). Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019a): Merkblatt DWA-M 543-2 Geodaten in der Fließgewässermodellierung Teil 1: Geodaten in der Fließgewässermodellierung. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-1). Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019b): Merkblatt DWA-M 543-2 Geodaten in der Fließgewässermodellierung Teil 2: Bedarfsgerechte Datenerfassung und -aufbereitung. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-2). Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019c): Merkblatt DWA-M 543-3 Geodaten in der Fließgewässermodellierung - Teil 3: Aspekte der Strömungsmodellierung und Fallbeispiele. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-3). Hervouet, Jean-Michel (2007): Hydrodynamics of free surface flows. Modelling with the finite element method. Chichester: Wiley. Online verfügbar unter http://www.loc.gov/catdir/enhancements/fy0741/2007296953-b.html. IAHR (2015): Professional Specifications for Physical and Numerical Studies in Environmental Hydraulics. In: Hydrolink (3/2015), S. 90-92. Olsen, Nils Reidar B. (2012): Numerical Modelling and Hydraulics. 3. Aufl. Department of Hydraulic and Environmental Engineering, The Norwegian University of Science and Technology. Szymkiewicz, Romuald (2010): Numerical modeling in open channel hydraulics. Dordrecht: Springer (Water science and technology library, 83). van Waveren, Harold (1999-): Good modelling practice handbook. [Utrecht], Lelystad, Den Haag: STOWA; Rijkswaterstaat-RIZA; SDU, afd. SEO/RIZA [etc. distr.] (Nota, nr. 99.036). Zielke, Werner (Hg.) (1999): Numerische Modelle von Flüssen, Seen und Küstengewässern. Deutscher Verband für Wasserwirtschaft und Kulturbau. Bonn: Wirtschafts- und Verl.-Ges. Gas und Wasser (Schriftenreihe des Deutschen Verbandes für Wasserwirtschaft und Kulturbau, 127).

Module M1895: Digital Twinning in Civil Engineering

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Digital Twinning in Civil Engineering (L3136)	Lecture	2	2
Digital Twinning in Civil Engineering (L3137)	Seminar	2	4

Module Responsible	Alexander Chmelnizkij
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	
Skills	
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Presentation
Examination duration and scale	20 min presentation and 5 pages handout
Assignment for the Following Curricula	Civil Engineering: Specialisation Computational Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory

Course L3136: Digital Twinning in Civil Engineering

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Alexander Chmelnizkij, Prof. Bastian Oesterle, Prof. Kay Smarsly
Language	DE
Cycle	SoSe
Content	
Literature	

Course L3137: Digital Twinning in Civil Engineering

Typ	Seminar
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Alexander Chmelnizkij, Prof. Bastian Oesterle, Prof. Kay Smarsly
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0999: Steel Construction Project

Courses

Title	Typ	Hrs/wk	CP
Steel Construction Project (L1206)	Project Seminar	4	6

Module Responsible	Prof. Marcus Rutner
Admission Requirements	None
Recommended Previous Knowledge	Steel and Composite Structures
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to prepare a part of the whole project and explain it to the others.
Skills	Students can produce sketches and calculations of their part of the project. They are able to adjust their work in reaction to changing conditions resulting from other participants of the project.
Personal Competence	
Social Competence	Students can present their results to other members of the group. They have the ability to work for a broad agreement with respect to intergroup dependencies. They can distribute and process tasks independently.
Autonomy	Students can handle their part of the project on their own resposibility-
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	approx. 15-20 pages (without appendix)
Assignment for the Following Curricula	Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory

Course L1206: Steel Construction Project

Typ	Project Seminar
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Marcus Rutner
Language	DE
Cycle	SoSe
Content	Design of a big construction project (i.e skyscraper, large bridge, roof of a stadiuim) in small groups
Literature	Wird je nach Projekt individuell angegeben.

Module M0663: Marine Geotechnics

Courses

Title	Typ	Hrs/wk	CP
Marine Geotechnics (L0548)	Lecture	1	2
Marine Geotechnics (L0549)	Recitation Section (large)	2	2
Steel Structures in Foundation and Hydraulic Engineering (L1146)	Lecture	2	2

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	Complete modules: Geotechnics I-III, Mathematics I-III Courses: Soil laboratory course
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students get a deeper knowledge of steel and ground engineering as well as constructions knowledge concerning quay walls. Furthermore, the students get all the necessary knowledge to design singular construction elements for sheet pile walls and they know how to choose the right construction elements depending on the influencing conditions.
Skills	Furthermore, the students are able to dimension sheet pile wall construction regarding all construction elements, to choose the suitable construction elements with respect to the influencing conditions, to design all kinds of sheet pile walls (wave sheet pile walls and combined sheet pile walls) and to dimension all construction elements and connections.
Personal Competence	
Social Competence	
Autonomy	Students are able to assess their own strengths and weaknesses and organize their time and learning management based on this.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory

Course L0548: Marine Geotechnics

Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	SoSe
Content	• Geotechnical investigation an description of the seabed • Foundations of Offshore-Constructions • cCliff erosion • Sea dikes • Port structures • Flood protection structures
Literature	• EAK (2002): Empfehlungen für Küstenschutzbauwerke • EAU (2004): Empfehlungen des Arbeitsausschusses Uferbauwerke • Poulos H.G. (1988): Marine Geotechnics. Unwin Hyman, London • Wagner P. (1990): Meerestechnik: Eine Einführung für Bauingenieure. Ernst & Sohn, Berlin

Course L0549: Marine Geotechnics	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1146: Steel Structures in Foundation and Hydraulic Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Frank Feindt
Language	DE
Cycle	SoSe
Content	Design of a sheet pile wall, design of a combined sheet pile wall, piles, walings, connections, fatigue
Literature	EAU 2012, EA-Pfähle, EAB

Module M0605: Computational Structural Dynamics

Courses

Title	Typ	Hrs/wk	CP
Computational Structural Dynamics (L0282)	Lecture	3	4
Computational Structural Dynamics (L0283)	Recitation Section (small)	1	2

Module Responsible	Prof. Alexander Düster
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of partial differential equations is recommended.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to + give an overview of the computational procedures for problems of structural dynamics. + explain the application of finite element programs to solve problems of structural dynamics. + specify problems of computational structural dynamics, to identify them in a given situation and to explain their mathematical and mechanical background.
Skills	Students are able to + model problems of structural dynamics. + select a suitable solution procedure for a given problem of structural dynamics. + apply computational procedures to solve problems of structural dynamics. + verify and critically judge results of computational structural dynamics.
Personal Competence	
Social Competence	Students are able to + solve problems in heterogeneous groups. + present and discuss their results in front of others. + give and accept professional constructive criticism.
Autonomy	Students are able to + assess their knowledge by means of exercises and E-Learning. + acquaint themselves with the necessary knowledge to solve research oriented tasks. + to transform the acquired knowledge to similar problems.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	2h
Assignment for the Following Curricula	Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Materials Science: Specialisation Modeling: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L0282: Computational Structural Dynamics

Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Alexander Düster
Language	EN
Cycle	SoSe
Content	1. Motivation 2. Basics of dynamics 3. Time integration methods 4. Modal analysis 5. Fourier transform 6. Applications
Literature	[1] K.-J. Bathe, Finite-Elemente-Methoden, Springer, 2002. [2] J.L. Humar, Dynamics of Structures, Taylor & Francis, 2012.

Course L0283: Computational Structural Dynamics	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Alexander Düster
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0606: Numerical Algorithms in Structural Mechanics

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Numerical Algorithms in Structural Mechanics (L0284)	Lecture	2	3
Numerical Algorithms in Structural Mechanics (L0285)	Recitation Section (small)	2	3

Module Responsible	Prof. Alexander Düster
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of partial differential equations is recommended.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to + give an overview of the standard algorithms that are used in finite element programs. + explain the structure and algorithm of finite element programs. + specify problems of numerical algorithms, to identify them in a given situation and to explain their mathematical and computer science background.
Skills	Students are able to + construct algorithms for given numerical methods. + select for a given problem of structural mechanics a suitable algorithm. + apply numerical algorithms to solve problems of structural mechanics. + implement algorithms in a high-level programming languate (here C++). + critically judge and verfiy numerical algorithms.
Personal Competence	
Social Competence	Students are able to + solve problems in heterogeneous groups. + present and discuss their results in front of others. + give and accept professional constructive criticism.
Autonomy	Students are able to + assess their knowledge by means of exercises and E-Learning. + acquaint themselves with the necessary knowledge to solve research oriented tasks. + to transform the acquired knowledge to similar problems.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	2h
Assignment for the Following Curricula	Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Materials Science: Specialisation Modeling: Elective Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L0284: Numerical Algorithms in Structural Mechanics

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Düster
Language	EN
Cycle	SoSe
Content	1. Motivation 2. Basics of C++ 3. Numerical integration 4. Solution of nonlinear problems 5. Solution of linear equation systems 6. Verification of numerical algorithms 7. Selected algorithms and data structures of a finite element code
Literature	[1] D. Yang, C++ and object-oriented numeric computing, Springer, 2001. [2] K.-J. Bathe, Finite-Elemente-Methoden, Springer, 2002.

Course L0285: Numerical Algorithms in Structural Mechanics	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Düster
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0604: High-Order FEM

Courses

Title	Typ	Hrs/wk	CP
High-Order FEM (L0280)	Lecture	3	4
High-Order FEM (L0281)	Recitation Section (large)	1	2

Module Responsible	Prof. Alexander Düster
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of partial differential equations is recommended.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to + give an overview of the different (h, p, hp) finite element procedures. + explain high-order finite element procedures. + specify problems of finite element procedures, to identify them in a given situation and to explain their mathematical and mechanical background.
Skills	Students are able to + apply high-order finite elements to problems of structural mechanics. + select for a given problem of structural mechanics a suitable finite element procedure. + critically judge results of high-order finite elements. + transfer their knowledge of high-order finite elements to new problems.
Personal Competence	
Social Competence	Students are able to + solve problems in heterogeneous groups. + present and discuss their results in front of others. + give and accept professional constructive criticism.
Autonomy	Students are able to + assess their knowledge by means of exercises and E-Learning. + acquaint themselves with the necessary knowledge to solve research oriented tasks. + to transform the acquired knowledge to similar problems.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory** No; **Bonus** 10 %; **Form** Presentation; **Description** Forschendes Lernen
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Materials Science: Specialisation Modeling: Elective Compulsory Mechanical Engineering and Management: Specialisation Product Development and Production: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory

Course L0280: High-Order FEM	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Alexander Düster
Language	EN
Cycle	SoSe
Content	1. Introduction 2. Motivation 3. Hierarchic shape functions 4. Mapping functions 5. Computation of element matrices, assembly, constraint enforcement and solution 6. Convergence characteristics 7. Mechanical models and finite elements for thin-walled structures 8. Computation of thin-walled structures 9. Error estimation and hp-adaptivity 10. High-order fictitious domain methods
Literature	[1] Alexander Düster, High-Order FEM, Lecture Notes, Technische Universität Hamburg-Harburg, 164 pages, 2014 [2] Barna Szabo, Ivo Babuska, Introduction to Finite Element Analysis – Formulation, Verification and Validation, John Wiley & Sons, 2011

Course L0281: High-Order FEM	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Alexander Düster
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0998: Statics and Dynamics of Structures

Courses

Title	Typ	Hrs/wk	CP
Structural Dynamics (L1202)	Lecture	2	2
Structural Dynamics (L1203)	Recitation Section (large)	2	2
Fracture mechanics and fatigue in steel structures (L0564)	Lecture	1	1
Fracture mechanics and fatigue in steel structures (L0565)	Recitation Section (large)	1	1

Module Responsible	Prof. Bastian Oesterle
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of linear structural analysis of statically determinate and indeterminate structures; Mechanics I/II, Mathematics I/II, Differential equations I
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of this module, the student can explain the basic aspects of dynamic effects on structures and the respective methods.
Skills	After successful completion of this module, the students will be able to predict the response of material and structures to dynamics loading using the appropriate computational approaches and methods.
Personal Competence	
Social Competence	Students can • participate in subject-specific and interdisciplinary discussions, • defend their own work results in front of others • promote the scientific development of colleagues • Furthermore, they can give and accept professional constructive criticism
Autonomy	Students are able to gain knowledge of the subject area from given and other sources and apply it to new problems. Furthermore, they are able to structure the solution process for problems in the area of Structural Analysis.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	150 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L1202: Structural Dynamics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	DE
Cycle	SoSe
Content	• mechanical background of dynamics • harmonic vibrations, damped and undamped free and forced vibrations • frequency and time domain • modelling aspects • principle of d'Alembert • systems with multiple degrees of freedom • consistent and lumped mass matrices • finite elements for dynamics problems • impact problems • eigenvalue problems and modal analysis • direct time integration schemes, transient analyses
Literature	• Vorlesungsmanuskript • Clough, R.W., Penzien, J.: Dynamics of Structures. 2. Aufl., McGraw-Hill, New York, 1993.

Course L1203: Structural Dynamics	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0564: Fracture mechanics and fatigue in steel structures	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Jürgen Priebe
Language	DE
Cycle	SoSe
Content	• basics of fatigue stress and fatigue resistance and determination of fatigue strength, • determination anduse of S-N-curves and classification of notch effects, • set up of determination of fatigue strength under dynamic load using the accumulation formula by Palmgren-Miner, • set up of determination of fatigue strength in different examples, • basics of construction and design regarding the problem of material fatigue, • basics of linear elastic fracture mechanics under static and dynamic load, • determination of lifetime of steel construction based on linear elastic fracture mechanics in different examples.
Literature	• Seeßelberg, C.; Kranbahnen - Bemessung und konstruktive Gestaltung; 3. Auflage; Bauwerk-Verlag; Berlin 2009 • Kuhlmann, Dürr, Günther; Kranbahnen und Betriebsfestigkeit; in Stahlbau Kalender 2003; Verlag Ernst & Sohn; Berlin 2003 • Deutscher Stahlbau-Verband (Hrsg.); Stahlbau Handbuch Band 1 Teil B; 3. Auflage; Stahlbau-Verlagsgesellschaft; Köln 1996 • Petersen, C.; Stahlbau; 3. überarb. und erw. Auflage; Vieweg-Verlag; Braunschweig 1993 • DIN V ENV 1993-1-1: Eurocode 3; Bemessung und Konstruktion von Stahlbauwerken; Teil 1-1: Allgemeine Bemessungsregeln, Bemessungsregeln für den Hochbau; 1993 • DIN V ENV 1993-6: Eurocode 3; Bemessung und Konstruktion von Stahlbauwerken; Teil 6: Kranbahnen; 2001 • DIN-Fachbericht 126. Richtlinie zur Anwendung von DIN V ENV 1993-6; Nationales Anwendungsdokument (NAD); Berlin 2002

Course L0565: Fracture mechanics and fatigue in steel structures	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Jürgen Priebe
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0827: Modeling in Water Management

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Groundwater Modeling using Modflow (L0543)	Lecture	1	1
Groundwater Modeling using Modflow (L0544)	Recitation Section (small)	2	2
Modeling of Water Supply Network (L0875)	Project-/problem-based Learning	2	3

Module Responsible	Dr. Klaus Johannsen
Admission Requirements	None
Recommended Previous Knowledge	Groundwater • groundwater hydraulics and transport of substances Pipe Systems • Knowledge on urban water infrastructures, in particular drinking water systemsand urban drainage systems including special structures • Hydraulics of drinking water supply systems and sewer systems • Basic knowledge on water management
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe the modelling of groundwater flow and transport as well as urban water infrastructures. They can carry out systems analyses and can detect technical and conceptual weak points within the systems in case studies. Besides they are able to analyse interdependencies of hydraulic and toxic phenomena in soil and water.
Skills	The students are able to construct and apply scientific groundwater models indipendently. They can work on different scenarios and can compare or assess different solutions for existing problems by application of selected software products. The students are able to use different software solutions (e.g. EPANET, EPA-SWMM).
Personal Competence	
Social Competence	Wird nicht vermittelt.
Autonomy	Wird nicht vermittelt.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L0543: Groundwater Modeling using Modflow

Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Sonja Götz
Language	DE/EN
Cycle	SoSe
Content	Introduction and application of the groundwater model MODFLOW (PMWIN); theoretical backround of the modell, students do work with the model PMWIN for practical case studies.
Literature	MODFLOW-Handbuch Chiang, Wen Hsien: PMWIN

Course L0544: Groundwater Modeling using Modflow	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Sonja Götz
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0875: Modeling of Water Supply Network	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Klaus Johannsen
Language	DE
Cycle	SoSe
Content	
Literature	Mutschmann/Stimmelmayr: Taschenbuch der Wasserversorgung, 16. Auflage. Springer Vieweg - Verlag. Wiesbaden 2014.

Module M0871: Hydrological Systems

Courses

Title	Typ	Hrs/wk	CP
Applied Surface Hydrology (L0289)	Lecture	2	2
Applied Surface Hydrology (L1412)	Project-/problem-based Learning	1	2
Interaction Water - Environment in Fluvial Areas (L0295)	Project-/problem-based Learning	1	2

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Fundamentals of Hydromechanics and Hydraulic Engineering: Hydraulic Engineering I and Hydraulic Engineering II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to define the basic concepts of hydrology and water management. They are able to describe and quantify the relevant processes of the hydrological water cycle. Besides, the students know the main aspects of rainfall-run-off-models and are able to theoretically derive established reservoir / storage models and a unit-hydrograph.
Skills	The students are able to use the basic hydrological concepts and approaches and are able to theoretically derive established reservoir / storage models or a unit-hydrograph as the basis for rainfall-run-off-models. The student are able to explain the basic concepts of measurements of hydrological and hydrodynamic values in nature and are able to perform, analyze and statistically assess these measurements. Furthermore, they are able to apply a hydrological model to basic hydrological problems.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in applied problems of the hydrology and water management. Additionaly, they will be able to work in team with engineers of other disciplines.
Autonomy	The students will be able to independently extend their knowledge and apply it to new problems
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	The duration of the examination is 90 min. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L0289: Applied Surface Hydrology

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	Basics of hydrology: • Hydrological cycle • Data acquisition • Data analyses and statistical assessment • Statistics of extremes • Regionalization methods for hydrological values • Rainfall-run-off modelling on the basis of a unit hydrograph conceps • Application of rainfall-run-off models on the basis of Kalypso-Hydrology which is an OpenSource Software Tool.
Literature	http://de.wikipedia.org/wiki/Kalypso_(Software) http://kalypso.bjoernsen.de/ http://sourceforge.net/projects/kalypso/

Course L1412: Applied Surface Hydrology	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0295: Interaction Water - Environment in Fluvial Areas	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	A problem based learning course. The problem will be solved by the students more or less self-contained. The topics will be introduced and elaborated over the semester.
Literature	-

Module M0723: Design of Prestressed Structures and Concrete Bridges

Courses

Title	Typ	Hrs/wk	CP
Design of Prestressed Structures and Concreet Bridges (L0603)	Lecture	3	4
Design of Prestressed Structures and Concreet Bridges (L0604)	Recitation Section (large)	2	2

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	Detailed knowledge on the design of concrete structures. Modules: Reinforced Concrete Structures I+II, Structural Analysis I+II, Mechanics I+II, Concrete Structures
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students know the main bridge types, their applications and the various loads. They can explain the basic design methods. They can explain the design of a prestressed bridge.
Skills	The students are able to design reinforced or prestressed concrete bridges.
Personal Competence	
Social Competence	The students can design in teamwork a real concrete bridge.
Autonomy	The students are able to design a prestressed concrete bridge and discuss the problems and results with other students.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	180 minutes
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L0603: Design of Prestressed Structures and Concreet Bridges	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	NN
Language	DE
Cycle	SoSe
Content	prestressed structures • basis of prestressed structures, field of application • differences between reinforced and prestressed concrete structures • history of prestressing • construction materials: concrete, tendons, ducts, anchorage systems • construction: prestressing methods • prestressing forces and member forces (friction, elongation) • tendon layout • time dependant prestressing losses • design of prestressed structures • design of anchorage region • non-bonded prestressing • prestressed flat slabs Concrete bridges • history of bridges • design of bridges • loads on bridges • member forces for slab, T-beam, hollow box, frame and arch bridges • precast bridges - precast segmental bridges • bearings • abutments, columns • construction methods • damages - checking of bridges
Literature	• Vorlesungsumdruckim STUDiP • Rombach, G. (2003): Spannbetonbau. Ernst & Sohn, Berlin • Wicke, M. (2002): Anwendung des Spannbetons. Betonkalender 2002, Teil II, S. 113-180, Verlag Ernst & Sohn, Berlin • Leonhardt, F. (1980): Vorlesungen über Massivbau. Teil 5: Spannbeton. Berlin • Mehlhorn, G. (2007): Handbuch Brücken, Springer Verlag • Schäfer, H.; Kaufeld, K. (1997): Massivbrücken. Betonkalender Teil II, S. 443ff, Ernst & Sohn, Berlin • Menn, Ch. (1986): Stahlbetonbrücken. Springer Verlag, Wien

Course L0604: Design of Prestressed Structures and Concreet Bridges	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	NN
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0756: Soil Mechanics and -Dynamics

Courses

Title	Typ	Hrs/wk	CP
Soil Mechanics - Selected Topics (L0374)	Lecture	2	2
Soil Dynamics (L0452)	Lecture	2	2
Experimental Researches in Geotechnics (L0706)	Practical Course	2	2

Module Responsible: Prof. Jürgen Grabe

Admission Requirements: None

Recommended Previous Knowledge: Modules: Mathematics I-III, Mechanics I-II, Geotechnics I

Courses: Soil laboratory course, (Applied structural dynamics)

Educational Objectives: After taking part successfully, students have reached the following learning results

Professional Competence

Knowledge

Students will be able to,

- describe wave propagation in the ground under dynamic excitation and define the relevant parameters,
- to measure vibrations and to interpret the data obtained with regard to their effect on people and structures,
- justify when elastodynamic methods are sufficient and when plastodynamic effects must be taken into account,
- to reproduce the collapse theorems of plasticity theory,
- describe the viscous behavior of cohesive soils and computationally account for creep deformation and rate-dependent shear strengths
- as well as to determine the effect of partial saturation on the seepage flow and the shear strength.

