Description of the degree program

Civil Engineering (Master)
PO 8

Date: 09.02.2026

Table of contents

Specialisation Waste Management

Title	Waste and Resource Management		
Number	4398320	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät Architektur, Bauingenieurwesen und Umweltwissenschaften
Module duration	1	**Institution**	Abteilung Abfall- und Ressourcenwirtschaft
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Julia Gebert
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 Min.) or oral exam (approx. 30 Min.) (in the Master's programme in Social Sciences as a course achievement)		
Course achievement			

Contents

Waste management concepts; acquisition logistics; plant and process technology (with focus on biological processes; methods for process control and monitoring; emission control; product development; secondary raw materials; methods for quality control of secondary raw materials; design principles, plant planning and design, and waste analytics.

Objective qualification

Students acquire in-depth knowledge of tasks and solution methods of municipal and industrial waste and resource management as well as material flow-related recycling management. The special focus is on biological treatment and recycling processes for municipal waste. Here, required work steps and methods for the implementation of management measures and plant technologies are learned.
Evaluation methods for describing and assessing economic, ecological and social impacts are taught and applied. Special knowledge in the field of the use of regenerative energies from municipal waste is acquired. In this lecture, students will be able to use their acquired knowledge to evaluate waste management concepts and to perform rough measurements of selected process steps/aggregates

Literature

Detailed script, Powerpoint slides,

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	german

Title	Landfill Technology and Remediation of Contaminated Sites		
Number	4398330	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Abteilung Abfall- und Ressourcenwirtschaft
Hours per Week / ECTS	4 / 6,0	**Module owner**	Dr. Kai Münnich
Workload (h)			
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (120 Min.) or oral exam (approx. 30 Min.)		
Course achievement			

Contents

[Landfill Mining, Landfill Construction and Geotechnique of Wastes (VÜ)}
Fundamentals of waste mechanics und the hydarulic behaviour of wastes; interaction between the different parameters; constructive elements of landfills; emissions from landfills and their monitoring; longterm behaviour of landfills; position and after-use of landfills; Landfills in emerging and developing countries; legal basis.

[Investigation and Remediation of Contaminated Sites (VÜ)]
Contaminants in soil and groundwater; procedures for exploration; control of soil air; sampling of soil, soil air and groundwater; evaluation and assessment of analytical results; techniques for in-site and on-/off-sites remediation; procedures for groundwater treatment; biological, thermal and physical treatment of soils; after-use of contaminated sites; landfill mining.

Objective qualification

Students acquire in-depth knowledge of the construction and operation of landfills for municipal solid waste (MSW). The aspects of the position of the landfill in the waste management, the legal framework, the site search, the technical installations up to the aftercare, the monitoring and the landfill mining are considered. Furthermore, they gain detailed knowledge about the mechanical properties of waste as well as the long-term behavior in terms of water and gas emissions. Overall, there is a focus on the situation in emerging and developing countries. This will enable students to understand and evaluate the major dynamic processes of a landfill and to size the required structural components.

Students gain in-depth knowledge of the identification and remediation of contaminated sites. The basic aspects concerning possible pollutants, sources of input and exploration of the soil and groundwater are considered. The possible techniques for remediation of contaminated sites (biological, chemical and physical) are learned. The special case of remediation of old MSW dumps is elaborated in detail. This will enable students to assess a suspected contaminated site and select an appropriate remediation technique for the specific case.

Literature

Powerpoint slides
Remark

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture/Exercise	german
	2,0	Lecture/Exercise	german

Title	International Wastewater and Waste Management		
Number	4398310	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Siedlungswasserwirtschaft
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Thomas Dockhorn
Workload (h)	180		
Class attendance (h)	50	**Self studying (h)**	130
Compulsory requirements			
Recommended requirements	Prior successful completion of the module ‘Wastewater and Sludge Treatment’ or the module ‘Waste and Ressource Management’ is strongly recommended.		
Expected performance/ Type of examination	Portfolio and presentation		
Course achievement	Students will prepare a 30-minute presentation in teams. The information given in the lectures and in the student presentations are the basis for developing disposal concepts in team work at the end of the class. The portfolio covers a structured presentation of the team results for the developed disposal concepts. Portfolios are created by the teams under supervision of the institute’s assistants. It is possible to drop the class up to two weeks before the final group project. Organization of groups and assignment of research topics takes place in the first class meeting. This class has a compulsory attendance of 50 hours (first class meeting, student presentations, final group project). If students are absent with valid excuse (e.g. illness, child care etc.) individual solutions can be found for being able to complete the class successfully and still reach educational objectives of the class. Periods of absence may not exceed 15% of compulsory attendance, in order to reach educational objectives of the class.		

Contents

[International Wastewater and Waste Management (V)]
The class introduces the topic of waste and wastewater treatment in an international context by presenting various problems and solutions from developing and emerging countries. These lectures are the introduction, basis and preparation for the team work of the following seminar ‘Waste, Wastewater and Resource Management for Developing and Emerging Countries’.

[Waste, Wastewater and Resource Management for Developing and Emerging Countries (S)]
Participants will work independently in student teams and will develop a concept for the disposal of municipal waste and wastewater. Two locations in different parts of the world will be chosen each semester and students will establish a disposal concept for these locations taking into consideration specific legal, geographical, political and social conditions.
As preparatory work, teams of two students each will prepare a 30-minute presentation dealing with basic questions such as processes of wastewater and waste treatment, costs and planning of treatment plants, economy, infrastructure, culture and religion in the area and present their results to the class.

With this information, two teams (one for each location) will then develop a complete disposal concept as a group project during the 2-day block seminar at the end of the course. Finally, the developed concepts will be introduced to the class in a 30-minute presentation and will be discussed with the participants. A written report is required to complete the class.

Objective qualification

Students are able to understand and solve problems in the field of international wastewater and waste management. They will acquire fundamental knowledge for solving problems concerning waste and wastewater in developing and emerging countries taking into special consideration country-specific aspects. They will have the ability to adapt suitable concepts and technologies to given locations with special reference to globalization. Understanding material flow management and resource protection in a global context are a further teaching objective. Students are able to scientifically discuss engineering problems in a team and to acquire additional required knowledge independently. They are able to analyse and evaluate existing problems under consideration of country-specific aspects and are able to find and realize strategies for solving these problems under given local conditions (regional governance). They are able to skillfully present their solutions to the public. A special focus in this seminar is on practicing teamwork, acquiring debate techniques and rhetorical skills and learning how to discuss controversial questions in a scientific setting.

Literature

Die relevante Fachliteratur kann je nach Aufgabenstellung variieren. Die erforderliche Literatur steht den Studierenden in
der Institutsbibliothek zur Verfügung.

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Related courses

Rules for the choice of courses

Prior successful completion of the module ‘Wastewater and Sludge Treatment’ or the module ‘Waste and Ressource Management’ is strongly recommended.
This module is only availabe to students specializing in Sanitary and Environmental Engineering or Waste Management. Number of participants is limited to max. 40 participants.

Compulsory attendance

This class has a compulsory attendance of 50 hours (first class meeting, student presentations, final group project). If students are absent with valid excuse (e.g. illness, child care etc.) individual solutions can be found for being able to complete the class successfully and still reach educational objectives of the class. Periods of absence may not exceed 15% of compulsory attendance, in order to reach educational objectives of the class.

Name of the course	SWS	Eventtype	Language
	1,0	Lecture	german
	3,0	Seminar	german

Title	Mechanical and Thermal Waste Treatment and Air Pollution Control		
Number	4398340	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Abteilung Abfall- und Ressourcenwirtschaft
Hours per Week / ECTS	4 / 6,0	**Module owner**	Dr. Kai Münnich
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (120 Min.) or oral exam (approx. 30 Min.)		
Course achievement			

Contents

[Mechanical and Thermal Treatment of Waste (VÜ)]
The lecture "Mechanical and Thermal Treatment of Waste" imparts knowledge on the thermo-chemical conversion of municipal waste. It focuses on household waste, commercial waste, sewage sludge and hazardous waste. The route from mechanical preparation to conversion and gas purification is described; design principles, planning and design of plants. In addition to technical aspects, legal and licensing aspects are covered.

[Technologies and Concepts for Air Pollution Control and Climate Protection (VÜ)]
Knowledge of legal regulations relevant to exhaust air, of construction and operational requirements, of different technologies for air purification; methods for monitoring and analyses and teaching the ability to design and plan individual components.

Objective qualification

Students gain in-depth knowledge of processes for the mechanical and thermal treatment of waste. The relevant basics of the waste law, in particular with the legal regulations for thermal waste treatment, are taken into account here. Furthermore, detailed knowledge about waste incineration plants, the thermal use of waste in industrial processes as well as in biomass power plants with the respective upstream treatment chains is imparted. The course enables the students to calculate performance data of incineration plants as well as to perform the rough design of plants.

Students acquire basic knowledge of technologies and concepts for emission prevention and reduction as well as air pollution control with a focus on the sectors of waste, wastewater and energy production. Students will be able to develop, plan, implement/execute and operate total solutions. Furthermore, they are able to recognize, analyze and evaluate regional and supra-regional ecological contexts in order to take these findings into account in planning tasks.

Literature

Powerpoint slides

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture/Exercise	german
	2,0	Lecture/Exercise	german

Title	Fundamentals Waste Management Officer		
Number	3321000000	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät Architektur, Bauingenieurwesen und Umweltwissenschaften
Module duration		**Institution**	Abteilung Abfall- und Ressourcenwirtschaft
Hours per Week / ECTS	3 / 4,0	**Module owner**	Prof. Dr. Julia Gebert
Workload (h)	128		
Class attendance (h)	33	**Self studying (h)**	95
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Contents			
Objective qualification			
Literature			
Folien u.a. durch die Lehrenden bereitgestelltes Material; Nagel, J. (2022): Der Abfallbeauftragte. Erich Schmidt Verlag GmbH & Co. KG Berlin. https://doi.org/10.37307/b.978-3-503-20079-5			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	3,0	Lecture/Exercise	german

Specialisation Construction Production Systems and Construction Management

Title	Systemic Principles of Construction Project Delivery		
Number	4321020	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Bauwirtschaft und Baubetrieb
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Patrick Schwerdtner
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written Exam (120 min) or oral exam (20 min)		
Course achievement			

Contents

Developments and Mechanisms in the Construction:
Industry First, the characteristics of the construction market and construction production are explained and justified on the basis of the specific structures of the construction market. Responsibilities and interfaces are discussed in more detail on the basis of different roles, focusing on the respective contribution of different actors to the planning and implementation of construction production. In this context, the role of the public sector in the implementation of construction projects as a commissioning and licensing authority is also examined in more detail. The specific current and future challenges of the construction industry will be addressed in particular through selected aspects of the three dimensions of sustainability and the philosophy of lean management. Based on this, the basic requirements for the planning and execution process will be derived from contractual and regulatory constraints as a starting point for further courses and modules.

Project Delivery Systems:
At the start of a project, in the initiation phase, essential constraints and requirements are defined. Building on this, the German construction market offers various guiding principles for project management. These are presented with their specific characteristics - supplemented by insights into international models - and examined from different perspectives. From the unit-price contract with sole proprietors to the general contractor and partnering model to integrated project management, responsibilities, rights and obligations are defined and the appropriate projects or project types are assessed. The focus is on assessing opportunities and risks through early integration of execution expertise into the planning process and the importance of collaboration between project stakeholders. Particular attention is paid to the remuneration model, risk allocation and dispute resolution procedures.

Objective qualification

Students will have an in-depth knowledge of the structures of the construction industry and the organisation of planning and execution processes. They will be familiar with the basic requirements for the implementation of construction projects based on the demands of particular interests and social or regulatory expectations for the sustainability of construction production. Particular attention will be paid to explaining the interaction of the various participants against the background of their respective responsibilities for the preparation and implementation of the construction production process, so that students are enabled to think in their respective roles and to recognise the emerging interfaces. In this context, students will be able to iden-

tify suitable models of project management in construction from different perspectives and evaluate their impact on responsibilities and opportunities for efficient and goal-oriented implementation of the planning and execution phases. Due to the range of models presented, students will be familiar with both conventional models and alternative models of project management based on increased levels of collaboration.
Literature

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	2,0	Lecture	german

Title	Construction Methods and Strategies		
Number	4321000	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Bauwirtschaft und Baubetrieb
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Patrick Schwerdtner
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (120 min) or oral exam (20 min)		
Course achievement			

Contents

Methodical Approach for Construction Method Selection:
After introductory remarks on the importance of construction process decisions and relevant production factors, as well as ideas on the basics of risk management, various construction process engineering concepts of in-situ production are presented. In addition to equipment-intensive processes (including special civil engineering and demolition measures, including possibilities for reuse), labour-intensive processes in the shell and extension phases of construction and civil engineering are also covered. Building on this, options for pre-production (on-site/off-site) and automation will be presented, with particular emphasis on additive manufacturing (3D printing). Process comparisons will be carried out in different scenarios and their impact on production factors, resilience of the processes to framework conditions and other criteria (including occupational safety) will be discussed.

Construction Safety and Health:
Students will learn how statutory accident insurance works and basic aspects of health and safety at work. After an introduction to the organisation of health and safety at work, different regulations for different construction activities (excavation, earthworks, building construction) are presented. The handling of hazardous substances and the design of workplaces and traffic routes are also discussed. An introduction to risk assessment and the use of personal protective equipment is provided for practical application. On successful completion of the course, you will have the opportunity to take part in a multi-day course to become a health and safety coordinator (not part of a university course; limited number of participants).

Objective qualification

Students will gain in-depth knowledge of specific issues in construction process engineering. They know the underlying processes and principles as well as the resources required for their implementation. Of particular importance are methodological comparisons of construction method variants, taking into account relevant health and safety regulations and relevant technical risks. Students will be able to make engineering considerations and decisions in the planning of construction production, and then implement and control the processes operationally. Students will also be able to make links with other sustainability objectives (including the environmental impact of processes and the requirements of the circular economy) in order to make decisions on the basis of holistic considerations and to optimise processes in terms of the best possible resource efficiency (including the reuse/recycling of building materials). This also includes the possibility of shifting construction processes to stationary (pre)production. Through intensive instruction in the fundamen-

tals of occupational safety, students will acquire a sound knowledge of accident prevention and will be able to deal responsibly with related issues of liability and the organisation of construction processes.
Literature

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	2,0	Lecture	german

Title	Integrated Production Planning in Construction		
Number	4321070	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Bauwirtschaft und Baubetrieb
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Patrick Schwerdtner
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (120 min) or oral exam (20 min)		
Course achievement			

Contents

Lean Construction Management:
After learning the basics of construction production planning, with a focus on scheduling and resource planning, students are introduced to the methods of lean (construction) management. The difficulties and trade-offs involved in planning and optimising construction production are illustrated, always taking into account the (sub)project objectives. Of particular importance are the project-specific influencing factors, which significantly determine the planned course of construction production and must be taken into account during planning. In this context, the special importance of dealing with interfaces is also made clear. Exercises and team-oriented workshops will be used to explain cycle planning and the last planner method using practical construction scenarios. The face-to-face meetings will take place on the Digital Construction Site to create a real connection and to discuss the possibilities and limitations of digital solutions.

Construction Logistics:
Based on the model of a 'mobile factory', construction logistics tasks in the context of supply, production and waste disposal in the different phases and stages of a construction project are first explained - including their significance from a sustainability perspective (including increasing resource efficiency), Based on this, various construction logistics models are presented (including the department store concept) Digital solutions based on the BIM methodology are also presented The application of various principles of lean construction management leads to an examination of relevant parameters for the planning and control of construction logistics This also includes the determination and visualisation of resource requirements based on an overlay of the quantity take-off and a schedule On this basis, the necessary construction site equipment is analysed in detail, including the dimensioning of the key elements The in-depth exercises are based on real scenarios from construction practice.

Objective qualification

Based on the philosophy and principles of Lean Construction, students will be able to carry out construction production planning taking into account construction logistics requirements. Students will have mastered the basics of scheduling and cycle planning and will be able to determine the resources required. To this end, students will be able to identify different requirements of construction processes and create a project breakdown structure as a basis for scheduling. In addition to the technological interdependencies to be considered, students will gain in-depth knowledge of the accompanying consideration of logistical constraints. By learning the conceptual principles of supply, production and disposal logistics, students will be able to plan and optimise construction production holistically and identify potential bottlenecks in the relevant production factors at an early stage. Furthermore, students will be able to assess the specific importance of sup-

ply chains in the supply of building materials and products to construction production and in reuse and recycling in the context of disposal. To this end, students will be familiar with relevant regulatory requirements and current solutions in the DIY market.
Literature

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Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	SWS	Eventtype	Language
	2,0	Lecture/Exercise	german
	2,0	Lecture/Exercise	german

Title	Economic Assessment and Procurement of Construction Services		
Number	4321090	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Bauwirtschaft und Baubetrieb
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Patrick Schwerdtner
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination	Written exam (120 min) or oral exam (20 min) or Written exam (60 min) or oral exam (15 min) and Course Achievement (successfull participation simulation game)		
Course achievement			

Contents

Public Tender and Contract Award:
Starting with the service description as the link between architecture/planning/construction on the one hand and construction on the other, the importance of clear and complete tender documents is explained. After a brief overview of the procurement of design services, different procurement procedures (national and European) and the rules of legal protection for public procurement are explained from the perspective of the client and contractor for construction services, and a possible transferability to privately financed projects is discussed. Sustainability requirements for design and construction processes are also addressed. Considerations are also given on how to draft a contract that fully describes the performance objective and all the rights and obligations of the contracting parties.

BIM-based Acquisition of Construction Projects (Role-Playing Game): The interactive and hands-on course presents and practises the essential steps of a tendering process. Students are divided into several teams and compete as (virtual) construction companies for a construction contract. The preparation of a tender based on a given specification is supported by the Building Information Modelling (BIM) methodology, after the basics of the methodology and the necessary software have been presented in self-developed tutorials. The construction companies and their indicative bids are presented by the respective teams to the potential clients (IBBs) in face-to-face meetings. In a second face-to-face meeting, additional information has to be integrated and the binding offers have to be negotiated in terms of financial and legal conditions before the contract is awarded to the best construction company.

Objective qualification

Students will acquire in-depth knowledge of the design of tender processes and specifications by the client, and of cost estimation and pricing by the contractor. Students will be familiar with the objectives and methods of costing as a planning task, as well as cost and performance accounting under the responsibility of executing companies. Different forms of planner and contractor deployment and remuneration models are considered. This will enable students to differentiate between the planner's or project manager's perspective (cost planning) and the contractor's perspective (cost accounting) and to understand the specific characteristics of each project phase. Students will also be able to take into account the constraints and specifications for the implementation of public sector projects and the specific implications for the tendering and awarding process and the drafting of contracts. In this context, students will also learn about the opportunities and consequences of integrating specific environmental and social requirements, including the import-

ance of supply chains. Alternatively, students can either take the perspective of a construction company in a planning and role-playing exercise, and then use BIM methodology to actively accompany a procurement process in construction projects with regard to calculating the bid price and negotiating the legal framework.
Literature

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture/Exercise	german
	2,0	Lecture/Exercise	german
	2,0	Lecture	german

Title	Organisation and Management of Construction and Business Processes		
Number	4321080	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Bauwirtschaft und Baubetrieb
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Patrick Schwerdtner
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination	Written exam (60 min) or Exam (30 min)		
Course achievement			

Contents

Construction Business Management:
The course presents and practises the three levels of business management and explores them in depth in a variety of scenarios with current references. While normative management explains the development of a vision and mission as well as the development of a corporate culture and corresponding goals, strategic management deals with fundamental questions and methods of strategy development as well as strategic tools. Operational management focuses on organisation and process management. Finally, problem-solving methods are presented.

Construction Site Management:
The course focuses on the typical responsibilities and tasks of construction management from the perspective of a contractor. The topics covered are based on the phases of construction management activities. Firstly, there are the preparatory considerations with clarification of the performance target and the agreed remuneration, as well as the project team and other parties involved. This is followed by the start-up phase, which involves scheduling and the procurement of goods and services. During implementation, processes need to be monitored and controlled for quality, time and cost. In this context, lean construction management methods are also presented. In the event of changes, the handling of additional offers and agreements is shown - accompanied by explanations on communication and documentation.

Private Construction and Architectural Law:
Contractual agreements form the basis for the provision of services in the course of the implementation of construction projects. After an explanation of the main features of public construction law and private construction contracts, special features of general terms and conditions are presented. This is followed by a discussion of the contractor's right to remuneration, distinguishing between contracts governed by the German Civil Code (BGB) and contracts governed by the German Construction Contract Procedures (VOB/B). This distinction also applies to the treatment of warranty rights, with acceptance being of particular importance and therefore treated separately. As further aspects of contract design and implementation, security and penalty clauses are also dealt with separately.

Objective qualification

Upon completion of the module, students will be able to take on company or site-specific management tasks in technical, organisational and economic terms for simple and medium-sized projects. On the one hand, students will learn to differentiate between the different perspectives and responsibilities of the client and contractor in the management of construction projects. On the other hand, students are familiarised with

the different levels of construction management and learn how to use strategic tools and problem-solving methods. The structure of the courses takes into account the content previously developed in other modules, so that students have a particular systemic understanding. Alternatively, students will acquire legal skills for drafting and implementing contracts based on the provisions of the German Civil Code (BGB) and the German Construction Contract Procedures (VOB) for assessing the resulting rights and obligations or claims.
Literature

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	2,0	Lecture	german
	2,0	Lecture	german

Specialisation Building Material

Title	Concrete Technology and Materials Engineering		
Number	4334090	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Fachgebiet Baustoffe
Hours per Week / ECTS	6 / 6,0	**Module owner**	Dr. Thorsten Leusmann
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination	Oral exam (approx. 30 Min.)		
Course achievement			

Contents

[Concrete Technology (V)]
The Concrete Technology course deals with modern concrete technology which includes normal concrete, lightweight concrete, high-strength concrete, self-compacting concrete, and architectural concrete. Furthermore, the topics of rheology, hardening, heat release and structure formation, production of dense and massive concrete structures, recycling, and additive manufacturing in construction are covered.

[Materials behavior (V)]
The Material Behaviour course is dedicated to the chemico-physical behaviour of building materials. The focus of the course is on describing the structure and porosity of hardened cement pastes as well as the strength and load-dependent deformations of concretes. In addition, processes such as shrinkage, creep and relaxation of concretes are presented in detail. This is followed by an explanation of the load-bearing behaviour of concrete, reinforcing steel and concrete, and fibre reinforced polymer bonding. Then the production and chemico-physical behaviour of the reinforcement materials, reinforcing steel and fibre reinforced polymers, are presented.