Skills

After the successful completion of the module the students should be able to:

- to derive and apply the basic equation of a simple mass oscillator,
- to understand the wave propagation in the soil under dynamic excitation and to detect the relevant parameters,
- to know the essential laboratory and field tests to determine soil dynamic characteristics and to evaluate them,
- to design machine foundations to dynamic load,
- to measure shocks to perform vibration forecast,
- to evaluate shocks in terms of their effect on people and buildings,
- to evaluate possibilities of isolation,
- to understand mechanisms that cause earthquakes and evaluate earthquakes in terms of their magnitude and intensity,
- to know methods to determine axial pile capacity, integrity, and the dynamic bedding modulus,
- to know the mechanisms that lead to a deformation accumulation due to cyclic loading and to estimate these deformations mathematically,
- to distinguish the area of application of the method of elastodynamics and plastodynamics,
- to detect the undrained shear strength as a function of a number of state variables,
- to capture the visous behaviour of cohesive soils and to consider the effects of creep and rate-dependent shear strength in calculations,
- to consider the impact of the partly saturated of a seepage and shear strength.

Personal Competence

Social Competence

Students will be able to work in teams to achieve results on measurement and experimental principles and present their results together at the end of the semester.

Autonomy

Students are able to assess their own strengths and weaknesses and organize their time and learning management based on this.

Workload in Hours: Independent Study Time 96, Study Time in Lecture 84

Credit points: 6

Course achievement

Compulsory	Bonus	Form	Description
Yes	None	Subject theoretical and practical work	

Examination: Written exam

Examination duration and scale: 135 min

Assignment for the Following Curricula:

Civil Engineering: Specialisation Structural Engineering: Elective Compulsory
Civil Engineering: Specialisation Geotechnical Engineering: Compulsory
Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory
Civil Engineering: Specialisation Computational Engineering: Elective Compulsory

Course L0374: Soil Mechanics - Selected Topics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Hans Mathäus Stanford
Language	DE
Cycle	SoSe
Content	selected topis: • Stress-strain behaviour (experiments, observations, models) • Hydraulic behaviour (experiments, observations, models) • Physical modelling (similarity theory, 1g model tests, ng model tests) • Limit and safety analysis (collapse theorems of plasticity theory, upper and lower bound analysis, limit equilibrium analysis, numerical analysis) • Heat transport (heat conduction, convective heat transport, freezing/thawing)
Literature	• Kolymbas D. (2019): Geotechnik - Bodenmechanik, Grundbau und Tunnelbau. Springer Verlag, 5. Auflage • Muir Wood D. (2004). Geotechnical modelling. CRC Press Nova, R. (2010). Soil mechanics. Wiley Verruijt, A. (2012). Soil mechanics. u r l: https://geo.verruijt.net Verrujit A. (2018). An introduction to soil mechanics. Vol. 30, Springer Series Theory and Applications of Transport in Porous Media

Course L0452: Soil Dynamics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Anne Hagemann
Language	DE
Cycle	SoSe
Content	• mass-spring-damper systems, • wave propagation in soils, • dynamic soil parameters, • Determination of dynamic soil parameters, • machine foundations, • in-situ measurement of ground motion, ground motion prediction, evaluation of ground motion, • ground motion shielding, • introduction into earthquake engineering, • dynamic pile tests, • cyclic accumulation, • plastodynamics
Literature	• Das B.M.: Fundamentals of Soil Dynamics, Elsevier • Empfehlungen des Arbeitskreises Baugrunddynamik. Hrsg. Deutsche Gesellschaft für Geotechnik (DGGT) • Haupt W.: Bodendynamik. Vieweg und Teubner • Meskouris K. und Hinzen K.-G.: Bauwerke und Erdbeben. Vieweg Verlag • Studer J.A., Koller M.G. und Laue J.: Bodendynamik, Springer Verlag

Course L0706: Experimental Researches in Geotechnics	
Typ	Practical Course
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Hans Mathäus Stanford, Göta Bürkner
Language	DE
Cycle	SoSe
Content	The students are supposed to: • become acquainted with geotechnical model tests, field tests and laboratory tests as well as corresponding measurement techniques. These compromise amongst others inclinometer measurements and geophone measurements as well as high-grade laboratory tests on the stress-strain relationship of soil specimens, e. g. triaxial tests, simple shear tests and resonant column tests. • gain insight into current soil mechanical research. • plan, coordinate, perform and evaluate soil mechanical tests in a team. • discuss, reflect, review and present the obtained results in a group. An important learning target is the introduction to scientific work for students who plan a scientific career, and for those who will work in practice with the responsibility to order corresponding tests and evaluate the results. The practical laboratory work is based on annualy changing problems, which are however related to the experience and results of the preceding year's course group.
Literature	- Grabe, J. (2004): Bodenmechanik und Grundbau, Band 3 der Veröffentlichungsreihe des Instituts für Geotechnik und Baubetrieb, Technische Universität Hamburg-Harburg. - Kolymbas, D. (2007): Geotechnik - Bodenmechanik, Grundbau und Tunnelbau. 2., korrigierte und ergänzte Auflage, Springer Verlag. - Normen zu geotechnischen Versuchsgeräten und Versuchsverfahren: - DIN 18135:2012-04: Baugrund, Untersuchung von Bodenproben - Eindimensionaler Kompressionsversuch, Deutsches Institut für Normung, e. V. - DIN 18137-2:2011-04: Baugrund, Untersuchung von Bodenproben - Bestimmung der Scherfestigkeit - Teil 2: Triaxialversuch, Deutsches Institut für Normung e. V.

Module M0854: Mathematics IV

Courses

Title	Typ	Hrs/wk	CP
Differential Equations 2 (Partial Differential Equations) (L1043)	Lecture	2	1
Differential Equations 2 (Partial Differential Equations) (L1044)	Recitation Section (small)	1	1
Differential Equations 2 (Partial Differential Equations) (L1045)	Recitation Section (large)	1	1
Complex Functions (L1038)	Lecture	2	1
Complex Functions (L1041)	Recitation Section (small)	1	1
Complex Functions (L1042)	Recitation Section (large)	1	1

Module Responsible	Prof. Marko Lindner
Admission Requirements	None
Recommended Previous Knowledge	Mathematics I - III
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can name the basic concepts in Mathematics IV. They are able to explain them using appropriate examples. • Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples. • They know proof strategies and can reproduce them.
Skills	• Students can model problems in Mathematics IV with the help of the concepts studied in this course. Moreover, they are capable of solving them by applying established methods. • Students are able to discover and verify further logical connections between the concepts studied in the course. • For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.
Personal Competence	
Social Competence	• Students are able to work together in teams. They are capable to use mathematics as a common language. • In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.
Autonomy	• Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them. • Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.
Workload in Hours	Independent Study Time 68, Study Time in Lecture 112
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	60 min (Complex Functions) + 60 min (Differential Equations 2)
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Electrical Engineering: Core Qualification: Compulsory General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Elective Compulsory Mechanical Engineering: Specialisation Mechatronics: Compulsory Mechatronics: Core Qualification: Compulsory Naval Architecture: Core Qualification: Compulsory Theoretical Mechanical Engineering: Technical Complementary Course Core Studies: Elective Compulsory

Course L1043: Differential Equations 2 (Partial Differential Equations)	
Typ	Lecture
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	SoSe
Content	Main features of the theory and numerical treatment of partial differential equations • Examples of partial differential equations • First order quasilinear differential equations • Normal forms of second order differential equations • Harmonic functions and maximum principle • Maximum principle for the heat equation • Wave equation • Liouville's formula • Special functions • Difference methods • Finite elements
Literature	• http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html

Course L1044: Differential Equations 2 (Partial Differential Equations)	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1045: Differential Equations 2 (Partial Differential Equations)	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1038: Complex Functions	
Typ	Lecture
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	SoSe
Content	Main features of complex analysis • Functions of one complex variable • Complex differentiation • Conformal mappings • Complex integration • Cauchy's integral theorem • Cauchy's integral formula • Taylor and Laurent series expansion • Singularities and residuals • Integral transformations: Fourier and Laplace transformation
Literature	• http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html

Course L1041: Complex Functions	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Hanna Peywand Kiani
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1042: Complex Functions	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M2032: Advanced Vadose Zone Hydrology

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Modeling Processes in Vadose Zone (L2735)	Recitation Section (small)	2	2
Vadose Zone Hydrology (L2732)	Lecture	2	2
Vadose Zone Hydrology (L2733)	Recitation Section (large)	2	2

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in water and soil Comfortable with math and physics, critical thinking, creative problem solving Analytic skills
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students will learn about soil characterization (solid and liquid phase), the energy state of soil water, the soil water characteristic curve, flow in saturated and unsaturated soil as well as about solute transport in soil
Skills	Students will work on practical examples modelling transport processes in soil using different quantitative tools including computer simulations and analytical tools. This will help them to apply knowledge in order to solve problems and tasks.
Personal Competence	
Social Competence	The module aims at raising awareness and enthusiasm for new knowledge related to water, soil and environment. This will positively contribute to shape their work and life environment.
Autonomy	The students will be involved in many problem solving exercises. This will contribute toward their willingness to work independently and responsibly.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Report and Presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory

Course L2735: Modeling Processes in Vadose Zone

Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Mohammad Aziz Zarif
Language	EN
Cycle	SoSe
Content	Numerical tools will be introduced and used to quantify flow and transport processes in soil
Literature	NA

Course L2732: Vadose Zone Hydrology	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	Soil solid phase characterization, Soil liquid phase characterization, The energy state of soil water, Soil Water Characteristic Curve, Flow in saturated soil, Flow in unsaturated soil, Solute transport in porous media
Literature	- Environmental Soil Physics, by Daniel Hillel - Soil Physics, Sixth Edition, by William A. Jury and Robert Horton - Physical Hydrology, Second Edition, by S. Lawrence Dingman - Introduction to Physical Hydrology, by Martin R. Hendriks

Course L2733: Vadose Zone Hydrology	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0603: Nonlinear Structural Analysis

Courses

Title	Typ	Hrs/wk	CP
Nonlinear Structural Analysis (L0277)	Lecture	3	4
Nonlinear Structural Analysis (L0279)	Recitation Section (small)	1	2

Module Responsible	Prof. Alexander Düster
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of partial differential equations is recommended.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to + give an overview of the different nonlinear phenomena in structural mechanics. + explain the mechanical background of nonlinear phenomena in structural mechanics. + to specify problems of nonlinear structural analysis, to identify them in a given situation and to explain their mathematical and mechanical background.
Skills	Students are able to + model nonlinear structural problems. + select for a given nonlinear structural problem a suitable computational procedure. + apply finite element procedures for nonlinear structural analysis. + critically verify and judge results of nonlinear finite elements. + to transfer their knowledge of nonlinear solution procedures to new problems.
Personal Competence	
Social Competence	Students are able to + solve problems in heterogeneous groups. + present and discuss their results in front of others. + give and accept professional constructive criticism.
Autonomy	Students are able to + assess their knowledge by means of exercises and E-Learning. + acquaint themselves with the necessary knowledge to solve research oriented tasks. + to transform the acquired knowledge to similar problems.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Materials Science: Specialisation Modeling: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory Ship and Offshore Technology: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L0277: Nonlinear Structural Analysis	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Alexander Düster
Language	EN
Cycle	WiSe
Content	1. Introduction 2. Nonlinear phenomena 3. Mathematical preliminaries 4. Basic equations of continuum mechanics 5. Spatial discretization with finite elements 6. Solution of nonlinear systems of equations 7. Solution of elastoplastic problems 8. Stability problems 9. Contact problems
Literature	[1] Alexander Düster, Nonlinear Structrual Analysis, Lecture Notes, Technische Universität Hamburg-Harburg, 2014. [2] Peter Wriggers, Nonlinear Finite Element Methods, Springer 2008. [3] Peter Wriggers, Nichtlineare Finite-Elemente-Methoden, Springer 2001. [4] Javier Bonet and Richard D. Wood, Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge University Press, 2008.

Course L0279: Nonlinear Structural Analysis	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Alexander Düster
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0964: Underground Constructions

Courses

Title	Typ	Hrs/wk	CP
Applied Tunnel Constructions (L2407)	Lecture	2	3
Introduction to tunnel construction (L0707)	Lecture	1	2
Introduction to tunnel construction (L1811)	Recitation Section (large)	1	1

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	Modules from Bachelor studies Civil and environmental engineering: • Geotechnics I-II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Knowledge of different tunnel construction types as well as special methods and techniques of subsoil construction.
Skills	Basic knowledge of tunnel design as well as practical skills in structural tunnel analysis.
Personal Competence	
Social Competence	Capacity for teamwork concerning project management and design of tunnels.
Autonomy	Promotion of independent and creative work flow in the framework of a design exercise.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory** No · **Bonus** 5 % · **Form** Excercises · **Description**
Examination	Written exam
Examination duration and scale	120 minutes
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L2407: Applied Tunnel Constructions

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Jürgen Grabe, Tim Babendererde
Language	DE
Cycle	WiSe
Content	
Literature	

Course L0707: Introduction to tunnel construction	
Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dr. Julian Bubel
Language	DE
Cycle	WiSe
Content	• Definitions • Historical development in tunneling • Geology for tunneling • Hard rock tunneling (construction composite and machines) • Tunnelung in temporarly stable soil with conventional construction methods • Tunneling in soft soils (form of supports, shield types, compressed air application) • Pipe jacking • Tunnel Lining, tunnel supporting structures • Calculation approaches for supporting structures in shield-driven tunnels • Surveying for tunneling • Safety requirements • Construction Contract • Literature and sources
Literature	• Vorlesung/Übung s. www.tu-harburg.de/gbt

Course L1811: Introduction to tunnel construction	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Julian Bubel
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1725: Scientific Working in Computational Engineering

Courses

Title	Typ	Hrs/wk	CP
Scientific Working in Computational Engineering (L2764)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Kay Smarsly
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in scientific writing. String interest in topics related to computing in civil engineering.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students will learn to apply concepts and methods of scientific working in computational engineering. In interaction with the course instructors and in collaboration with each other, the students will also learn to understand the complex process of scientific thinking, being able to accurately plan, implement and analyze scientific projects, such as prospective master theses. A project will be conducted throughout the semester, which will contribute to the grade. Since scientific writing is of particular importance in this course, a scientific paper will be developed based, which is a prerequisite for the final examination. The paper will be written based on the project conducted within this course. Project meetings in small groups, presentations, and critical discussions of scientific publications are further key activities.
Skills	The students will be capable (i) of solving a scientific problem following a scientific methodology, (ii) of documenting their work effectively in the form of a paper, and (iii) of sharing their work in a presentation.
Personal Competence	
Social Competence	The students will be able to work in a multidisciplinary team and develop communication skills necessary for problem solving.
Autonomy	The students will be able to extend their knowledge and apply it to solve scientific problems by working independently in a project.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	10 pages of work with 15-minute oral presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory

Course L2764: Scientific Working in Computational Engineering

Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Kay Smarsly
Language	EN
Cycle	WiSe/SoSe
Content	In the course, a scientific problem of practical relevance will first be defined, taking into account the interests of the students participating in the course. The scientific problem will then systematically be solved within the framework of a comprehensive project. The principles of scientific working will be taught based on the scientific problem defined previously. As an integral part of scientific working, fundamentals of scientific writing will be presented and applied to a scientific paper to be written during the course. Topics related to scientific writing include structuring in scientific writing (structuring the abstract, the introduction, the main part, the summary and conclusions, and the acknowledgments and references) and recommendations on effective scientific writing (principles of composition, use of English in scientific writing, useful tips, creating figures, writing in mathematics, referencing, and formal email correspondence). A final paper and a final presentation will be assembled by the students.
Literature	Smarsly, K. & Dragos, K., 2019. Scientific Writing in Engineering. Tredition, Hamburg, Germany.

Module M1844: Modern discretization methods in structural mechanics

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Modern discretization methods in structural mechanics (L3043)	Lecture	2	3
Modern discretization methods in structural mechanics (L3044)	Recitation Section (small)	2	3

Module Responsible	Prof. Bastian Oesterle
Admission Requirements	None
Recommended Previous Knowledge	• Finite Element Methods • Flächentragwerke
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of this module, students can express the basic aspects of modern discretization methods in structural mechanics.
Skills	After successful completion of this module, the students will be able to use and further improve modern discretization methods for problems in structural mechanics.
Personal Competence	
Social Competence	Students can • participate in subject-specific and interdisciplinary discussions, • defend their own work results in front of others • promote the scientific development of colleagues • Furthermore, they can give and accept professional constructive criticism
Autonomy	Students are able to gain knowledge of the subject area from given and other sources and apply it to new problems. Furthermore, they are able to structure the solution process for problems in the area of modern discretization methods.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L3043: Modern discretization methods in structural mechanics

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	EN
Cycle	WiSe
Content	The course covers variational formulations, various locking phenomena and alternative formulations for finite elements and modern discretization schemes in the context of structural mechanics, like isogeometric analysis. • variational formulation of finite elements, mixed variational principles • geometrical and material locking effects in structural and solid mechanics • hybrid-mixed and enhanced assumed strain finite element formulations, reduced integration and stabilization, DSG method, u-p formulations • patch test, stability, convergence • linear and non-linear analyses • introduction to isogeometric analysis • isogeometric beam, plate and shell formulations • locking effects and their avoidance in modern, smooth discretization schemes, like isogeometric analysis
Literature	• lecture notes and selected scientific papers • O.C. Zienkiewicz, R.L. Taylor, and J.Z. Zhu: Finite Element Method: Its Basis and Fundamentals. Elsevier, 2013. • J. Austin Cottrell, Thomas J. R Hughes, Yuri Bazilevs: Isogeometric Analysis: Toward Integration of CAD and FEA. Wiley, 2009.

Course L3044: Modern discretization methods in structural mechanics	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1906: Study work computational engineering

Courses			
Title	**Typ**	**Hrs/wk**	**CP**

Module Responsible	Dozenten des SD B
Admission Requirements	None
Recommended Previous Knowledge	Subjects of the computational engineering specialisation.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to demonstrate their detailed knowledge in the field of computational engineering engineering. They can exemplify the state of technology and application and discuss critically in the context of actual problems and general conditions of science and society. The students can develop solving strategies and approaches for fundamental and practical problems in computational engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view points of science and society. Scientific work techniques that are used can be described and critically reviewed.
Skills	The students are able to independently select methods for the project work and to justify this choice. They can explain how these methods relate to the field of work and how the context of application has to be adjusted. General findings and further developments may essentially be outlined.
Personal Competence	
Social Competence	The students are able to condense the relevance and the structure of the project work, the work steps and the sub-problems for the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to their colleagues.
Autonomy	The students are capable of independently planning and documenting the work steps and procedures while considering the given deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedback from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology.
Workload in Hours	Independent Study Time 180, Study Time in Lecture 0
Credit points	6
Course achievement	None
Examination	Study work
Examination duration and scale	see FSPO
Assignment for the Following Curricula	Civil Engineering: Specialisation Computational Engineering: Compulsory

Module M0969: Selected Topics in Civil Engineering

Courses

Title	Typ	Hrs/wk	CP
Design of Composite Bridges (L3092)	Integrated Lecture	2	3
Analysis of Offshore Structures (L1867)	Lecture	1	1
Energy Geotechnics (L3227)	Lecture	3	3
Solid Matter Process Technology for Biomass (L0052)	Lecture	2	3
Forum I - Geotechnics and Construction Management (L1634)	Seminar	1	1
Forum II - Geotechnics and Construction Management (L1635)	Seminar	1	1
Timber Structures (L1151)	Seminar	2	2
Innovative Timber Construction (L2666)	Lecture	2	4
Glass Structures (L1152)	Lecture	2	2
Glass Structures (L1447)	Recitation Section (large)	1	1
Sustainable landfill design and operation (L3270)	Integrated Lecture	3	3
Special Topics in Steel Design (L3091)	Integrated Lecture	2	3
Special topics of civil engineering 1CP (L2378)		1	1
Special topics of civil engineering 2 LP (L2379)		2	2
Special topics of civil engineering 3 LP (L2380)		3	3
Structural Design (L2789)	Seminar	2	2

Module Responsible	Prof. Frank Schmidt-Döhl
Admission Requirements	None
Recommended Previous Knowledge	none
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students are able to find their way through selected special areas within civil and structural engineering. • Students are able to explain basic models and procedures in selected special areas of civil and structural engineering. • Students are able to interrelate scientific and technical knowledge.
Skills	• Students are able to apply basic methods in selected areas of civil and structural engineering.
Personal Competence	
Social Competence	---
Autonomy	• Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses.
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory

Course L3092: Design of Composite Bridges

Typ	Integrated Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Marcus Rutner
Language	DE
Cycle	SoSe
Content	
Literature	

Course L1867: Analysis of Offshore Structures	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Said Fawad Mohammadi
Language	DE/EN
Cycle	SoSe
Content	Topic 1: Types of Offshore Structures, Fixed and floating structures for Oil & Gas and Offshore Wind industry Topic 2: Wave Forces, Morisons equation Topic 3: Irregular Seastates, Power spectrum and application of FFT Topic 4: Additional Environmental Forces, wind spectra, current forces Topic 5: Linear-Time-Invariant Systems, response of an LTI-system in frequency domain Topic 6: Tubular Welded Connections, stress concentration factors, weld geometry Topic 7: Introduction to Fracture Mechanics, criteria for fracture initiation and crack growth Topic 8: Time and Frequency Domain Fatigue Analyses, rainflow counting, application of LTI-systems for frequency domain fatigue Topic 9: Offshore Installation and Exam, installation of structures, pile driving, pipe laying techniques
Literature	Chakrabarti, Handbook of Offshore Engineering, 2005 Sarpkaya, Wave Forces on Offshore Structures, 2010 Faltinsen, Sea Loads on Ships and Offshore Structures, 1998 Sorensen, Basic Coastal Engineering, 2006 Dowling, Mechanical Behavior of Materials, 2007 Haibach, Betriebsfestigkeit, 2006 Marshall, Design of Welded Tubular Connections, 1992 Newland, Random vibrations, spectral and wavelet analysis, 1993

Course L3227: Energy Geotechnics	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Schriftliche Ausarbeitung (laut FPrO)
Examination duration and scale	wird zu Beginn der Lehrveranstaltung festgelegt
Lecturer	Pauline Kaminski
Language	DE/EN
Cycle	WiSe
Content	Energy geotechnics is a young field in geotechnical engineering with the aim of developing sustainable geotechnical solutions for future-oriented issues relating to the production, transport, operation, decommissioning, and waste utilisation of various energy sources. Examples of possible fields of activity in energy geotechnics include geothermal energy and thermally activated foundation components, foundations for onshore and offshore wind turbines, the decommissioning of mining facilities and the handling of waste products from fossil fuels such as tailings and the geological storage of CO2. Relevant soil mechanical processes in these applications include the thermo-hydro-mechanically coupled behaviour of soils, multiphase flow in porous media and partially saturated soils. The lecture gives an overview of various aspects of energy geotechnics and provides in-depth knowledge of the associated soil mechanical processes. In addition, CO2-scarce geotechnical applications are discussed and emission estimates as well as the optimisation of geotechnical structures according to sustainability aspects are addressed.
Literature	

Course L0052: Solid Matter Process Technology for Biomass	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Prof. Werner Sitzmann
Language	DE
Cycle	SoSe
Content	The industrial application of unit operations as part of process engineering is explained by actual examples of solid biomass processes. Size reduction, transportation and dosing, drying and agglomeration of renewable resources are described as important unit operations when producing solid fuels and bioethanol, producing and refining edible oils, when making Btl - and WPC -products. Aspects of explosion protection and plant design complete the lecture.
Literature	Kaltschmitt M., Hartmann H. (Hrsg.): Energie aus Bioamsse, Springer Verlag, 2001, ISBN 3-540-64853-4 Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, Schriftenreihe Nachwachsende Rohstoffe, Fachagentur Nachwachsende Rohstoffe e.V. www.nachwachsende-rohstoffe.de Bockisch M.: Nahrungsfette und -öle, Ulmer Verlag, 1993, ISBN 380000158175

Course L1634: Forum I - Geotechnics and Construction Management	
Typ	Seminar
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	WiSe
Content	Lectures about projects and issues with practical and scientific relevance.
Literature	--

Course L1635: Forum II - Geotechnics and Construction Management	
Typ	Seminar
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	SoSe
Content	Lectures about projects and issues with practical and scientific relevance.
Literature	--

Course L1151: Timber Structures	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Referat
Examination duration and scale	90 min
Lecturer	Prof. Torsten Faber
Language	DE
Cycle	WiSe
Content	
Literature	

Course L2666: Innovative Timber Construction	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Schriftliche Ausarbeitung
Examination duration and scale	45 Minuten
Lecturer	Dr. Andreas Meisel
Language	DE
Cycle	WiSe
Content	
Literature	- Blass, J.: "Ingenieurholzbau" - Schickhofer, G.: "BSPhandbuch: Holz-Massivbauweise in Brettsperrholz" - Informationsdienst Holz: div. Merkblätter und Broschüren - Wallner-Novak M.: Brettsperrholz Bemessung, Band 1 und 2 - Gerner M.: "Fachwerk: Entwicklung, Instandsetzung, Neubau" - Meisel, A.: "Historische Dachwerke: Beurteilung, realitätsnahe statische Analyse und Instandsetzung" - Kempe K.: "Dokumentation Holzschädlinge" - Huckfeldt T.: "Hausfäule- und Bauholzpilze"

Course L1152: Glass Structures	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Marvin Matzik
Language	DE
Cycle	WiSe
Content	Glass structures - Introduction of the material glass (production, refinement, material characteristic) - design of facades - facade types - static calculation of glazing - static calculation of facades - load bearing behavior of glazing (plate or membrane stiffness) - vertical / horizontal glazing with safety-related requirements - glass structures - fire safety of glass facades - construction physics of facades and glazing
Literature	

Course L1447: Glass Structures	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Marvin Matzik
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L3270: Sustainable landfill design and operation	
Typ	Integrated Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Dr. Marco Ritzkowski
Language	EN
Cycle	SoSe
Content	The course introduces the development of modern waste resource management and demonstrates the importance of landfills in the context of recycling processes. Based on international (EU) and national legislation, the current landfill situation is presented and the future significance of landfills will be discussed. A central element of the course deals with the main transformation processes in the landfilled waste, the emission of gases and leachate, the long-term behaviour of landfills as well as aftercare and after-utilisation measures. Further focal points of the course are measures for the sustainable reduction of environmentally and climate-damaging emissions and aspects of landfill technology in an international context.
Literature	1) **Waste Management**. Bernd Bilitewski; Georg Härdtle; Klaus Marek (Eds.), ISBN: 9783540592105 , Springer Verlag Lehrbuchsammlung der TUB, Signatur USH-305 2) **Solid Waste Technology and Management.** Thomas Christensen (Ed.), ISBN: 978-1-4051-7517-3 , Wiley Verlag Lesesaal 2: US - Umweltschutz, Signatur USH-332 3) **Solid Waste Landfilling - Concepts, Processes, Technologies.** Cossu, R. and Stegmann, R. (Eds.), ISBN: 978-0-12-818336-6 PDF (Volltext) über TUB

Course L3091: Special Topics in Steel Design	
Typ	Integrated Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Marcus Rutner, Nikolay Lalkovski
Language	DE
Cycle	SoSe
Content	
Literature	

Course L2378: Special topics of civil engineering 1CP	
Typ	
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Fachtheoretisch-fachpraktische Arbeit
Examination duration and scale	wird zu Beginn der Lehrveranstaltung festgelegt
Lecturer	Dozenten des SD B
Language	DE
Cycle	WiSe/SoSe
Content	The course occurs only if required. The content is defined at short notice.
Literature	Die Literatur wird kurzfristig festgelegt.

Course L2379: Special topics of civil engineering 2 LP	
Typ	
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Fachtheoretisch-fachpraktische Arbeit
Examination duration and scale	wird zu Beginn der Lehrveranstaltung festgelegt
Lecturer	Dozenten des SD B
Language	DE
Cycle	WiSe/SoSe
Content	The course occurs only if required. The content is defined at short notice.
Literature	Die Literatur wird kurzfristig festgelegt.

Course L2380: Special topics of civil engineering 3 LP	
Typ	
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Fachtheoretisch-fachpraktische Arbeit
Examination duration and scale	wird zu Beginn der Lehrveranstaltung festgelegt
Lecturer	Dozenten des SD B
Language	DE
Cycle	WiSe/SoSe
Content	The course occurs only if required. The content is defined at short notice.
Literature	Die Literatur wird kurzfristig festgelegt.

Course L2789: Structural Design	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	20 min
Lecturer	Dr. Jan Mittelstädt
Language	DE/EN
Cycle	SoSe
Content	
Literature	[1] Structure Systems by Heino Engel, Hantje Cantz, 3rd edition (Feb 2007), ISBN-10: 3775718761 Form and Force, Designing Efficient, Expressive Structures by Allan, E., Zalewski, W. et al, John Wiley and Sons; 1st edition (Sept 2009), ISBN-10: 047017465X [2] Peter Rice: An Engineer Imagines, ISBN-10 : 1849944237 [3] Konrad Wachsmann and the Grapevine Structure by C. Sumi et al., Park Books (Oct 2018), ISBN-10: 9783038601104 [4] Manual of Multi-Story Timber Construction by Hermann Kaufmann, Stefan Krotsch, Stefan Winter, DETAIL, (June 2018), ISBN-10: 3955533948 [5] The Art of Structural Design: A Swiss Legacy by B. Billington, Princeton University Art Museum; First Edition edition (Mar 2003), ISBN-10: 0300097867 [6] Structured Lineages: Learning from Japanese Structural Design by G. Nordenson et al, The Museum of Modern Art (Jul 2019), ISBN-10: 1633450562 [7] The Structure: Works of Mahendra Raj by V. Mehta, R. Mehndiretta, A. Huber, Park Books (Oct 2015), ISBN-10: 3038600253

Module M1956: Building and Excavation Law

Courses

Title	Typ	Hrs/wk	CP
Construction law BGB and VOB - law in (excavation) practice (L3182)	Lecture	2	3
Construction disputes from construction (excavation) practice (L3181)	Lecture	2	3

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	Complete modules: Geotechnics I-III
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will gain knowledge of • the history of civil engineering law, • basics of foundation and civil engineering law, • legal aspects of technical regulations in civil engineering (with case studies), • the civil engineering contract, • the liability of the designer and contractor in civil engineering, • the subsoil risk and the system risk, • the total debt in (civil) engineering law, • the (construction) conflict, dispute avoidance models and the construction process, • the systematics of construction contract law, • the BGB construction contract law, • responsibilities on the construction site, • remuneration and contract management, • liability for defects, • public procurement law • Disturbed construction processes: How much money am I entitled to? • Correct calculation of supplements.
Skills	Students learn to apply legal aspects in planning and construction in a legally balanced way. Students learn how to use legal and construction management aspects in practice (planning and construction) on the construction site in a targeted manner and how to manage the construction project optimally.
Personal Competence	
Social Competence	Students can work in groups and support each other in finding solutions.
Autonomy	Students are able to assess their own strengths and weaknesses and organize their time and learning management based on this.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory

Course L3182: Construction law BGB and VOB - law in (excavation) practice

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Günther Schalk
Language	DE
Cycle	WiSe
Content	
Literature	Literatur: - Folienskript (in der Vorlesung erhältlich) - Fuchs/Maurer/Schalk: Handbuch Tiefbaurecht

Course L3181: Construction disputes from construction (excavation) practice	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Ingo Junker
Language	DE
Cycle	WiSe
Content	
Literature	

Module M2025: Finite element modeling of structures

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Finite element modeling of structures (L3046)	Lecture	2	3
Finite element modeling of structures (L3047)	Recitation Section (small)	2	3

Module Responsible	Prof. Bastian Oesterle
Admission Requirements	None
Recommended Previous Knowledge	• Finite Element Methods • Thin-walled structures
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of this module, students can express the basic aspects of modelling of structures with finite elements.
Skills	After successful completion of this module, the students will be able to model structures with finite elements and to analyse structures using appropriate computational methods.
Personal Competence	
Social Competence	Students can • participate in subject-specific and interdisciplinary discussions, • defend their own work results in front of others • promote the scientific development of colleagues • Furthermore, they can give and accept professional constructive criticism
Autonomy	Students are able to gain knowledge of the subject area from given and other sources and apply it to new problems. Furthermore, they are able to structure the solution process for problems in the area of finite element modelling of structures.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	written elaboration of a project work (10-15 pages)
Assignment for the Following Curricula	Civil Engineering: Specialisation Computational Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L3046: Finite element modeling of structures

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	EN
Cycle	WiSe
Content	Basic phenomena and aspects of the finite element modelling of structures are discussed. Besides theoretical decription of the phenomena and methods, a strong focus is on the practical use a commercial finite element software within computer-based exercises. The covered topics are: • finite element modeling of trusses/beams/frames, plates subject to in-plane/out-of-plane loading and shells • convergence properties of displacements and stresses • singularities • locking effects • critical assessment, interpretation and check of results • mixed-dimensional coupling of finite elements • geometrically linear and non-linear, and material linear and non-linear analyses • stability: bifurcation and snap-through problems • dynamic problems, modal analyses
Literature	Vorlesungsmanuskript, Vorlesungsfolien

Course L3047: Finite element modeling of structures	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Specialization Water and Traffic

Module M0964: Underground Constructions

Courses

Title	Typ	Hrs/wk	CP
Applied Tunnel Constructions (L2407)	Lecture	2	3
Introduction to tunnel construction (L0707)	Lecture	1	2
Introduction to tunnel construction (L1811)	Recitation Section (large)	1	1

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	Modules from Bachelor studies Civil and environmental engineering: • Geotechnics I-II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Knowledge of different tunnel construction types as well as special methods and techniques of subsoil construction.
Skills	Basic knowledge of tunnel design as well as practical skills in structural tunnel analysis.
Personal Competence	
Social Competence	Capacity for teamwork concerning project management and design of tunnels.
Autonomy	Promotion of independent and creative work flow in the framework of a design exercise.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory** No, **Bonus** 5 %, **Form** Excercises, **Description**
Examination	Written exam
Examination duration and scale	120 minutes
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L2407: Applied Tunnel Constructions

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Jürgen Grabe, Tim Babendererde
Language	DE
Cycle	WiSe
Content	
Literature	

Course L0707: Introduction to tunnel construction	
Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dr. Julian Bubel
Language	DE
Cycle	WiSe
Content	• Definitions • Historical development in tunneling • Geology for tunneling • Hard rock tunneling (construction composite and machines) • Tunnelung in temporarly stable soil with conventional construction methods • Tunneling in soft soils (form of supports, shield types, compressed air application) • Pipe jacking • Tunnel Lining, tunnel supporting structures • Calculation approaches for supporting structures in shield-driven tunnels • Surveying for tunneling • Safety requirements • Construction Contract • Literature and sources
Literature	• Vorlesung/Übung s. www.tu-harburg.de/gbt

Course L1811: Introduction to tunnel construction	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Julian Bubel
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0595: Examination of Materials, Structural Condition and Damages

Courses

Title	Typ	Hrs/wk	CP
Examination of Materials, Structural Condition and Damages (L0260)	Lecture	3	4
Examination of Materials, Structural Condition and Damages (L0261)	Recitation Section (small)	1	2

Module Responsible	Prof. Frank Schmidt-Döhl
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge about building materials or material science, for example by the module Building Materials and Building Chemistry.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe the rules for trading, use and marking of construction products in Germany. They know which methods for the testing of building material properties are usable and know the limitations and characterics of the most important testing methods.
Skills	The students are able to responsibly discover the rules for trading and using of building products in Germany. They are able to chose suitable methods for the testing and inspection of construction products, the examination of damages and the examination of the structural conditions of buildings. They are able to conclude from symptons to the cause of damages. They are able to describe an examination in form of a test report or expert opinion.
Personal Competence	
Social Competence	The students can describe the different roles of manufacturers as well as testing, supervisory and certification bodies within the framework of material testing. They can describe the different roles of the participants in legal proceedings.
Autonomy	The students are able to make the timing and the operation steps to learn the specialist knowledge of a very extensive field.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Materials Science and Engineering: Specialisation Engineering Materials: Elective Compulsory Materials Science: Specialisation Engineering Materials: Elective Compulsory

Course L0260: Examination of Materials, Structural Condition and Damages

Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	WiSe
Content	Materials testing and marking process of construction products, testing methods for building materials and structures, testing reports and expert opinions, describing the condition of a structure, from symptons to the cause of damages
Literature	Frank Schmidt-Döhl: Materialprüfung im Bauwesen. Fraunhofer irb-Verlag, Stuttgart, 2013.

Course L0261: Examination of Materials, Structural Condition and Damages

Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0923: Integrated Transportation Planning

Courses

Title	Typ	Hrs/wk	CP
Integrated Transportation Planning (L1068)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Carsten Gertz
Admission Requirements	None
Recommended Previous Knowledge	some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineerin
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • describe interdependencies between land-use/location choice and transportation/mobility behaviour • explain and evaluate the social, ecological and economic effects of transport and land-use policy measures. • relate current issues in the area of integrated transport planning and formulate an opinion on them.
Skills	Students are able to: • quantify important parameters, which influence travel demand or are influenced by it. • comprehensively examine a pre-defined or self-selected topic from a transportation studies perspective and document the results in accordance with scientific conventions.
Personal Competence	
Social Competence	Students are able to: • provide feedback on topical contents and their teaching. • constructively handle feedback on their own work. • produce results in group work and document these.
Autonomy	Students are able to: • assess potential consequences of their future professional activities • independently plan working on a pre-defined project topic, acquire the necessary knowledge and use appropriate means for its execution.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	written assignment with presentation during the semester
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L1068: Integrated Transportation Planning	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Carsten Gertz, Dr. Philine Gaffron, Jacqueline Bianca Maaß
Language	DE
Cycle	WiSe
Content	The course will provide students with an understanding of interdependencies between land-use and transportation. Specific topics include a.o.: • interactions between transport and the environment and consequent limitations • characteristics of integrated planning • complex planning processes • interdependencies of location choice and mobility behaviour • transport and land-use policies • project on current issues in transportation studies
Literature	Kutter, Eckhard (2019) Stadtstruktur und Erreichbarkeit in der postfossilen Zukunft. Erich Schmidt Verlag. Berlin. Gies, Huber u. a. (Hrsg.) (93. Ergänzung 2022) Handbuch der kommunalen Verkehrsplanung. Herbert Wichmann Verlag. Berlin, Offenbach. (Loseblattsammlung mit kontinuierlichen Ergänzungen)

Module M0801: Water Resources and -Supply

Courses

Title	Typ	Hrs/wk	CP
Chemistry of Drinking Water Treatment (L0311)	Lecture	2	1
Chemistry of Drinking Water Treatment (L0312)	Recitation Section (large)	1	2
Water Resource Management (L0402)	Lecture	2	2
Water Resource Management (L0403)	Recitation Section (small)	1	1

Module Responsible	Prof. Mathias Ernst
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of water management and the key processes involved in water treatment.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will be able to outline key areas of conflict in water management, as well as their mutual dependence for sustainable water supply. They will understand relevant economic, environmental and social factors. Students will be able to explain and outline the organisational structures of water companies. They will be able to explain the available water treatment processes and the scope of their application.
Skills	Students will be able to assess complex problems in drinking water production and establish solutions involving water management and technical measures. They will be able to assess the evaluation methods that can be used for this. Students will be able to carry out chemical calculations for selected treatment processes and apply generally accepted technical rules and standards to these processes.
Personal Competence	
Social Competence	Working in a diverse group of specialists, students will be able to develop and document complex solutions for the management and treatment of drinking water. They will be able to take an appropriate professional position, for example representing user interests. They will be able to develop joint solutions in teams of diverse experts and present these solutions to others.
Autonomy	Students will be in a position to work on a subject independently and present on this subject.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	60 min (chemistry) + presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0311: Chemistry of Drinking Water Treatment	
Typ	Lecture
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Dr. Klaus Johannsen
Language	DE
Cycle	WiSe
Content	The topic of this course is water chemistry with respect to drinking water treatment and water distribution Major topics are solubility of gases, carbonic acid system and calcium carbonate, blending, softening, redox processes, materials and legal requirements on drinking water treatment. Focus is put on generally accepted rules of technology (DVGW- and DIN-standards). Special emphasis is put on calculations using realistic analysis data (e.g. calculation of pH or calcium carbonate dissolution potential) in exercises. Students can get a feedback and gain extra points for exam by solving problems for homework. Knowledge of drinking water treatment processes is vital for this lecture. Therefore the most important processes are explained coordinated with the course " Water resources management" in the beginning of the semester.
Literature	**MHW (rev. by Crittenden, J. et al.):** Water treatment principles and design. John Wiley & Sons, Hoboken, 2005. **Stumm, W., Morgan, J.J.**: Aquatic chemistry. John Wiley & Sons, New York, 1996. **DVGW (Hrsg.):** Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004. **Jensen, J. N.**: A Problem Solving Approach to Aquatic Chemistry. John Wiley & Sons, Inc., New York, 2003.