Objective qualification

After attending the module, students will be able to identify and define requirements on concrete as a material for special constructions and applications, select suitable high-performance concretes, design them according to the requirements, and, if necessary, develop them. Students will gain competence in assessing modern concrete technology with regard to its application. With the in-depth knowledge gained of the physical, chemical and mechanical behaviour of building materials, students will be able to make application-oriented decisions for structures and implement them in proper planning and realisation, thus counteracting potential defects and damage. They will be able to describe the structure-related characteristics of building materials in depth and link properties such as rheological properties, hardening, and fracture formation, as well as load-dependent and load-independent deformations, with the elementary structure of the materials based on scientific fundamentals. Through the link with current issues from research and development, students will also be able to discuss scientific issues and research results critically.

Literature

ausführliches Vorlesungsmanuskript, aktuelle Themen werden in ergänzenden Unterlagen aufbereitet

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Seminar	german
	2,0	Lecture	german
	2,0	Lecture	german

Title	Structural Repair		
Number	4398210	**Module version**	V1
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Fachgebiet Baustoffe
Hours per Week / ECTS	6 / 6,0	**Module owner**	Dr. Thorsten Leusmann
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 Min.)		
Course achievement			

Contents

In the course Building Damages, knowledge is given on the durability of structures made of mineral building materials, on origins and mechanisms of damage, on models for the description of damage and on strategies for the prevention of structural damage. Based on this, concepts for repair and strengthening of reinforced and prestressed concrete structures as well as masonry, plasters and screeds are discussed in the context of current standardization.
Furthermore, tasks, objectives and methods of structural investigation and material testing will be addressed. In addition, the topics of planning, organization and evaluation of measurement and testing tasks, safety, reliability, standardization and approval, application of methods and instruments for experimental investigation and monitoring of reinforced concrete structures are discussed. Case studies are presented and analysed in the course, which train interdisciplinary problem-solving skills. Moreover, a practical course on the use of investigative methods is offered.
The topics discussed are based on the fundamentals of the bachelor's subject Building Materials Science.

Objective qualification

After completing the course Building Damages, the students will be able to describe, explain and differentiate the causes as well as the mechanical, chemical and physical mechanisms of damage to structures made of mineral building materials. Based on this, the students will be able to design strategies for the prevention of damage, assess structural damage, design target-oriented repair strategies, develop suitable repair concepts and carry out a success control.
After successful participation in the course Building Investigation, students are able to describe methods for damage analysis of reinforced and pre-stressed concrete structures and to define building inspection strategies depending on the condition of the structures and the building materials used. In addition, they will be able to understand how current non-destructive testing methods for quality control, inspection and long-term monitoring of structural components, facilities and structures work, apply them practically and assess their fields of application and limitations.
Targeted case studies are designed to give students the ability to abstract and to transfer what they have learned to a new problem area and to develop their own investigation concepts.

Literature

Remark
The module can only be included in one specialisation. Please ensure the correct assignment when registering.

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Related courses			
Rules for the choice of courses			
Building Damages and Building Investigation must be documented. Furthermore, either the Building Maintenance Adventure or Sealing of Buildings adventure can be taken. The Building Maintenance Adventure can be taken by a maximum of 20 people.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	1,0	Exercise	german
	3,0	Lecture/Exercise	german
	2,0	Lecture	german
	1,0	Lecture/Exercise	german

Title	Additive Manufacturing in Construction		
Number	4398700	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Fachgebiet Baustoffe
Hours per Week / ECTS	6 / 6,0	**Module owner**	Dr. Thorsten Leusmann
Workload (h)	180		
Class attendance (h)	91	**Self studying (h)**	89
Compulsory requirements			
Expected performance/ Type of examination	Written exam (60 Minuten) and laboratory experiment		
Course achievement			
Module grade composition	The grade is made up of half of the grades for each of the two examinations.		

Contents

In the course Materials and Processes in Additive Manufacturing, basic knowledge of the various additive manufacturing processes in the construction industry is first obtained across all materials. Subsequently, a special focus is set on 3D concrete printing. The main topics are 3D concrete printing processes (Selective Cement Activation, Selective Paste Intrusion, Large Particle 3D Concrete Printing, Concrete Extrusion, Shotcrete 3D Printing, Injection 3D Concrete Printing), material development (concrete technology, composition, use of additives), testing of additively manufactured objects (rheology, mechanics), quality control and application in practice.
In the course Methods of Digital Construction the basic knowledge of programming in Rhino Grasshopper and Python is taught. Based on the lecture, students learn in practical exercises to create printable geometries parametrically, to prepare them for 3D printing and to generate robot paths. Robot simulation is also taught to test the manufacturability of designed objects.
In the collaborative exercise Applied Additive Manufacturing, the acquired knowledge is applied to implement physical objects by means of a selected additive manufacturing process.

Objective qualification

After completing the module, the students will be able to make an application-oriented choice of additive manufacturing methods in the construction industry and to characterize and evaluate the material technology, process technology and robotic aspects.
Students will be able to recognize important material-process interactions and evaluate them on the basis of learned relationships. Basic design methods for material and structural behavior are learned and applied to various applications. In addition, knowledge of the composition of materials for additive manufacturing is available, which can be further developed and subsequently manufactured using the knowledge obtained. The students also know relevant investigation methods for evaluating an additive manufacturing process, can apply them and evaluate the data obtained.
In addition, students will be able to design 3D objects using computer-aided design and prepare the data appropriately for the additive manufacturing process. In addition, students will be able to perform robot path planning and control the robot in a simple process.
By participating in the exercise, students will also be able to apply specific additive manufacturing processes and produce physical objects.

Literature
Remark
The module can only be included in one specialisation. Please ensure the correct assignment when registering. Methods of Digital Construction Fabrication and Applied Additive Manufacturing can be attended by a maximum of 20 participants.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	2,0	Lecture/Exercise	german
	2,0	Exercise	german

Title	Organic Materials in Construction		
Number	4310670	**Module version**	V1
Shorttext		**Language**	english german
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	1	**Institution**	Fachgebiet Organische Baustoffe und Holzwerkstoffe
Hours per Week / ECTS	6 / 6,0	**Module owner**	Dr. Thorsten Leusmann
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination	2 Written exams (each 45min) The module examination comprises 2 x 45 min., as each of the courses offered in the module deals with different aspects of organic materials. The wood-based materials are natural renewable raw materials, while the plastics are synthetically produced organic polymers. The materials differ significantly in their structure and in their mechanical		
Course achievement			

Contents

General: location determination and introduction
Structure of polymers: chemical structure, formation reactions, macromolecules (shape, size and arrangement), bonding forces, classification of plastics
Processing of polymers: pressing, injection molding, extrusion, blow molding, calendering, foaming, forming, machining, welding, bonding, mechanical joining
Properties of polymers: strength and deformation behavior, temperature influence, loading influence, influence of molecular orientations, stress cracking, physical properties, thermal properties, electrical properties, density, weathering behavior and chemical resistance, important standard plastics
Application of polymers: Site aids, construction aids and binders (polymer impregnated concrete [PIC], polymer modified cement-bound concrete [PCC], reaction resin bound concrete [PC], rigid foam lightweight concrete, joint sealants and joint profiles); polymers in building construction (thermal and acoustic insulation, light elements, windows, facades, installation materials, roofing membranes); polymers in civil engineering (sealing membranes, supply and disposal systems, frost protection layers); polymer structures (structures made of fiber-reinforced composites, textile structures); structural repair, damage to polymers in civil engineering.

[Plant-based Natural Fibre Reinforcements in Construction (VÜ)] :
Natural fibres as construction materials. Fibre structure and properties.
Properties of natural fibre reinforced polymer (NFRP) composites. Natural fibre reinforced cementitious (NFRC) materials in construction. NFRP materials in construction.
NFRP tube encased NFRC hybrid structure. NFRP and NFRC for Structure Strengthening. Durability of NFRP and NFRC in construction. Degradation mechanism.
Fibre modifications.

Objective qualification

Students acquire the essential anatomical, morphological, physical and chemical properties of organic building materials (wood-based materials and polymers) and acquire in-depth knowledge of raw materials, properties, manufacture and application of organic building materials and wood-based materials. The materials science aspects of organic materials such as constitutive laws, creep, mechanosorptive creep, etc. are emphasized.
Students will also acquire the essential non-destructive and semi-destructive methods for the in-situ evaluation of wood in structures and acquire in-depth knowledge of principles, procedures, and limitations of various methods. Practical knowledge is reinforced through laboratory exercises and "in-field" (field) exercises.
With reference to polymers, the influence of macromolecular structure on the properties of polymers is considered in detail. Another important aspect is the long-term behavior of polymers under the influence of loads, media and weathering. Furthermore, the students learn methods of plastics analysis.
By achieving the qualification objectives, the students will be able to select wood materials and polymers in civil engineering for the respective application purpose and to carry out evaluations on existing buildings and structures properly during the planning phase, not only in the event of damage.

Literature

-Forest Products Laboratory. Wood handbook - Wood as an engineering material. General Technical Report FPL-GTR- 190. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory: 508 p. 2010. Free download http://www.fpl.fs.fed.us/products/publications/specific_pub.php?posting_id=18102
-Niemz, P., and W. U. Soderegger. 2017. Holzphysik. Physik des Holzes und der Holzwerkstoffe. Hanser-Verlag Leipzig, 580 p. ISBN 978-3-446-44526-0.
Holzmann, G., Wangelin, M., and R. Bruns. 2012. Natürliche und pflanzliche Baustoffe. 2. Auflage. Springer-Vieweg. 394 p. ISBN 978-3-8348-1321-3.
-Folien in PDF-Format, vom Dozenten benannte Veröffentlichungen aus dem Fachbereich
-Menges / Schmachtenberg / Michaeli / Haberstroh: Werkstoffkunde Kunststoffe, ISBN 3-446-21257-4, Carl Hanser Verlag 2002
-Oberbach: Saechtling Kunststoff Taschenbuch, ISBN: 3-446-22670-2, Carl Hanser Verlag 2004
-Frank: Kunststoff-Kompendium, ISBN: 3-8023-1589-8, Vogel Fachbbuchverlag 2000
-Braun: Kunststofftechnik für Einsteiger, ISBN 3-446-22273-1, Carl Hanser Verlag 2003
-Braun: Erkennen von Kunststoffen, Qualitative Kunststoffanalyse mit einfachen Mitteln, Carl Hanser Verlag 2003
-Gächter / Müller: Kunststoff-Additive, ISBN: 3-446-15627-5, Carl Hanser Verlag 1989
-Bargel / Schulze: Werkstoffkunde, Springer Verlag 2004
-Potente: Fügen von Kunststoffen, Grundlagen, Verfahren, Anwendung, ISBN: 3-446-22755-5, Carl Hanser Verlag 2004

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	3,0	Lecture/Exercise	german
	3,0	Lecture/Exercise	english

Title	Procedures for Preservation and Restoration		
Number	4310780	**Module version**	V1
Shorttext		**Language**	english german
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Fachgebiet Organische Baustoffe und Holzwerkstoffe
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Bohumil Kasal
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination	2 Written exams (45min)		
Course achievement			

Contents

[Bautenschutz und Bauwerkssanierung (V+Ü)]
(Building restoration) Damage to concrete and reinforced concrete devices, building inspectorate treatment of repair measures, repair of cracked reinforced and prestressed concrete structures, replacement of structural concrete and surface protection on concrete and reinforced concrete structures, chloride removal of reinforced concrete structures contaminated with de-icing salt and hydrogen chloride, basics on fibrous hazardous substances including asbestos, Asbestos inventory, restructuring urgency, asbestos abatement and protective measures (building protection). Building physics and materials with regard to thermal and moisture protection, basics of the Energy Conservation Act and the Energy Conservation Ordinance, construction, materials, advantages and disadvantages of various wall constructions and roof constructions as well as roof sealing, landfill base sealing.

This course is designed for Bachelor and Master students in architecture and civil engineering and will be held in English. Advanced composite materials made of glass and carbon fibers have been used for infrastructure globally for many years. The course will focus on use and design of structures with fiber reinforced polymer (FRP) composite materials.
Material properties of FRP composites, Manufacturing of composite structures, Mechanics and failure analysis of FRP, Flexural and Shear strengthening of RC structures with externally bonded FRP reinforcement, Concrete column confinement, FRP strengthening of masonry and timber structures, Design of FRP profile and all FRP structures, Monitoring and testing methods of FRP will be taught. Students will learn about relevant physical and mechanical properties of advanced composite materials and acquire in-depth knowledge about raw materials, properties, manufacturing, and design of composite materials as well as their hybrid structures for structural engineering.

Objective qualification

Students learn essential aspects of thermal and moisture protection based on building physics and material technology, as well as fundamentals of roof constructions, roof sealing, and landfill base sealing, each with an emphasis on plastic-based materials and structures. Relevant standards and regulations are consulted in relation to the application.

This will enable you to prevent damage caused by building physics in execution and planning, to carry out an initial analysis of damage that has occurred and damage in this respect, to commission in-depth investigations in a targeted manner and to draw up suitable repair concepts.
The students acquire knowledge of the main physical, chemical and electrochemical damage mechanisms in concrete structures and acquire in-depth knowledge of damage analysis, repair construction materials and their practical application in construction. The focus is on plastic-based repair building materials. Furthermore, the fundamentals of fibrous hazardous materials including asbestos, assessment of urgency for asbestos abatement and its implementation are learned. Practical demonstrations of analytical methods will supplement the lecture. This will enable you to assess existing damage, establish and implement an appropriate repair conception.
Students will acquire the essential non-destructive and semi-destructive methods for in-situ assessment of wood in structures and acquire in-depth knowledge of principles, procedures and limitations of various methods. Practical knowledge is deepened by laboratory and "in-field" (field) exercises.

Advance Composite Materials in Construction (VÜ)
Students acquire knowledge of the properties of fiber-reinforced composite materials and their use in construction. This will enable them to use such materials in a targeted manner in planning, construction and building reinforcement.

Literature

ausführliches Vorlesungsmanuskript, Handouts

Kasal, B., Tannert, T. (Editors). 2011. In-situ assessment of timber. RILEM State of the Art Reports, Vol. 7. Springer
Verlag. ISBN: 978-94-007-0559-3. 150 p.

Forest Products Laboratory. Wood handbook - Wood as an engineering material. General Technical Report FPL-GTR- 190. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory: 508 p. 2010. Free download http://www.fpl.fs.fed.us/products/publications/specific_pub.php?posting_id=18102

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	4,0	Lecture/Exercise	german
	2,0	Lecture/Exercise	english

Specialisation Building Preservation

Title	Basics in Conservation of Building Stocks		
Number	4398220	**Module version**	V1
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Stahlbau
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Klaus Thiele
Workload (h)	180 h		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (60 Min.)		
Course achievement	Presentation		

Contents

Presentation of the increasing importance of building preservation as a responsible task in the construction industry. Building preservation in the context of historical buildings, dealing with cultural high-value buildings. Building analysis methods and knowledge of historical building materials and building structures. Overview of basic damage mechanisms and causes of damage divided into the areas of steel, solid, masonry and timber construction.
Presentation of common test methods as well as measuring instruments for damage assessment or condition assessment (anamnesis and diagnosis). Demonstration of methods for damage prevention, retrofitting and strengthening of structures and constructions (therapy). Aspects of history, material science, building physics and construction are illuminated. Project-oriented exercises.

Objective qualification

Upon completion of the course, students will have knowledge of the fundamentals of preservation of buildings. They know the methodical procedure for assessing the condition of an existing structure. They have the necessary knowledge of the basic causes and consequences of damage. They have an overview of possible strategies for repair and preservation. They have gained insights into the handling of high-value architectural monuments. Students will be able to recognize problems in the preservation and/or further development of the building stock as a resource. They know methods to select suitable measures from a transdisciplinary context and to represent these in a professional discussion.

For didactic reasons, the fundamentals taught will be elaborated in small groups to an exercise example and presented in the plenary session.

Literature

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	german

Title	Structural Design - Theory		
Number	4398260	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Stahlbau
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Klaus Thiele
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Portfolio		
Course achievement			

Contents

Lectures by the project participants as well external scholars are offered as part of the module. In a weekly seminar, students prepare and present papers and student research projects; successful participants in the module “Design and Construction in Existing Contexts - project” can deepen their student research projects or further develop them in terms of design. The two modules Design and Construction in Existing Contexts - Project and Theory can be taken separately and independently of each other.

Objective qualification

Knowledge of theoretical and strategic principles of building preservation: handling of culturally/historically high-ranking building heritage, economically supported strategies for the preservation of larger (historical as well as modern) building stocks, constructive aspects of building preservation.
Students will be able to reason in the context of socio-cultural, ecological, and economic values and to develop and discuss sustainable strategies in groups.

Literature

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Related courses

Rules for the choice of courses

Compulsory attendance

Attendance is compulsory, the scope of possible absences is determined at the beginning of the course.

Name of the course	SWS	Eventtype	Language
	4,0	Lecture/Exercise	german

Title	Structural Design - Project		
Number	4398250	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Stahlbau
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Klaus Thiele
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Portfolio		
Course achievement			

Contents

The topic of building in existing contexts will be studied in theory and practice on a selected building. For this purpose, lectures are offered on two block dates, illuminating the interdisciplinary aspects of building in existing contexts.
In parallel, a selected building is analyzed and documented in interdisciplinary groups in the form of a supervised seminar. This ranges from the urban planning analysis, the evaluation of architectural design, the building construction and load-bearing systems used, to the inventory of building materials and building physics. In the second step, possibilities for repair and retrofitting are discussed and scenarios for a further use of the structure are developed. On the basis of the results elaborated here, a Studienarbeit can subsequently take place. The project Design and Construction in Existing Contexts - Theory in the winter semester is recommended as a theoretical consolidation. Anyway, the two modules Design and Construction in Existing Contexts - Project and Design and Construction in Existing Contexts - Theory can be taken independently of each other.

Objective qualification

The main approach is the interdisciplinary cooperation of architecture and engineering students of various disciplines on project examples. The focus is less on the individual structure or building, but rather on typical representatives of construction tasks in the project. The goal is a redefinition of the planning task of building in existing contexts, which places an emphasis on the complex analysis of the respective structural-technical and architectural framework conditions in order to enable a clever handling of the existing. Due to the interdisciplinary supervision and staffing, the subject is viewed from its holistic approach.
Students are enabled to plan and carry out necessary investigations on a selected object and to evaluate them in the overall context in order to develop suitable strategies and immediate measures for preservation and/or conversion

Literature

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Attendance is compulsory, the scope of possible absences is determined at the beginning of the course.			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	german

Title	Additive Manufacturing in Construction		
Number	4398700	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Fachgebiet Baustoffe
Hours per Week / ECTS	6 / 6,0	**Module owner**	Dr. Thorsten Leusmann
Workload (h)	180		
Class attendance (h)	91	**Self studying (h)**	89
Compulsory requirements			
Expected performance/ Type of examination	Written exam (60 Minuten) and laboratory experiment		
Course achievement			
Module grade composition	The grade is made up of half of the grades for each of the two examinations.		

Contents

In the course Materials and Processes in Additive Manufacturing, basic knowledge of the various additive manufacturing processes in the construction industry is first obtained across all materials. Subsequently, a special focus is set on 3D concrete printing. The main topics are 3D concrete printing processes (Selective Cement Activation, Selective Paste Intrusion, Large Particle 3D Concrete Printing, Concrete Extrusion, Shotcrete 3D Printing, Injection 3D Concrete Printing), material development (concrete technology, composition, use of additives), testing of additively manufactured objects (rheology, mechanics), quality control and application in practice.
In the course Methods of Digital Construction the basic knowledge of programming in Rhino Grasshopper and Python is taught. Based on the lecture, students learn in practical exercises to create printable geometries parametrically, to prepare them for 3D printing and to generate robot paths. Robot simulation is also taught to test the manufacturability of designed objects.
In the collaborative exercise Applied Additive Manufacturing, the acquired knowledge is applied to implement physical objects by means of a selected additive manufacturing process.

Objective qualification

After completing the module, the students will be able to make an application-oriented choice of additive manufacturing methods in the construction industry and to characterize and evaluate the material technology, process technology and robotic aspects.
Students will be able to recognize important material-process interactions and evaluate them on the basis of learned relationships. Basic design methods for material and structural behavior are learned and applied to various applications. In addition, knowledge of the composition of materials for additive manufacturing is available, which can be further developed and subsequently manufactured using the knowledge obtained. The students also know relevant investigation methods for evaluating an additive manufacturing process, can apply them and evaluate the data obtained.
In addition, students will be able to design 3D objects using computer-aided design and prepare the data appropriately for the additive manufacturing process. In addition, students will be able to perform robot path planning and control the robot in a simple process.
By participating in the exercise, students will also be able to apply specific additive manufacturing processes and produce physical objects.

Literature
Remark
The module can only be included in one specialisation. Please ensure the correct assignment when registering. Methods of Digital Construction Fabrication and Applied Additive Manufacturing can be attended by a maximum of 20 participants.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	2,0	Lecture/Exercise	german
	2,0	Exercise	german

Title	Fire Protection for Existing Buildings		
Number	4310980	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Fachgebiet Brandschutz
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Jochen Zehfuß
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam+ (120min.) or oral exam (approx. 45 min.)		
Course achievement	The homework can be done in advance and can be included with 10% in the final grade of the module. The request for a written homework (exam+) has to be made by the student at the beginning of the exam. More detailed information on submission deadline of the homework will be provided during the lectures.		

Contents

Presentation of the fundamentals of preventive fire protection and fire fighting. Presentation of the historical development of fire safety regulations and the typical deviations of existing buildings from the current state of the art. Possibilities for upgrading structural fire protection measures and associated proof of usability. Concept creation for the fire protection upgrade of a historic building, taking into account the protection of monument aspects. Discussion of upgrade measures using specific project examples (excursion if applicable).
Independent application of the learned methodical approaches and concepts to different examples of special constructions (processing in groups and presentation of the results).

Objective qualification

The students know the typical deviations of existing buildings from the building code requirements of fire safety and the alternative measures for compensation. They are able to plan and evaluate compensation measures, taking into account the existing building and monument protection aspects

Literature

Zehfuß, J.; Wesche, J.; Lyzwa, J.: Brandschutz bestehender Gebäude (Skript); Geburtig, G.: Brandschutz im
Baudenkmal, Beuth-Verlag (2009).