Course L0312: Chemistry of Drinking Water Treatment	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dr. Klaus Johannsen
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0402: Water Resource Management	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Mathias Ernst
Language	DE
Cycle	WiSe
Content	The lecture provides comprehensive knowledge on interaction of water ressource management and drinking water supply. Content overview: • Current situation of global water resources - User and Stakeholder conflicts - Wasserressourcenmanagement in urbane Gebieten - Rechtliche Aspekte, Organisationsformen Trinkwasserversorgungsunternehmen. - Ökobilanzierung, Benchmarking in der Wasserversorgung
Literature	• Aktuelle UN World Water Development Reports • Branchenbild der deutschen Wasserwirtschaft, VKU (2011) • Aktuelle Artikel wissenschaftlicher Zeitschriften • Ppt der Vorlesung

Course L0403: Water Resource Management	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Mathias Ernst
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1748: Construction Robotics

Courses

Title	Typ	Hrs/wk	CP
Construction Robotics (L2867)	Project-/problem-based Learning	6	6

Module Responsible	Prof. Kay Smarsly
Admission Requirements	None
Recommended Previous Knowledge	Basics of project-oriented programming
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Basics of robotics Applications in civil engineering Kinematics
Skills	Use of specific hardware Development of software routines Python programming language Image processing Basics of localization (LIDAR, SLAM)
Personal Competence	
Social Competence	Teamwork Communication skills
Autonomy	Independent work Independent decisions
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	ca. 10 Seiten
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Course L2867: Construction Robotics	
Typ	Project-/problem-based Learning
Hrs/wk	6
CP	6
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Lecturer	Prof. Kay Smarsly, Jan Stührenberg
Language	EN
Cycle	WiSe

Content	1. Introduction: Robotics in civil engineering
	2. Presentation of potential topics
	3. Programming of algorithms in Python
	4. Application of software systems: LINUX distribution, ROS, CloudCompare, ...
	5. Application of hardware systems: Petoi Bittle Dog, Raspberry Pi, Arduino, sensing ...
	6. Topics considered for robotics using the Petoi Bittle Dog:
	    1. Movement
	    2. Use of sensors (camera, infrared, ...)
	    3. Data structures/data acquisition
	    4. Programming
	7. Topics technically relevant to building inspection:
	    1. Geodetic evaluations
	    2. Image processing
	    3. Localization

Literature	Bock/Linner: Construction Robotics Verl et al.: Soft Robotics Pasquale: New Laws of robotics

Module M1974: Environmental microbiology and analytics

Courses

Title	Typ	Hrs/wk	CP
Environmental Analysis (L0354)	Lecture	2	3
Environmental microbiology (L3223)	Lecture	2	3

Module Responsible	Dr. Dorothea Rechtenbach
Admission Requirements	None
Recommended Previous Knowledge	Fundamentals of inorganic/organic chemistry and biology (knowledge acquired at school).
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	On completion of this module, students will be able to describe the mechanisms of biological systems. They will know the main biological metabolic routes and can categorise their influence on global metabolic routes. They will be familiar with the basic analytical methods for investigating and assessing the quality of various environmental compartments.
Skills	On completion of this module, students will be able to categorise which metabolism will predominate under which environmental conditions. Students will be able to apply the theoretical principles they have learnt to exemplary sites and assess the resulting relationships from a technical and conceptual perspective. They will be able to draw comparisons on different investigation strategies and techniques. Model projects can be devised and treated.
Personal Competence	
Social Competence	The students are able to organize working processes within a team in a targeted way and based on the divison of labour.
Autonomy	Students can independently exploit sources, acquire the particular knowledge of the subject and apply it to new problems.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Water and Environmental Engineering: Core Qualification: Compulsory

Course L0354: Environmental Analysis	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Dorothea Rechtenbach, Dr. Henning Mangels
Language	EN
Cycle	WiSe
Content	Introduction Sampling in different environmental compartments, sample transportation, sample storage Sample preparation Photometry Wastewater analysis Introduction into chromatography Gas chromatography HPLC Mass spectrometry Optical emission spectrometry Atom absorption spectrometry Quality assurance in environmental analysis
Literature	Roger Reeve, Introduction to Environmental Analysis, John Wiley & Sons Ltd., 2002 (TUB: USD-728) Pradyot Patnaik, Handbook of environmental analysis: chemical pollutants in air, water, soil, and solid wastes, CRC Press, Boca Raton, 2010 (TUB: USD-716) Chunlong Zhang, Fundamentals of Environmental Sampling and Analysis, John Wiley & Sons Ltd., Hoboken, New Jersey, 2007 (TUB: USD-741) Miroslav Radojević, Vladimir N. Bashkin, Practical Environmental Analysis RSC Publ., Cambridge, 2006 (TUB: USD-720) Werner Funk, Vera Dammann, Gerhild Donnevert, Sarah Iannelli (Translator), Eric Iannelli (Translator), Quality Assurance in Analytical Chemistry: Applications in Environmental, Food and Materials Analysis, Biotechnology, and Medical Engineering, 2nd Edition, WILEY-VCH Verlag GmbH & Co. KGaA,Weinheim, 2007 (TUB: CHF-350) STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER, 21st Edition, Andrew D. Eaton, Leonore S. Clesceri, Eugene W. Rice, and Arnold E. Greenberg, editors, 2005 (TUB:CHF-428) K. Robards, P. R. Haddad, P. E. Jackson, Principles and Practice of Modern Chromatographic Methods, Academic Press G. Schwedt, Chromatographische Trennmethoden, Thieme Verlag H. M. McNair, J. M. Miller, Basic Gas Chromatography, Wiley W. Gottwald, GC für Anwender, VCH B. A. Bidlingmeyer, Practical HPLC Methodology and Applications, Wiley K. K. Unger, Handbuch der HPLC, GIT Verlag G. Aced, H. J. Möckel, Liquidchromatographie, VCH Charles B. Boss and Kenneth J. Fredeen, Concepts, Instrumentation and Techniques in Inductively Coupled Plasma Optical Emission Spectrometry Perkin-Elmer Corporation 1997, On-line available at: http://files.instrument.com.cn/bbs/upfile/2006291448.pdf Atomic absorption spectrometry: theory, design and applications, ed. by S. J. Haswell 1991 (TUB: 2727-5614) Royal Society of Chemistry, Atomic absorption spectometry (http://www.kau.edu.sa/Files/130002/Files/6785_AAs.pdf)

Course L3223: Environmental microbiology	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Johannes Gescher
Language	EN
Cycle	WiSe
Content	This lecture deals with the importance of microorganisms for biological material cycles and the health of water and soil. After the development of biochemical and cell biological basics, methods are presented that are necessary to investigate microbial communities and their activity. In addition, the role of microorganisms in the biogas process and in the biorefinery is discussed. The third part presents methods for purifying air, water and soil as well as environmentally friendly production processes involving microorganisms.
Literature	Umweltmikrobiologie; Reineke, W. und Schlömann, M. (2015) 2. Aufl., Springer Spektrum Verlag Brock Mikrobiologie; Michael T. Madigan, Kelly S. Bender, Daniel H. Buckley, W. Matthew Sattley, David A. Stahl (2020) 15. Aufl., Pearson Studium Verlag

Module M0874: Wastewater Systems

Courses

Title	Typ	Hrs/wk	CP
Biological Wastewater Treatment (L0517)	Lecture	2	2
Biological Wastewater Treatment (L3122)	Recitation Section (large)	1	1
Advanced Wastewater Treatment (L0357)	Lecture	2	2
Advanced Wastewater Treatment (L0358)	Recitation Section (large)	1	1

Module Responsible	Dr. Joachim Behrendt
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of wastewater management and the key processes involved in wastewater treatment.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to outline key areas of the full range of treatment systems in waste water management, as well as their mutual dependence for sustainable water protection. They can describe relevant economic, environmental and social factors.
Skills	Students are able to pre-design and explain the available wastewater treatment processes and the scope of their application in municipal and for some industrial treatment plants.
Personal Competence	
Social Competence	Social skills are not targeted in this module.
Autonomy	Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L0517: Biological Wastewater Treatment

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Joachim Behrendt
Language	DE/EN
Cycle	SoSe
Content	Charaterisation of Wastewater Metobolism of Microorganisms Kinetic of mirobiotic processes Calculation of bioreactor for wastewater treatment Concepts of Wastewater treatment Design of WWTP Excursion to a WWTP Biofilms Biofim Reactors Anaerobic Wastewater and sldge treatment resources oriented sanitation technology Future challenges of wastewater treatment
Literature	**Gujer, Willi** Siedlungswasserwirtschaft : mit 84 Tabellen

	ISBN: 3540343296 (Gb.) URL: http://www.gbv.de/dms/bs/toc/516261924.pdf URL: http://deposit.d-nb.de/cgi-bin/dokserv?id=2842122&prov=M&dok_var=1&dok_ext=htm Berlin [u.a.] : Springer, 2007 TUB_HH_Katalog **Henze, Mogens** Wastewater treatment : biological and chemical processes ISBN: 3540422285 (Pp.) Berlin [u.a.] : Springer, 2002 TUB_HH_Katalog **Imhoff, Karl** (Imhoff, Klaus R.;) Taschenbuch der Stadtentwässerung : mit 10 Tafeln ISBN: 3486263331 ((Gb.)) München [u.a.] : Oldenbourg, 1999 TUB_HH_Katalog **Lange, Jörg** (Otterpohl, Ralf; Steger-Hartmann, Thomas;) Abwasser : Handbuch zu einer zukunftsfähigen Wasserwirtschaft ISBN: 3980350215 (kart.) URL: http://www.gbv.de/du/services/agi/52567E5D44DA0809C12570220050BF25/000000700334 Donaueschingen-Pfohren : Mall-Beton-Verl., 2000 TUB_HH_Katalog **Mudrack, Klaus** (Kunst, Sabine;) Biologie der Abwasserreinigung : 18 Tabellen ISBN: 382741427X URL: http://www.gbv.de/du/services/agi/94B581161B6EC747C1256E3F005A8143/420000114903 Heidelberg [u.a.] : Spektrum, Akad. Verl., 2003 TUB_HH_Katalog **Tchobanoglous, George** (Metcalf & Eddy, Inc., ;) Wastewater engineering : treatment and reuse ISBN: 0070418780 (alk. paper) ISBN: 0071122508 (ISE (*pbk)) Boston [u.a.] : McGraw-Hill, 2003 TUB_HH_Katalog **Henze, Mogens** Activated sludge models ASM1, ASM2, ASM2d and ASM3 ISBN: 1900222248 London : IWA Publ., 2002 TUB_HH_Katalog **Kunz, Peter** Umwelt-Bioverfahrenstechnik Vieweg, 1992 **Bauhaus-Universität., Arbeitsgruppe Weiterbildendes Studium Wasser und Umwelt** (Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall, ;) Abwasserbehandlung : Gewässerbelastung, Bemessungsgrundlagen, Mechanische Verfahren, Biologische Verfahren, Reststoffe aus der Abwasserbehandlung, Kleinkläranlagen ISBN: 3860682725 URL: http://www.gbv.de/dms/weimar/toc/513989765_toc.pdf URL: http://www.gbv.de/dms/weimar/abs/513989765_abs.pdf Weimar : Universitätsverl, 2006 TUB_HH_Katalog **Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall** DWA-Regelwerk Hennef : DWA, 2004 TUB_HH_Katalog **Wiesmann, Udo** (Choi, In Su; Dombrowski, Eva-Maria;) Fundamentals of biological wastewater treatment ISBN: 3527312196 (Gb.) URL: http://deposit.ddb.de/cgi-bin/dokserv?id=2774611&prov=M&dok_var=1&dok_ext=htm Weinheim : WILEY-VCH, 2007 TUB_HH_Katalog

Course L3122: Biological Wastewater Treatment	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Joachim Behrendt
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0357: Advanced Wastewater Treatment	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Joachim Behrendt
Language	EN
Cycle	SoSe
Content	Survey on advanced wastewater treatment reuse of reclaimed municipal wastewater Precipitation Flocculation Depth filtration Membrane Processes Activated carbon adsorption Ozonation "Advanced Oxidation Processes" Disinfection
Literature	Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003 Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987 Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007 Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003

Course L0358: Advanced Wastewater Treatment	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Joachim Behrendt
Language	EN
Cycle	SoSe
Content	Aggregate organic compounds (sum parameters) Industrial wastewater Processes for industrial wastewater treatment Precipitation Flocculation Activated carbon adsorption Recalcitrant organic compounds
Literature	Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003 Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987 Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007 Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003

Module M0828: Urban Environmental Management

Courses

Title	Typ	Hrs/wk	CP
Noise Protection (L1109)	Lecture	2	2
Urban Infrastructures (L0874)	Project-/problem-based Learning	2	4

Module Responsible	Dr. Dorothea Rechtenbach
Admission Requirements	None
Recommended Previous Knowledge	• Knowledge on Urban planning • Knowledge on measures for climate protection • General knowledge of scientific writing/working
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can describe urban development corridors as well as current and future urban environmental problems. They are able to explain the causes of environmental problems (like noise). Students can specify applications for various technical innovations and explain why these contribute to the improvement of urban life. They can, for example, derive and discuss measures for effective noise abatement.
Skills	Students are able to develop specific solutions for correcting existing or future environment-related problems of urban development. They can define a range of conceptual and technical solutions for environmental problems for different development paths. To solve specific urban environmental problems they can select technical innovations and integrate them into the urban context.
Personal Competence	
Social Competence	The students can work together in international groups.
Autonomy	Students are able to organize their work flow to prepare themselves for presentations and contributions to the discussions. They can acquire appropriate knowledge by making enquiries independently.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Written Report plus oral Presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L1109: Noise Protection

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Martin Jäschke
Language	EN
Cycle	SoSe
Content	
Literature	1) Müller & Möser (2013): Handbook of Engineering Acoustics (also available in German) 2) WHO (1999): Guidelines for Community Noise 3) Environmental Noise Directive 2002/49/EG 4) ISO 9613-2 (1996): Acoustics, Attenuation of sound during propagation outdoors, Part 2: General method of calculation

Course L0874: Urban Infrastructures	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Dr. Dorothea Rechtenbach
Language	EN
Cycle	SoSe
Content	Problem Based Learning Main topics are: • Central vs. Decentral Wastewater Treatment. • Compaction of Cities. • Car Free Cities. • Multifunctional Places in Cities. • The Sustainability of Freight Transport in Cities.
Literature	Depends on chosen topic.

Module M0875: Nexus Engineering - Water, Soil, Food and Energy

Courses

Title	Typ	Hrs/wk	CP
Ecological Town Design - Water, Energy, Soil and Food Nexus (L1229)	Seminar	2	2
Water & Wastewater Systems in a Global Context (L0939)	Lecture	2	4

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of the global situation with rising poverty, soil degradation, migration to cities, lack of water resources and sanitation
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can describe the facets of the global water situation. Students can judge the enormous potential of the implementation of synergistic systems in Water, Soil, Food and Energy supply.
Skills	Students are able to design ecological settlements for different geographic and socio-economic conditions for the main climates around the world.
Personal Competence	
Social Competence	The students are able to develop a specific topic in a team and to work out milestones according to a given plan.
Autonomy	Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	During the course of the semester, the students work towards mile stones. The work includes presentations and papers. Detailed information can be found at the beginning of the smester in the StudIP course module handbook.
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L1229: Ecological Town Design - Water, Energy, Soil and Food Nexus	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	SoSe
Content	• Participants Workshop: Design of the most attractive productive Town • Keynote lecture and video • The limits of Urbanization / Green Cities • The tragedy of the Rural: Soil degradation, agro chemical toxification, migration to cities • Global Ecovillage Network: Upsides and Downsides around the World • Visit of an Ecovillage • Participants Workshop: Resources for thriving rural areas, Short presentations by participants, video competion • TUHH Rural Development Toolbox • Integrated New Town Development • Participants workshop: Design of New Towns: Northern, Arid and Tropical cases • Outreach: Participants campaign • City with the Rural: Resilience, quality of live and productive biodiversity
Literature	• Ralf Otterpohl 2013: Gründer-Gruppen als Lebensentwurf: "Synergistische Wertschöpfung in erweiterten Kleinstadt- und Dorfstrukturen", in „Regionales Zukunftsmanagement Band 7: Existenzgründung unter regionalökonomischer Perspektive, Pabst Publisher, Lengerich • http://youtu.be/9hmkgn0nBgk (Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation) • TEDx New Town Ralf Otterpohl: http://youtu.be/_M0J2u9BrbU

Course L0939: Water & Wastewater Systems in a Global Context	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	SoSe
Content	• Keynote lecture and video • Water & Soil: Water availability as a consequence of healthy soils • Water and it's utilization, Integrated Urban Water Management • Water & Energy, lecture and panel discussion pro and con for a specific big dam project • Rainwater Harvesting on Catchment level, Holistic Planned Grazing, Multi-Use-Reforestation • Sanitation and Reuse of water, nutrients and soil conditioners, Conventional and Innovative Approaches • Why are there excreta in water? Public Health, Awareness Campaigns • Rehearsal session, Q&A
Literature	• Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press • Liu, John D.: http://eempc.org/hope-in-a-changing_climate/ (Integrated regeneration of the Loess Plateau, China, and sites in Ethiopia and Rwanda) • http://youtu.be/9hmkgn0nBgk (Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation)

Module M0922: City Planning

Courses

Title	Typ	Hrs/wk	CP
City Planning (L1066)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Carsten Gertz
Admission Requirements	None
Recommended Previous Knowledge	for "Principles of Urban Planning": none for "Designing Urban Streetscapes": some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineering“
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • use technical terms of urban planning. • describe the main determinants of urban development. • explain and compare different possibilities of how urban development can be influenced. • discuss requirements for public streetscapes. • explain the importance of street design.
Skills	Students are able to: • read and analyze urban development concepts and designs for streetscapes • appraise such concepts in the context of competing requirements. • design, justify and reflect their own solutions for concrete examples.
Personal Competence	
Social Competence	Students are able to: • discuss intermediate results with each other. • constructively accept feedback on their own work. • provide constructive feedback to others.
Autonomy	Students are able to: • independently complete a written report including drawings following a broadly pre-defined process. • assess the consequences of their proposed solutions. • independently acquire knowledge and apply this to new issues or problem areas.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	written assignment, designwork during the semester
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L1066: City Planning	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Carsten Gertz
Language	DE
Cycle	SoSe
Content	„Principles of Urban Planning“ deals with the determinants of urban development and their interactions. Topics include: • legal framework, • instruments and methods of planning, • functional requirements, • stakeholders and actors • basic design requirements • different planning levels and • historical contexts. The objective of the course is for students to acquire a basic understanding of urban development problems and approaches for solving them. They will also be able to comprehend the process of urban planning. The course also covers the various functional and aesthetic requirements for designing streetscape as the most important elements of public space. The project work deals with a real life scenario and includes drawing up a development plan, an urban design concept, a building masterplan and a street redesign.
Literature	Albers, Gerd; Wekel, Julian (2021) Stadtplanung: Eine illustrierte Einführung. 4. überarbeitete Auflage. Primus Verlag. Darmstadt. Frick, Dieter (2011) Theorie des Städtebaus: Zur baulich-räumlichen Organisation von Stadt. 3. veränderte Auflage. Wasmuth-Verlag. Tübingen Jonas, Carsten (2009) Die Stadt und ihr Grundriss. Wasmuth-Verlag. Tübingen Kostof, Spiro; Castillo, Greg (1998) Die Anatomie der Stadt. Geschichte städtischer Strukturen. Campus-Verlag. Frankfurt/New York.

Module M0977: Construction Logistics and Project Management

Courses

Title	Typ	Hrs/wk	CP
Construction Logistics (L1163)	Lecture	1	2
Construction Logistics (L1164)	Recitation Section (small)	1	2
Project Development and Management (L1161)	Lecture	1	1
Project Development and Management (L1162)	Project-/problem-based Learning	1	1

Module Responsible	Prof. Heike Flämig
Admission Requirements	None
Recommended Previous Knowledge	none
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can... • give definitions of the main terms of construction logistics and project development and management • name advantages and disadvantages of internal or external construction logistics • explain characteristics of products, demand and production of construction objects and their consequences for construction specific supply chains • differentiate constructions logistics from other logistics systems
Skills	Students can... • carry out project life cycle assessments • apply methods and instruments of construction logistics • apply methods and instruments of project development and management • apply methods and instruments of conflict management • design supply and waste removal concepts for a construction project
Personal Competence	
Social Competence	Students can... • hold presentations in and for groups • apply methods of conflict solving skills in group work and case studies
Autonomy	Students can... • solve problems by holistic, systemic and flow oriented thinking • improve their creativity, negotiation skills, conflict and crises solution skills by applying methods of moderation in case studies
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Two written papers with presentations
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory

Course L1163: Construction Logistics	
Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Heike Flämig
Language	DE
Cycle	SoSe
Content	The lecture gives deeper insight how important logistics are as a competetive factor for construction projects and which issues are to be adressed. The following toppics are covered: • competetive factor logistics • the concept of systems, planning and coordination of logistics • material, equipment and reverse logistics • IT in construction logistics • elements of the planning model of construction logistics and their connections • flow oriented logistics systems for construction projects • logistics concepts for ready to use construction projects (especially procurement and waste removel logistics) • best practice examples (construction logistics Potsdamer Platz, recent case study of the region) Contents of the lecture are deepened in special exercises.
Literature	Flämig, Heike: Produktionslogistik in Stadtregionen. In: Forschungsverbund Ökologische Mobilität (Hrsg.) Forschungsbericht Bd. 15.2. Wuppertal 2000. Krauss, Siri: Die Baulogistik in der schlüsselfertigen Ausführung, Bauwerk Verlag GmbH Berlin 2005. Lipsmeier, Klaus: Abfallkennzahlen für Neubauleistungen im Hochbau : Verlag Forum für Abfallwirtschaft und Altlasten, 2004. Schmidt, Norbert: Wettbewerbsfaktor Baulogistik. Neue Wertschöpfungspotenziale in der Baustoffversorgung. In: Klaus, Peter: Edition Logistik. Band 6. Deutscher Verkehrs-Verlag. Hamburg 2003. Seemann, Y.F. (2007): Logistikkoordination als Organisationseinheit bei der Bauausführung Wissenschaftsverlag Mainz in Aachen, Aachen. (Mitteilungen aus dem Fachgebiet Baubetrieb und Bauwirtschaft (Hrsg. Kuhne, V.): Heft 20)

Course L1164: Construction Logistics	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Heike Flämig
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1161: Project Development and Management	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Heike Flämig, Dr. Anton Worobei
Language	DE
Cycle	SoSe
Content	Within the lecture, the main aspects of project development and management are tought: • Terms and definitions of project management • Advantages and disadvantages of different ways of project handling • organization, information, coordination and documentation • cost and fincance management in projects • time- and capacity management in projects • specific methods and instruments for successful team work Contents of the lecture are deepened in special exercises.
Literature	Projektmanagement-Fachmann. Band 1 und Band 2. RKW-Verlag, Eschborn, 2004.

Course L1162: Project Development and Management	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Heike Flämig, Dr. Anton Worobei
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0593: Building Materials and Building Preservation

Courses

Title	Typ	Hrs/wk	CP
Repair of Structures (L0255)	Lecture	1	1
Mineral Building Materials (L0253)	Lecture	2	2
Technology of mineral Building Materials (L0256)	Project-/problem-based Learning	1	2
Transport Processes in Building Materials and Damage Processes (L0254)	Lecture	1	1

Module Responsible	Prof. Frank Schmidt-Döhl
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge about building materials, building physics and building chemistry, for example by the modules Principles of Building Materials and Building Physics and Building Materials and Building Chemistry.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe the components of mineral building materials and their function in detail and to use them for the manufacture of special mineral building materials. They are able to show the characteristics of mineral building materials. They are able to describe the manufacture, properties and fields of application of special mortars and special concretes and the correlations of their material parameters. They are able to show the principles of anchor technology and design.
Skills	The students are able to perform an optimization of granulometry of a mineral building material. They are able to design a special mineral mortar and to manufacture this mortar. The students are able to manufacture post installed rebar connections. They are able to recognize damages, to assess possible causes, to use the fundamentals of construction preservation and to select repair and strengthening measures.
Personal Competence	
Social Competence	The students are able to develop in small grous the mixture of a special mortar. They present their results to the lecturer and the other students. In a critical discussion they defend and adjust their results. The students are able to manufacture their special building material on the basis of this feedback.
Autonomy	The students are able to responsibly use the resources of materials and lab equipment for their project and to investigate and to get missing components.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** Yes / 20 % / Subject theoretical and practical work /
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory

Course L0255: Repair of Structures

Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	SoSe
Content	Maintenance of structures, repair and strengthening, subsequent waterproofing of structures
Literature	BetonMarketing Deutschland (Hrsg.): Stahlbetonoberflächen - schützen, erhalten, instandsetzen

Course L0253: Mineral Building Materials	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	SoSe
Content	Components of mineral building materials and their function, binding materials, concrete and mortar, special mortars, special concretes
Literature	Taylor, H.F.W.: Cement Chemistry Springenschmid, R.: Betontechnologie für die Praxis

Course L0256: Technology of mineral Building Materials	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	SoSe
Content	Design and production of a special mineral building material
Literature	Taylor, H.F.W.: Cement Chemistry Springenschmid, R.: Betontechnologie für die Praxis

Course L0254: Transport Processes in Building Materials and Damage Processes	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	SoSe
Content	Transport Processes in Building Materials and Damage Processes
Literature	Blaich, J.: Bauschäden, Analyse und Vermeidung

Module M0998: Statics and Dynamics of Structures

Courses

Title	Typ	Hrs/wk	CP
Structural Dynamics (L1202)	Lecture	2	2
Structural Dynamics (L1203)	Recitation Section (large)	2	2
Fracture mechanics and fatigue in steel structures (L0564)	Lecture	1	1
Fracture mechanics and fatigue in steel structures (L0565)	Recitation Section (large)	1	1

Module Responsible	Prof. Bastian Oesterle
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of linear structural analysis of statically determinate and indeterminate structures; Mechanics I/II, Mathematics I/II, Differential equations I
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of this module, the student can explain the basic aspects of dynamic effects on structures and the respective methods.
Skills	After successful completion of this module, the students will be able to predict the response of material and structures to dynamics loading using the appropriate computational approaches and methods.
Personal Competence	
Social Competence	Students can • participate in subject-specific and interdisciplinary discussions, • defend their own work results in front of others • promote the scientific development of colleagues • Furthermore, they can give and accept professional constructive criticism
Autonomy	Students are able to gain knowledge of the subject area from given and other sources and apply it to new problems. Furthermore, they are able to structure the solution process for problems in the area of Structural Analysis.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	150 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L1202: Structural Dynamics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	DE
Cycle	SoSe
Content	• mechanical background of dynamics • harmonic vibrations, damped and undamped free and forced vibrations • frequency and time domain • modelling aspects • principle of d'Alembert • systems with multiple degrees of freedom • consistent and lumped mass matrices • finite elements for dynamics problems • impact problems • eigenvalue problems and modal analysis • direct time integration schemes, transient analyses
Literature	• Vorlesungsmanuskript • Clough, R.W., Penzien, J.: Dynamics of Structures. 2. Aufl., McGraw-Hill, New York, 1993.

Course L1203: Structural Dynamics	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0564: Fracture mechanics and fatigue in steel structures	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Jürgen Priebe
Language	DE
Cycle	SoSe
Content	• basics of fatigue stress and fatigue resistance and determination of fatigue strength, • determination anduse of S-N-curves and classification of notch effects, • set up of determination of fatigue strength under dynamic load using the accumulation formula by Palmgren-Miner, • set up of determination of fatigue strength in different examples, • basics of construction and design regarding the problem of material fatigue, • basics of linear elastic fracture mechanics under static and dynamic load, • determination of lifetime of steel construction based on linear elastic fracture mechanics in different examples.
Literature	• Seeßelberg, C.; Kranbahnen - Bemessung und konstruktive Gestaltung; 3. Auflage; Bauwerk-Verlag; Berlin 2009 • Kuhlmann, Dürr, Günther; Kranbahnen und Betriebsfestigkeit; in Stahlbau Kalender 2003; Verlag Ernst & Sohn; Berlin 2003 • Deutscher Stahlbau-Verband (Hrsg.); Stahlbau Handbuch Band 1 Teil B; 3. Auflage; Stahlbau-Verlagsgesellschaft; Köln 1996 • Petersen, C.; Stahlbau; 3. überarb. und erw. Auflage; Vieweg-Verlag; Braunschweig 1993 • DIN V ENV 1993-1-1: Eurocode 3; Bemessung und Konstruktion von Stahlbauwerken; Teil 1-1: Allgemeine Bemessungsregeln, Bemessungsregeln für den Hochbau; 1993 • DIN V ENV 1993-6: Eurocode 3; Bemessung und Konstruktion von Stahlbauwerken; Teil 6: Kranbahnen; 2001 • DIN-Fachbericht 126. Richtlinie zur Anwendung von DIN V ENV 1993-6; Nationales Anwendungsdokument (NAD); Berlin 2002

Course L0565: Fracture mechanics and fatigue in steel structures	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Jürgen Priebe
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0982: Transportation Modelling

Courses

Title	Typ	Hrs/wk	CP
Transportation Modelling (L1180)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Carsten Gertz
Admission Requirements	None
Recommended Previous Knowledge	some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineering"
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to understand the operation and potential applications of transport models.
Skills	Students are able to: • use travel demand modelling software packages for solving practical problems. • design a database structure for travel demand models. • assess modelling results. • appraise potential applications and limitations of such models.
Personal Competence	
Social Competence	Students are able to independently develop and document solutions.
Autonomy	Students are able to: • independently organise, manage and solve set tasks. • independently prepare written reports.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	written assignment with presentation during the semester
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L1180: Transportation Modelling

Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Carsten Gertz
Language	DE
Cycle	SoSe
Content	• Principles of transport modelling • Role of transport modelling in the planning process • Fundamentals of mobility behaviour • Design and evaluation of transport/mobility surveys • mode of operation and data requirements for different stages of modelling • Forecasting and scenarios in the transport planning • The range of model applications (from transport infrastructure planning over simulation of traffic flows to integrated land-use and transport models as well as the use of models for evaluating locations) • Practice-oriented project for assessing consequences of infrastructure projects and changes in land-use
Literature	Lohse, Dieter und Schnabel, Werner (2011): Grundlagen der Straßenverkehrstechnik und der Verkehrsplanung – Band 2. 3. Auflage. Beuth. Ortúzar, Juan de Dios und Willumsen, Luis G. (2011): Modelling Transport. 4. Auflage. John Wiley & Sons.

Module M0827: Modeling in Water Management

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Groundwater Modeling using Modflow (L0543)	Lecture	1	1
Groundwater Modeling using Modflow (L0544)	Recitation Section (small)	2	2
Modeling of Water Supply Network (L0875)	Project-/problem-based Learning	2	3

Module Responsible	Dr. Klaus Johannsen
Admission Requirements	None
Recommended Previous Knowledge	Groundwater • groundwater hydraulics and transport of substances Pipe Systems • Knowledge on urban water infrastructures, in particular drinking water systemsand urban drainage systems including special structures • Hydraulics of drinking water supply systems and sewer systems • Basic knowledge on water management
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe the modelling of groundwater flow and transport as well as urban water infrastructures. They can carry out systems analyses and can detect technical and conceptual weak points within the systems in case studies. Besides they are able to analyse interdependencies of hydraulic and toxic phenomena in soil and water.
Skills	The students are able to construct and apply scientific groundwater models indipendently. They can work on different scenarios and can compare or assess different solutions for existing problems by application of selected software products. The students are able to use different software solutions (e.g. EPANET, EPA-SWMM).
Personal Competence	
Social Competence	Wird nicht vermittelt.
Autonomy	Wird nicht vermittelt.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L0543: Groundwater Modeling using Modflow

Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Sonja Götz
Language	DE/EN
Cycle	SoSe
Content	Introduction and application of the groundwater model MODFLOW (PMWIN); theoretical backround of the modell, students do work with the model PMWIN for practical case studies.
Literature	MODFLOW-Handbuch Chiang, Wen Hsien: PMWIN

Course L0544: Groundwater Modeling using Modflow	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Sonja Götz
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0875: Modeling of Water Supply Network	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Klaus Johannsen
Language	DE
Cycle	SoSe
Content	
Literature	Mutschmann/Stimmelmayr: Taschenbuch der Wasserversorgung, 16. Auflage. Springer Vieweg - Verlag. Wiesbaden 2014.

Module M0870: Management of Surface Water

Courses

Title	Typ	Hrs/wk	CP
Modelling of Flow in Rivers and Estuaries (L0810)	Lecture	3	4
Nature-Oriented Hydraulic Engineering / Integrated Flood Protection (L0961)	Project-/problem-based Learning	2	2

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Fundamentals of Hydromechanics, Hydraulics, Hydrology and Hydraulic Engineering; Hydraulic Engineering I and Hydraulic Engineering II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to define in detail the basic processes that are related to the modelling of flows in hydraulic engineering. Besides, they can describe the basic aspects of numerical modelling and actual numerical models for the simulation of flows and waves. They can also depict the concepts of nature oriented hydraulic engineering.
Skills	Students are able to apply hydrodynamic-numerical models to practical hydraulic engineering tasks. Furthermore, the students are able to set up flood-risk management concepts and are able to apply basic concepts of renaturation to practical problems.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in applied problems of the practical nature-based hydraulic engineering. Additionaly, they will be able to work in team with engineers of other disciplines.
Autonomy	The students will be able to independently extend their knowledge and apply it to new problems.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	The duration of the examination is 150 min. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0810: Modelling of Flow in Rivers and Estuaries	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Edgar Nehlsen, Prof. Peter Fröhle
Language	EN
Cycle	SoSe
Content	Introduction to numerical flow modelling • Processes affecting tht flow • Examples and applications of numerical models • Procedure of numerical modelling • Model concept Basic equations of hydrodynamics • Saint-Venant equations • Euler Equations • Navier-Stokes equations • Reynolds-averaged Navier-Stokes equations • Shallow water equations Solving schemes • Numerical discretization • Solution algorithms • Convergence
Literature	Vorlesungsskript Literaturempfehlungen Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau (1997): Hydraulische Berechnung von naturnahen Fließgewässern. Düsseldorf: BWK (BWK-Merkblatt). Chow, Ven-te (1959): Open-channel Hydraulics. New York usw.: McGraw-Hill (McGraw-Hill Civil Engineering Series). Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019a): Merkblatt DWA-M 543-2 Geodaten in der Fließgewässermodellierung Teil 1: Geodaten in der Fließgewässermodellierung. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-1). Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019b): Merkblatt DWA-M 543-2 Geodaten in der Fließgewässermodellierung Teil 2: Bedarfsgerechte Datenerfassung und -aufbereitung. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-2). Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019c): Merkblatt DWA-M 543-3 Geodaten in der Fließgewässermodellierung - Teil 3: Aspekte der Strömungsmodellierung und Fallbeispiele. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-3). Hervouet, Jean-Michel (2007): Hydrodynamics of free surface flows. Modelling with the finite element method. Chichester: Wiley. Online verfügbar unter http://www.loc.gov/catdir/enhancements/fy0741/2007296953-b.html. IAHR (2015): Professional Specifications for Physical and Numerical Studies in Environmental Hydraulics. In: Hydrolink (3/2015), S. 90-92. Olsen, Nils Reidar B. (2012): Numerical Modelling and Hydraulics. 3. Aufl. Department of Hydraulic and Environmental Engineering, The Norwegian University of Science and Technology. Szymkiewicz, Romuald (2010): Numerical modeling in open channel hydraulics. Dordrecht: Springer (Water science and technology library, 83). van Waveren, Harold (1999-): Good modelling practice handbook. [Utrecht], Lelystad, Den Haag: STOWA; Rijkswaterstaat-RIZA; SDU, afd. SEO/RIZA [etc. distr.] (Nota, nr. 99.036). Zielke, Werner (Hg.) (1999): Numerische Modelle von Flüssen, Seen und Küstengewässern. Deutscher Verband für Wasserwirtschaft und Kulturbau. Bonn: Wirtschafts- und Verl.-Ges. Gas und Wasser (Schriftenreihe des Deutschen Verbandes für Wasserwirtschaft und Kulturbau, 127).

Course L0961: Nature-Oriented Hydraulic Engineering / Integrated Flood Protection	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Natasa Manojlovic, Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	• Regime-Theory and application for the development of environmental guiding priciples of rivers • Engineering - biological measures for the stabilization of rivers • Risk management in flood protection • Design techniques in technical flood protection • Methods for the assessment of flood caused damages
Literature	Vorlesungsumdruck

Module M0860: Harbour Engineering and Harbour Planning

Courses

Title	Typ	Hrs/wk	CP
Harbour Engineering (L0809)	Lecture	2	2
Harbour Engineering (L1414)	Project-/problem-based Learning	1	2
Port Planning and Port Construction (L0378)	Lecture	2	2

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Basics of coastal engineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to define in details and to choose design approaches for the functional design of a port and apply them to design tasks. They can design the fundamental elements of a port.
Skills	The students are able to select and apply appropriate approaches for the functional design of ports.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in applied problems such as the functional design of ports. Additionaly, they will be able to work in team with engineers of other disciplines.
Autonomy	The students will be able to independently extend their knowledge and apply it to new problems.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	The duration of the examination is 150 min. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L0809: Harbour Engineering

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Peter Fröhle
Language	DE
Cycle	SoSe

Content	• Fundamentals of harbor engineering
	  ◦ Maritime transportation and waterways engineering
	  ◦ Ships
	• Elements of harbors
	  ◦ Harbor approaches and water-side harbor areas
	  ◦ Terminal design and handling of cargo
	  ◦ Quay-walls and piers
	  ◦ Equipment of harbors
	  ◦ Sluices and other special constructions
	• Connection to inland transportation / inland waterway transportation
	• Protection of harbors
	  ◦ Breakwaters and Jetties
	  ◦ Wave protection of harbors
	• Fishery and other small harbors

Literature	Brinkmann, B.: Seehäfen, Springer 2005

Course L1414: Harbour Engineering	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0378: Port Planning and Port Construction	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Frank Feindt
Language	DE
Cycle	SoSe
Content	• Planning and implementation of major projects • Market analysis and traffic relations • Planning process and plan • Port planning in urban neighborhood • Development of the logistics center "Port of Hamburg" in the metropolis • Quays and waterfront structure • Special planning Law Harbor - securing of a flexible use of the port • Dimensioning of quays • Flood protection structures • Port of Hamburg - Infrastructure and development • Preparation of areas • Scour formation in front of shore structures
Literature	Vorlesungsumdruck, s. www.tu-harburg.de/gbt

Module M1721: Water and Environment: Theory and Application

Courses

Title	Typ	Hrs/wk	CP
Water and Environment (L2754)	Project-/problem-based Learning	3	3
Water and Environment (L2753)	Lecture	3	3

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in water and environmental research, Hydrology
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Common research tools and techniques together with the fundamental knowledge relevant to multi-scale and multi-phase challenges present in water and environmental research will be discussed in this module. Both theory and application will be considered.
Skills	In addition to the fundamental knowledge, the students will be exposed to several analytical, experimental and numerical tools and techniques relevant to water and environmental research at different scales. This will provide the students with an excellent opportunity to improve their skills on multiple fronts which will be useful in their future career.
Personal Competence	
Social Competence	Developing teamwork and problem solving skills through Research-Based Teaching approaches will be at the core of this module.
Autonomy	The students will be involved in writing individual reports and presentation. This will contribute to the students' ability and willingness to work independently and responsibly.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	Report and Presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory

Course L2754: Water and Environment

Typ	Project-/problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Dr. Salome Shokri-Kuehni
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L2753: Water and Environment

Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	Research based learning: The students will be engaged in active research focused on water and environmental related challenges. The required knowledge and tools will be discussed during the semester.
Literature	NA

Module M1724: Smart Monitoring

Courses

Title	Typ	Hrs/wk	CP
Smart Monitoring (L2762)	Integrated Lecture	2	2
Smart Monitoring (L2763)	Recitation Section (small)	2	4

Module Responsible	Prof. Kay Smarsly
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge or interest in object-oriented modeling, programming, and sensor technologies are helpful. Interest in modern research and teaching areas, such as Internet of Things, Industry 4.0 and cyber-physical systems, as well as the will to deepen skills of scientific working, are required. Basic knowledge in scientific writing and good English skills.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students will become familiar with the principles and practices of smart monitoring. The students will be able to design decentralized smart systems to be applied for continuous (remote) monitoring of systems in the built and in the natural environment. In addition, the students will learn to design and to implement intelligent sensor systems using state-of-the-art data analysis techniques, modern software design concepts, and embedded computing methodologies. Besides lectures, project work is also part of this module, which will be conducted throughout the semester and will contribute to the grade. In small groups, the students will design smart monitoring systems that integrate a number of “intelligent” sensors to be implemented by the students. Specific focus will be put on the application of machine learning techniques. The smart monitoring systems will be mounted on real-world (built or natural) systems, such as bridges or slopes, or on scaled lab structures for validation purposes. The outcome of every group will be documented in a paper. All students of this module will “automatically” participate with their smart monitoring system in the annual "Smart Monitoring" competition. The written papers and oral examinations form the final grades. The module will be taught in English. Limited enrollment.
Skills	The students will gain insights into operating state-of-the-art smart sensor systems, used for monitoring a wide range of physical processes relevant to engineering, such as environmental, structural, or comfort monitoring. The students will be capable of devising monitoring strategies of physical processes as part of group projects, tailored to their knowledge backgrounds, and to implement the strategies in smart wireless sensor nodes, using embedded computing and programming. Finally, the students will be able to document the findings of their projects in short reports.
Personal Competence	
Social Competence	The students will be able to work in groups, share parts of the work for their projects, and develop communication skills, towards achieving the common project goals.
Autonomy	The students will be able to gain a solid basis on approaching and solving problems in engineering, as well as on documenting results, through their involvement in their monitoring group projects.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	10 pages of work with 15-minute oral presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2762: Smart Monitoring	
Typ	Integrated Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Kay Smarsly
Language	EN
Cycle	SoSe
Content	In this course, principles of smart monitoring will be taught, focusing on modern concepts of data acquisition, data storage, and data analysis. Also, fundamentals of intelligent sensors and embedded computing will be illuminated. Autonomous software and decentralized data processing are further crucial parts of the course, including concepts of the Internet of Things, Industry 4.0 and cyber-physical systems. Furthermore, measuring principles, data acquisition systems, data management and data analysis algorithms will be discussed. Besides the theoretical background, numerous practical examples will be shown to demonstrate how smart monitoring may advantageously be used for assessing the condition of systems in the built or natural environment.
Literature	The course contents couples different fields, such as signal processing, sensing technologies, data analytics, environmental engineering, civil engineering, artificial intelligence, database systems, and many more. The basics will be taught in this course. However, specific literature that covers all these topics does not exist. Instead, literature will be referenced in the lectures, all of which are papers that are freely available online.