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture/Exercise	german
	2,0	Lecture/Exercise	german

Title	Structural Repair		
Number	4398210	**Module version**	V1
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Fachgebiet Baustoffe
Hours per Week / ECTS	6 / 6,0	**Module owner**	Dr. Thorsten Leusmann
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 Min.)		
Course achievement			

Contents

In the course Building Damages, knowledge is given on the durability of structures made of mineral building materials, on origins and mechanisms of damage, on models for the description of damage and on strategies for the prevention of structural damage. Based on this, concepts for repair and strengthening of reinforced and prestressed concrete structures as well as masonry, plasters and screeds are discussed in the context of current standardization.
Furthermore, tasks, objectives and methods of structural investigation and material testing will be addressed. In addition, the topics of planning, organization and evaluation of measurement and testing tasks, safety, reliability, standardization and approval, application of methods and instruments for experimental investigation and monitoring of reinforced concrete structures are discussed. Case studies are presented and analysed in the course, which train interdisciplinary problem-solving skills. Moreover, a practical course on the use of investigative methods is offered.
The topics discussed are based on the fundamentals of the bachelor's subject Building Materials Science.

Objective qualification

After completing the course Building Damages, the students will be able to describe, explain and differentiate the causes as well as the mechanical, chemical and physical mechanisms of damage to structures made of mineral building materials. Based on this, the students will be able to design strategies for the prevention of damage, assess structural damage, design target-oriented repair strategies, develop suitable repair concepts and carry out a success control.
After successful participation in the course Building Investigation, students are able to describe methods for damage analysis of reinforced and pre-stressed concrete structures and to define building inspection strategies depending on the condition of the structures and the building materials used. In addition, they will be able to understand how current non-destructive testing methods for quality control, inspection and long-term monitoring of structural components, facilities and structures work, apply them practically and assess their fields of application and limitations.
Targeted case studies are designed to give students the ability to abstract and to transfer what they have learned to a new problem area and to develop their own investigation concepts.

Literature

Remark
The module can only be included in one specialisation. Please ensure the correct assignment when registering.

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Related courses			
Rules for the choice of courses			
Building Damages and Building Investigation must be documented. Furthermore, either the Building Maintenance Adventure or Sealing of Buildings adventure can be taken. The Building Maintenance Adventure can be taken by a maximum of 20 people.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	1,0	Exercise	german
	3,0	Lecture/Exercise	german
	2,0	Lecture	german
	1,0	Lecture/Exercise	german

Title	Steel Structures in Building Preservation		
Number	4310250	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Stahlbau
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Klaus Thiele
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination	Written exam (60min) or oral exam (30min) and term paper		
Course achievement			

Contents

[Experimental Structural Diagnostics (V)]
Lecture and demonstration experiments on measurement techniques in civil engineering with emphasis on steel structures.
- Measuring with strain gages: problems, models.
- Transducers: displacement, acceleration, vibration measurements
- Component testing with non-destructive testing methods I
  (dye penetrant testing, magnetic particle testing, potential probe)
- Component testing with non-destructive testing methods II
  (active thermographic methods, radiographic testing),
- material testing: hardness testing methods and tensile tests
- statistical evaluation of test data

[Test-based structural diagnostics (Ü)] Practical laboratory tests with homework/project
[Service-Life and Fatigue 2(VÜ)]
Advanced verification in the field of fatigue of steel structures and introduction to fracture mechanics.

[Historic Steel Structures(V)]
Introduction to the construction and design of historical steel structures made of cast iron and steel. Material fundamentals of cast iron and old steels. Joining techniques: welding of old steels, riveting.

Objective qualification

Students are able to evaluate and assess old, historic steel structures made of cast iron or steel with regard to their
load-bearing capacity and develop suitable repair measures.

Literature

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	3,0	Lecture/Exercise	german
	2,0	Seminar	german

Specialisation Fire Protection Engineering

Title	Fundamentals of Fire Protection		
Number	4310990	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	1	**Institution**	Fachgebiet Brandschutz
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Jochen Zehfuß
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam+ (120min.) or oral exam (approx. 45 min.)		
Course achievement	seminar paper The presentation can be prepared in advance and contribute 10% to the final grade of the module. The student at the start of the exam must make the request for an exam+. Students will receive more information on presentation submission deadlines in the module's courses.		

Contents

Explanation of fire risks, causes of fire and typical fire damage and the corresponding preventive fire protection measures. Presentation of the legal basis and prerequisites for preventive fire protection, general and material requirements in building regulations law. Explanation of the planning principles for structural fire protection and the concept components for fire protection verification. Presentation and practice of the structure and function of fire safety concepts. Explanation of organizational fire safety measures. Discussion of the societal duty of fire protection and the role of fire brigades. Explanation of the prerequisites and requirements for firefighting operations. Presentation of fires system measures, their effectiveness and areas of application (fire alarm systems, smoke and heat extraction systems, equipment for the fire department, extinguishing water retention systems, control matrices). Tutorial and independent practices for the planning and dimensioning of the fire system measures according to the technical rules.

Objective qualification

Students know about the elements of preventive fire protection, fire fighting and fire systems and are able to apply them correctly in the context of fire safety design and planning for a building of normal type and use. Interdependencies and limits to the effectiveness of the measures are identified. Students will recognize the suitability of fire protection measures to compensate for deviations from the requirements of the building code and are able to develop a fire safety concept for a standard building.

Literature

-Zehfuß, J. et al.: Vorbeugender baulicher Brandschutz (Skript);
-Gressmann, H.-J.: Abwehrender und anlagentechnischer Brandschutz, expert verlag

-Zehfuß, J.; Kampmeier, B.: Konstruktiver baulicher Brandschutz im Betonbau. In: Betonkalender, 2018.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture/Exercise	german
	2,0	Lecture/Exercise	german

Title	Fire Safety Engineering Methods for Fire and Egress Simulation		
Number	4398820	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Fachgebiet Brandschutz
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Jochen Zehfuß
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam+ (60 min.) or oral exam (approx. 30 min.)		
Course achievement	The homework can be done in advance and can be included in the final grade of the module. The request for a written homework (Klausur+) has to be made by the student at the beginning of the exam. More detailed information on submission deadline of the homework will be provided during the lectures.		

Contents

Understanding the basics of fire science, natural fire behaviour as well as the relevant parameters and physical and thermodynamic relationships. Illustration of plume models and parametric temperature-time curves. Explanation of the basics of zone and CFD models for the simulation of fire development and the determination of fire consequences. Depiction of extinction and recognition ranges. Introduction to the models for evacuation evaluations. Self employed application and working on a chosen topic independently. Individual treatment of typical fire related problems (fire impact of natural fires, smoke spread, influence on people, evacuation of buildings with large crowds of occupants).
Seminar presentations of special topics from the field of fire modeling by lecturers and by external experts.

Objective qualification

The students are familiar with the basics of fire science as well as the methods and models of fire safety engineering. They learn how to apply engineering methods in the context of fire safety and crowd management and recognise the scope of application. In addition the students know the exertion ability of these methods in the context of performance based design

Literature

-Zehfuß, J.: Ingenieurmethoden für die Brand- und Personenstromsimulation, Vorlesungsskript
-Zehfuß, J.. (Hrsg.): Leitfaden Ingenieurmethoden im Brandschutz, 4. Auflage, 2020 (elektronisch zum download)
-Karlsson, B.; Quintierre, G.: Enclosure fire dynamics
-Zehfuß, J., Riese, O.: Anwendung von Brandsimulationsmodellen für die Berechnung der thermischen -Einwirkungen im
-Brandfall und der Rauchableitung. In: Fouad, N. (Hrsg.):Bauphysik Kalender 2015. Verlag Ernst & Sohn, Berlin.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture/Exercise	german
	1,5	Internship	german
	0,5	Seminar	german

Title	Fire Safety Engineering Methods for Structural Fire Design		
Number	4398810	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Fachgebiet Brandschutz
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Jochen Zehfuß
Workload (h)			
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam+ (60 min.) or oral exam (approx. 30 min.)		
Course achievement	The homework can be done in advance and can be included in the final grade of the module. The request for a written homework (Klausur+) has to be made by the student at the beginning of the exam. More detailed information on submission deadline of the homework will be provided during the lectures.		

Contents

Explanation and comprehensive description of the three-stage verification concept of the Eurocode for structural design in case of fire and its application in the scope of structural fire design of a special building. Introduction of the tabular verification based on national supplementary standard DIN 4102-4. Explanation of the concept of equivalent fire duration and presentation of the verification methods according to DIN 18230 for fire safety design of industrial buildings. Independent processing of typical questions concerning fire resistance and the mechanical behavior of load-bearing structures exposed to fire. Independent application of the software for specific tasks. Independent processing of a selected topic.
Seminar presentations of special topics in the field of structural fire design by lecturers and external experts.

Objective qualification

The students will be familiar with the fundamental procedures in structural fire design. They can correctly apply the Eurocode design methods in the 3 levels (tabular, simplified and advanced design procedures). They can also identify application areas and limitations. Students will understand the appropriate use of engineering methods for alternative performance-based fire safety design.

Literature

-Zehfuß, J.: Ingenieurmethoden für die Brandschutzbemessung von Bauteilen und Tragwerken, Vorlesungsskript
-Zehfuß, J. (Hrsg.): Leitfaden Ingenieurmethoden im Brandschutz, 4. Auflage, 2020 (elektronisch zum download) Hosser,
-D.; Zehfuß, J. (Hrsg.): Brandschutz in Europa Bemessung nach Eurocodes, Beuth Verlag, 2017
-Zehfuß, J.: Grundlagen nach Eurocode 1. In: Bauphysik-Kalender 2021.
-Zehfuß, J.; Kampmeier, B. (2021): Brandschutzbemessung von Betonbauteilen nach Eurocode 2. In: Bauphysik-Kalender 2021.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Mandatory attendance to the lecture series, max. 1 absence is allowed.			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture/Exercise	german
	1,5	Internship	german
	0,5	Lecture/Exercise	german

Title	Special areas of fire safety 1		
Number	4334210	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	2	**Institution**	Fachgebiet Brandschutz
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Jochen Zehfuß
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	3 examinations: written exam (30 min. or 60 min.) or oral exam (15 or 30 min.)		
Course achievement			

Contents

[Fire protection of existing buildings (VÜ)]
Presentation of the fundamentals of preventive fire protection and fire fighting. Presentation of the historical development of fire safety regulations and the typical deviations of existing buildings from the current state of the art. Possibilities for upgrading structural fire protection measures and associated proof of usability. Concept creation for the fire protection upgrade of a historic building, taking into account the protection of monument aspects. Discussion of upgrade measures using specific project examples (excursion if applicable).

[Fire protection for special-purpose buildings (VÜ)]
Presentation of the material requirements for buildings of special type and use. Possibilities of compensatory measures within the framework of fire-safety-objective-oriented fire protection reports. Fire protection evaluation of unregulated special-purpose buildings. Presentation of project examples.

[Risk methods in fire safety (V)]
Presentation of internationally used qualitative and quantitative risk methods for determining fire risk in buildings. Determination of acceptable risks. Presentation of risk methods for the economic optimization of fire safety measures. Safety concept for life safety.

[Preventive disaster control (V)]
Presentation of the basics and organization of preventive civil protection and disaster response. Explanation of organizational and management structures in disaster response. Presentation of the design of structures for extreme load cases.

Objective qualification

Students acquire knowledge and competencies in special and peripheral areas of fire safety and are able to apply them correctly. In doing so, they will recognize interfaces and points of conflict with regard to the fire safety design of buildings and learn solution approaches. They know which compensation measures can be used to achieve the objectives of fire safety in special-purpose buildings and how this can be verified.

Literature

-Vorlesungsskripte und die Handouts der Vorlesungsfolien (in elektronischer Form) werden zur Verfügung gestellt. Zehfuß,

-J.; Kampmeier, B.: Konstruktiver baulicher Brandschutz im Betonbau. In: Betonkalender, 2018.
-Mayr, J.; Battran, L. (Hrsg.): Brandschutzatlas. FeuerTrutz
-Geburtig, G.: Brandschutz im Baudenkmal, Beuth-Verlag (2009).

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Related courses

Rules for the choice of courses

Selection of courses so that at least 6 LP are achieved.
The module can only be selected if the module fire protection in building redevelopments has not been selected. Risk methods in fire safety cannot be selected if taken in the math.-sci. fundamentals module.

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	2,0	Lecture/Exercise	german
Risk Methods in Fire Protection	1,0	Lecture	english
	1,0	Lecture	german
	2,0	Lecture/Exercise	german

Specialisation Data-Driven Modeling

Title	Data-Driven Material Modeling		
Number	4398690	**Module version**	V1
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät Architektur, Bauingenieurwesen und Umweltwissenschaften
Module duration	1	**Institution**	Institut für Angewandte Mechanik
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Henning Wessels
Workload (h)	180 h		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	written exam+ (60 minutes) or oral exam+ (30 minutes)		
Course achievement	for Master's programme Bauingenieurwesen and Umweltingenieurwesen: Term paper		

Contents
Digital twin concept, principles of continuum mechanics, function regression, finite elements, neural networks, optimization algorithms, data-driven material modeling
Objective qualification
Students are able to develop material models with machine learning methods and to implement such models into a simulation environment. They are aware of the importance of thermodynamics for material modeling. Moreover, students will be able to evaluate whether the use of data-driven methods is appropriate for a given model problem.
Literature

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Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	**SWS**	**Eventtype**	**Language**

	4,0	Lecture/Exercise	english

Title	Advanced Data-Driven Modeling		
Number	4398600	**Module version**	V1
Shorttext		**Language**	english
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Angewandte Mechanik
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Henning Wessels
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	written exam+ (90min) or oral exam+ (30min)		
Course achievement	Term paper		

Contents

Keywords: neural networks, Gaussian processes, continuum mechanics, finite elements, inverse problems, parameter identification, multi-scale modeling, model updating, digital twin

Objective qualification

Students learn to apply and to develop hybrid modeling concepts, that make use of physical knowledge and experimental data. The course is structured in three blocks that cover the topics (1) inverse problems and parameter identification, (2) data-driven multi-scale modeling and (3) model updating. At the end of the course, students will be able to apply and develop machine learning algorithms for the aforementioned problem classes.

Literature

Lecture script

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	4,0	Lecture/Exercise	english

Literature

Lecture script

Title	Algorithms & Programming		
Number	3325000000	**Module version**	V1
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät Architektur, Bauingenieurwesen und Umweltwissenschaften
Module duration	1	**Institution**	Institut für Angewandte Mechanik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Henning Wessels
Workload (h)	180		
Class attendance (h)	42	**Self studying (h)**	138
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 min) or oral exam (30 min)		
Course achievement	Graded assignments		
Contents			
Keywords: python, programming, research software engineering, object oriented programming, algorithms			
Objective qualification			
In the course Algorithms and Programming, concepts are taught that enable students to un- derstand existing codes and especially to build new R&D software. In general, software de- velopment expertise is useful in all engineering disciplines and provides invaluable benefits especially in the context of numerics and machine learning, covered for instance by courses on finite elements or finite volumes or data-driven material modeling. Throughout the exercises, the programming language Python is used. However, all concepts taught are applicable in a variety of languages, e.g. Java or C++, to only name a few.			
Literature			
Lecture script			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Algorithms & Programming	3,0	Lecture/Exercise	english

Title	Linear Solid Mechanics		
Number	4228010	**Module version**	V1
Shorttext		**Language**	english
Frequency of offer	every term	**Teaching unit**	Fakultät Architektur, Bauingenieurwesen und Umweltwissenschaften
Module duration	1	**Institution**	Institut für Angewandte Mechanik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Ralf Jänicke
Workload (h)	180 h		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 Min)		
Course achievement			

Contents

Fundamentals of vector and tensor calculus; Linear kinematics; Stress state; Two-dimensional problems; Equilibrium conditions; Linear elasticity; Isotropic and anisotropic behavior; Thermal expansion; Introduction to boundary value problems and their numerical solution.

Objective qualification

The students are familiar with the description of stress and deformation in solids. They know linear material models, including thermal expansion. They use these basics for the solution of elementary problems, predominantly in two dimensions

Literature

Gross, Hauger, Wriggers, Technische Mechanik 4

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	4,0	Lecture/Exercise	english

Title	Methods of Uncertainty Analysis and Quantification		
Number	2540420	**Module version**	
Shorttext	MB-DuS-42	**Language**	
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Sabine Langer
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements	Basic knowledge of the finite element method, numerical procedures for quadrature and polynomial approximation as well as probability theory and statistics are helpful. Attending the course "Unsicherheiten in technischen Systemen" is not a requirement.		
Expected performance/ Type of examination	1 examination element: Written exam (90 min) or oral exam (30 min)		
Course achievement			

Contents

Probability and random variables, advanced Monte Carlo methods, stochastic quadrature, stochastic spectral methods, global sensitivity analysis, data-driven uncertainty quantification

Objective qualification

Students can formulate and name elementary rules of probability theory and different ways to describe probability distributions. They can model technical/physical systems in a stochastic way using random variables. The students are further able to apply Monte Carlo and stochastic spectral methods to quantify uncertainties and also to assess the impact and propagation of uncertainties in models through global sensitivity analysis. Moreover, they are able to evaluate the numerical efficiency of the aforementioned methods. The students are also able to outline the principles of data-driven approaches to uncertainty analysis.

Literature

- O. Le Maitre, O.M. Knio: Spectral Methods for Uncertainty Quantification, Springer Netherlands, 2010
- D. Xiu: Numerical Methods for Stochastic Computations: A Spectral Method Approach, Princeton University Press, 2010
- G. J. Lord, C.E. Powell, T. Shardlow: An introduction to computational stochastic PDEs, Cambridge University Press, 2014

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	english
	1,0	Exercise	english

Title	Mechanical Material Testing Methods		
Number	4310200	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Angewandte Mechanik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Ralf Jänicke
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	experimental work		
Course achievement			
Contents			
Material models (elasticity, visco-elasticity, plasticity, fracture mechanics). Testing machines and test procedures: static and dynamic testing, force and displacement measurement. Test evaluation.			
Objective qualification			
The students are familiar with models describing the mechanical behaviour of materials. They are able to select methods to determine the parameters of such models, conduct the measurement and evaluate the results.			
Literature			
Remark			
Can only be added in one specialization.			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Mechanical Material Testing Methods	1,0	Lecture	english german

Mechanical Material Testing Methods	2,0	Laboratory	english ger-man

Specialisation Geodetic Monitoring and Geoinformation

Title	Photogrammetry		
Number	4310690	**Module version**	V1
Shorttext	BAU-STD3-65	**Language**	english german
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Geodäsie und Photogrammetrie
Hours per Week / ECTS	4 / 6,0	**Module owner**	
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	written exam+ (90 min) or oral exam+ (30 min)		
Course achievement	term paper During the lecture period, several term papers are offered, which are graded. The average grade counts for 50% of the final grade for the module. The application for an exam+ must be submitted by the student at the end of the lecture period. Further information on deadlines for the submission of assignments is provided in the courses of the module.		

Contents

- the geometry of the perspective image
- projection from 3D space into the image
- image orientation and bundle block adjustment
- dense point matching and derived products
- ortho projection
- UAV (drone)-based photogrammetry
- practical examples and (programming) exercises in which typical fields of application are addressed.

Objective qualification

Photogrammetry is the science that derives geometric and semantic information from images. In this course, basic knowledge and methods are taught so that the participating students are able to independently capture, evaluate and analyze data. Commercial products are used in the exercise to demonstrate the processing steps. To reinforce the methodological understanding, individual tasks are also solved as part of small programming tasks. Some tasks are defined mandatory (*Studienleistung*)

Literature

Wird während der Vorlesung bekanntgegeben

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Photogrammetry	4,0	Lecture/Exercise	english german

Title	Remote Sensing		
Number	3324000000	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Geodäsie und Photogrammetrie
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Markus Gerke
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Portfolio		
Course achievement			

Contents

-physical principles
-selected sensors of multispectral remote sensing
-backscatter values and indices
-Classification methods
-Change detection
-Terrestrial microwave interferometry
-Radar remote sensing and SAR interferometry
-Intensity and coherence analysis of radar data
-Multi-temporal evaluation processing of radar interferometry

Objective qualification

Students are taught basic theoretical knowledge, acquisition and analysis methods of multispectral and radar remote sensing. Through the combination of lectures and application-related exercises in the PC pool, students acquire the competence to independently derive selected questions regarding the determination of basic states and changes of the earth's surface on the basis of multispectral satellite data. The evaluation and analysis of radar data extends their skills to the area of geometric monitoring of changes in the earth's surface and infra-structural objects.

Literature

Wird während der Vorlesung bekanntgegeben.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	german

Title	Engineering surveying		
Number	3324000010	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Geodäsie und Photogrammetrie
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Markus Gerke
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	written exam (60 min) or oral exam (30 min) and portfolio		
Course achievement			

Contents

Geodetic Sensors:
- Automated total stations for monitoring tasks
- Basics of laser scanning: methodology, technology, systems
- Use of GNSS for monitoring tasks
- Sensor networks
- Typical fields of application, practical examples and exercises

Evaluation Methods:
- Coordinate calculation
- Variance propagation
- Introduction to the adjustment theory
- Analysis of epochal solutions
- Basics of time series analysis

Objective qualification

Geodetic Sensors:
- Automated total stations for monitoring tasks
- Basics of laser scanning: methodology, technology, systems
- Use of GNSS for monitoring tasks
- Sensor networks
- Typical fields of application, practical examples and exercises

Evaluation Methods:
- Coordinate calculation
- Variance propagation
- Introduction to the adjustment theory
- Analysis of epochal solutions
- Basics of time series analysis

Literature

Literature will be announced and provided during lectures

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Geodetic Sensors	2,0	Lecture/Exercise	german
	2,0	Lecture/Exercise	german

Title	Image Processing and Interpretation		
Number	3324000030	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Geodäsie und Photogrammetrie
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Markus Gerke
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	written exam (90 min) or oral exam (30 min)		
Course achievement	term paper		

Contents

[Image Processing]
- image formation
- pixel operations
- linear and non-linear filters
- image segmentation
- morphology
- Typical fields of application, practical examples and exercises

[Image Interpretation]
-Supervised classification
-Unsupervised classification
-dimensionality reduction
-pixel-based and object-based approaches
- Typical fields of application, practical examples and exercises

Objective qualification

[Image Processing]
In this lecture/excercise, students are introduced to digital image processing, including the application of filters or operators that improve the image or represent a pre-processing step for image interpretation. Basic knowledge and methods are taught in the courses so that the participating students are able to independently record, evaluate and analyze data.

[Image Interpretation]
This course provides basic knowledge of methods for extracting information from images. It deals with supervised and unsupervised classification, as well as techniques for dimension reduction. Furthermore, a distinction is made between approaches that classify individual pixels and those that generate an object-based description. Basic knowledge and methods are taught in the courses so that the participating students are able to collect, evaluate and analyze data independently.