Course L2763: Smart Monitoring	
Typ	Recitation Section (small)
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Kay Smarsly
Language	EN
Cycle	SoSe
Content	The contents of the exercises are based on the lecture contents. In addition to the exercises, project work will be conducted throughout the semester, which will consume the majority of the workload. As part of the project work, students will design smart monitoring systems that will be tested in the laboratory or in the field. As mentioned in the module description, the students will participate in the “Smart Monitoring” competition, hosted annually by the Institute of Digital and Autonomous Construction. Students are encouraged to contribute their own ideas. The tools required to implement the smart monitoring systems will be taught in the group exercises as well as through external sources, such as video tutorials and literature.
Literature	The course contents couples different fields, such as signal processing, sensing technologies, data analytics, environmental engineering, civil engineering, artificial intelligence, database systems, and many more. The basics will be taught in this course. However, specific literature that covers all these topics does not exist. Instead, literature will be referenced in the lectures, all of which are papers that are freely available online.

Module M2002: Waste and Resource Management

Courses

Title	Typ	Hrs/wk	CP
Waste management (L3261)	Project-/problem-based Learning	3	3
International waste concepts (L3259)	Lecture	2	2
International waste concepts (L3260)	Recitation Section (small)	1	1

Module Responsible	Prof. Kerstin Kuchta
Admission Requirements	None
Recommended Previous Knowledge	Basics in process engineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe waste as a resource as well as advanced technologies for recycling and recovery of resources from waste in detail. This covers collection, transport, treatment and disposal in national and international contexts.
Skills	Students are able to select suitable processes for the treatment with respect to the national or cultural and developmental context. They can evaluate the ecological impact and the technical effort of different technologies and management systems.
Personal Competence	
Social Competence	Students can work together as a team of 2-5 persons, participate in subject-specific and interdisciplinary discussions, develop cooperated solutions and defend their own work results in front of others and promote the scientific development of colleagues. Furthermore, they can give and accept professional constructive criticisms.
Autonomy	Students can independently gain additional knowledge of the subject area and apply it in solving the given course tasks and projects.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	Compulsory: Yes; Bonus: 20 %; Form: Written elaboration; Description:
Examination	Presentation
Examination duration and scale	PowerPoint presentation (10-15 minutes)
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory

Course L3261: Waste management	
Typ	Project-/problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Rüdiger Siechau
Language	EN
Cycle	SoSe
Content	• Introduction into the "Waste Management" consisting of: ◦ Thermal Process (incinerator, RDF combustion) ◦ Biological processes (Wet-/Dryfermentation) ◦ technology, energy, emissions, approval , etc. • Group work ◦ design of systems/plants for energy recovery from waste ◦ The following points are to be processed: ▪ Input: waste (fraction collection and transportation, current quantity, material flows , possible amount of development) ▪ Plant (design, process diagram, technology, energy production) ▪ Output (energy quantity / type, by-products) ▪ Costs and revenues ▪ Climate and resource protection (CO2 balance , substitution of primary raw materials / fossil fuels) ▪ Location and approval (infrastructure , expiration authorization procedure) ▪ Focus at the whole concept (advantages, disadvantages , risks and opportunities , discussion)
Literature	Einführung in die Abfallwirtschaft; Martin Kranert, Klaus Cord-Landwehr (Hrsg.); Vieweg + Teubner Verlag; 2010 Powerpoint-Folien in Stud IP

Course L3259: International waste concepts	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	SoSe
Content	Waste avoidance and recycling are the focus of this lecture. Additionally, waste logistics (Collection, transport, export, fees and taxes) as well as international waste shipment solutions are presented. Other specific wastes, e.g. industrial waste, treatment concepts will be presented and developed by students themselves Waste composition and production on international level, wast eulogistic, collection and treatment in emerging and developing countries. Single national projects and studies will be prepared and presented by students
Literature	Basel convention

Course L3260: International waste concepts	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0871: Hydrological Systems

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Applied Surface Hydrology (L0289)	Lecture	2	2
Applied Surface Hydrology (L1412)	Project-/problem-based Learning	1	2
Interaction Water - Environment in Fluvial Areas (L0295)	Project-/problem-based Learning	1	2

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Fundamentals of Hydromechanics and Hydraulic Engineering: Hydraulic Engineering I and Hydraulic Engineering II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to define the basic concepts of hydrology and water management. They are able to describe and quantify the relevant processes of the hydrological water cycle. Besides, the students know the main aspects of rainfall-run-off-models and are able to theoretically derive established reservoir / storage models and a unit-hydrograph.
Skills	The students are able to use the basic hydrological concepts and approaches and are able to theoretically derive established reservoir / storage models or a unit-hydrograph as the basis for rainfall-run-off-models. The student are able to explain the basic concepts of measurements of hydrological and hydrodynamic values in nature and are able to perform, analyze and statistically assess these measurements. Furthermore, they are able to apply a hydrological model to basic hydrological problems.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in applied problems of the hydrology and water management. Additionaly, they will be able to work in team with engineers of other disciplines.
Autonomy	The students will be able to independently extend their knowledge and apply it to new problems
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	The duration of the examination is 90 min. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L0289: Applied Surface Hydrology

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	Basics of hydrology: • Hydrological cycle • Data acquisition • Data analyses and statistical assessment • Statistics of extremes • Regionalization methods for hydrological values • Rainfall-run-off modelling on the basis of a unit hydrograph conceps • Application of rainfall-run-off models on the basis of Kalypso-Hydrology which is an OpenSource Software Tool.
Literature	http://de.wikipedia.org/wiki/Kalypso_(Software) http://kalypso.bjoernsen.de/ http://sourceforge.net/projects/kalypso/

Course L1412: Applied Surface Hydrology	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0295: Interaction Water - Environment in Fluvial Areas	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	A problem based learning course. The problem will be solved by the students more or less self-contained. The topics will be introduced and elaborated over the semester.
Literature	-

Module M2032: Advanced Vadose Zone Hydrology

Courses

Title	Typ	Hrs/wk	CP
Modeling Processes in Vadose Zone (L2735)	Recitation Section (small)	2	2
Vadose Zone Hydrology (L2732)	Lecture	2	2
Vadose Zone Hydrology (L2733)	Recitation Section (large)	2	2

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in water and soil Comfortable with math and physics, critical thinking, creative problem solving Analytic skills
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students will learn about soil characterization (solid and liquid phase), the energy state of soil water, the soil water characteristic curve, flow in saturated and unsaturated soil as well as about solute transport in soil
Skills	Students will work on practical examples modelling transport processes in soil using different quantitative tools including computer simulations and analytical tools. This will help them to apply knowledge in order to solve problems and tasks.
Personal Competence	
Social Competence	The module aims at raising awareness and enthusiasm for new knowledge related to water, soil and environment. This will positively contribute to shape their work and life environment.
Autonomy	The students will be involved in many problem solving exercises. This will contribute toward their willingness to work independently and responsibly.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Report and Presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory

Course L2735: Modeling Processes in Vadose Zone

Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Mohammad Aziz Zarif
Language	EN
Cycle	SoSe
Content	Numerical tools will be introduced and used to quantify flow and transport processes in soil
Literature	NA

Course L2732: Vadose Zone Hydrology	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	Soil solid phase characterization, Soil liquid phase characterization, The energy state of soil water, Soil Water Characteristic Curve, Flow in saturated soil, Flow in unsaturated soil, Solute transport in porous media
Literature	- Environmental Soil Physics, by Daniel Hillel - Soil Physics, Sixth Edition, by William A. Jury and Robert Horton - Physical Hydrology, Second Edition, by S. Lawrence Dingman - Introduction to Physical Hydrology, by Martin R. Hendriks

Course L2733: Vadose Zone Hydrology	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0949: Rural Development and Resources Oriented Sanitation for different Climate Zones

Courses

Title	Typ	Hrs/wk	CP
Rural Development and Resources Oriented Sanitation for different Climate Zones (L0942)	Seminar	2	3
Rural Development and Resources Oriented Sanitation for different Climate Zones (L0941)	Lecture	2	3

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of the global situation with rising poverty, soil degradation, lack of water resources and sanitation
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can describe resources oriented wastewater systems mainly based on source control in detail. They can comment on techniques designed for reuse of water, nutrients and soil conditioners. Students are able to discuss a wide range of proven approaches in Rural Development from and for many regions of the world.
Skills	Students are able to design low-tech/low-cost sanitation, rural water supply, rainwater harvesting systems, measures for the rehabilitation of top soil quality combined with food and water security. Students can consult on the basics of soil building through “Holisitc Planned Grazing” as developed by Allan Savory.
Personal Competence	
Social Competence	The students are able to develop a specific topic in a team and to work out milestones according to a given plan.
Autonomy	Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	During the course of the semester, the students work towards mile stones. The work includes presentations and papers. Detailed information will be provided at the beginning of the smester.
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0942: Rural Development and Resources Oriented Sanitation for different Climate Zones

Typ	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	• Central part of this module is a group work on a subtopic of the lectures. The focus of these projects will be based on an interview with a target audience, practitioners or scientists. • The group work is divided into several Milestones and Assignments. The outcome will be presented in a final presentation at the end of the semester.
Literature	• J. Lange, R. Otterpohl 2000: Abwasser - Handbuch zu einer zukunftsfähigen Abwasserwirtschaft. Mallbeton Verlag (TUHH Bibliothek) • Winblad, Uno and Simpson-Hébert, Mayling 2004: Ecological Sanitation, EcoSanRes, Sweden (free download) • Schober, Sabine: WTO/TUHH Award winning Terra Preta Toilet Design: http://youtu.be/w_R09cYq6ys

Course L0941: Rural Development and Resources Oriented Sanitation for different Climate Zones	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	• Living Soil - THE key element of Rural Development • Participatory Approaches • Rainwater Harvesting • Ecological Sanitation Principles and practical examples • Permaculture Principles of Rural Development • Performance and Resilience of Organic Small Farms • Going Further: The TUHH Toolbox for Rural Development • EMAS Technologies, Low cost drinking water supply
Literature	• Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation: http://youtu.be/9hmkgn0nBgk • Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press

Module M0822: Process Modeling in Water Technology

Courses

Title	Typ	Hrs/wk	CP
Process Modelling of Wastewater Treatment (L0522)	Project-/problem-based Learning	2	3
Process Modeling in Drinking Water Treatment (L0314)	Project-/problem-based Learning	2	3

Module Responsible	Dr. Klaus Johannsen
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of the most important processes in drinking water and waste water treatment.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to explain selected processes of drinking water and waste water treatment in detail. They are able to explain basics as well as possibilities and limitations of dynamic modeling.
Skills	Students are able to use the most important features Modelica offers. They are able to transpose selected processes in drinking water and waste water treatment into a mathematical model in Modelica with respect to equilibrium, kinetics and mass balances. They are able to set up and apply models and assess their possibilities and limitations.
Personal Competence	
Social Competence	Students are able to solve problems and document solutions in a group with members of different technical background. They are able to give appropriate feedback and can work constructively with feedback concerning their work.
Autonomy	Students are able to define a problem, gain the required knowledge and set up a model.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0522: Process Modelling of Wastewater Treatment	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Joachim Behrendt
Language	DE/EN
Cycle	WiSe
Content	Mass and energy balances Tracer modelling Activated Sludge Model Wastewater Treatment Plant Modelling (continously and SBR) Sludge Treatment (ADM, aerobic autothermal) Biofilm Modelling
Literature	**Henze, Mogens** (Seminar on Activated Sludge Modelling, ; Kollekolle Seminar on Activated Sludge Modelling, ;) Activated sludge modelling : processes in theory and practice ; selected proceedings of the 5th Kollekolle Seminar on Activated Sludge Modelling, held in Kollekolle, Denmark, 10 - 12 September 2001 ISBN: 1843394146 [London] : IWA Publ., 2002 TUB_HH_Katalog **Henze, Mogens** Activated sludge models ASM1, ASM2, ASM2d and ASM3 ISBN: 1900222248 London : IWA Publ., 2002 TUB_HH_Katalog **Henze, Mogens** Wastewater treatment : biological and chemical processes ISBN: 3540422285 (Pp.) Berlin [u.a.] : Springer, 2002 TUB_HH_Katalog **Wiesmann, Udo** (Choi, In Su; Dombrowski, Eva-Maria;) Fundamentals of biological wastewater treatment ISBN: 3527312196 (Gb.) URL: http://deposit.ddb.de/cgi-bin/dokserv?id=2774611&prov=M&dok_var=1&dok_ext=htm Weinheim : WILEY-VCH, 2007 TUB_HH_Katalog

Course L0314: Process Modeling in Drinking Water Treatment	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Klaus Johannsen
Language	EN
Cycle	WiSe
Content	In this course selected drinking water treatment processes (e.g. aeration or activated carbon adsorption) are modeled dynamically using the programming language Modelica, that is increasingly used in industry. In this course OpenModelica is used, an free access frontend of the programming language Modelica. In the beginning of the course the use of OpenModelica is explainded by means of simple examples. Together required elements and structure of the model are developed. The implementation in OpenModelica and the application of the model is done individually or in groups respectively. Students get feedback and can gain extra points for the exam.
Literature	**OpenModelica:** https://openmodelica.org/index.php/download/download-windows **OpenModelica - Modelica Tutorial:** https://openmodelica.org/index.php/useresresources/userdocumentation **OpenModelica - Users Guide:** https://openmodelica.org/index.php/useresresources/userdocumentation **Peter Fritzson:** Principles of Object-Oriented Modeling and Simulation with Modelica 2.1,Wiley-IEEE Press, ISBN 0-471-471631. **MHW (rev. by Crittenden, J. et al.):** Water treatment principles and design. John Wiley & Sons, Hoboken, 2005. **Stumm, W., Morgan, J.J.**: Aquatic chemistry. John Wiley & Sons, New York, 1996. **DVGW (Hrsg.):** Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004.

Module M0713: Concrete Structures

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Concrete Structures (L0579)	Seminar	1	1
Structural Concrete Members (L0577)	Lecture	2	3
Structural Concrete Members (L0578)	Recitation Section (large)	2	2

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	Basics of structural analysis, conception and dimensioning of structural concrete Modules: Reinforced Concrete Structures I+II, Structural Analysis I+II, Mechanics I+II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students broaden their skills in structural engineering, especially in the field of buildings (houses, roofs, halls). They dispose of the knowledge for the conception and design of concrete buildings and structural members that are often used.
Skills	The students are able to apply procedures of the conception and dimensioning to to practical problems of structural engineering. They are capable to draft concrete buildings and to design them for general action effects and to plan their detailing and execution. Moreover, they can make design and construction sketches and draw up technical descriptions.
Personal Competence	
Social Competence	The students are able to obtain results of high quality in teamwork.
Autonomy	The students are able to carry out complex conception and dimensioning tasks of structures under the guidance of tutors.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** No / None / Presentation / Es werden 2 Referate ausgegeben
Examination	Written exam
Examination duration and scale	120 minutes
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L0579: Concrete Structures

Typ	Seminar
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	NN
Language	DE
Cycle	WiSe
Content	With help of a project teamwork the subjects of the course "Concrete Structures" is practiced, discussed and presented.
Literature	- Projektbezogene Unterlagen werden abgegeben.

Course L0577: Structural Concrete Members	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	NN
Language	DE
Cycle	WiSe
Content	• skyscrapers: structural elements • actions on structrues • bracing systems • design orf slabs (line and point supported plates and floor slabs) • membranes and deep beams • folded plates and shells • truss models • reinforced and prestressed members
Literature	Vorlesungsunterlagen können im STUDiP heruntergeladen werden • Zilch K., Zehetmaier G.: Bemessung im konstruktiven Ingenieurbau. Springer, Heidelberg 2010 • König, G., Liphardt S.: Hochhäuser aus Stahlbeton, Betonkalender 2003, Teil II, Seite 1-69, Verlag Ernst & Sohn, Berlin 2003 • Phocas, Marios C.: Hochhäuser : Tragwerk und Konstruktion, Stuttgart, Teubner, 2005 • Deutscher Ausschuss für Stahlbeton: Heft 600: Erläuterungen zu DIN EN 1992-1-1, Beuth Verlag, Berlin 2012 • Deutscher Ausschuss für Stahlbeton: Heft 240: Hilfsmittel zur Berechnung der Schnittgrößen und Formänderungen von Stahlbetontragwerken, Verlag Ernst & Sohn, Berlin 1978 • Stiglat, K., Wippel, H.: Massive Platten - Ausgewählte Kapitel der Schnittkraftermittlung und Bemessung, Betonkalender 1992, Teil I, 287-366, Verlag Ernst & Sohn, Berlin 1992 • Stiglat/Wippel: Platten. Verlag Ernst & Sohn, Berlin,1973 • Schlaich J.; Schäfer K.: Konstruieren im Stahlbetonbau. Betonkalender 1998, Teil II, S. 721ff, Verlag Ernst & Sohn, Berlin, 1998 • Dames K.-H.: Rohbauzeichnungen Bewehrungszeichnungen. Bauverlag, Wiesbaden 1997

Course L0578: Structural Concrete Members	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	NN
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0963: Steel and Composite Structures

Courses

Title	Typ	Hrs/wk	CP
Steel and Composite Structures (L1204)	Lecture	2	2
Steel and Composite Structures (L1205)	Recitation Section (large)	2	2
Steel Bridges (L1097)	Lecture	2	2

Module Responsible	Prof. Marcus Rutner
Admission Requirements	None
Recommended Previous Knowledge	Basics of steel construction (i.e. Steel Structures I and II, BUBC)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completition, students can • describe the phenomenon of local buckling • explain warping torsion • illustrate the behaviour of composite structures • specify the principles in design of composite sttructures • sketch the contructions of steel and composite bridges
Skills	After successful participation students are able to • check stiffened and unstiffened plated structures • recognize and verify warping tosion in strucures • design composite structures • design bridges and o perform the detailing
Personal Competence	
Social Competence	--
Autonomy	--
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	180 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L1204: Steel and Composite Structures

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Marcus Rutner
Language	DE
Cycle	WiSe
Content	• Local-buckling of plated structures • Warping torsion • Composite-girders, -columns, -slabs, -bridges • Principles in composite constructions • Bridge-design and -construction
Literature	Petersen, C.: Stahlbau, 4.Auflage 2013, Springer-Vieweg Verlag Minnert, J. Wagenknecht, G.: Verbundbau-Praxis - Berechnung und Konstruktion nach Eurocode 4, 2.Auflage 2013, Bauwerk Beuth Verlag