To reinforce the methodological understanding, individual tasks are also solved as part of small programming tasks. Some tasks are defined mandatory (*Studienleistung*)
Literature
Literature will be provided during lectures

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture/Exercise	english
	2,0	Lecture/Exercise	english

Title	Geoinformatics		
Number	3324000020	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Geodäsie und Photogrammetrie
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Markus Gerke
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Portfolio		
Course achievement			

Contents

- Web technologies (HTML, CSS, JavaScript)
- WebGIS frameworks (e.g. Leaflet)
- Geodata formats (GeoJSON)
- Working with map services (WMS / WFS)
- Practical experience with geodatabases
- Publishing, integrating and editing geodata in web-based systems
- Creation of REST APIs
- Development of mobile, map-based web applications

Objective qualification

In this module, theoretical and practical fundamental skills for the creation of web-based applications for the visualization and analysis of geodata are taught. In addition to the general technologies/frameworks that can be used to create a web application (HTML, CSS, Ja-vaScript), the course focuses on WebGIS components that can be used to implement map-centered web applications. In addition, server-side components such as geodatabases, map services and REST APIs are covered. Students gain a comprehensive overview of distributed systems for the visualization, collection and storage of geoinformation. In a final project, students apply the skills they have learned independently and implement a web application in the group based on predefined criteria.

Literature

Literature will be announced during lectures.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	german

Specialisation Geotechnical Engineering

Title	Theoretical and Experimental Soil and Rock Mechanics		
Number	4315030	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Geomechanik und Geotechnik
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Marius Milatz
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination	Exam (120 min)		
Course achievement			

Contents

Soil and rock mechanics:
Basic understanding of soil and rock mechanics for the planning and execution of works in the ground. Soil investigation and geotechnical reports, geophysical methods of soil investigation, strength and deformation behavior of cohesive soils, stability investigation, material models, calculation of area foundations, subgrade reaction modulus method, stability of flow-through embankments, spreading stresses in embankments, static and dynamic pile tests, load-bearing behavior of piles, calculation of horizontally loaded piles / lateral pressure on piles, rock mechanics, rock hydraulics, rock structure models, rock classification, rock mechanical investigations, risk considerations in geotechnics.

Soil mechanics, practical course:
Soil identification, site investigation, laboratory and field tests for classification, water permeability in laboratory tests, strength and deformation behavior depending on the soil type.

Objective qualification

Literature

- Vorlesungsunterlagen
- Grundbautaschenbuch Teil 1 bis Teil 3, Ernst & Sohn, 8. Auflage, 2018
- Geotechnik Bodenmechanik, G. Möller, Ernst & Sohn, 1. Auflage, 2007

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Internship	german
	4,0	Lecture/Exercise	german

Title	Construction Techniques, Methods and ... [Fehlt]		
Number	4315040	**Module version**	V1
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Geomechanik und Geotechnik
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Marius Milatz
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			

Contents

Foundation and rock engineering:
Understanding of foundation and rock engineering for the design and construction of works in the ground. Catch dams and marine quays, special forms of excavation enclosures, special forms of support structures (e.g. reinforced earth), special earth pressure approaches, underpinning, pipe drilling, micro-tunnelling, pile grids, combined pile-raft foundations, subsoil improvement, soil stabilization, environmental aspects in geotechnical engineering, wedge statics, legal issues in geotechnical engineering.

Ground dynamics:
Principles of dynamics, description of dynamic processes in foundation engineering dynamics, vibration theory, waves and wave propagation, frequency response, magnification functions, modeling in foundation engineering dynamics, dynamically loaded foundations, machine foundations, transfer factors, vibration isolation, reduction of vibrations, design and construction guidance, monitoring.

Objective qualification

Literature

-Vorlesungsunterlagen
-Grundbautaschenbuch Teil 1 bis Teil 3, Ernst & Sohn, 8. Auflage, 2018
-Geotechnik kompakt Band 2: Grundbau nach Eurocode 7, G. Möller, Bauwerkverlag, 5. Auflage, 2017

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	german
	2,0	Lecture/Exercise	german

Title	Numerical Simulations and Field Measurements in Geotechnical Engineering		
Number	4310760	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Geomechanik und Geotechnik
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Marius Milatz
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			

Contents

Principle of the finite element method in structural mechanics, different element types, isoparametric elements, material models and their characteristics (linear elasticity, Mohr-Coulomb, Hardening Soil Model), numerical integration, discretization and boundary conditions, simulation of construction conditions, results and plausibility checks.

Objective qualification

Literature

- Vorlesungsunterlagen
- Finite-Elemente-Methoden, K.-J. Bathe, Springerverlag, 2. Auflage, 2002
- Kontinuumsmechanik, J. Betten, Springerverlag, 2. Auflage, 2001
- Grundbautaschenbuch Teil 1 bis Teil 3, Ernst & Sohn, 8. Auflage, 2018

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	3,0	Lecture/Exercise	german
	2,0	Lecture/Exercise	german

Title	Subsurface Excavation Construction		
Number	4315050	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Geomechanik und Geotechnik
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Marius Milatz
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 min)		
Course achievement			

Contents

Planning of tunnelling structures, preliminary geological exploration, rock and excavation classification, rock mechanics in tunnelling, geology, excavation types, blasting and roadheaders, cutter operation, safety measures and monitoring measurement, dewatering, sealing and lining, caverns, escape routes and rescue concepts, open shields, air pressure shields, fluid shields, earth pressure and mix shields, tunnel boring machines in hard rock, excavation tools and methods, haulage equipment, separation, classification and prediction of performance and wear parameters, securing equipment in mechanized tunnelling, tubbings, pipe drilling and micro-tunnelling, rock support behavior of salt, planning of underground cavities, explosives and detonating devices, tunnel statics, finite element calculations (predical course) practical course in tunnel statics.

Objective qualification

Literature

Vorlesungsunterlagen

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	2,0	Excursion	german

	4,0	Lecture/Exercise	german

Title	Deep Storage		
Number	4399780	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Geomechanik und Geotechnik
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Marius Milatz
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 min)		
Course achievement			
Contents			
Introduction to the disposal of hazardous waste in deep geological formations.			
Objective qualification			
Literature			
Forschungsberichte, Veröffentlichungen, aktuelle Informationen im Internet, Skript			

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	6,0	Lecture/Exercise	german

Specialisation Timber Design

Title	Timber Components and Connections		
Number	4316050	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Baukonstruktion und Holzbau
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Mike Sieder
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Contents			
Objective qualification			
Literature			
Skript			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	german

Title	New Timber Structures		
Number	4398660	**Module version**	2024-25
Shorttext	BAU-STD5-66	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	2	**Institution**	Institut für Baukonstruktion und Holzbau
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Mike Sieder
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination	Written Exam (60 Min.) or Oral Exam (30 Min.) 3/6 CP and Portfolio 3/6 LP		
Course achievement	Portfolio		
Contents			
Objective qualification			
Literature			
Skripte			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Seminar	german
	2,0	Seminar	german
	2,0	Lecture/Exercise	german

Title	Special Subjects of Timber Structures		
Number	4310650	**Module version**	2024-25
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	2	**Institution**	Institut für Baukonstruktion und Holzbau
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Mike Sieder
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Contents			
Objective qualification			
Literature			
Skripte			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture/Exercise	german
	2,0		german
	2,0	Seminar	german
	2,0	Seminar	german
	2,0	Lecture/Exercise	german

	2,0	Block course	german
Computer-Based Structural Analysis in Timber Structure	2,0	Lecture/Exercise	german
	2,0	Lecture/Exercise	german

Specialisation Hydrologie, Water Management and Water Protection

Title	Hydrology and Water Resources Management		
Number	4310260	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Abteilung Hydrologie und Flussgebietsmanagement
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Kai Schröter
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (120 Min.) or oral exam (approx. 60 Min.)		
Course achievement			

Contents

[Hydrology and water management (VÜ)]
Hydrological processes and process models for precipitation, evaporation, snow, soil moisture, runoff generation, runoff concentration and flood routing; integration of processes in catchment models for event and long-term continuous systems and determination of design values. Model applications using the PC for catchment modeling, flood protection planning and water balance studies; evaluation of the results.

Objective qualification

Students will gain knowledge of the processes of runoff formation, runoff concentration, and flood-routing and their implementation in simulation models. They will be able to apply a mesoscale rainfall-runoff model to a catchment area, to evaluate results and to carry out flood prevention planning. They acquire the basics to perform an economic evaluation of flood protection measures in terms of benefits and costs.

Literature

- Baumgartner, A., Liebscher, H.-J., & Benecke, P. (2011, February 25). Allgemeine Hydrologie. Schweizerbart'sche Verlagsbuchhandlung. https://www.schweizerbart.de/publications/detail/isbn/9783443300029
- Dyck, S., & Peschke, G. (1995). Grundlagen der Hydrologie (3., stark bearb. Aufl.). Verlag für Bauwesen.
- Maniak, U. (2016). Hydrologie und Wasserwirtschaft: Eine Einführung für Ingenieure (7., neu bearbeitete Auflage). Springer Vieweg. https://doi.org/10.1007/978-3-662-49087-7
- Fohrer, N. (Hrsg.), Bormann, H., Miegel, K., Casper, M., Bronstert, A., Schumann, A., Weiler, M. (2016): Hydrologie. utb.basics, Haupt Verlag, Bern.
- Patt, H., & Jüpner, R. (Eds.). (2020). Hochwasser-Handbuch: Auswirkungen und Schutz. Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-26743-8
- Shaw, E. M., Beven, K. J., Chappell, N. A., & Lamb, R. (2011). Hydrology in Practice, Fourth Edition. Spon Press. http://www.crcpress.com/product/isbn/9780415370417

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	german

Title	River Basin Management		
Number	4320090	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Abteilung Hydrologie und Flussgebietsmanagement
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Kai Schröter
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (120 Min.) or oral exam (approx. 60 Min.)		
Course achievement	2 Term papers		

Contents

River Basin Management (VÜ).
River basin management (RBM) for the implementation of the EU Water Framework Directive and the EU Floods Directive; International RBM; Model applications for reservoir management; Flood risk management.
[GIS - Applications in River Basin Management (RBM).
Geographic information for hydrologic and hydraulic modeling; digital maps, vector and raster data; intersection techniques; georeferencing; macro languages and programming.

Objective qualification

The students will acquire the ability to perform river basin management according to the requirements of the EU directives. Students will be familiarized with computer-based model applications for river basin management with a focus on reservoir management.
They will be able to process and analyze geographical data in raster and vector form.
They will be able to solve spatial problems and present the results in thematic maps.

Literature

Scripts and Simulation programs

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture/Exercise	german
	2,0	Lecture/Exercise	german

Title	Water Protection - Measurement Technologies and Data analyses		
Number	4310970	**Module version**	V1
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Abteilung Hydrologie und Flussgebietsmanagement
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Kai Schröter
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Term paper		
Course achievement			

Contents

[Measuring Techniques for Water Quantity and Water Quality (P)]
Measuring techniques for meteorological and hydrological data and their processing (surface water and groundwater); measuring of water quality parameters (physical-chemical variables, biological indicators); sampling from the water body (river, lake) and laboratory analysis; online measuring networks; analysis of measurement data

[Data Processing for Hydrologic and Hydraulic simulations (V)]
Testing, processing and analyzing of data to answer application-related questions and for subsequent usage as input data for hydrologic and hydraulic models. The relevant processes of precipitation, evapotranspiration, soil water movement and runoff transformation are covered in the lecture. Teaching content are universal applicable methods as time series analysis (homogeneity, consistency), regionalisation and extreme value analysis, as well as process-specific methods as correction of measurement errors and the usage of alternative precipitation data sets.

Objective qualification

The students gain varied and interdisciplinary knowledge in data processing and the development of own algorithms for data analysis. An understanding of data structures, data amounts and data plausibility is established. The gained knowledge can be transferred to other disciplines and model software.

Literature

Scripts and simulation programs

Remark

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Related courses			
Rules for the choice of courses			
maximum 12 participants			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Internship	german
	2,0	Lecture/Exercise	german

Title	Water Protection - Water Quality Modeling		
Number	4310730	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Abteilung Hydrologie und Flussgebietsmanagement
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Kai Schröter
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 Min.) or oral exam (approx. 60 Min.)		
Course achievement	Term paper		

Contents

[Water quality modeling (VÜ)]

water quality parameters and processes; methods for the analysis of measurement data; differential equations for the simulation of completely and incompletely mixed systems; analytical and numerical methods; heat balance; transport and transformation processes of pollutants (e.g. sediment, nitrogen, phosphorus) in water bodies, solving model equations in R programming

Objective qualification

The students gain in-depth knowledge of the interaction of water quantity and water quality in standing and flowing waters at the reach scale. The students will be qualified to quantify the pollution scientifically and technically and to describe it using model algorithms. Using model applications, the students get to know solutions for the improvement of water quality.

Literature

Steven C. Chapra, Surface Water-Quality Modeling, Waveland Press 2008 James L. Martin & Steven C. McCutcheon, Hydrodynamics and Transport for Water Quality Modeling, CRC Press, 1998

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Related courses

Rules for the choice of courses

Basic knowledge of water quality parameters and processes is required.

Compulsory attendance

Name of the course	SWS	Eventtype	Language

	4,0	Lecture/Exercise	german

Title	Ecohydrological Modelling of Catchments		
Number	4398800	**Module version**	V1
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät Architektur, Bauingenieurwesen und Umweltwissenschaften
Module duration	1	**Institution**	Abteilung Hydrologie und Flussgebietsmanagement
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Kai Schröter
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam+ (120min) or oral exam+ (30min)		
Course achievement			

Contents

Components of an ecohydrological model system
- Modeling of the water balance (precipitation, evapotranspiration, soil water, runoff formation, runoff concentration, flood-routing)
- Modeling of plant growth
- Modeling of transport and transformation processes of substances (e.g. sediment, nitrogen, phosphorus) in the landscape and in water bodies
- Application of an ecohydrological model on a PC to a mesoscale catchment area
- Influence of different forms of land use, land cultivation and land management on the landscape water regime and nutrient budget
- Modeling and evaluation of management measures for the reduction of emissions from the landscape (technical and nature-based)
- Solving model equations in R programming

Objective qualification

Students will gain in-depth knowledge of the transport and transformation processes of substances in a catchment that occur in the landscape and in a water body, as well as their mathematical description in an eco-hydrological model system. They will be able to set-up an ecohydrological model for a mesoscale catchment, prepare and analyze the model outputs, and evaluate the simulation results. They will acquire fundamental knowledge in modeling and evaluating management measures to reduce substance emissions within and from the catchment.

Literature

Harper, D.M., Zalewski, M., Pacini, N., 2008. Ecohydrology: Processes, Models and Case Studies: an Approach to the Sustainable Management of Water Resources. CABL
Haygarth, P.M., Jarvis, S.C., 2002. Agriculture, hydrology and water quality.
Pers, C. 2007. HBV-NP Model Manual

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	english

Title	Urban Ecohydrology		
Number	1514300	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät Architektur, Bauingenieurwesen und Umweltwissenschaften
Module duration	1	**Institution**	Abteilung für Bodenwissenschaften
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Ilhan Özgen
Workload (h)	180 h		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 Min.) or oral exam (20 Min.)		
Course achievement			

Contents

[Urban Ecohydrology (V)]
The lecture presents topics of ecohydrology in the urban area: urban groundwater, measurement and modelling techniques, decentralised stormwater management and green-blue infrastructure

[Urban Ecohydrology (Ü)]
The exercise consists of calculation exercises that are based on the lecture's topics. Part of the exercise is carried out using the programming language "R".

Objective qualification

Upon completing this module, students will be able to:

- apply theoretical knowledge of the effect of ecosystem services on the urban water cycle
- quantitatively solve ecohydrological problems in the urban area
- apply urban ecohydrological methods

Literature

Baird & Wilby (2000) Eco-Hydrology, Routledge, Oxfordshire, UK.

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language

	4,0	Lecture/Exercise	english
Literature			
Baird & Wilby (2000) Eco-Hydrology, Routledge, Oxfordshire, UK			

Specialisation Infrastructure and Real Estate Management

Title	Digitalization in the Operation and Valuation of Real Estate		
Number	3341000030	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Tanja Kessel
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Facility Management: 1 written exam (60 min.) Value Assessment of Real Estate: 1 written exam (60 min.)		
Course achievement			

Contents

In the lecture **Facility Management**, the focus is on the roles/functions, tasks/services and the operational organization form in the usage phase of real estate. In particular, digital processes, e.g., ticketing, fault reports, maintenance, are presented as part of a digital FM laboratory with in-depth insights into CAFM software and the resulting management tasks are derived.

In the lecture **Value Assessment of Real Estate**, the various methods of value assessment in Germany and internationally are presented and applied using case studies. The basics of real estate market-related analyses are also taught.

Objective qualification

In **Facility Management**, students acquire in-depth knowledge of operator responsibility, roles, functions and processes in the operating phase for different types of use of real estate.

In **Value Assessment of Real Estate**, students learn how to determine the market value of real estate using various calculation methods and are familiar with the parameters required for valuation.

Literature

Presentation slides of the lecture, exercises, bibliography

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	2,0	Block course	german

Title	Development and Realization of Real Estate		
Number	3341000010	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	2	**Institution**	
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Tanja Kessel
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Real Estate Project Development: 1 written exam (60 min.) Project Management in Construction: 1 oral exam+ (15 min.)		
Course achievement			

Contents

Decisions in real estate project development are the trigger for planning and construction measures and have a considerable influence on the subsequent phases through to operation and demolition by defining different objectives. In the lecture **Real Estate Project Development**, the areas of development, revitalization and redevelopment are discussed in the field of tension between economic efficiency, ecological sustainability and social/sociocultural compatibility. Based on the determination of requirements and basic principles, in-depth insights into project development processes and fields of action are provided and development calculations are carried out. The impact of real estate on the SDGs is deepened through insights into the circular economy and sustainability assessment.

The lecture **Project Management in Construction** shows the organizational, structural and methodological connections for successful project implementation. In addition to an effective client organization, various methods, concepts and tools for stakeholder and risk management, scheduling and cost planning and control as well as quality management are presented. While some of the students apply what they have learned in role plays, students of waterway engineering gain an in-depth insight into the processes and organization of the waterways and shipping administration as well as the technical and legal challenges of water transport construction projects.

Objective qualification

In the lecture **Real Estate Project Development**, students gain well-founded knowledge about real estate in the area of conflict between economy, ecology and society from the perspectives of the various stakeholders. They learn tools and methods to deal with opportunities and risks in this early planning phase and to arrive at a holistic and responsible decision.

In the lecture **Project Management in Construction**, students acquire in-depth knowledge of the initiation, management and completion of projects in construction. They are taught operational methods and tools with which a construction project can be implemented and completed in a goal-oriented manner from an organizational, legal, technical, economical and scheduling perspective.

Literature

Presentation slides of the lecture, exercises, bibliography

Remark

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture/Exercise	german
	2,0	Lecture/Exercise	german

Title	Financing and Sustainable Management of Real Estate		
Number	3341000020	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	2	**Institution**	
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Tanja Kessel
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Real Estate Management: 1 written exam (60 min.) ESG in Real Estate Practice: 1 written exam (60 min.)		
Course achievement			

Contents

The **Real Estate Management** lecture focuses on the roles, primary objectives and strategies of the real estate activities and investments of different portfolio holders. Operational instruments for investment decisions and the financing of real estate are presented and explained using case studies.

With the EU's Green Deal, real estate is subject to considerable influence from the financial sector in the areas of environmental, social and governance. This influence, the effects and correlations on the various life cycle phases of a property and on property valuation in the existing portfolio are presented to students in an in-depth analysis in the lecture **ESG in Real Estate Practice**.

Objective qualification

In the lecture **Real Estate Management**, students acquire in-depth knowledge of the sustainable management of real estate portfolios of different types of use and from the perspective of different portfolio holders. The focus is on questions of financing and investment decisions. For this, students acquire the skills to develop proposals for solutions and prepare decisions.

The aim of the **ESG in Real Estate Practice** lecture is to provide students with well-founded knowledge and strategies for implementing ESG criteria (environmental, social, governance) along the real estate life cycle.

Literature

Presentation slides of the lecture, exercises, bibliography

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
ESG in Real Estate Practice	2,0	Lecture	german

Title	Infrastructure Management		
Number	3341000000	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	2	**Institution**	
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Tanja Kessel
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Infrastructure and Project Financing: 1 written exam (60 min.) Management of Transportation Infrastructure Networks: 1 oral exam (15 min.)		
Course achievement			

Contents

The lecture **Infrastructure and Project Financing** focuses on the transfer of knowledge about operational instruments as well as the role and function of financing in the entire life cycle of infrastructure networks, especially road networks. The conflicting priorities between the economical and efficient use of taxpayers' money and the (ecological) sustainability of construction and maintenance measures are highlighted. Special attention is paid to the different incentive mechanisms of the actors and financing participants as well as the different public and private understanding of financing and sustainable action in the context of the normative framework.

In the lecture **Management of Transport Infrastructure Networks**, the connections between organizational and social structures as well as the influences of the various stakeholders on the orientation and implementation of network management tasks with a focus on transport infrastructure are shown. Based on this, various (ecological) sustainability and digitalization strategies of the three main modes of transport in maintenance management as well as methods and tools for application and evaluation are presented. Topics of the resilience of structures in climate change are discussed in the context of ecological sustainability assessment and the economical and efficient use of taxpayers' money.

Objective qualification

In the **Infrastructure and Project Financing** lecture, students learn about various financing structures in infrastructure management and are able to establish the role of financing in the life cycle and in the economic efficiency analysis of infrastructures. They acquire the skills to develop proposed solutions and prepare decisions.

In the lecture **Management of Transportation Infrastructure Networks**, students acquire in-depth knowledge of strategic management activities throughout the life cycle of transportation infrastructure networks. Students acquire the skills to develop a holistic decision-making basis for responsible engineering action in the utilization phase as well as in the feedback to other life cycle phases.