Course L1205: Steel and Composite Structures	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Marcus Rutner
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1097: Steel Bridges	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Yves Freundt
Language	DE
Cycle	WiSe
Content	**Lecture Contents ‚Steel Bridge Construction'** **Dr.-Ing. Jörg Ahlgrimm** - From tendering and contracting to completion - the development of a steel bridge - Contents of a bridge static - structural details, examples of analysis in detail: -> effective width in regard to the longitudinal stiffeners -> Bearing point, bearing stiffener -> Crossbeam breakthrough, crossbeam reinforcement -> Analysis of the Rib-to-Floorbeam (RF) connection (web-tooth of the floorbeam between trapezoidal shaped Ribs) - Steel grades, -designation, testing methods and approval certificates - Nondestructive weld inspecting - Corrosion protection - Bridge bearing - types, format, function, dimensioning, installation - Expansion Joints - Oscillation of bridge hangers and cables - oscillation damper - Opening bridges- Detailed reviews to different assembling procedures and - implements - Selective damage events Requirements: Basic knowledge in the calculation, dimensioning, and construction of structural elements and joints of constructional steelwork
Literature	• Herbert Schmidt, Ulrich Schulte, Rainer Zwätz, Lothar Bär: Ausführung von Stahlbauten • Petersen, Christian: Stahlbau, Abschnitt Brückenbau • Ahlgrimm, J., Lohrer, I.: Erneuerung der Eisenbahnüberführung in Fulda-Horas über die Fulda, Stahlbau 74 (2005), Heft 2, S. 114

Module M0699: Geotechnics III

Courses

Title	Typ	Hrs/wk	CP
Numerical Methods in Geotechnics (L0375)	Lecture	3	3
Advanced Foundation Engineering (L0497)	Lecture	2	2
Advanced Foundation Engineering (L0498)	Recitation Section (large)	1	1

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	Geotechnics I and II, Mathematics I-III
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successfully completing the module, students will be able to • describe individual procedures for the geotechnical monitoring of civil engineering measures, • reproduce exploration and investigation methods of the subsoil, • select suitable types of field and laboratory tests for subsoil investigation and evaluate their results, • state the differences between various stress and deformation states and the physical significance of invariants of the stress and distortion tensor, • outline the standard and special soil mechanics tests used to determine the stress-strain behavior of soil, • describe continuum models and the resulting boundary value problems, • as well as define boundary value problems from the field of geotechnical engineering in such a way that they can be solved unambiguously.
Skills	Students will be able to • dimension vertical drains for soil improvement of soft soils, • calculate depth compaction using various appropriate methods, • apply principles of horizontal bearing capacity of piles, • verify the internal and external stability of fluid-supported diaphragm walls, • evaluate the boundary conditions for the design of a deep excavation and design the individual components of the excavation, • perform, evaluate and interpret tests for the description and classification of soils according to applicable standards, • computationally implement numerical algorithms to solve boundary value problems, • select and apply the types of analyses depending on the degree of saturation, the impact, and the material behavior • determine appropriate model parameters for different possibilities and limitations of material models for the grain structure of soils.
Personal Competence	
Social Competence	Students can work in groups and support each other in finding solutions.
Autonomy	Students are able to assess their own strengths and weaknesses and, based on this, organize their time and learning management and think in terms of processes.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory

Course L0375: Numerical Methods in Geotechnics	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Dr. Hans Mathäus Stanford
Language	DE
Cycle	WiSe
Content	Topics: • Introduction to numerical soil mechanics • Introduction to numerical mathematics • Finite Element Method (analysis procedures, algorithms) • Finite Element Method (application in geotechnical engineering)
Literature	• Wriggers P. (2001): Nichtlineare Finite-Elemente-Methoden. Springer • Wriggers P. (2008): Nonlinear Finite Element Methods. Springer • Deutsche Gesellschaft für Geotechnik e.V. (Hrsg., 2014): Empfehlungen des Arbeitskreises "Numerik in der Geotechnik". Ernst & Sohn

Course L0497: Advanced Foundation Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	WiSe
Content	• Vertical drains • Piles • Ground improvement (Deep Compaction, Soil mixing) • Vibration driving • Jet grouting • Slurry wall • Deep excavation
Literature	• EAK (2002): Empfehlungen für Küstenschutzbauwerke • EAU (2004): Empfehlungen des Arbeitsausschusses Uferbauwerke • EAB (1988): Empfehlungen des Arbeitskreises Baugruben • Grundbau-Taschenbuch, Teil 1-3, (1997), Ernst & Sohn Verlag

Course L0498: Advanced Foundation Engineering	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1401: Study work Water and Traffic

Courses

Title	Typ	Hrs/wk	CP

Module Responsible	Dozenten des SD B
Admission Requirements	None
Recommended Previous Knowledge	Subjects of the Water Management and Waste specialisation.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to demonstrate their detailed knowledge in the field of water management and waste. They can exemplify the state of technology and application and discuss critically in the context of actual problems and general conditions of science and society. The students can develop solving strategies and approaches for fundamental and practical problems in the field of water management and waste. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view points of science and society. Scientific work techniques that are used can be described and critically reviewed.
Skills	The students are able to independently select methods or planning approaches for the project work and to justify their choice. They can explain how these methods or approaches relate to solutions in the field of work and how the context of application has to be adjusted. General findings and further developments may essentially be outlined.
Personal Competence	
Social Competence	The students are able to condense the relevance and the structure of the project work, the work steps and the sub-problems for the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to their colleagues.
Autonomy	The students are capable of independently planning and documenting the work steps and procedures while considering the given deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedback from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology.
Workload in Hours	Independent Study Time 180, Study Time in Lecture 0
Credit points	6
Course achievement	None
Examination	Study work
Examination duration and scale	See FSPO
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Compulsory

Module M0802: Membrane Technology

Courses

Title	Typ	Hrs/wk	CP
Membrane Technology (L0399)	Lecture	2	3
Membrane Technology (L0400)	Recitation Section (small)	1	2
Membrane Technology (L0401)	Practical Course	1	1

Module Responsible	Prof. Mathias Ernst
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of water chemistry. Knowledge of the core processes involved in water, gas and steam treatment
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will be able to rank the technical applications of industrially important membrane processes. They will be able to explain the different driving forces behind existing membrane separation processes. Students will be able to name materials used in membrane filtration and their advantages and disadvantages. Students will be able to explain the key differences in the use of membranes in water, other liquid media, gases and in liquid/gas mixtures.
Skills	Students will be able to prepare mathematical equations for material transport in porous and solution-diffusion membranes and calculate key parameters in the membrane separation process. They will be able to handle technical membrane processes using available boundary data and provide recommendations for the sequence of different treatment processes. Through their own experiments, students will be able to classify the separation efficiency, filtration characteristics and application of different membrane materials. Students will be able to characterise the formation of the fouling layer in different waters and apply technical measures to control this.
Personal Competence	
Social Competence	Students will be able to work in diverse teams on tasks in the field of membrane technology. They will be able to make decisions within their group on laboratory experiments to be undertaken jointly and present these to others.
Autonomy	Students will be in a position to solve homework on the topic of membrane technology independently. They will be capable of finding creative solutions to technical questions.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation B - Industrial Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0399: Membrane Technology	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Mathias Ernst
Language	EN
Cycle	WiSe
Content	The lecture on membrane technology supply provides students with a broad understanding of existing membrane treatment processes, encompassing pressure driven membrane processes, membrane application in electrodialyis, pervaporation as well as membrane distillation. The lectures main focus is the industrial production of drinking water like particle separation or desalination; however gas separation processes as well as specific wastewater oriented applications such as membrane bioreactor systems will be discussed as well. Initially, basics in low pressure and high pressure membrane applications are presented (microfiltration, ultrafiltration, nanofiltration, reverse osmosis). Students learn about essential water quality parameter, transport equations and key parameter for pore membrane as well as solution diffusion membrane systems. The lecture sets a specific focus on fouling and scaling issues and provides knowledge on methods how to tackle with these phenomena in real water treatment application. A further part of the lecture deals with the character and manufacturing of different membrane materials and the characterization of membrane material by simple methods and advanced analysis. The functions, advantages and drawbacks of different membrane housings and modules are explained. Students learn how an industrial membrane application is designed in the succession of treatment steps like pre-treatment, water conditioning, membrane integration and post-treatment of water. Besides theory, the students will be provided with knowledge on membrane demo-site examples and insights in industrial practice.
Literature	• T. Melin, R. Rautenbach: Membranverfahren: Grundlagen der Modul- und Anlagenauslegung (2., erweiterte Auflage), Springer-Verlag, Berlin 2004. • Marcel Mulder, Basic Principles of Membrane Technology, Kluwer Academic Publishers, Dordrecht, The Netherlands • Richard W. Baker, Membrane Technology and Applications, Second Edition, John Wiley & Sons, Ltd., 2004

Course L0400: Membrane Technology	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Mathias Ernst
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0401: Membrane Technology	
Typ	Practical Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Mathias Ernst
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0581: Water Protection

Courses

Title	Typ	Hrs/wk	CP
Water Protection and Wastewater Management (L0226)	Lecture	3	3
Water Protection and Wastewater Management (L2008)	Project Seminar	3	3

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	• Basic knowledge in water management; • Good knowledge in urban drainage; • Good knowledge of wastewater treatment techniques; • Good knowledge of pollutants (e.g. COD, BOD, TS, N, P) and their properties;
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can describe the basic principles of the regulatory framework related to the international and European water sector. They can explain limnological processes, substance cycles and water morphology in detail. They are able to assess complex problems related to water protection, such as ecosystem service and wastewater treatment with a special focus on innovative solutions, remediation measures as well as conceptual approaches.
Skills	Students can accurately assess current problems and situations in a country-specific or local context. They can suggest concrete actions to contribute to the planning of tomorrow's urban water cycle. Furthermore, they can suggest appropriate technical, administrative and legislative solutions to solve these problems.
Personal Competence	
Social Competence	The students can work together in international groups.
Autonomy	Students are able to organize their work flow to prepare presentations and discussions. They can acquire appropriate knowledge by making enquiries independently.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Presentation
Examination duration and scale	Term paper plus presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory

Course L0226: Water Protection and Wastewater Management	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	The lecture focusses on: • Regulatory Framework (e.g. WFD) • Main instruments for the water management and protection • In depth knowledge of relevant measures of water pollution control • Urban drainage, treatment options in different regions on the world • Rainwater management, improved management of heavy rainfalls, downpours, rainwater harvesting, rainwater infiltration • Case Studies and Field Trips
Literature	The literature listed below is available in the library of the TUHH. • Water and wastewater technology Hammer, M. J. 1., & . (2012). (7. ed., internat. ed.). Boston [u.a.]: Pearson Education International. • Water and wastewater engineering : design principles and practice: Davis, M. L. 1. (2011). . New York, NY: McGraw-Hill. • Biological wastewater treatment: (2011). C. P. Leslie Grady, Jr. (3. ed.). London, Boca Raton, Fla. [u.a.]: IWA Publ.

Course L2008: Water Protection and Wastewater Management	
Typ	Project Seminar
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	
Literature	

Module M1720: Emerging Trends in Environmental Engineering

Courses

Title	Typ	Hrs/wk	CP
Environmental Research Trends (L2752)	Seminar	2	2
Microplastics in Environment (L2750)	Lecture	2	2
Scientific Communication and Methods (L2751)	Lecture	1	2

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge on water, soil and environmental research.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students will be exposed to up-to-date research topics focused on soil, water and climate related challenges with a particular focus on the effects of microplastics in environment. Data analysis, data measurement, curation and presentation will be other skills that the students will develop in this module.
Skills	Students' research skills will be improved in this module. How to prepare and deliver an effective presentation, how to write an abstract, research paper and proposal will be discussed in this module. Moreover, through Research-Based Learning approaches, the students will be exposed to current research trends in environmental engineering.
Personal Competence	
Social Competence	Developing teamwork and problem solving skills through Research-Based Teaching approaches will be at the core of this module.
Autonomy	The students will be involved in writing individual reports and presentation. This will contribute to the students' ability and willingness to work independently and responsibly.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	Report and Presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2752: Environmental Research Trends	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Salome Shokri-Kuehni
Language	EN
Cycle	WiSe
Content	Introduction - course objectives, expectations and format Analyzing the Audience, purpose and occasion Constructing and delivering effective technical presentations How to write an abstract How to write a scientific paper Developing competitive and persuasive research proposals Databases and resources available for water and environmental research Individual proposal on water and environmental research Individual project on water and environmental research Presentation on water and environmental research
Literature	• The Craft of Scientific Writing Fourth edition Author: Michael Alley Springer-Verlag New York, Copyright 2018, DOI 10.1007/978-1-4419-8288-9 • Supplemental materials and web links which will be available to registered students.

Course L2750: Microplastics in Environment	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	WiSe
Content	- Introduction, objectives, expectations, format, importance - Sources of microplastics in environment - Microplastics sampling; Characterization of microplastics - Distribution of microplastics in terrestrial environments - Fate of microplastics in terrestrial environments - Project discussion - Effects of microplastics on terrestrial environments - Health risks of microplastics in environments - Project presentations by all students
Literature	- Microplastics in Terrestrial Environments (2021), Edited by Defu He and Yongming Luo - Particulate Plastics in Terrestrial and Aquatic Environments (2020), Edited by Nanthi S. Bolan et al. - Microplastic Pollutants (2017), by Christopher B. Crawford and Brian Quinn

Course L2751: Scientific Communication and Methods	
Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	WiSe
Content	Introduction - course objectives, expectations and format Analyzing the Audience, purpose and occasion Constructing and delivering effective technical presentations How to write an abstract How to create a scientific poster How to write a scientific paper Developing competitive and persuasive research proposals Individual project (report and presentation) related to soil, water and environmental research
Literature	• The Craft of Scientific Writing Fourth edition Author: Michael Alley Springer-Verlag New York, Copyright 2018, DOI 10.1007/978-1-4419-8288-9 • Supplemental materials and web links which will be available to registered students.

Module M1505: Adaptation to Climate Change in Hydraulic Engineering (AKWAS)

Courses

Title	Typ	Hrs/wk	CP
Adaptation to climate change in hydraulic engineering (L2291)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	• Hydrology, Hydraulic Engineering • Hydromechanic, Hydraulics • Fundamentals of Coastal Engineering, Coastal- and Flood Protection • Hydrological Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Climate protection and climate adaptation • Insights into climate change and its regional characteristics - fundamentals, climate modelling / climate models • Impacts of climate change on the components of the regional hydrological cycle • Fundamentals of analysis of climate data • Consequences of the impact of the climate change • Measures for climate adaptation • Assessment, prioritization and communication of adaptation measures • Fundamentals of the analysis of hydrometeorological and hydrological data
Skills	• Critical thinking: analysis of processes and relations, assessment of needs for action • Creative thinking: development of adaptation strategies and adaptation measures • Practical thinking: inclusion of restrictions, application of calculation approaches, methods, numerical models, planning methods • Consideration of complex tasks
Personal Competence	
Social Competence	• Working in heterogenous groups • Working with different scientific / non-scientific disciplines • Self reflection
Autonomy	• Application oriented use of knowledge and skills • Autonomous work on complex tasks
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Preparation of a written report and a presentation of a complex task.
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2291: Adaptation to climate change in hydraulic engineering	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Peter Fröhle
Language	DE
Cycle	WiSe
Content	• Climate protection and climate adaptation • Findings on climate change and its regional characteristics: fundamentals of climate change, climate modelling / climate models • Impacts of climate change on the components of the regional hydrological cycle(climate science view) • Fundamentals of the analysis of climate data • Concequences of the impacts of climate change (ingenieering science view) • Measures for climate change adaptation • Assessment, prioritization and communication of measures • Fundamentals of analysis of hydrometeorological and hydrological data
Literature	• Wird bereitgestellt über die HOOU - eLearning Plattform • abhängig von den jeweils schwerpunktmäßig behandelten Fragestellungen wird das Schrifttum (aktuelle Paper) in der Veranstaltung bzw. über StudIP zur Verfügung gestellt.

Module M1725: Scientific Working in Computational Engineering

Courses

Title	Typ	Hrs/wk	CP
Scientific Working in Computational Engineering (L2764)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Kay Smarsly
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in scientific writing. String interest in topics related to computing in civil engineering.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students will learn to apply concepts and methods of scientific working in computational engineering. In interaction with the course instructors and in collaboration with each other, the students will also learn to understand the complex process of scientific thinking, being able to accurately plan, implement and analyze scientific projects, such as prospective master theses. A project will be conducted throughout the semester, which will contribute to the grade. Since scientific writing is of particular importance in this course, a scientific paper will be developed based, which is a prerequisite for the final examination. The paper will be written based on the project conducted within this course. Project meetings in small groups, presentations, and critical discussions of scientific publications are further key activities.
Skills	The students will be capable (i) of solving a scientific problem following a scientific methodology, (ii) of documenting their work effectively in the form of a paper, and (iii) of sharing their work in a presentation.
Personal Competence	
Social Competence	The students will be able to work in a multidisciplinary team and develop communication skills necessary for problem solving.
Autonomy	The students will be able to extend their knowledge and apply it to solve scientific problems by working independently in a project.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	10 pages of work with 15-minute oral presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory

Course L2764: Scientific Working in Computational Engineering

Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Kay Smarsly
Language	EN
Cycle	WiSe/SoSe
Content	In the course, a scientific problem of practical relevance will first be defined, taking into account the interests of the students participating in the course. The scientific problem will then systematically be solved within the framework of a comprehensive project. The principles of scientific working will be taught based on the scientific problem defined previously. As an integral part of scientific working, fundamentals of scientific writing will be presented and applied to a scientific paper to be written during the course. Topics related to scientific writing include structuring in scientific writing (structuring the abstract, the introduction, the main part, the summary and conclusions, and the acknowledgments and references) and recommendations on effective scientific writing (principles of composition, use of English in scientific writing, useful tips, creating figures, writing in mathematics, referencing, and formal email correspondence). A final paper and a final presentation will be assembled by the students.
Literature	Smarsly, K. & Dragos, K., 2019. Scientific Writing in Engineering. Tredition, Hamburg, Germany.

Module M0969: Selected Topics in Civil Engineering

Courses

Title	Typ	Hrs/wk	CP
Design of Composite Bridges (L3092)	Integrated Lecture	2	3
Analysis of Offshore Structures (L1867)	Lecture	1	1
Energy Geotechnics (L3227)	Lecture	3	3
Solid Matter Process Technology for Biomass (L0052)	Lecture	2	3
Forum I - Geotechnics and Construction Management (L1634)	Seminar	1	1
Forum II - Geotechnics and Construction Management (L1635)	Seminar	1	1
Timber Structures (L1151)	Seminar	2	2
Innovative Timber Construction (L2666)	Lecture	2	4
Glass Structures (L1152)	Lecture	2	2
Glass Structures (L1447)	Recitation Section (large)	1	1
Sustainable landfill design and operation (L3270)	Integrated Lecture	3	3
Special Topics in Steel Design (L3091)	Integrated Lecture	2	3
Special topics of civil engineering 1CP (L2378)		1	1
Special topics of civil engineering 2 LP (L2379)		2	2
Special topics of civil engineering 3 LP (L2380)		3	3
Structural Design (L2789)	Seminar	2	2

Module Responsible	Prof. Frank Schmidt-Döhl
Admission Requirements	None
Recommended Previous Knowledge	none
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students are able to find their way through selected special areas within civil and structural engineering. • Students are able to explain basic models and procedures in selected special areas of civil and structural engineering. • Students are able to interrelate scientific and technical knowledge.
Skills	• Students are able to apply basic methods in selected areas of civil and structural engineering.
Personal Competence	
Social Competence	---
Autonomy	• Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses.
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory

Course L3092: Design of Composite Bridges

Typ	Integrated Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Marcus Rutner
Language	DE
Cycle	SoSe
Content	
Literature	

Course L1867: Analysis of Offshore Structures	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Said Fawad Mohammadi
Language	DE/EN
Cycle	SoSe
Content	Topic 1: Types of Offshore Structures, Fixed and floating structures for Oil & Gas and Offshore Wind industry Topic 2: Wave Forces, Morisons equation Topic 3: Irregular Seastates, Power spectrum and application of FFT Topic 4: Additional Environmental Forces, wind spectra, current forces Topic 5: Linear-Time-Invariant Systems, response of an LTI-system in frequency domain Topic 6: Tubular Welded Connections, stress concentration factors, weld geometry Topic 7: Introduction to Fracture Mechanics, criteria for fracture initiation and crack growth Topic 8: Time and Frequency Domain Fatigue Analyses, rainflow counting, application of LTI-systems for frequency domain fatigue Topic 9: Offshore Installation and Exam, installation of structures, pile driving, pipe laying techniques
Literature	Chakrabarti, Handbook of Offshore Engineering, 2005 Sarpkaya, Wave Forces on Offshore Structures, 2010 Faltinsen, Sea Loads on Ships and Offshore Structures, 1998 Sorensen, Basic Coastal Engineering, 2006 Dowling, Mechanical Behavior of Materials, 2007 Haibach, Betriebsfestigkeit, 2006 Marshall, Design of Welded Tubular Connections, 1992 Newland, Random vibrations, spectral and wavelet analysis, 1993