Literature

Presentation slides of the lecture, exercises, bibliography

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Block course	german
	2,0	Lecture	german

Specialisation Engineering Mechanics

Title	Linear Solid Mechanics		
Number	4228010	**Module version**	V1
Shorttext		**Language**	english
Frequency of offer	every term	**Teaching unit**	Fakultät Architektur, Bauingenieurwesen und Umweltwissenschaften
Module duration	1	**Institution**	Institut für Angewandte Mechanik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Ralf Jänicke
Workload (h)	180 h		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 Min)		
Course achievement			

Contents
Fundamentals of vector and tensor calculus; Linear kinematics; Stress state; Two-dimensional problems; Equilibrium conditions; Linear elasticity; Isotropic and anisotropic behavior; Thermal expansion; Introduction to boundary value problems and their numerical solution.
Objective qualification
The students are familiar with the description of stress and deformation in solids. They know linear material models, including thermal expansion. They use these basics for the solution of elementary problems, predominantly in two dimensions
Literature
Gross, Hauger, Wriggers, Technische Mechanik 4

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Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	english

Title	Nonlinear Finite Element Method		
Number	3315000060	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Angewandte Mechanik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Ralf Jänicke
Workload (h)	180 h		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Writte exam (90 Min.)		
Course achievement			

Contents

The Finite Element Method for linear and nonlinear problems in solid mechanics: Heat equation, nonlinear elasticity. Variational format, weighted residuals. Numerical implementation in a Finite Element Toolbox

Objective qualification

The students learn how to employ the Finite Element Method to solve boundary value problems in solid mechanics applications. They are able to solve linear and nonlinear problems (heat equation, nonlinear elasticity). The students are able to numerically implement the methods in a Finite Element Toolbox.

Literature

(1) TJR. Hughes, The Finite Element Method: Linear Static and Dynamic Finite Element Analysis
(2) C. Johnson, Numerical Solution of Partial Differential Equations by the Finite Element Method
(3) DV. Hutton, Fundamentals of Finite Element Analysis
(4) M. Fagan, Finite Element Analysis Theory and Practice
(5) P. Steinke, Finite-Elemente-Methode - Rechnergestützte Einführung

↑

Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	4,0	Lecture/Exercise	english

Title	Nonlinear Solid Mechanics		
Number	3315000040	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Angewandte Mechanik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Ralf Jänicke
Workload (h)	180 h		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 Min.)		
Course achievement			

Contents

Review of basics of vector and tensor calculus; Current and reference configuration; Non-linear kinematics (large deformations and rotations); Stress measures; Piola transform; Elasticity tensors; Non-linear constitutive relations: hyper-elasticity, visco-elasticity, plasticity; Implementation of material models in a programming language.

Objective qualification

The students are able to describe stress and deformation in presence of large deformations. They know selected non-linear material models. Using these basics, they can assess the suitability of materials with regard to mechanical loading even under non-idealized conditions.

Literature

-Gross, Hauger, Wriggers, Technische Mechanik 4
-Bonet, Nonlinear Continuum Mechanics for Finite Element Analysis
-Simo, Hughes, Computational Inelasticity
-Holzapfel, Nonlinear Solid Mechanics

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	4,0	Lecture/Exercise	english

Title	Multiscale Methods		
Number	3315000050	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Angewandte Mechanik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Ralf Jänicke
Workload (h)	180 h		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 Min.) or oral exam (30 Min.)		
Course achievement	Additional Homeworks/Term paper can be prepared in advance, which cover 20% of the points of the examination .		

Contents

Analytical averaging techniques (Voigt/Reuss, Hashin-Shtrikman); Separation of scales; Representative and Statistical Volume Elements; Hill-Mandel condition; Choice of boundary conditins; Variationally Methods; FE2 strategy

Objective qualification

The Students are acquainted with analytical methods to compute the macroscopic material properties of microstructured materials. They are familiar with the concept of Representative Volume Elements and with numerical averaging techniques. The students are aware of the effect, advantages and disadvantages by using different set of boundary conditions.

Literature

-Jänicke, Larsson, Runesson: Computational Homogenization, Course Compendium, 2021.
-Zohdi, Wriggers: An introduction to computational micromechanics, Springer, 2008.

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	4,0	Lecture/Exercise	english

Title	Mechanical Material Testing Methods		
Number	4310200	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Angewandte Mechanik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Ralf Jänicke
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	experimental work		
Course achievement			

Contents

Material models (elasticity, visco-elasticity, plasticity, fracture mechanics). Testing machines and test procedures: static and dynamic testing, force and displacement measurement. Test evaluation.

Objective qualification

The students are familiar with models describing the mechanical behaviour of materials. They are able to select methods to determine the parameters of such models, conduct the measurement and evaluate the results.

Literature

Remark

Can only be added in one specialization.

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
Mechanical Material Testing Methods	1,0	Lecture	english german

Mechanical Material Testing Methods	2,0	Laboratory	english ger-man

Specialisation Coastal Engineering and Ocean Engineering

Title	Coastal Engineering		
Number	4398090	**Module version**	V1
Shorttext		**Language**	english german
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	1	**Institution**	Abteilung Hydromechanik, Küsteningenieurwesen und Seebau
Hours per Week / ECTS	5 / 6,0	**Module owner**	Prof. Dr. Nils Goseberg
Workload (h)	180		
Class attendance (h)	70	**Self studying (h)**	110
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 min.)		
Course achievement	Term paper		

Contents

- Introduction to coastal engineering (sociological and ecological significance of the coastal zone, tasks and future of the coastal engineer)
- Linear and nonlinear wave theories, including areas of validity and application
- Wave transformation in shallow water (shoaling, refraction, breaking) and in interaction with obstacles (reflection, diffraction)
- Formation mechanisms of the sea state, including procedures for its parameterization and prediction
- Formation and prediction of tides in coastal areas and estuaries, including their special forms, significance and benefits
- Formation and prediction of storm surges and design water levels

Insight into the current state of research in various fields of coastal engineering

Objective qualification

After successful completion of the module, students will have a broad and solid basic knowledge of the mechanics of water waves and hydrodynamic processes in the coastal area, which enables them to determine the load, erosion and transport parameters for the required constructive and functional planning of engineering measures.
The students are able to use the linear and nonlinear theory of water waves to calculate the total wave induced current parameters and the associated effects on sediments, structures and other obstacles. By the mediated calculation basics for wave transformation the students can calculate the effects of the bottom in shallow water (shoaling, refraction, wave breaking) as well as of buildings and other obstacles (reflection, diffraction) on the parameters (height, length, direction) of the waves and their stability (refraction criterion) at the given planning location.
On the basis of the acquired basics of the origin, parameterization, mathematical/statistical description and prediction of the sea state, the students are able to determine the design waves for the functional and constructive planning. They can determine the design water levels on the basis of the acquired knowledge on the formation and prediction of tides on open coasts and in estuaries as well as of storm surges on the Ger-

man North Sea and Baltic Sea coasts. In the seminar, students are enabled to conduct scientific research and to present research results from current publications in an appropriate manner.

Literature

unter anderem / amongst others:
- Detailed Presentation Slides of the Lecture, Exercises, Solutions (PDF)
- Teaching Platform with educational videos, interactive diagrams, screencasts and lab videos (coastal.l-wi.tu-bs.de)
- Task Library of the Institute
- EAK (2003): Empfehlungen für Küstenschutzwerke. Die Küste, Heft 65, Heide i. Holstein.
- Oumeraci, H. (2001): Küsteningenieurwesen. Kapitel 12 in: Lecher, K. et al.: Taschenbuch der Wasserwirtschaft, Berlin.
- CEM (2008): Coastal Engineering Manual. Washington, D.C: U.S. Army Corps of Engineers, Online-Ressource.
- Dean, Robert G.; Dalrymple, Robert A. (1991): Water wave mechanics for engineers and scientists. Advanced Series on Ocean Engineering, Singapore: World Scientific.
- Goda, Yoshimi (2010): Reanalysis of regular and random breaking wave statistics. Coastal Engineering Journal, vol. 52, no.1, JSCE.

Remark

In the Seminar in Coastal Engineering on the topic Data Science & Coastal Engineering, an introduction is given to the use of Python as a universal tool for the evaluation and presentation of data; students will implement and evaluate data and methods from the lecture. The successful completion and submission of code implementations will be credited as study achievement (Studienleistung).

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	4,0	Lecture/Exercise	english german
	1,0	Lecture/Exercise	english german

Title	Coastal Dynamics and Engineering Design		
Number	4398100	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Abteilung Hydromechanik, Küsteningenieurwesen und Seebau
Hours per Week / ECTS	5 / 6,0	**Module owner**	Prof. Dr. Nils Goseberg
Workload (h)	180		
Class attendance (h)	70	**Self studying (h)**	110
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 Min.)		
Course achievement	Presentation (20 Min.)		

Contents

-Sedimentological and coastal morphological basics (coastal shapes and formations, initiation of motion, suspension and transport of sediments).
-Longitudinal and transverse coastal transport by sea state (significance, calculation methods, applications and limitations).
-Local morphological processes (processes of interaction between sea state, structure and sediment, calculation of scour, windward landfall and leeward erosion)

-Wave protection structures and offshore structures (structure types, operation, loading, design, and construction).
-Innovative structures (development process based on examples)
-Hydraulic laboratory practice as a planning tool

-Insight into the current state of research in diverse fields of coastal engineering

Objective qualification

After completing the module, students will be able to use hydraulic fundamentals to determine the loading and transport variables for sediments and other substances in the coastal zone as well as the effects on coastal structures and other marine engineering facilities.
The fundamentals of sediment transport enable students to calculate natural and structure-induced coastal morphological changes. Determination of longitudinal and transverse coastal transport makes it possible to predict and justify changes in coastal profile and shoreline caused by storm surges and other nearshore currents.
Understanding local morphological processes and qualitatively recording them will enable students to predict the effects and impacts of engineering activities (scour, landfall, coastal erosion, and coastal recession).

With the acquired knowledge of coastal and flood protection structures, their mode of operation and the procedures for their hydraulic loading by sea states as well as their design and construction, the students are able to prepare themselves for the special features of the constructive tasks of the coastal engineer. Since these tasks do not stop in the coastal area, they will likewise learn the specifics of offshore structures in terms of loading and design. An overview of innovative wave protection structures and offshore structures

as well as their development enables the students to apply the acquired knowledge of the processes involved in the interaction between sea state, structure and sediment to the development of innovative designs.

Through the introduction to the basics of hydraulic laboratory practice and the practical application using some examples, students have sufficient knowledge to optimize functional and structural design.

In the seminar, students will be able to conduct scientific research and present research results from current publications in an appropriate manner.

Literature

unter anderem / amongst others:
- Detailed Presentation Slides of the Lecture, Exercises, Solutions (PDF)
- Teaching Platform with educational videos, interactive diagrams, screencasts and lab videos (coastal.lwi.tu-bs.de)
- Task Library of the Institute
- EAK (2003): Empfehlungen für Küstenschutzwerke. Die Küste, Heft 65, Heide i. Holstein.
- Oumeraci, H. (2001): Küsteningenieurwesen. Kapitel 12 in: Lecher, K. et al.: Taschenbuch der Wasserwirtschaft, Berlin.
- CEM (2008): Coastal Engineering Manual. Washington, D.C: U.S. Army Corps of Engineers, Online-Ressource.
- Dean, Robert G.; Dalrymple, Robert A. (1991): Water wave mechanics for engineers and scientists. Advanced Series on Ocean Engineering, Singapore: World Scientific.
- Goda, Yoshimi (2010): Reanalysis of regular and random breaking wave statistics. Coastal Engineering Journal, vol. 52, no.1, JSCE.

Remark

In the Seminar in Coastal Engineering, students should get an insight into research-oriented studies by working out and discussing presentations of publications. During the discussion, both students and staff members will give advice on how students can further improve their skills in scientific research and their presentation skills. The Seminar in Coastal Engineering is therefore compulsory, since the qualification goals for all students can only be achieved if the students actively participate in the presentation and discussion phase. The presentation will be held in English.

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	4,0	Lecture/Exercise	english german
	1,0	Seminar	english

Title	Sustainable Ocean Engineering		
Number	3321400000	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Abteilung Hydromechanik, Küsteningenieurwesen und Seebau
Hours per Week / ECTS	5 / 6,0	**Module owner**	Prof. Dr. Nils Goseberg
Workload (h)	180		
Class attendance (h)	70	**Self studying (h)**	110
Compulsory requirements			
Expected performance/ Type of examination	Written Exam+ (90min)		
Course achievement	Home Assignment A term paper is completed as coursework, which can count for 20% of the final grade for the module. The application for an exam+ must be submitted by the student at the start of the examination. You will receive more detailed information on the term paper in the courses of the module.		

Contents

- Introduction to ocean engineering and offshore structures (classification, definitions), as well as aspects of sustainability in ocean engineering
- Fundamental of loading on fixed offshore structures (example system, loads on a monopile for wind energy conversion, definition of relevant parameters, Morison equation, design load cases)
- Calculation of scour (analytical, experimental and numerical methods) and scour-induced failure (using the example of a founded pile)
- Seabed liquefaction around marine structures (fundamentals and calculation methods)
- Fundamentals of loading on and movement of floating offshore structures (example systems, definition of relevant parameters, loads on a floating structure for renewable energy generation, linear potential theory, equation of motion and Cummins equation, modelling in the frequency and time domain)
- Mooring and anchor systems (load calculation, mooring design and dynamics)
- Life-cycle assessment and environmental impact
- Sustainable research aspects and innovative offshore structures

Objective qualification

After completing the module, students will have a broad and solid knowledge of the design, loading, and dynamics of offshore structures, as well as aspects of sustainability in the field of offshore engineering.
The basics of calculating loads on fixed offshore structures enables students to perform initial designs of such structures. Using the example of offshore wind, the basic parameters are taught and relevant calculation methods are derived.
Also using the example of offshore wind, students are taught the aspect of scour formation and the relevant calculation principles. Particular attention is paid to the various analysis methods. The consideration of morphodynamic processes is extended by teaching the fundamentals of seabed

liquefaction around marine structures. This content enables students to make basic predictions of failures and morphodynamic processes.
In addition to fixed offshore structures, students are taught the basics on loads and motion of floating offshore structures. Using examples of floating structures for marine renewable energy generation (e.g. ocean wave energy or floating photovoltaics), the basics of linear potential theory, equation of motion and Cummins equation are explained. The additional knowledge on the application of the governing equations and modelling of motions of simple floating structures enables students to design simple, floating systems in the offshore environment.
As part of the fundamentals of floating offshore structures, the module also addresses the mooring and anchoring of such systems and provides students with basic knowledge of load calculation, mooring design and dynamics.
Finally, the module specifically covers aspect of sustainability of systems in offshore engineering and the basics of life-cycle assessment and environmental impact, in order to enable students to make assessments regarding the sustainability of offshore structures.

Literature

unter anderem / amongst others:
- Detailed Presentation Slides of the Lecture, Exercises, Solutions (PDF)
- O.M. Faltinsen (1993): Sea loads on ships and offshore structures
- J. Falnes (2010): Ocean Waves and Oscillating Systems

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
Sustainable Ocean Engineering	5,0	Lecture/Exercise	english

Title	Advanced Coastal Engineering 1		
Number	4398110	**Module version**	V1
Shorttext		**Language**	english german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Abteilung Hydromechanik, Küsteningenieurwesen und Seebau
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Nils Goseberg
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination	oral exam (approx. 60 Min.) or 2 oral exams (30 Min. each)		
Course achievement			

Contents

[Practical Course in Coastal Engineering (P)]
EIntroduction to measurement and experimental techniques in coastal hydraulic engineering, planning and execution of model tests (standard tests and current projects), acquisition and analysis of measurement data, evaluation of model tests.

[Ecohydraulic Processes from Field to Laboratory (P)]
Ecosystems and coastal ecohydraulic processes, stages of the research cycle with individual work steps, basics of literature research, development of research questions, introduction to measurement and experimental techniques for ecohydraulic field measurements in coastal hydraulic engineering, basics of field study planning, planning and conducting a field study, acquisition and analysis of measurement data, Analysis and evaluation of a field study, scientific elaboration and presentation of research results, peer review of scientific papers, scale laws, introduction to measurement and experimental techniques for ecohydraulic laboratory measurements in coastal hydraulic engineering, basics of laboratory study planning, planning of laboratory experiments by transfer field observations.

[Harbour Planning and Maritime Waterways Engineering (B)]
Characteristics, tasks and importance of waterways, tidal dynamics, hydraulic engineering system analysis, river engineering measures and concepts for estuaries, maintenance of waterways as well as interactions between seagoing vessels and shipping lanes.
Planning, management and operation of seaports, problems and future perspectives of a port location, Dimensioning of a container terminal

[Coastal Engineering and Coastal Protection at the North Sea and the Baltic Sea (B)]
Historical development of coastal protection, special features of coastal protection in the North Sea and Baltic Sea regions, strategies and official organization of coastal protection, current projects of island and coastal protection.

[Spectral Analysis of nonlinear Waves in the Coastal Area (VÜ)]
Linear and nonlinear wave theories, cnoidal waves and theta functions, basics of Fourier and Hilbert-Huang transforms, basics and algorithms of direct and inverse nonlinear Fourier transformation, advantages and disadvantages of the different analysis methods, application of the methods to different examples

of surface waves and different problems from coastal engineering, interpretation of the obtained spectra, comparative analyses, discussion and evaluation of the result.

[Tsunami engineering (V)]
Tsunami hazard and risk, tsunami phenomena (definition, main tsunami characteristics compared to wind-induced waves, tsunami classification, intensity scales), tsunami generation mechanisms, tsunami propagation and inundation (tsunami characteristics in deep and shallow water, coastal manifestations, tsunami runup), tsunami impact on the coast (tsunamigenerated forces, impact on buildings, environment and society), historical tsunami events, tsunami coastal protection measures (structural, non-structural protection measures, hybrid protection systems), disaster management and land use planning, visions of tsunami-resilient cities, tsunami generation in the laboratory, numerical modeling of tsunamis, tsunami research at LWI.

[Numerical Modeling of Coastal Processes (VÜ)]
Overview of current modeling methods (SPH, Reef3D, Delft3D, Mike, Telemac, SMS, Untrim) their applications, limitations and recent developments. Fundamentals of numerical modeling, numerical modeling of sea state, wave action equation, mild slope equation, phase-averaged and phase-resolved wave modeling, tidal flow, transport processes of sediments and salt, modeling of erosion processes and coastal barrier failure due to storm surges, applications of open source and internationally accepted numerical models for modeling with e.g. Delft3D, SWAN and XBeach.

Objective qualification

Upon completion of the module, students will have the knowledge of how to apply the course contents from the modules Basic Coastal Engineering and Coastal Dynamics and Engineering Design in practice. They are able to carry out the planning, execution and evaluation of hydraulic model tests as a tool for planning tasks. Based on the internship they have carried out themselves, they can develop appropriate solutions, propose them appropriately and evaluate and assess the results professionally based on their knowledge of the hydrodynamic and morphological processes in coastal areas.
Students will know the principles of construction and operation of ports, harbor facilities, and marine waterways. Due to the excursions in the different areas, the students have the knowledge of how complex problems are optimally solved in practice. The students know the similarities and special features of coastal and flood protection on the German North Sea and Baltic Sea coasts. Due to the excursions in the different areas, the students have the knowledge of how complex problems are optimally solved in practice.
Students will know advanced fundamentals as well as practical examples of theory and application of new nonlinear analysis methods of waves in coastal areas and will be able to interpret obtained analysis results.
The students know the physical processes underlying the interactions between the fluid, the structure and the seabed. They will know the main approaches to numerical modeling of these processes and the coupling of different models. Students will be able to apply different open source tools for fluid-structure-seabed modeling.
Students will know the characteristics of tsunamis in the phases from tsunami generation to coastal inundation. They can define tsunami hazards and risks and classify the damage caused and failure mechanisms of structures based on the forces exerted. Based on examples of implemented protection strategies in tsunami-prone countries, they have the knowledge of available protection measures and their advantages and disadvantages. The students know the laboratory methods and
numerical tools for the simulation of tsunamis.

Literature

unter anderem/amongst others:
- Skripte und Vortragspräsentationen zu den einzelnen Lehrveranstaltungen
- NLWKN (2010): Generalplan Küstenschutz Niedersachsen - Ostfriesische Inseln-. Niedersächsisches Landesamt für Wasserwirtschaft, Küsten- und Naturschutz, Norden.
- LU (2009): Regelwerk Küstenschutz Mecklenburg-Vorpommern. Ministerium für Landwirtschaft, Umwelt und
Verbraucherschutz, Rostock.

- EAU (2012): Empfehlungen des Arbeitsausschusses Ufereinfassungen, Häfen und Wasserstraßen. Hafenbautechnische Gesellschaft, Deutsche Gesellschaft für Erd- und Grundbau,11. Auflage, Berlin.
- EAK (2002): Empfehlungen für Küstenschutzwerke. Die Küste, Heft 65, Heide i. Holstein.
- Kuratorium für Forschung im Küsteningenieurwesen (2008): Archiv für Forschung und Technik an der Nord- und Ostsee. Die Küste, Heft 74, Heide i. Holstein.
- Kahlfeld, A., Schüttrumpf, H. (2006): Auswirkungen des JadeWeserPorts auf die Tide- und Morphodynamik der Jade, PIANC Kongress, Estoril
- Kondziella, B., Uliczka, K. (2006): Dynamisches Fahrverhalten sehr großer Containerschiffe unter extremen
Flachwasserbedingungen, PIANC Kongress, Estoril
- Brühl, M. (2014): Direct and inverse nonlinear Fourier transform based on the Korteweg-deVries equation (KdV-NLFT) - A spectral analysis of nonlinear surface waves in shallow water. Dissertation.
- Dean, R.G.; Dalrymple, R.A. (1991): Water Wave Mechanics for Engineers and Scientists. Advanced Series on Ocean Engineering - Volume 2, Singapore: World Scientific, 353 pp.
- Huang, N.E.;Shen, Z.;Long, S.R.;Wu, M.C.;Shih, H.H.;Zheng, Q.;Yen, N.-C.;Tung, C.C.; Liu, H.H. (1998): The empirical mode decomposition and the Hilbert spectrum for nonlinear and non-stationary time series analysis. London: Proceedings of the Royal Society of London A, vol. 454, pp. 903-995.
- Osborne, A. (2010): Nonlinear ocean waves and the inverse scattering transform. Amsterdam: Elsevier, 977 pp.
-Bernard, E.N., Robinson, A.R. (2009): Tsunamis. The sea, Vol. 15. Harvard Univ. Press.
-Camfield, F. (1980): Tsunami engineering. Fort Belvoir.
-Santiago-Fadiño, V., Kontar, Y.A., Kaneda, Y. (2015): Post-tsunami hazard. Reconstruction and restoration. Advances in Natural and Technological Hazards Research.
-Holthuijsen, L.H. (2010): Waves in Oceanic and Coastal Waters. Cambridge University Press; 1 edition, 404 pp.
-Roelvink, D., and Reniers, A. (2012). A guide to modelling coastal morphology. World Scientific, 292pp.

Remark

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Related courses

Rules for the choice of courses

Taking the Practical Course in Coastal Engineering (Studienleistung) is mandatory. From the other six courses, either Ecohydraulic Processes from Field to Laboratory or two of the other courses must be selected and taken

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	2,0	Internship	english german
	2,0	Block course	german
	3,0	Block course	german
	2,0	Block course	german
	2,0	Lecture	english
	2,0	Lecture/Exercise	english
	4,0	Internship	german

Title	Advanced Coastal Engineering 2		
Number	4398120	**Module version**	V1
Shorttext		**Language**	english german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Abteilung Hydromechanik, Küsteningenieurwesen und Seebau
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Nils Goseberg
Workload (h)			
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination	Oral exam (approx. 60 Min.) or 2 oral exams (approx. 30 Min. each)		
Course achievement			

Contents

[Harbour Planning and Maritime Waterways Engineering (B)]
Characteristics, tasks and importance of waterways, tidal dynamics, hydraulic engineering system analysis, river engineering measures and concepts for estuaries, maintenance of waterways as well as interactions between seagoing vessels and shipping lanes.
Planning, management and operation of seaports, problems and future perspectives of a port location, Dimensioning of a container terminal

[Coastal Engineering and Coastal Protection at the North Sea and the Baltic Sea (B)]
Historical development of coastal protection, special features of coastal protection in the North Sea and Baltic Sea regions, strategies and official organization of coastal protection, current projects of island and coastal protection.

[Spectral Analysis of nonlinear Waves in the Coastal Area (VÜ)]
Linear and nonlinear wave theories, cnoidal waves and theta functions, basics of Fourier and Hilbert-Huang transforms, basics and algorithms of direct and inverse nonlinear Fourier transformation, advantages and disadvantages of the different analysis methods, application of the methods to different examples of surface waves and different problems from coastal engineering, interpretation of the obtained spectra, comparative analyses, discussion and evaluation of the result.

[Tsunami engineering (V)]
Tsunami hazard and risk, tsunami phenomena (definition, main tsunami characteristics compared to wind-induced waves, tsunami classification, intensity scales), tsunami generation mechanisms, tsunami propagation and inundation (tsunami characteristics in deep and shallow water, coastal manifestations, tsunami runup), tsunami impact on the coast (tsunamigenerated forces, impact on buildings, environment and society), historical tsunami events, tsunami coastal protection measures (structural, non-structural protection measures, hybrid protection systems), disaster management and land use planning, visions of tsunami-resilient cities, tsunami generation in the laboratory, numerical modeling of tsunamis, tsunami research at LWI.
[Numerical Modeling of Coastal Processes (VÜ)]
Overview of current modeling methods (SPH, Reef3D, Delft3D, Mike, Telemac, SMS, Untrim) their applications, limitations and recent developments. Fundamentals of numerical modeling, numerical modeling of sea state, wave action equation, mild slope equation, phase-averaged and phase-resolved wave modeling, tidal

flow, transport processes of sediments and salt, modeling of erosion processes and coastal barrier failure due to storm surges, applications of open source and internationally accepted numerical models for modeling with e.g. Delft3D, SWAN and XBeach.

Objective qualification

Upon completion of the module, students will have the knowledge of how to apply the course contents from the modules Basic Coastal Engineering and Coastal Dynamics and Engineering Design in practice. They are able to carry out the planning, execution and evaluation of hydraulic model tests as a tool for planning tasks. Based on the internship they have carried out themselves, they can develop appropriate solutions, propose them appropriately and evaluate and assess the results professionally based on their knowledge of the hydrodynamic and morphological processes in coastal areas.
Students will know the principles of construction and operation of ports, harbor facilities, and marine waterways. Due to the excursions in the different areas, the students have the knowledge of how complex problems are optimally solved in practice. The students know the similarities and special features of coastal and flood protection on the German North Sea and Baltic Sea coasts. Due to the excursions in the different areas, the students have the knowledge of how complex problems are optimally solved in practice.
Students will know advanced fundamentals as well as practical examples of theory and application of new nonlinear analysis methods of waves in coastal areas and will be able to interpret obtained analysis results.
The students know the physical processes underlying the interactions between the fluid, the structure and the seabed. They will know the main approaches to numerical modeling of these processes and the coupling of different models. Students will be able to apply different open source tools for fluid-structure-seabed modeling.
Students will know the characteristics of tsunamis in the phases from tsunami generation to coastal inundation. They can define tsunami hazards and risks and classify the damage caused and failure mechanisms of structures based on the forces exerted. Based on examples of implemented protection strategies in tsunami-prone countries, they have the knowledge of available protection measures and their advantages and disadvantages. The students know the laboratory methods and
numerical tools for the simulation of tsunamis.

Literature

unter anderem/amongst others:
- Skripte und Vortragspräsentationen zu den einzelnen Lehrveranstaltungen
- NLWKN (2010): Generalplan Küstenschutz Niedersachsen - Ostfriesische Inseln-. Niedersächsisches Landesamt für Wasserwirtschaft, Küsten- und Naturschutz, Norden.
- LU (2009): Regelwerk Küstenschutz Mecklenburg-Vorpommern. Ministerium für Landwirtschaft, Umwelt und
Verbraucherschutz, Rostock.
- EAU (2012): Empfehlungen des Arbeitsausschusses Ufereinfassungen, Häfen und Wasserstraßen. Hafenbautechnische Gesellschaft, Deutsche Gesellschaft für Erd- und Grundbau,11. Auflage, Berlin.
- EAK (2002): Empfehlungen für Küstenschutzwerke. Die Küste, Heft 65, Heide i. Holstein.
- Kuratorium für Forschung im Küsteningenieurwesen (2008): Archiv für Forschung und Technik an der Nord- und Ostsee. Die Küste, Heft 74, Heide i. Holstein.
- Kahlfeld, A., Schüttrumpf, H. (2006): Auswirkungen des JadeWeserPorts auf die Tide- und Morphodynamik der Jade, PIANC Kongress, Estoril
- Kondziella, B., Uliczka, K. (2006): Dynamisches Fahrverhalten sehr großer Containerschiffe unter extremen
Flachwasserbedingungen, PIANC Kongress, Estoril
- Brühl, M. (2014): Direct and inverse nonlinear Fourier transform based on the Korteweg-deVries equation (KdV-NLFT) - A spectral analysis of nonlinear surface waves in shallow water. Dissertation.
- Dean, R.G.; Dalrymple, R.A. (1991): Water Wave Mechanics for Engineers and Scientists. Advanced Series on Ocean Engineering - Volume 2, Singapore: World Scientific, 353 pp.
- Huang, N.E.;Shen, Z.;Long, S.R.;Wu, M.C.;Shih, H.H.;Zheng, Q.;Yen, N.-C.;Tung, C.C.; Liu, H.H. (1998): The empirical mode decomposition and the Hilbert spectrum for nonlinear and non-stationary time series analysis. London: Proceedings of the Royal Society of London A, vol. 454, pp. 903-995.
- Osborne, A. (2010): Nonlinear ocean waves and the inverse scattering transform. Amsterdam: Elsevier, 977 pp.

-Bernard, E.N., Robinson, A.R. (2009): Tsunamis. The sea, Vol. 15. Harvard Univ. Press.
-Camfield, F. (1980): Tsunami engineering. Fort Belvoir.
-Santiago-Fadiño, V., Kontar, Y.A., Kaneda, Y. (2015): Post-tsunami hazard. Reconstruction and restoration. Advances in Natural and Technological Hazards Research.
-Holthuijsen, L.H. (2010): Waves in Oceanic and Coastal Waters. Cambridge University Press; 1 edition, 404 pp.
-Roelvink, D., and Reniers, A. (2012). A guide to modelling coastal morphology. World Scientific, 292pp.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Block course	german
	3,0	Block course	german
	2,0	Block course	german
	2,0	Lecture	english
	2,0	Lecture/Exercise	english

Specialisation Solid Constructions

Title	Prestressed Concrete Constructions		
Number	4334060	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Fachgebiet Massivbau
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Vincent Oettel
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 Min.) or oral exam (30 Min.)		
Course achievement			

Contents

Building materials; prestressing methods; tendon anchorage; internal forces from prestressing, effects of creep and shrinkage; proofs in the limit state of serviceability and load-bearing capacity; constructive detailing of prestressed concrete components; fatigue verification

Post-tensioning systems; applications of prestressed concrete in civil and industrial construction (halls, bridges etc.)

Objective qualification

By the end of this course, the students will have deep knowledge of the basics principles and applications of prestressed concrete. They will be able to calculate internal forces for statically determinate and indeterminate prestressed concrete structures and to carry out verifications in the ultimate limit and service states. Finally, the students will be capable of independently designing, dimensioning and detailing prestressed concrete components.

Literature

A detailed script with all contents from the lectures is available.

-Fingerloos, F. et al.: Eurocode 2 für Deutschland DIN EN 1992-1-1 Bemessung und Konstruktion von Stahlbeton- und Spannbetontragwerken, Teil 1-1: Allgemeine Bemessungsregeln und Regeln für den Hochbau mit -Nationalem Anhang, Kommentierte Fassung, 2. Auflage, Beuth Verlag, Berlin, 2016.
-Albert, A. et. al.: Spannbeton Grundlagen und Anwendungsbeispiele, 2. Auflage, Werner Verlag, 2013.
-Avak, R.; Meiss, K.: Spannbetonbau Theorie, Praxis, Berechnungsbeispiele nach Eurocode 2, 3. Auflage, Beuth Verlag, 2015.
-Krüger, W.; Mertzsch, O.: Spannbetonbau-Praxis nach Eurocode 2 Mit Berechnungsbeispielen, 3. Auflage, Beuth Verlag, 2012.
-Rombach, G.: Spannbetonbau, 2. Auflage, Ernst & Sohn, 2010.
-Rossner, W.; Graubner, C.-A.: Spannbetonbauwerke Teil 4: Bemessungsbeispiele nach Eurocode 2, Ernst & Sohn,

2012.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	2,0	Exercise	german
	2,0	Lecture/Exercise	german

Title	Concrete Bridge Construction		
Number	4398760	**Module version**	V1
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Fachgebiet Massivbau
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Vincent Oettel
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Recommended requirements	Students are expected to have a thorough knowledge of Prestressed Concrete Construction in order to participate in this class.		
Expected performance/ Type of examination	Portfolio or oral exam (30 Min.)		
Course achievement			

Contents

[Concrete Bridges - Design and Construction]
Bridge types, regulations and guidelines, loads, design and construction design, cross-sections for superstructures, substructures (columns, abutments, foundations), bridge equipment, construction methods

[Concrete Bridges - Structural Design and Applications]
Practical examples and possible applications of bridges in reinforced concrete and prestressed concrete construction, design and pre-dimensioning of bridge structures

Objective qualification

Students have knowledge of the design and construction of bridges in reinforced concrete and prestressed concrete construction. They have advanced knowledge of the loads on bridges, bridge types, cross-sections for superstructures, substructures and bridge-specific details (bearings, transitions etc.). They also have knowledge of different construction methods, the structural design of bridge structures and specific verifications in the ultimate and serviceability limit states.

Literature

A detailed script with all contents from the lectures is available.

-DIN Deutsches Institut für Normung e. V.: Handbuch Eurocode 2 Betonbau Band 2: Brücken, 1. Auflage, Beuth Verlag, 2013.
-Tue, N. V., Reichel, M., Fischer, M.: Berechnung und Bemessung von Betonbrücken. Ernst & Sohn, 2015.
-Holst, R., Holst, K. H.: Brücken aus Stahlbeton und Spannbeton Entwurf, Konstruktion und Berechnung, 6. Auflage, Ernst & Sohn, 2013.
-Mehlhorn, G., Curbach, M.: Handbuch Brücken Entwerfen, Konstruieren, Berechnen, Bauen und Erhalten, 3. Auflage, Springer, 2014.
-Geißler, K.: Handbuch Brückenbau Entwurf, Konstruktion, Bewertung und Ertüchtigung, Ernst & Sohn, 2014

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	2,0	Exercise	german
	2,0	Lecture/Exercise	german

Title			
Number	3314000000	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Fachgebiet Massivbau
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Vincent Oettel
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Contents			
Objective qualification			
Literature			
Es stehen ausführliche Foliensätze mit Quellenangaben zur Verfügung. [Ingenieurbauwerke im Wasserbau] DIN 19702: Massivbauwerke im Wasserbau – Tragfähigkeit, Gebrauchstauglichkeit und Dauerhaftigkeit, 2013. Kunz, C.: Massive (Verkehrs-)Wasserbauwerke – ein aktueller bautechnischer Überblick, Betonkalender 2020: Wasserbau. Konstruktion und Bemessung. (Teil 1), Ernst & Sohn Verlag, Berlin, 2020. DIN 19661-1: Wasserbauwerke – Teil 1: Kreuzungsbauwerke, Durchleitungs- und Mündungsbauwerke, 1998. DIN 19703: Schleusen der Binnenschifffahrtsstraßen – Grundsätze für Abmessungen und Ausrüstung, 2014. [Automatisiertes und modulares Bauen] Bergmeister, K. et al.: Beton-Kalender 2006 – Schwerpunkte: Turmbauwerke –Industriebauten, Ernst & Sohn Verlag, Berlin, 2006. Beer, B.: Beton-Kalender 2019 – Schwerpunkte: Parkbauten, Geotechnik und Eurocode 7, Ernst & Sohn Verlag, Berlin, 2019. DIN EN 61400-3: Windenergieanlagen –Teil 3: Auslegungsanforderungen für Windenergieanlagen auf offener See. VDE Verlag, Berlin, 2010.			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	2,0	Exercise	german
	2,0	Lecture/Exercise	german

Title	Sustainability in Concrete Construction		
Number	4398650	**Module version**	V1
Shorttext	BAU-STD5-65	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	1	**Institution**	Fachgebiet Massivbau
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Vincent Oettel
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 min.) or oral exam (30 min.)		
Course achievement			

Contents

[Maintenance and Rehabilitation]
Regulations and guidelines, condition assessment of structures, assessment of load-bearing capacity and serviceability, strengthening with concrete reinforcement, strengthening with additional reinforcement, strengthening with steel components etc.

[Innovations and Sustainability Aspects]
Lightweight concrete, steel fibre concrete, ultra high-strength concrete, non-metallic reinforcement, solutions for the sustainable use of concrete construction methods

Objective qualification

Students have advanced knowledge of the maintenance and rehabilitation of concrete structures and are able to plan and calculate the strengthening of a structure. In addition, students have knowledge of innovative applications of concrete construction, the optimisation of concrete structures and sustainability aspects.

Literature

Detailed scripts are available.

[Maintenance and Rehabilitation]

-Schnell, J. et. al.: Sachstandbericht – Bauen im Bestand – Teil I: Mechanische Kennwerte historischer Betone, Betonstähle und Spannstähle für die Nachrechnung von bestehenden Bauwerken, Deutscher Ausschuss für Stahlbeton (DAfStb), Heft 616, Beuth Verlag, Berlin, 2016.

-Seim, W.: Bewertung und Verstärkung von Stahlbetontragwerken, 2. Auflage, Ernst & Sohn, 2007.

-DAfStb-Richtlinie Verstärken von Betonbauteilen mit geklebter Bewehrung, Teil 1 bis 4, Deutscher Ausschuss für Stahlbeton (DAfStb), Beuth Verlag, Berlin, 2012. DAfStb-Richtlinie Schutz und Instandsetzung von Betonbauteilen (Instandsetzungsrichtlinie), Teil 1 bis 4, Deutscher Ausschuss für Stahlbeton (DAfStb), Beuth Verlag, Berlin, 2001.

[Innovations and Sustainability Aspects]

-DAfStb-Richtlinie Stahlfaserbeton, Deutscher Ausschuss für Stahlbeton (DAfStb), Beuth Verlag, Berlin, 2021. DAfStb-Richtlinie Betonbauteile mit nichtmetallischer Bewehrung – Entwurf, Deutscher Ausschuss für Stahlbeton (DAfStb), Beuth Verlag, Berlin, 2024.

-Schmidt, M. et. al.: Nachhaltiges Bauen mit ultra-hochfestem Beton, Schriftenreihe Baustoffe und Massivbau, Universität Kassel, 2014.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	2,0	Exercise	german
Innovations and Sustainability Aspects	2,0	Lecture/Exercise	german

Specialisation Local Public Transport

Title	Local Public Transport - Supply Planning		
Number	4310770	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Verkehr und Stadtbauwesen
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Bernhard Friedrich
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 Min.) or oral exam (approx. 30 Min.) (in the Master's programme in Social Sciences as a course achievement)		
Course achievement	Term paper		

Contents

Public transport - service planning (VÜ)
- organizational and legal basics of the public transport system
- network planning in the context of settlement development
- public transport systems and their performance capabilities
- overview of circulation, vehicle and personnel planning
- distribution of tickets, the organization in transport associations and tariffing
- financing of public transport,
- marketing strategies in public transport
- differentiated modes of operation in public transport
- acceleration of public transport in urban road networks

Objective qualification

Students will gain knowledge of the interrelationships, systems and laws that must be taken into account when planning public transport services. They will be able to design or further develop and implement public transport services for urban and rural public transport, with the respective boundary conditions and systems to be taken into account. Public transport services are differentiated for road (IVS – Prof. Friedrich) and rail transport (IVE – Prof. Siefer).

Literature

-Differenzierte Bedienung im ÖPNV - Flexible Bedienungsweisen als Baustein eines markorientierten Leistungsangebotes,
-Blaue Buchreihe des VDV, Heft 15, DVV Media Group GmbH, April 2009.
-Stadtbahnsysteme Light Rail Systems. Grundlagen, Technik, Betrieb und Finanzierung. Blaue Buchreiche des VDV,
DVV Media Group GmbH, Juni 2014
-Richtlinien, Hinweise und Merkblätter der Forschungsgesellschaft für Straßen- und Verkehrswesen (www.fgsv-verlag.de).

-Reinhardt, W. Öffentlicher Personennahverkehr. Vieweg + Teubner Verlag. Springer Fachmedien Wiesbaden GmbH,
2012.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	german

Title	Local Public Transport - Planning and Infrastructure		
Number	4398060	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Planung des öffentlichen Verkehrs
Hours per Week / ECTS	4 / 6,0	**Module owner**	Alejandro Tirachini
Workload (h)	₁₈₀		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 Min.) or oral exam (approx. 30 Min.)		
Course achievement			

Contents

[Public Transport - Infrastructure Planning (V/Ü)]
- Definition of lane-guided systems in urban transport
- Development of light rail systems
- Planning approaches/ responsibilities
- Legal basis
- Financing
- Planning approval and project sequence
- System design
- Planning principles for alignment and routes
- Construction and maintenance of infrastructure
- stations
- Energy supply (trackside)
- Current developments in Germany and worldwide
- Overview of safety systems for railways in urban traffic
- Train protection
- Route protection
- Train control and driverless operation
- Route protection in areas with road traffic participation

Objective qualification

The students are able to plan infrastructure facilities for public transport (rail and road) in Germany according to the relevant procedures and rules for a specific application and to accompany the construction. The knowledge of these basics is necessary for economic and ecological operation. As employees of a local transport operator or a planning office for a planned application, they are able to select suitable safety systems and dimension them operationally. They are able, under the guidance of experienced planning engineers in the planning of safety equipment.

Literature

-Reinhardt: Öffentlicher Personennahverkehr
-Pachl: Systemtechnik des Schienenverkehrs

-Naumann: Leit- und Sicherungstechnik im Bahnbetrieb

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	german

Title	Transport Planning		
Number	4318020	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Verkehr und Stadtbauwesen
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Bernhard Friedrich
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 Min.) or oral exam (30 Min.)		
Course achievement	Homework assignment		

Contents

[Verkehrsplanung (VÜ)]
- Introduction to transport planning
- Planning Methodology
- Behavioural traffic surveys
- Planning of transport networks
- Planning of measures in public transport (external lecturer from the field)
- Decision models
- Traffic models (traffic generation, traffic distribution, traffic allocation)
- Impact models and evaluation procedures
- Traffic safety

Objective qualification

The students gain an overview of the characteristics of mobility, the socio-economic significance of transport that can be derived from this and the resulting legal anchoring of spatial and transport planning. Based on the understanding of the problems and tasks of transport planning, the planning methodology and the instruments of transport network planning in public transport and individual transport are introduced. In this context, the students get to know the requirements of the German guidelines in transport planning and can apply them to planning tasks. Through the in-depth examination of the theory and practice of transport demand modelling, the students are enabled to carry out own planning studies and to quantitatively evaluate planning alternatives. They are thus qualified to make reliable recommendations for the development of the transport infrastructure.

Literature

vgl. Vorlesung

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	german

Title			
Number	3329000000	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät Architektur, Bauingenieurwesen und Umweltwissenschaften
Module duration		**Institution**	
Hours per Week / ECTS	4 / 6,0	**Module owner**	Alejandro Tirachini
Workload (h)	180h		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Exam (120 Min.)		
Course achievement			

Contents

- Motivation: why public transport and history of public transport
- Public transport planning: strategic, tactical and operational decisions
- User costs and values of time in public transport
- Single line design: Determination of frequency of service, type of vehicle
- Single line design: stop/station design and density
- Network design: general rules, simple models, complex models
- Waiting time modelling and timetabling
- Pricing and financing
- Public transport ownership and regulation
- Demand modelling, quality of service and user satisfaction
- Future public transport

Objective qualification

The students acquire an in-depth understanding of planning processes in public transport systems. Upon successful completion, students will be able to: (1) apply methods for designing single public transport lines (including route alignment, stop location, frequency, and vehicle size determination), considering the concepts of value of time, user cost components (access, waiting, in-vehicle time, transfers), and operator cost, informed by empirical data; (2) formulate and solve fundamental frequency setting and optimal stop spacing problems; (3) evaluate public transport network structures based on density principles and solve basic network design problems under constraints; (4) analyse public transport timetabling problems using different objective functions; (5) critically assess fare systems and pricing principles using welfare economics and practical fare setting rules; (6) compare models of public transport organization and ownership including regulation; (7) utilize fundamental concepts of public transport demand modelling including mode choice,

and (8) discuss topics pertaining to future developments such as automation and sustainability challenges in the public transport industry.
Literature
Präsentation, Artikel, Buchkapitel

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	german

Specialisation Computational Modeling

Title	Applied CFD Software Engineering		
Number	3325000030	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	2	**Institution**	Institut für rechnergestützte Modellierung im Bauingenieurwesen
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Martin Geier
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	oral exam (approx. 60min)		
Course achievement			

Contents

Applied Software Engineering 1: After a compact repetition of basic elements of object orientation the fundamental concepts as well as established design principles and patterns in the context of object-oriented programming are discussed and applied.