Course L3227: Energy Geotechnics	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Schriftliche Ausarbeitung (laut FPrO)
Examination duration and scale	wird zu Beginn der Lehrveranstaltung festgelegt
Lecturer	Pauline Kaminski
Language	DE/EN
Cycle	WiSe
Content	Energy geotechnics is a young field in geotechnical engineering with the aim of developing sustainable geotechnical solutions for future-oriented issues relating to the production, transport, operation, decommissioning, and waste utilisation of various energy sources. Examples of possible fields of activity in energy geotechnics include geothermal energy and thermally activated foundation components, foundations for onshore and offshore wind turbines, the decommissioning of mining facilities and the handling of waste products from fossil fuels such as tailings and the geological storage of CO2. Relevant soil mechanical processes in these applications include the thermo-hydro-mechanically coupled behaviour of soils, multiphase flow in porous media and partially saturated soils. The lecture gives an overview of various aspects of energy geotechnics and provides in-depth knowledge of the associated soil mechanical processes. In addition, CO2-scarce geotechnical applications are discussed and emission estimates as well as the optimisation of geotechnical structures according to sustainability aspects are addressed.
Literature	

Course L0052: Solid Matter Process Technology for Biomass	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Prof. Werner Sitzmann
Language	DE
Cycle	SoSe
Content	The industrial application of unit operations as part of process engineering is explained by actual examples of solid biomass processes. Size reduction, transportation and dosing, drying and agglomeration of renewable resources are described as important unit operations when producing solid fuels and bioethanol, producing and refining edible oils, when making Btl - and WPC - products. Aspects of explosion protection and plant design complete the lecture.
Literature	Kaltschmitt M., Hartmann H. (Hrsg.): Energie aus Bioamsse, Springer Verlag, 2001, ISBN 3-540-64853-4 Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, Schriftenreihe Nachwachsende Rohstoffe, Fachagentur Nachwachsende Rohstoffe e.V. www.nachwachsende-rohstoffe.de Bockisch M.: Nahrungsfette und -öle, Ulmer Verlag, 1993, ISBN 380000158175

Course L1634: Forum I - Geotechnics and Construction Management	
Typ	Seminar
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	WiSe
Content	Lectures about projects and issues with practical and scientific relevance.
Literature	--

Course L1635: Forum II - Geotechnics and Construction Management	
Typ	Seminar
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	SoSe
Content	Lectures about projects and issues with practical and scientific relevance.
Literature	--

Course L1151: Timber Structures	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Referat
Examination duration and scale	90 min
Lecturer	Prof. Torsten Faber
Language	DE
Cycle	WiSe
Content	
Literature	

Course L2666: Innovative Timber Construction	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Schriftliche Ausarbeitung
Examination duration and scale	45 Minuten
Lecturer	Dr. Andreas Meisel
Language	DE
Cycle	WiSe
Content	
Literature	- Blass, J.: "Ingenieurholzbau" - Schickhofer, G.: "BSPhandbuch: Holz-Massivbauweise in Brettsperrholz" - Informationsdienst Holz: div. Merkblätter und Broschüren - Wallner-Novak M.: Brettsperrholz Bemessung, Band 1 und 2 - Gerner M.: "Fachwerk: Entwicklung, Instandsetzung, Neubau" - Meisel, A.: "Historische Dachwerke: Beurteilung, realitätsnahe statische Analyse und Instandsetzung" - Kempe K.: "Dokumentation Holzschädlinge" - Huckfeldt T.: "Hausfäule- und Bauholzpilze"

Course L1152: Glass Structures	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Marvin Matzik
Language	DE
Cycle	WiSe
Content	Glass structures - Introduction of the material glass (production, refinement, material characteristic) - design of facades - facade types - static calculation of glazing - static calculation of facades - load bearing behavior of glazing (plate or membrane stiffness) - vertical / horizontal glazing with safety-related requirements - glass structures - fire safety of glass facades - construction physics of facades and glazing
Literature	

Course L1447: Glass Structures	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Marvin Matzik
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L3270: Sustainable landfill design and operation	
Typ	Integrated Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Dr. Marco Ritzkowski
Language	EN
Cycle	SoSe
Content	The course introduces the development of modern waste resource management and demonstrates the importance of landfills in the context of recycling processes. Based on international (EU) and national legislation, the current landfill situation is presented and the future significance of landfills will be discussed. A central element of the course deals with the main transformation processes in the landfilled waste, the emission of gases and leachate, the long-term behaviour of landfills as well as aftercare and after-utilisation measures. Further focal points of the course are measures for the sustainable reduction of environmentally and climate-damaging emissions and aspects of landfill technology in an international context.
Literature	1) **Waste Management**. Bernd Bilitewski; Georg Härdtle; Klaus Marek (Eds.), ISBN: 9783540592105 , Springer Verlag Lehrbuchsammlung der TUB, Signatur USH-305 2) **Solid Waste Technology and Management.** Thomas Christensen (Ed.), ISBN: 978-1-4051-7517-3 , Wiley Verlag Lesesaal 2: US - Umweltschutz, Signatur USH-332 3) **Solid Waste Landfilling - Concepts, Processes, Technologies.** Cossu, R. and Stegmann, R. (Eds.), ISBN: 978-0-12-818336-6 PDF (Volltext) über TUB

Course L3091: Special Topics in Steel Design	
Typ	Integrated Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Marcus Rutner, Nikolay Lalkovski
Language	DE
Cycle	SoSe
Content	
Literature	

Course L2378: Special topics of civil engineering 1CP	
Typ	
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Fachtheoretisch-fachpraktische Arbeit
Examination duration and scale	wird zu Beginn der Lehrveranstaltung festgelegt
Lecturer	Dozenten des SD B
Language	DE
Cycle	WiSe/SoSe
Content	The course occurs only if required. The content is defined at short notice.
Literature	Die Literatur wird kurzfristig festgelegt.

Course L2379: Special topics of civil engineering 2 LP	
Typ	
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Fachtheoretisch-fachpraktische Arbeit
Examination duration and scale	wird zu Beginn der Lehrveranstaltung festgelegt
Lecturer	Dozenten des SD B
Language	DE
Cycle	WiSe/SoSe
Content	The course occurs only if required. The content is defined at short notice.
Literature	Die Literatur wird kurzfristig festgelegt.

Course L2380: Special topics of civil engineering 3 LP	
Typ	
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Fachtheoretisch-fachpraktische Arbeit
Examination duration and scale	wird zu Beginn der Lehrveranstaltung festgelegt
Lecturer	Dozenten des SD B
Language	DE
Cycle	WiSe/SoSe
Content	The course occurs only if required. The content is defined at short notice.
Literature	Die Literatur wird kurzfristig festgelegt.

Course L2789: Structural Design	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	20 min
Lecturer	Dr. Jan Mittelstädt
Language	DE/EN
Cycle	SoSe
Content	
Literature	[1] Structure Systems by Heino Engel, Hantje Cantz, 3rd edition (Feb 2007), ISBN-10: 3775718761 Form and Force, Designing Efficient, Expressive Structures by Allan, E., Zalewski, W. et al, John Wiley and Sons; 1st edition (Sept 2009), ISBN-10: 047017465X [2] Peter Rice: An Engineer Imagines, ISBN-10 : 1849944237 [3] Konrad Wachsmann and the Grapevine Structure by C. Sumi et al., Park Books (Oct 2018), ISBN-10: 9783038601104 [4] Manual of Multi-Story Timber Construction by Hermann Kaufmann, Stefan Krotsch, Stefan Winter, DETAIL, (June 2018), ISBN-10: 3955533948 [5] The Art of Structural Design: A Swiss Legacy by B. Billington, Princeton University Art Museum; First Edition edition (Mar 2003), ISBN-10: 0300097867 [6] Structured Lineages: Learning from Japanese Structural Design by G. Nordenson et al, The Museum of Modern Art (Jul 2019), ISBN-10: 1633450562 [7] The Structure: Works of Mahendra Raj by V. Mehta, R. Mehndiretta, A. Huber, Park Books (Oct 2015), ISBN-10: 3038600253

Module M1779: Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC)

Courses

Title	Typ	Hrs/wk	CP
Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC) (L2926)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	• Hydraulic Engineering • Hydromechanics, Hydraulics • Fundamentals of Coastal Engineering, Coastal- and Flood Protection
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Climate and Climate Change • General Impacts of Climate Change on Wind Regime and Water Cycle • Consequences of Climate Change for Coastal Processes • Coastal Protection in Taiwan and Germany • Fundamentals of Climate Adaptation • Nature-based Solutions (NBS) for Coastal Protection
Skills	• Critical thinking: analysis of processes and relations, assessment of needs for action • Creative thinking: development of adaptation strategies and adaptation measures • Practical thinking: inclusion of restrictions, application of calculation approaches, methods, numerical models, planning methods • Consideration of complex tasks
Personal Competence	
Social Competence	• Working in heterogenous groups • Working in international groups • Working with different scientific / non-scientific disciplines • Self reflection
Autonomy	• Application oriented use of knowledge and skills • Autonomous work on complex tasks
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Preparation of a written report on a complex task with a presentation and subsequent discussion. The work on the complex task happens in the course of the lecture.
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2926: Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC)	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Peter Fröhle
Language	EN
Cycle	WiSe
Content	• Climate and Climate Change • General Impacts of Climate Change on Wind Regime and Water Cycle • Consequences of Climate Change for Coastal Processes • Coastal Protection in Taiwan and Germany • Fundamentals of Climate Adaptation • Nature-Based Solutions (NBS) for Coastal Protection
Literature	• Materials provided on eLearning Platform (HOOU Platform) • Depending on the main topics of the course in the respective year, the literature (recent papers) will be provided in the course-material or via StudIP.

Module M1956: Building and Excavation Law

Courses

Title	Typ	Hrs/wk	CP
Construction law BGB and VOB - law in (excavation) practice (L3182)	Lecture	2	3
Construction disputes from construction (excavation) practice (L3181)	Lecture	2	3

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	Complete modules: Geotechnics I-III
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will gain knowledge of • the history of civil engineering law, • basics of foundation and civil engineering law, • legal aspects of technical regulations in civil engineering (with case studies), • the civil engineering contract, • the liability of the designer and contractor in civil engineering, • the subsoil risk and the system risk, • the total debt in (civil) engineering law, • the (construction) conflict, dispute avoidance models and the construction process, • the systematics of construction contract law, • the BGB construction contract law, • responsibilities on the construction site, • remuneration and contract management, • liability for defects, • public procurement law • Disturbed construction processes: How much money am I entitled to? • Correct calculation of supplements.
Skills	Students learn to apply legal aspects in planning and construction in a legally balanced way. Students learn how to use legal and construction management aspects in practice (planning and construction) on the construction site in a targeted manner and how to manage the construction project optimally.
Personal Competence	
Social Competence	Students can work in groups and support each other in finding solutions.
Autonomy	Students are able to assess their own strengths and weaknesses and organize their time and learning management based on this.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory

Course L3182: Construction law BGB and VOB - law in (excavation) practice

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Günther Schalk
Language	DE
Cycle	WiSe
Content	
Literature	Literatur: - Folienskript (in der Vorlesung erhältlich) - Fuchs/Maurer/Schalk: Handbuch Tiefbaurecht

Course L3181: Construction disputes from construction (excavation) practice	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Ingo Junker
Language	DE
Cycle	WiSe
Content	
Literature	

Module M2003: Biological Waste Treatment

Courses

Title	Typ	Hrs/wk	CP
Waste and Environmental Chemistry (L0328)	Practical Course	2	2
Biological Waste Treatment (L0318)	Project-/problem-based Learning	3	4

Module Responsible	Prof. Kerstin Kuchta
Admission Requirements	None
Recommended Previous Knowledge	chemical and biological basics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The module aims possess knowledge concerning the planning of biological waste treatment plants. Students are able to explain the design and layout of anaerobic and aerobic waste treatment plants in detail, describe different techniques for waste gas treatment plants for biological waste treatment plants and explain different methods for waste analytics.
Skills	The students are able to discuss the compilation of design and layout of plants. They can critically evaluate techniques and quality control measurements. The students can recherché and evaluate literature and date connected to the tasks given in der module and plan additional tests. They are capable of reflecting and evaluating findings in the group.
Personal Competence	
Social Competence	Students can participate in subject-specific and interdisciplinary discussions, develop cooperated solutions and defend their own work results in front of others and promote the scientific development in front of colleagues. Furthermore, they can give and accept professional constructive criticism.
Autonomy	Students can independently tap knowledge from literature, business or test reports and transform it to the course projects. They are capable, in consultation with supervisors as well as in the interim presentation, to assess their learning level and define further steps on this basis. Furthermore, they can define targets for new application-or research-oriented duties in accordance with the potential social, economic and cultural impact.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** Yes / None / Subject theoretical and practical work /
Examination	Presentation
Examination duration and scale	Elaboration and Presentation (15-25 minutes in groups)
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Environmental Engineering: Core Qualification: Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory

Course L0328: Waste and Environmental Chemistry	
Typ	Practical Course
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	WiSe
Content	The participants are divided into groups. Each group prepares a transcript on the experiment performed, which is then used as basis for discussing the results and to evaluate the performance of the group and the individual student. In some experiments the test procedure and the results are presented in seminar form, accompanied by discussion and results evaluation. Experiments ar e.g. Screening and particle size determination Fos/Tac AAS Chalorific value
Literature	Scripte

Course L0318: Biological Waste Treatment	
Typ	Project-/problem-based Learning
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	WiSe
Content	1. Introduction 2. biological basics 3. determination process specific material characterization 4. aerobic degradation (Composting, stabilization) 5. anaerobic degradation (Biogas production, fermentation) 6. Technical layout and process design 7. Flue gas treatment 8. Plant design practical phase
Literature	

Module M2006: Waste Treatment and Recycling

Courses

Title	Typ	Hrs/wk	CP
Planning of waste treatment plants (L3267)	Project-/problem-based Learning	3	3
Recycling technologies and thermal waste treatment (L3265)	Lecture	2	2
Recycling technologies and thermal waste treatment (L3266)	Recitation Section (small)	1	1

Module Responsible	Prof. Kerstin Kuchta
Admission Requirements	None
Recommended Previous Knowledge	• Basics of thermo dynamics • Basics of fluid dynamics • fluid dynamics chemistry
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can name, describe current issue and problems in the field of waste treatment (mechanical, chemical and thermal) and contemplate them in the context of their field. The industrial application of unit operations as part of process engineering is explained by actual examples of waste technologies . Compostion, particle sizes, transportation and dosing of wastes are described as important unit operations . Students will be able to design and design waste treatment technology equipment.
Skills	The students are able to select suitable processes for the treatment of wastes or raw material with respect to their characteristics and the process aims. They can evaluate the efforts and costs for processes and select economically feasible treatment concepts.
Personal Competence	
Social Competence	Students can • respectfully work together as a team and discuss technical tasks • participate in subject-specific and interdisciplinary discussions, • develop cooperated solutions • promote the scientific development and accept professional constructive criticism.
Autonomy	Students can independently tap knowledge of the subject area and transform it to new questions. They are capable, in consultation with supervisors, to assess their learning level and define further steps on this basis. Furthermore, they can define targets for new application-or research-oriented duties in accordance with the potential social, economic and cultural impact.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L3267: Planning of waste treatment plants	
Typ	Project-/problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Rüdiger Siechau
Language	EN
Cycle	WiSe
Content	The focus is on getting to know the organization and practice of waste management companies. Topics such as planning, financing and logistics will be discussed and there will be an excursion (waste incineration plant, vehicle fleet and collection systems / containers). Project based learning: You will be given a task to work on independently in groups of 4 to 6 students. All tools and data needed for the project work will be discussed in the lecture "Recycling Technologies and Thermal Waste Treatment". Course documents can be downloaded from StudIP. Communication during the project work also takes place via StudIP.
Literature	• Einführung in die Abfallwirtschaft; Martin Kranert, Klaus Cord-Landwehr (Hrsg.); Vieweg + Teubner Verlag; 2010 • PowerPoint Präsentationen in Stud IP

Course L3265: Recycling technologies and thermal waste treatment	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	WiSe
Content	• Introduction, actual state-of-the-art of waste incineration, aims. legal background, reaction principals • basics of incineration processes: waste composition, calorific value, calculation of air demand and flue gas composition • Incineration techniques: grate firing, ash transfer, boiler • Flue gas cleaning: Volume, composition, legal frame work and emission limits, dry treatment, scrubber, de-nox techniques, dioxin elimination, Mercury elimination • Ash treatment: Mass, quality, treatment concepts, recycling, disposal
Literature	Thomé-Kozmiensky, K. J. (Hrsg.): Thermische Abfallbehandlung Bande 1-7. EF-Verlag für Energie- und Umwelttechnik, Berlin, 196 - 2013.

Course L3266: Recycling technologies and thermal waste treatment	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M2033: Subsurface Processes

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Modeling of Subsurface Processes (L2731)	Recitation Section (small)	3	3
Subsurface Solute Transport (L2728)	Lecture	2	2
Subsurface Solute Transport (L2729)	Recitation Section (large)	1	1

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	Basic Mathematics, Hydrology
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Upon completion of this module, the students will understand the mechanisms controlling solute transport in soil and natural porous media and will be able to work with the equations that govern the fate and transport of solutes in porous media. Analytical, numerical and experimental tools and techniques will be used in this module.
Skills	In addition to the physical insights, the students will be exposed to analytical, experimental and numerical tools and techniques in this module. This provides them with an excellent opportunity to improve their skills on multiple fronts which will be useful in their future career.
Personal Competence	
Social Competence	Teamwork & problem solving
Autonomy	The students will be involved in writing individual reports and presentation. This will contribute to the students' ability and willingness to work independently and responsibly.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	Report
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Environmental Engineering: Core Qualification: Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory

Course L2731: Modeling of Subsurface Processes

Typ	Recitation Section (small)
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Dr. Milad Aminzadeh
Language	EN
Cycle	WiSe
Content	Basic usage and background of chosen computer software to calculate flow and transport in the saturated and unsaturated zone and to analyze field data like pumping test data
Literature	

Course L2728: Subsurface Solute Transport	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	WiSe
Content	Basic physical properties of soil: Definition and quantification; Liquid flow in soils (Darcy’s law); Solute transport in soils; Practical analysis to measure dispersion coefficient in soil under different boundary conditions; Advanced topics (e.g. Application of Artificial Intelligence to predict soil salinization)
Literature	- Environmental Soil Physics, by Daniel Hillel - Soil Physics, Sixth Edition, by William A. Jury and Robert Horton

Course L2729: Subsurface Solute Transport	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Hannes Nevermann
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Thesis

Module M1801: Master thesis (dual study program)

Courses			
Title	Typ	Hrs/wk	CP

Module Responsible	Professoren der TUHH
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Dual students ... • ... use the specialised knowledge (facts, theories and methods) from their field of study and the acquired professional knowledge confidently to deal with technical and practical professional issues. • ... can explain the relevant approaches and terminologies in depth in one or more of their subject's specialist areas, describe current developments and take a critical stance. • ... formulate their own research assignment to tackle a professional problem and contextualise it within their subject area. They ascertain the current state of research and critically assess it.
Skills	Dual students ... • ... can select suitable methods for the respective subject-related professional problem, apply them and develop them further as required. • ... assess knowledge and methods acquired during their studies (including practical phases) and apply their expertise to complex and/or incompletely defined problems in a solution- and application-oriented manner. • ... acquire new academic knowledge in their subject area and critically evaluate it.
Personal Competence	
Social Competence	Dual students ... • ... can present a professional problem in the form of an academic question in a structured, comprehensible and factually correct manner, both in writing and orally, for a specialist audience and for professional stakeholders. • ... answer questions as part of a professional discussion in an expert, appropriate manner. They represent their own points of view and assessments convincingly.
Autonomy	Dual students ... • ... can structure their own project into work packages, work through them at an academic level and reflect on them with regard to feasible courses of action for professional practice. • ... work in-depth in a partially unknown area within the discipline and acquire the information required to do so. • ... apply the techniques of academic work comprehensively in their own research work when dealing with an operational problem and question.
Workload in Hours	Independent Study Time 900, Study Time in Lecture 0
Credit points	30
Course achievement	None
Examination	Thesis
Examination duration and scale	According to General Regulations
Assignment for the Following Curricula	Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Data Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Aircraft Systems Engineering: Thesis: Compulsory Computer Science in Engineering: Thesis: Compulsory Information and Communication Systems: Thesis: Compulsory International Management and Engineering: Thesis: Compulsory Logistics, Infrastructure and Mobility: Thesis: Compulsory Aeronautics: Thesis: Compulsory Materials Science and Engineering: Thesis: Compulsory Materials Science: Thesis: Compulsory Mechanical Engineering and Management: Thesis: Compulsory Mechatronics: Thesis: Compulsory Biomedical Engineering: Thesis: Compulsory Microelectronics and Microsystems: Thesis: Compulsory

	Product Development, Materials and Production: Thesis: Compulsory Renewable Energies: Thesis: Compulsory Naval Architecture and Ocean Engineering: Thesis: Compulsory Theoretical Mechanical Engineering: Thesis: Compulsory Process Engineering: Thesis: Compulsory Water and Environmental Engineering: Thesis: Compulsory