Applied Software Engineering 2: This course focuses on the development of an interactive fluid flow simulator. Starting point is a minimal 2D CAD program that allows interactive creation of objects such as circles, rectangles, and polygons and their manipulation. The course also covers appropriate system design, implementation of a simple algorithm for flow simulation, mesh generation, and appropriate representation of scalar and vector fields using efficient algorithms.

Objective qualification

Based on the basic knowledge gained during their Bachelor studies, students acquire in-depth knowledge in object-oriented modeling and implementation of computational problems in the field of civil- and environmental engineering.

Learning objectives of the second part are more comprehensive knowledge in object-oriented design, dynamic data structures for the management of geometric objects and basics of computer graphics. This lecture is the second part of the course Modeling and Simulation 1. The final goal is to extend a 2D CAD system to an interactive flow simulator (based on the Lattice-Boltzmann method).

Literature

Vorlesungsunterlagen, weblinks

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Applied CFD Software Engineering	2,0	Lecture/Exercise	german
Applied CFD Software Engineering 2	2,0	Lecture/Exercise	german

Title	Computational Fluid Dynamics and High Performance Computing		
Number	3325000020	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Institut für rechnergestützte Modellierung im Bauingenieurwesen
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Martin Geier
Workload (h)	180 h		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Oral exam (approx. 60 Min.)		
Course achievement			
Contents			
Objective qualification			
Literature			
Vorlesungsunterlagen, weblinks			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture/Exercise	english german
	4,0	Lecture/Exercise	english

Title	Digital Building Modeling		
Number	3325000010	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Institut für rechnergestützte Modellierung im Bauingenieurwesen
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Martin Geier
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination	Written exam (60 Min.) or oral exam (approx. 30 Min.) and written exam (60 Min.) and PC-exercise A homework assignment (3 parts) is offered during the semester as voluntary coursework, which can count for 10% of the final examination grade if it is completed successfully. You will receive further information on the homework assignment in the course.		
Course achievement			

Contents

Motivation of continuous three-dimensional modeling, geometric algorithms, visualization techniques, three-dimensional design techniques, parametric modeling, introduction to product models, extension of product model data for process simulation and physical simulations, versioning. In the practical course, complex models are to be created on which the advantages of three-dimensional modeling become evident.

Objective qualification

Methodological Principles of BIM:

- Basic understanding of the structure and possibilities of modern CAD systems
- consistent three-dimensional modeling
- consistent and efficient derivation of 2D part models
- understanding of the possibilities and limitations of available product models
- Integration of CAD and product modeling
- Overcoming the idea of CAD as a tool for drawing
- Independent development and implementation of CAD software extensions

Fundamentals of geometric Algorithm:
Introduction to the object-oriented programming model using the Java programming language- This will enable students to independently implement object-oriented modeling and software engineering implementation of moderately complex simulation tasks.

Literature

Literatur zu Techniken und Aufbau moderner CAD-Systeme, multimediales Material, Beispielentwürfe

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Related courses			
Rules for the choice of courses			
Prerequisite for this course is a basic knowledge of object-oriented programming.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	3,0	Lecture/Exercise	german
	3,0	Lecture/Exercise	german

Title	Mathematics and Geometrics Modeling		
Number	4301870	**Module version**	V1
Shorttext		**Language**	english
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für rechnergestützte Modellierung im Bauingenieurwesen
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Martin Geier
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	2 Examinations (each 50%): • Geometrische Algorithmen: oral exam (approx. 30 Min.) • Einführung in Computeralgebrasysteme: oral exam (approx. 30 Min.)		
Course achievement			

Contents

Geometric Algorithms: Algorithmic Geometry deals with the design and analysis of algorithms for geometric problems for objects such as points, lines, polygons, etc. Furthermore, this includes basic algorithms from the field of interpolation methods and Bézier curves.

Functional programming, Euler-Lagrange Equation and its application to mechanical problems, solving differential equations, derivation of numerical methods

Objective qualification

Students gain knowledge of basic methods in computational geometry with respect to basic methods in computer graphics, geographic information systems, CAD, CAM, and mesh generation.
In Introduction to computer algebra, the students learn to manipulate algebraic expressions automatically. In particular, they learn to use the Euler-Lagrange-Equation to transform dynamical systems of arbitrary size to ordinary differential equations, to solve them and to visualize the result.

Literature

Skript, Benutzeranleitungen, weblinks

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture/Exercise	english
	2,0	Lecture/Exercise	english

Specialisation Sanitary Engineering

Title	Wastewater and Sludge Treatment		
Number	4398270	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Siedlungswasserwirtschaft
Hours per Week / ECTS	5 / 6,0	**Module owner**	Prof. Dr. Thomas Dockhorn
Workload (h)	180		
Class attendance (h)	70	**Self studying (h)**	110
Compulsory requirements			
Expected performance/ Type of examination	Written exam (120 Min.) or oral exam (approx. 60 Min.)		
Course achievement			

Contents

[Processes of Wastewater Treatment (VÜ)]
The class gives a comprehensive overview of wastewater treatment an introduces wastewater parameters (organic carbon compounds, nitrogen, phosphorus compounds, relevant toxic substances) and all major processes of wastewater treatment (mechanical wastewater treatment, biological wastewater treatment, activated sludge process, special treatment procedures e.g. biofiltration, membrane processes, SBR-reactors, chemical treatment processes e.g. precipitation and flocculation as well as aeration and gas exchange).
An additional tutorial discusses special topics in detail and presents calculation and dimensioning examples.

[Sewage Sludge Treatment and Disposal (VÜ)]
The class presents the entire process of sewage sludge treatment, starting with sludge production, sludge characteristics (physical, chemical, biological), various types of sludge stabilisation (aerobic/anaerobic), biogas utilization and sludge disinfection up to sludge disposal options, legal regulations and disposal costs. Special importance is given to questions of sludge reuse and nutrient recovery

Objective qualification

Students will gain detailed and comprehensive understanding of processes and objectives of municipal wastewater and sludge treatment. On the basis of their fundamental knowledge in sanitary engineering from prior studies, students acquire advanced engineering qualifications and scientific skills to understand, design and operate wastewater and sludge treatment plants. They will be able to dimension all treatment processes independently and will be able to carry out research and practical projects in the field of wastewater and sludge treatment. They will be able to critically discuss various process options and find adequate solutions taking into consideration environmental, social, scientific and ethical concerns

Literature

Lecture notes for both classes are available.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture/Exercise	german
	3,0	Lecture/Exercise	german

Title	Practical Lab Training and Dimensioning of Treatment Plants		
Number	4398280	**Module version**	4398280-E-FK3
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Siedlungswasserwirtschaft
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Thomas Dockhorn
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements	Prerequisite is prior participation in the module "Wastewater and Sludge Treatment"		
Recommended requirements	Students are expected to have a thorough knowledge of treatment processes for wastewater and sludge treatment in order to participate in this class.		
Expected performance/ Type of examination	The portfolio covers a detailed handout for each class, showing lab results and scientific discussion of the results or dimensioning drafts and scientific evaluation of the draft. Portfolios are design in independent teams under tuition of the lecturer. Lab results and scientific background will be presented to the class participants and the lab tutors in a final 30-minute seminar presentation. Grading will be based on participation during the lab days and on the quality of the presentation and on the corresponding student handout. Deregistration from the exam is possible up to wo weeks before the scheduled class participation. Dates for class presentations are scheduled in the first class meeting. The class Dimensioning and Design of Treatment Plants has a compulsory attendance of 16 hours (first class meeting, final class meeting). If students are absent with valid excuse (e.g. illness, child care etc.) individual solutions can be found for being able to complete the class successfully and still reach educational objectives of the class. Periods of absence may not exceed 15% of compulsory attendance, in order to reach educational objectives of the class. Practical Lab Training has a compulsory attendance of 40 hours (first class meeting, lab days, final class meeting). If students are absent with valid excuse (e.g. illness, child care etc.) individual solutions can be found for being able to complete the class successfully and still reach educational objectives of the class. Periods of absence may not exceed 15% of compulsory attendance, in order to reach educational objectives of the class.		
Course achievement			

Contents

[Dimensioning and Design of Treatment Plants (S)]
During the class, participants will work independently in student teams and will dimension the most important components of a wastewater treatment plant. Using the information and knowledge acquired in the prior classes on wastewater and sludge treatment as well as given dimensioning data, the students will design a wastewater treatment plant. Every other week meetings with the instructor and/or tutor will take place in order to discuss problems encountered during the work process. At the end of the semester each team will present its project to the class and discuss it with the participants and turn in a written report on the project work.

[Practical Lab Training on Wastewater Treatment (Ü)]
During the practical lab training, tutored lab experiments will be conducted in relation to current research projects of the institute (e.g. degradation experiments, precipitation/flocculation, respiration experiments, microscopic experiments, monitoring of experimental set-ups). Several tutored lab days will be arranged for conducting the experiments. Lab results and scientific background will be presented to the class participants in a final 30-minute seminar presentation. Grading will be based on participation during the lab days and on the quality of the presentation and on the corresponding student handout.

Objective qualification

Students are able to work independently in a research lab for wastewater and sludge treatment and discuss environmental engineering questions at a scientific level. They are able to independently acquire additional knowledge in the field of environmental engineering and can find solutions for wastewater problems at various levels. They are able to skillfully present their solutions to the public. A special focus in this seminar is on doing practical lab work, practicing teamwork, acquiring debate techniques and rhetorical skills and learning how to discuss controversial questions in a scientific setting.

Literature

Technical literature and additional information are available at the institute's library.

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Related courses

Rules for the choice of courses

Prior successful completion of the module 'Wastewater and Sludge Treatment' is pre-requisite for participating in this module. Students from other universities must have sufficient basic knowledge in the field of wastewater and sludge treatment.

Compulsory attendance

The class Dimensioning and Design of Treatment Plants has a compulsory attendance of 16 hours (first class meeting, final class meeting). If students are absent with valid excuse (e.g. illness, child care etc.) individual solutions can be found for being able to complete the class successfully and still reach educational objectives of the class. Periods of absence may not exceed 15% of compulsory attendance, in order to reach educational objectives of the class.

Practical Lab Training has a compulsory attendance of 40 hours (first class meeting, lab days, final class meeting). If students are absent with valid excuse (e.g. illness, child care etc.) individual solutions can be found for being able to complete the class successfully and still reach educational objectives of the class. Periods of absence may not exceed 15% of compulsory attendance, in order to reach educational objectives of the class.

Name of the course	SWS	Eventtype	Language
	2,0	Seminar	german
	2,0	Internship	german

Title	Drinking Water Treatment, Water Chemistry and Wastewater Discharge		
Number	4398290	**Module version**	
Shorttext	BAU-STD2-64	**Language**	german
Frequency of offer		**Teaching unit**	
Module duration	1	**Institution**	Institut für Siedlungswasserwirtschaft
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Thomas Dockhorn
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (120 Min.) or oral exam (approx. 60 Min.)		
Course achievement			

Contents

[Drinking Water Treatment]
The class introduces basic processes of drinking water treatment, legal regulations and drinking water standards. It presents treatment processes such as decarbonisation, flocculation, filtration, removal of iron and manganese, calcium carbonate equilibrium, processes for water softening, removal of organic compounds and water disinfection. The class also discusses world-wide problems concerning drinking water supply and treatment.

[Discharge of Municipal Wastewater (VÜ)]
The course presents a general introduction on various aspects of sewer systems. The class consists of three theoretical class meetings and two field trips. Class meetings cover the topics sewer net hydraulics, dimensioning of sewers, sewer inspection, pipes, pipe materials, separate and combined sewer systems. The field trips present the practical aspects such as manhole entry, sewer construction zones and an Oker boat tour in regard to drinking water aspects.

[Water Chemistry and Water Analytics (VÜ)]
The class covers basics of organic chemistry, characteristics of water, calculation and application examples for solubility and precipitation reactions, acid base equilibrium, sampling and sample preparation for environmental engineering questions, special chemical parameters for water and wastewater (sum parameters, rapid testing, standard analytics) and special instruments for water analytics (atomic absorption spectrometry, mass spectrometry, chromatography)

Objective qualification

[Drinking Water Treatment]
Students gain general knowledge of all questions concerning drinking water production, supply and treatment. They are able to dimension drinking water treatment plants. They understand world-wide concerns in regard to drinking water supply and treatment. They are able to critically discuss various treatment options and find adequate solutions taking into consideration social, scientific and ethical concerns.

[Discharge of Municipal Wastewater]
Students gain advanced knowledge of modern sewer systems and are able to analyse and understand hydraulic, topographic and operational correlations in a sewer system. They are able to design new

sewer systems and evaluate existing systems. They are able to critically discuss problems of wastewater discharge and find adequate solutions taking into consideration environmental, scientific and ethical concerns.

[Water Chemistry and Water Analytics]
Students will gain essential knowledge of general and inorganic chemistry and relevant problems in water chemistry. They will be able to understand the fundamental behavior of chemical elements and compounds, to solve stoiciometric calculations, to understand biochemical and chemical problems in water and wastewater treatment and find solutions for these problems.

Literature

Comprehensive lecture notes for ‘Drinking Water Treatment’ and ‘Water Chemistry and Water Analytics’ are available for download. Power point presentations for ‘Water Chemistry’ are also available for download. Technical literature and additional information for the class ‘Discharge of Municipal Wastewater’ is presented during the class.

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Related courses

Rules for the choice of courses

Two out of the tree offered classes must be selected. The course Water Chemistry and Analysis cannot be chosen in the Master's programme in Environmental Engineering.

Compulsory attendance

The class ‘Discharge of Municipal Wastewater’ has compulsory attendance (first class meeting, theoretical lectures, field trips). Participation in the theoretical lessons is pre-requisite to understand the problems presented in the field trips. If students are absent with valid excuse (e.g. illness, child care etc.) individual solutions can be found for being able to complete the class successfully and still reach educational objectives of the class. Periods of absence may not exceed 15% of compulsory attendance, in order to reach educational objectives of the class

Name of the course	SWS	Eventtype	Language
	2,0	Lecture/Exercise	german
Water Chemistry and Water Analytics	2,0	Lecture/Exercise	german
Drinking Water Treatment	2,0	Lecture/Exercise	german

Title	International Wastewater and Waste Management		
Number	4398310	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Siedlungswasserwirtschaft
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Thomas Dockhorn
Workload (h)	180		
Class attendance (h)	50	**Self studying (h)**	130
Compulsory requirements			
Recommended requirements	Prior successful completion of the module ‘Wastewater and Sludge Treatment’ or the module ‘Waste and Ressource Management’ is strongly recommended.		
Expected performance/ Type of examination	Portfolio and presentation		
Course achievement	Students will prepare a 30-minute presentation in teams. The information given in the lectures and in the student presentations are the basis for developing disposal concepts in team work at the end of the class. The portfolio covers a structured presentation of the team results for the developed disposal concepts. Portfolios are created by the teams under supervision of the institute’s assistants. It is possible to drop the class up to two weeks before the final group project. Organization of groups and assignment of research topics takes place in the first class meeting. This class has a compulsory attendance of 50 hours (first class meeting, student presentations, final group project). If students are absent with valid excuse (e.g. illness, child care etc.) individual solutions can be found for being able to complete the class successfully and still reach educational objectives of the class. Periods of absence may not exceed 15% of compulsory attendance, in order to reach educational objectives of the class.		

Contents

[International Wastewater and Waste Management (V)]
The class introduces the topic of waste and wastewater treatment in an international context by presenting various problems and solutions from developing and emerging countries. These lectures are the introduction, basis and preparation for the team work of the following seminar ‘Waste, Wastewater and Resource Management for Developing and Emerging Countries’.

[Waste, Wastewater and Resource Management for Developing and Emerging Countries (S)]
Participants will work independently in student teams and will develop a concept for the disposal of municipal waste and wastewater. Two locations in different parts of the world will be chosen each semester and students will establish a disposal concept for these locations taking into consideration specific legal, geographical, political and social conditions.
As preparatory work, teams of two students each will prepare a 30-minute presentation dealing with basic questions such as processes of wastewater and waste treatment, costs and planning of treatment plants, economy, infrastructure, culture and religion in the area and present their results to the class.

With this information, two teams (one for each location) will then develop a complete disposal concept as a group project during the 2-day block seminar at the end of the course. Finally, the developed concepts will be introduced to the class in a 30-minute presentation and will be discussed with the participants. A written report is required to complete the class.

Objective qualification

Students are able to understand and solve problems in the field of international wastewater and waste management. They will acquire fundamental knowledge for solving problems concerning waste and wastewater in developing and emerging countries taking into special consideration country-specific aspects. They will have the ability to adapt suitable concepts and technologies to given locations with special reference to globalization. Understanding material flow management and resource protection in a global context are a further teaching objective. Students are able to scientifically discuss engineering problems in a team and to acquire additional required knowledge independently. They are able to analyse and evaluate existing problems under consideration of country-specific aspects and are able to find and realize strategies for solving these problems under given local conditions (regional governance). They are able to skillfully present their solutions to the public. A special focus in this seminar is on practicing teamwork, acquiring debate techniques and rhetorical skills and learning how to discuss controversial questions in a scientific setting.

Literature

Die relevante Fachliteratur kann je nach Aufgabenstellung variieren. Die erforderliche Literatur steht den Studierenden in
der Institutsbibliothek zur Verfügung.

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Related courses

Rules for the choice of courses

Prior successful completion of the module ‘Wastewater and Sludge Treatment’ or the module ‘Waste and Ressource Management’ is strongly recommended.
This module is only availabe to students specializing in Sanitary and Environmental Engineering or Waste Management. Number of participants is limited to max. 40 participants.

Compulsory attendance

This class has a compulsory attendance of 50 hours (first class meeting, student presentations, final group project). If students are absent with valid excuse (e.g. illness, child care etc.) individual solutions can be found for being able to complete the class successfully and still reach educational objectives of the class. Periods of absence may not exceed 15% of compulsory attendance, in order to reach educational objectives of the class.

Name of the course	SWS	Eventtype	Language
	1,0	Lecture	german
	3,0	Seminar	german

Title	Basics of Environmental and Resource Protection		
Number	4306640	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Siedlungswasserwirtschaft
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Thomas Dockhorn
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (120 Min.) or oral exam (approx. 60 Min.)		
Course achievement			

Contents

[Basic Natural Sciences for Environmental and Resource Protection (V)]
The class covers advanced questions of biological, chemical and physical processes as well as engineering fundamentals for technical resource and environment protection. Material flow cycles, resource economy and alternative treatment concepts are also part of the course.

[Eco-Balancing (VÜ)]
The class teaches methods and procedures for creating eco-balances, offers tutored case studies for creating eco-balances and discusses the special aspects of eco-balancing in the field of waste management.

Objective qualification

Students will gain essential knowledge and skills for understanding scientific and technical basics of environmental and resource protection. They will have advanced knowledge of biological, chemical and physical processes as well as engineering fundamentals for resource and environment protection (material flow cycles, resource economy, alternative treatment concepts). They will be able to create mass balances as well as eco-balances and thus will be able to critically discuss environmental impacts and resource efficiencies of various measures and products. They will be able to evaluate measures in regard to environmental impact taking into consideration social, scientific and ethical questions. They will be able to use eco-balances to understand and scientifically assess environmentally relevant problems and thus be able to support the implementation of environmental targets.

Literature

Used power point presentations are available as download

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Scientific and technical fundamentals of environmental and resource protection	2,0	Lecture	german
	2,0	Lecture/Exercise	german

Specialisation Track-Guided Transportation Systems

Title	Service Planning and Transport Strategies for Railways		
Number	4302050	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Planung des öffentlichen Verkehrs
Hours per Week / ECTS	4 / 6,0	**Module owner**	Alejandro Tirachini
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Oral Exam (30min) (in the Master's programme in Social Sciences as a course achievement)		
Course achievement			

Contents
-Transport Policy -Transport economics -Track problems -Transport planning in passenger and freight transport -Supply strategies in passenger and freight transport
Objective qualification
Students learn about the political environment and the market aspects of rail transport. Under these boundary conditions, the supply planning and the transport strategies of both freight and passenger transport are taught. After completing the module, the students are able to take a differentiated look at the different forms of rail transport.
Literature
Vorlesungsskript

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	**SWS**	**Eventtype**	**Language**

	4,0	Lecture/Exercise	german

Title	Planning a Construction Site on Railway Infrastructure		
Number	4398840	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Planung des öffentlichen Verkehrs
Hours per Week / ECTS	4 / 6,0	**Module owner**	Alejandro Tirachini
Workload (h)	180		
Class attendance (h)	54	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	2 Examinations: • Written exam (60 Min.) • Presentation		
Course achievement			

Contents

Railway construction in the conflict field of driving and building (V)
The students are taught the requirements for construction process planning. Each focal point is worked out using concrete projects as examples.

Planning a construction site on railway infrastructure (Ü)
Students learn how to use the SOG software to plan the construction process. The acquired skills are applied to an example within the framework of group work. For this purpose, a written copy is to be prepared and the results are to be presented in the context of a lecture.

Objective qualification

The students acquire a basic understanding of the boundary conditions from spatial planning and environmental protection, for the requirements of the different types of railway traffic and stakeholders, for the service phases in railway construction and for the interaction of the trades on a railway construction site. In addition, they gain an overview of the BIM method and its possible application in railway projects.
They acquire knowledge about maintenance strategies and the service life of superstructure components and can transfer these appropriately to new situations.
The students are able to draw up the necessary specifications for simple construction planning for individual trades, taking into account LCC considerations, and to carry out quantity and cost calculations for this. The necessary construction sequence planning and construction site logistics can be developed taking into account the standard timetable in the conflict field of driving and construction.

Literature

Scripts

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Railway construction within the conflict between maintenance and traffic	2,0	Lecture	german
Planning a Construction Site on Railway Infrastructure	2,0	Exercise	german

Title	Railway Operation		
Number	4310610	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Eisenbahnwesen und Verkehrssicherung
Hours per Week / ECTS	5 / 6,0	**Module owner**	Prof. Dr. Jörn Pachl
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (60 Min.) or oral exam (approx. 30 Min.)		
Course achievement	Termpaper (approx. 30 h workload)		

Contents

- Basic operating terms and definitions
- Capacity research (capacity evaluation, analytical methods, simulation)
- Timetabling (traffic diagrams, time elements, running time calculation, planning of conflict-free train paths, cyclic timetables)
- Train path management (market structure, train path pricing, facility prices, station stop prices, train path requesting and assigning procedure)
- Traffic control (employees in traffic control, train movements in normal and degraded mode operations, shunting)
- Marshalling yards (purpose and structure of a marshalling yard, sorting procedure, hump dynamics, retarders)

Objective qualification

The students get profound knowledge on planning, management and control of train traffic. As employees of railway infrastructure companies or consulting firms, they are able to evaluate the operational capacity of the railway infrastructure, to select appropriate operational procedures, and to develop timetable concepts. They can take job positions in timetabling train path management and in supervision of train traffic control. They can also work in teams for the operational planning of construction and maintenance works. The students are familiar with the application of IT tools for capacity research and timetabling. They have the ability to evaluate the operational performance of railway lines and nodes under consideration of the constraints resulting from the infrastructure, and from signalling and vehicle constraints.

Literature

-Pachl, J.: Systemtechnik des Schienenverkehrs. 9. Aufl.,
-Vieweg Springer, Wiesbaden 2018, in der LV verteilte Materialien

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	5,0	Lecture/Exercise	german

Title	Railway Signalling		
Number	4310630	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Eisenbahnwesen und Verkehrssicherung
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Jörn Pachl
Workload (h)			
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (60 Min.) or oral exam (approx. 30 Min.)		
Course achievement	Term paper (approx. 30 h workload)		

Contents

- Relevant operational terms and definitions
- Systems safety criteria (classification of failures, human factors, safety strategies)
- Trackside elements controlled by signalling systems (lineside signals, points and crossings, line clear detection)
- Block systems (manual block systems, automatic block systems)
- Interlocking (route locking and release, flank protection, overlaps, interlocking systems)
- Automatic train protection (intermittent and continuous ATP, PZB 90, LZB , ETCS)
- Level crossings

Objective qualification

The students get a profound understanding of the fundamental elements and principles of railway signalling systems. As employees of railway infrastructure companies or engineering firms, they can select appropriate signalling technologies for a given use case and support the signal planning. As employees of a signalling manufacturing company, they can give advice to customers of how to apply signalling technology on their lines. Together with engineers of other trades, they can work in research & development teams of the signalling industry

Literature

-Maschek, U.: Sicherung des Schienenverkehrs - Grundlagen und Planung der Leit- und Sicherungstechnik, Springer
Vieweg, Wiesbaden 2012
-Pachl, J.: Systemtechnik des Schienenverkehrs, 9. Aufl., Vieweg Springer, Wiesbaden 2018
-Theeg, G.; Vlasenko, S. (Hrsg).: Railway Signalling & Interlocking - International Compendium, Eurailpress, Hamburg
2009
-Naumann, P.; Pachl, J.: Leit- und Sicherungstechnik - Fachlexikon, 2. Aufl., Tetzlaff Verlag, Hamburg 2004

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	5,0	Lecture/Exercise	german

Title	Railway Operation Research and Traffic Management		
Number	4398070	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Planung des öffentlichen Verkehrs
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Thomas Siefer
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	oral exam (approx. 30 Min.) and term paper		
Course achievement			

Contents

- Timetable design and path management
- Investigation methods for railway installations
- Basics of modern operational investigations
- Determination of the performance of railway lines
- Determination of the performance of route nodes
- Macroscopic models
- Calculation of running time
- Railway operation simulation basics
- Vehicle scheduling/Vehicle circulation planning

Objective qualification

Students will be able to construct a timetable and apply performance investigation methods. Students will be able to build railway operational simulation models and distinguish disposition methods. The handling of the programme system RailSys® is mastered by the students.

Literature

-Radtke: EDV-Verfahren zur Modellierung des Eisenbahnbetriebs
-Pachl: Railway Operation and Control
-Hansen, Pachl et. al.: Railway Timetable and Traffic

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	german

Title	Development Process of Railway Safety Systems		
Number	4310620	**Module version**	
Shorttext		**Language**	german
Frequency of offer		**Teaching unit**	
Module duration	1	**Institution**	Institut für Eisenbahnwesen und Verkehrssicherung
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Jörn Pachl
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Contents			
Objective qualification			
Literature			
Wird in der Lehrveranstaltung verteilt.			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	german

Title	Design of Railway Infrastructure		
Number	4310600	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Eisenbahnwesen und Verkehrssicherung
Hours per Week / ECTS	7 / 6,0	**Module owner**	Prof. Dr. Jörn Pachl
Workload (h)			
Class attendance (h)	70	**Self studying (h)**	110
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Contents			
Objective qualification			
Literature			
Wird in der Lehrveranstaltung bekanntgegeben.			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	5,0	Lecture/Exercise	german
	2,0	Exercise	german

Title	International Railway Operation and ETCS		
Number	4310140	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Eisenbahnwesen und Verkehrssicherung
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Jörn Pachl
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (60 Min.) or oral exam (30 Min.)		
Course achievement			

Contents

- Historical background
- Differences in basic definitions
- Forein block working methods
- Foreign interlocking principles
- Signal aspects used abroad
- European Train Control System

Objective qualification

By having learned about characteristic operational and signaling features, in which foreign railways differ from the German principles and rules, the students will be able to identify relevant features in international projects, evaluate the relevance of these features and judge about the chances to overcome differences by harmonization. As a central project to improve interoperability across Europe, the students will get profound knowledge on the functionalities of the European Train Control System (ETCS).

Literature

Vorlesungsskript, Pachl, J.: Systemtechnik des Schienenverkehrs. 9. Aufl.,Springer Vieweg, Wiesbaden 2018; weiteres Material wird in der LV verteilt

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	german

Title	Computer Aided Design of Railway Infrastructure		
Number	4310640	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Eisenbahnwesen und Verkehrssicherung
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Jörn Pachl
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Contents			
Objective qualification			
Literature			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	german

Title	Railway Signalling Principles		
Number	4310900	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	Fakultät Architektur, Bauingenieurwesen und Umweltwissenschaften
Module duration	1	**Institution**	Institut für Eisenbahnwesen und Verkehrssicherung
Hours per Week / ECTS	5 / 6,0	**Module owner**	Prof. Dr. Jörn Pachl
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	written exam (60 min) or oral examination (30 min)		
Course achievement	homework (workload about 30 h)		

Contents

- Basic terms and definitions
- Trackside elements controlled by signalling systems (lineside signals, points and crossings, line clear detection)
- Principles of train separation (non signal-controlled operation, signalled fixed block operation)
- Block systems (manual block systems, automatic block systems)
- Interlocking principles (Point Locking, Route Locking, Conflicting Routes, Flank Protection, Overlaps)
- Interlocking systems (tabular interlocking, geographical interlocking)
- Automatic train protection principles (intermittent and continuous ATP, examples of conventional systems)
- European Train Control System (ETCS as part of ERTMS, ETCS levels and modes, speed and movement authority supervision)

Objective qualification

The students get a profound understanding of the fundamental elements and principles of railway signalling systems. They will be able to apply that knowledge to the specific conditions of individual national railway systems. Under guidance of experienced signal engineers, they may start a career in signal planning or in signalling systems development. For jobs in railway operations, this module provides valuable background knowledge on the impact of signalling systems on operational capacity and traffic control procedures.

In contrast to the German module Bahnsicherungstechnik, the module Railway Signalling Principles is less focussed on the German rules. Instead, it describes fundamental principles to be found in railway signalling worldwide.

Literature

-Pachl, J.: Railway Operation and Control. 3rd ed. (2013)
-Theeg, G.; Vlasenko, S.: Railway Signalling & Interlocking International Compendium. 2nd ed. (2017)

-Stanley, ETCS for Engineers (2011)

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Related courses			
Rules for the choice of courses			
Can only be selected as a replacement of the module Bahnsicherungstechnik Requires basic knowledge in the railway domain			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	5,0	Lecture/Exercise	english

Specialisation Steel Constructions

Title	Fundamentals of Steel Structures		
Number	4313030	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Stahlbau
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Klaus Thiele
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination	Written exam (120 Min.) or oral exam (approx. 45 Min.)		
Course achievement			

Contents

St. Venant's torsion theory and warping torsion for open and closed cross-sections; branching and ultimate load problems for bars and plates, bending torsional buckling, plate buckling, code regulations; fundamentals of fatigue, damage accumulation, service life prediction for deterministic actions; performance of tests on steel components (dye penetrant method, magnetic particle testing, potential probe,
hardness measurement, coating thickness measurement, tensile test).

Objective qualification

Students will have in-depth knowledge of torsion theory and stability theory. Students will be able to assess, design and calculate steel structures under compressive and/or torsional loading. The essential code regulations are also taught.
In the subject Service-Life and Fatigue I, students acquire basic knowledge of the design of steel components under cyclic loading. Students are enabled to perform simple fatigue analyses for steel structures. The essential code regulations are known.
In the laboratory practical course, students acquire knowledge of simple testing methods for steel components, component testing with non-destructive testing methods (dye penetrant testing, magnetic particle testing, potential probe, hardness measurement, coating thickness measurement).
Students will be able to assess the properties of existing steel structures.

Literature

A detailed script with all contents from the lectures is available.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	1,0	Lecture	german
	1,0	Lecture	german
	3,0	Lecture/Exercise	german
	1,0	Lecture/Exercise	german

Title	Steel Building Design		
Number	4310070	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	2	**Institution**	Institut für Stahlbau
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Klaus Thiele
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination	6 presentations in colloquium Attendance is mandatory in the presentations		
Course achievement			

Contents

In the context of this lecture, it is not so much methods and procedures for designing, but rather ways of thinking that are in the focus. Thus one's own creative thinking in designing and constructing is stimulated. 3 such papers (presentations) are to be completed per semester.

Objective qualification

Students develop the ability to solve design tasks from various areas of steel construction. In doing so, they learn to recognize the aspects that are essential for load-bearing behavior and manufacturability and to design with rough but sufficient accuracy. They learn to present their results in sketches, to present them orally and to discuss and defend them in an appropriate and constructive manner.

Literature

A detailed script with all contents from the lectures is available.

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	3,0	Seminar	german
	3,0	Lecture	german

Title	Examples of Steel Structures and Special Issues		
Number	4310050	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	2	**Institution**	Institut für Stahlbau
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Klaus Thiele
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination	Written exam (120 Min.) or oral exam (approx. 60 Min.)		
Course achievement			

Contents

Mechanical and physical properties of glass and stainless steel. Special design features in the use of glass and stainless steel, introduction to the technical regulations for the use of glass and stainless steel;
Verification concepts for load-bearing capacity and serviceability of thin-walled steel structures. Utilization of supercritical load reserves, ("effective areas", "tensile models", etc.);
Applications of steel in hydraulic steel structures, design fundamentals, structural systems sealing problems;
Properties of natural wind, theory of aeroelastic vibration phenomena such as galloping and flutter. Basic dynamic information such as natural frequency, natural mode and damping of vibrating structures.
Main support systems and cross sections of bridge structures, bearings and support and erection issues of steel and composite bridge structures.
Crane runways, towers and masts.
Fabrication of steel structures, welding of steel structures, fabrication lines.
Design and calculation of cable structures
Discussion of real cases of damage in steel structures.
In-depth proofs in the field of fatigue of steel structures and introduction to fracture mechanics.

Objective qualification

In the subject Building with Glass and Stainless Steel, students acquire basic knowledge of the use and construction with the materials glass and stainless steel. They are enabled to design and calculate simple constructions made of glass or stainless steel. The essential code regulations are also taught.
In the subject of light steel construction, the fundamentals for the calculation of extremely thin-walled construction elements are taught. Students are enabled to design and calculate thin-walled steel structures. The essential code regulations are also taught.
In the subject of hydraulic steel structures, students acquire knowledge of typical structures from the field of hydraulic steel structures. Students will be able to design and calculate hydraulic steel structures. The essential code regulations are also taught.
In the subject of wind engineering and structural dynamics, the properties of natural wind are dealt with. Students learn to correctly assess vibration phenomena.
In the subject Special Structures in Steel Construction, students acquire knowledge of special steel structures. The topic is selected from topics such as crane runways, silo and tank structures or towers and masts.

In the subject Cable Structures, students acquire in-depth knowledge of construction with cables, including steel cast elements. The students are enabled to calculate constructions with ropes and / or cast components. The essential code regulations are also taught.
In the subject Fabrication of Steel Structures, students acquire knowledge about the fabrication of steel structures.
In the subject Steel Bridge Construction, students acquire in-depth knowledge of steel and composite bridge construction. Students are enabled to design and calculate simple bridge structures made of steel or steel composite. The essential code regulations are also taught.
In the seminar Failure of Structures, real damage cases are discussed.
In the subject Service-Life and Fatigue 2, students acquire in-depth knowledge of the design of steel components under cyclic loading. Basic knowledge of fracture mechanics is taught. The students will be able to carry out complex fatigue analyses for steel structures and simple analyses using fracture mechanics. The essential standard regulations are also taught.

Literature

A detailed script with all contents from the lectures is available.

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	1,0	Lecture	german
	1,0	Lecture	german
	1,0	Lecture	german
	1,0	Lecture	german
	1,0	Lecture	german

Title			
Number	3313000000	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät Architektur, Bauingenieurwesen und Umweltwissenschaften
Module duration	1	**Institution**	
Hours per Week / ECTS	6 / 6,0	**Module owner**	
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Contents			
Objective qualification			
Literature			
Es stehen ausführliche Skripte/Vorlesungsfoliensätze mit umfangreichen weiterführenden Literaturhinweisen in allen Fächern zur Verfügung			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	3,0	Block course	german
	3,0	Lecture	german

Specialisation Structural Analysis

Title	Fundamentals of Finite Element Methods		
Number	4312080	**Module version**	V1
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	2	**Institution**	Institut für Statik und Dynamik
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Ursula Kowalsky
Workload (h)	180 h		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination	Written exam (60 Min.)		
Course achievement	Projekt		

Contents
matrix-vector notation, numerical integration, solving systems of equations; governing differential equations, principle of virtual displacements, shape functions, criteria of convergency, element matrices for frame works, rectangular and triangular elements for heat conduction, potential and seepage flow, exercises for given examples, comparison of approximate solutions for different modelling and discretizations, lab experience with Ansys
Objective qualification
The students are able to discretize the related governing equations for a given construction, to include the boundary conditions, to interprete the results and to evaluate the convergency
Literature
A detailed script is available

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Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture/Exercise	german

LAB Fundamentals of FEM	1,0	Seminar	german

Title	Modeling and Numerical Analysis of Frame Structures		
Number	4312040	**Module version**	V1
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Statik und Dynamik
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Ursula Kowalsky
Workload (h)	180 h		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (60 Min.) or oral exam (approx. 30 Min.) Portfolio (20% of the overall grade)		
Course achievement			

Contents

matrix-vector computational analysis for plane and spatial frameworks, theory of 2nd order for continuous beam structures and frameworks; consideration of bedding and shear deformations, arches, girder grids, cable nets, soil-structure interaction, stiffening concepts; numerical methods based on governing equations, e.g. finite difference schemes, weighted residuals, energy principles, exercises and lab experience, home work

Objective qualification

Students are able to choose an appropriate structural model for a given construction and to compute the related state variables. They are able to analyse the load-bearing behaviour with adequate accuracy by means of the gained knowledge with respect to numerical methods.

Literature

A detailed script of approx. 100 pages

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	4,0	Lecture/Exercise	german

Title	Thinwalled Structures		
Number	4312050	**Module version**	V1
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Statik und Dynamik
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Ursula Kowalsky
Workload (h)	180 h		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (60 Min.) or oral exam (approx. 30 Min.) Portfolio: 20% of the overall grade		
Course achievement			

Contents

Governing equations and load-bearing behaviour for plane stress structures, influence of boundary conditions, principle stress trajectories, and dimensioning, plane strain states, generalization to spatial and rotationally symmetric structures; governing equations and load-bearing behaviour of Kirchhoff and Reissner-Mindlin plates respectively; principle moments and dimensioning, influence of boundary conditions, orthotropic plates; circular plates; governing equations and load-bearing behaviour of rotationally symmetric shells, membrane and bending theory, generalization to non-symmetric states, exercises and lab experience, home work

Objective qualification

Students are able to choose appropriate structural models to describe plane and curved 2D structures and to compute the related state variables. They are able to analyse the load-bearing behaviour by means of the gained knowledge.

Literature

A detailed Script of approx. 100 pages is available.

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	4,0	Lecture/Exercise	german

Title	Advanced Structural Analysis		
Number	4398770	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Statik und Dynamik
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Ursula Kowalsky
Workload (h)	180 h		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Recommended requirements	Basic knowledge of the Module "Introduction to Finite Element Methods " is expected		
Expected performance/ Type of examination	2 examinations: 2 portfolios (each 50%)		
Course achievement			
Contents			
Advanced FEM, Membrane Structures, Fluid-Structure Interaction, Particle Methods			
Objective qualification			
Students are able to develop complex structural mechanics models, to perform related numerical analyses and to evaluate the results.			
Literature			

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Related courses			
Rules for the choice of courses			
Two of the four lectures must be chosen			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture/Exercise	english
	2,0	Lecture/Exercise	english
	2,0	Lecture/Exercise	english
	2,0	Lecture/Exercise	english

Title	Structural Dynamics		
Number	4306100	**Module version**	V1
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	2	**Institution**	Institut für Statik und Dynamik
Hours per Week / ECTS	5 / 6,0	**Module owner**	Prof. Dr. Ursula Kowalsky
Workload (h)	180 h		
Class attendance (h)	70	**Self studying (h)**	110
Compulsory requirements			
Expected performance/ Type of examination	[Strukturdynamik 1]; 3/6 LP Written exam (60 Min.) [Strukturdynamik 2]; 3/6 LP Written exam (60 Min.) or Written exam (120 Min.) or oral exam (approx. 30 Min.)		
Course achievement	2 term papers		

Contents

[Strukturdynamik 1 (VÜ)]
periodic and non-periodic vibrations; modelling concerning rigid body systems and frame works; generating equations of motion: synthetic and analytic methods; linearization and solution of equations of motion; free and forced vibrations; home work

[Strukturdynamik 2 (VÜ)]
equations of motion concerning multi-mass oscillators with arbitrary degrees of freedom, modal analysis, modal synthesis, reduction methods, complex representations, earthquake excitation, home work

Objective qualification

The students are able to set up an engineering model for selected structures and to perform a vibration analysis. They can evaluate the results as well as are able to show possible modifications.

Literature

A detailed Textbook is available

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture/Exercise	german
	3,0	Lecture/Exercise	german

Title	Structural Dynamics - Application		
Number	4310940	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Statik und Dynamik
Hours per Week / ECTS	3 / 6,0	**Module owner**	Prof. Dr. Ursula Kowalsky
Workload (h)	180 h		
Class attendance (h)	42	**Self studying (h)**	138
Compulsory requirements	Prerequisite is prior participation in the module "Structural Dynamics"		
Expected performance/ Type of examination	Term paper		
Course achievement			
Contents			
Constructions excited by earthquakes and wind, pedestrian bridges, railway bridges, wind turbines.			
Objective qualification			
Students are able to analyse and to evaluate the vibration behaviour of selected civil engineering structures.			
Literature			
A detailed textbook is available.			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	3,0	Seminar	german

Specialisation Pavement Engineering

Title			
Number	3320000010	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Straßenwesen
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Michael Wistuba
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			

Contents

[Bituminous binders (VÜ)]

The binder in asphalt mixtures, the main construction material in road infrastructure, is bitumen. Its properties (temperature behavior, aging, adhesion behavior, reuse) are carefully tested in the laboratory because they have a significant influence on the performance of asphalt mixtures. In this course, rheological test methods are presented that are used in modern asphalt mixture technology and serve to increase the sustainability of asphalt mixtures. With their help, it is possible to assess alternative bituminous binders (e.g. bio-asphalt) and/or additive binders with regard to their effect on the road, e.g. with regard to increasing durability, the regenerative effect in asphalt mixture recycling or the reduction of environmental pollution.

[Performance of asphalt mixtures (VÜ)]

In this course, the requirements for the road structure (such as skid resistance, crack and resistance to permanent deformation, ageing resistance) are defined and suitable mechanical laboratory test methods are presented. In particular, it is shown how a specific asphalt mixture can be systematically tested in the laboratory on the basis of the performance properties of the composed and compacted asphalt mixture. Optimization conflicts with regard to the requirements are presented and possibilities for reacting to them in the best possible way through targeted formulation and design of the asphalt mixture composition.

[Road construction laboratory course (P)]

In the course, students carry out selected tests in the institute's own laboratory. For example, soil parameters are determined under supervision (density, water content, compaction), tests are carried out to determine the condition in situ (load-bearing capacity, evenness, skid resistance) and specimens are produced by a supervisor from rolled and mastic asphalt mixtures, the composition and characteristic values of which are then checked in the laboratory.

Objective qualification
Students gain in-depth knowledge of asphalt technology in order to understand the complex optimization process in the design of asphalt mixes and to carry out systematic testing in the laboratory, taking into account all performance properties. They will be able to carry out fundamental and rheological laboratory tests to determine the mechanical properties of construction materials and interpret the results correctly. Using selected material models, they will become familiar with the tools for predicting the performance of road construction materials in order to evaluate the effectiveness and quality of different types of construction materials. This is of particular interest against the background of the further development of sustainable road construction technology. They will then be able to critically evaluate existing asphalt construction methods and contribute to the development of new asphalt construction methods. In addition, they are qualified to promote the reuse of reclaimed asphalt at a high value-added level. Students also learn how to produce and test typical road construction test specimens. They will be able to estimate the costs and benefits of standard test procedures and correctly evaluate and interpret test results. They acquire in-depth theoretical and practical knowledge of the methods used to test the suitability and quality of raw materials, building material mixtures and additives, as well as the technical implementation of asphalt recycling.
Literature
Richtlinien und Empfehlungen Vorlesungsskripte

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Bituminous binders	2,0	Lecture/Exercise	german
Performance of asphalt mixtures	2,0	Lecture/Exercise	german
Road construction laboratory course	2,0	Internship	german

Title			
Number	3320000030	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Straßenwesen
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Michael Wistuba
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			

Contents

[Road planning and design (VÜ)

In this course, road planning is presented from the determination of the need for the construction of a road to its implementation. The planning process, the planning levels with their different levels of detail, environmental concerns, public participation, legal issues, the financing of public roads, the planning design of junctions and intersections, proof of traffic quality as well as economic efficiency and life cycle analysis are discussed.

[Computer-supported dimensioning and design of roads (VÜ)]

This course teaches the fundamentals of the structural design of road pavements and the computational dimensioning. The main focus is on highly loaded roads and flexible (asphalt) and rigid construction methods (cement concrete). The model representation of the layer structure, the time and load-dependent behavior of the construction material, the bonding of the layers and the load-bearing behavior of the subsoil are explained. The course also demonstrates practical planning and design work on a specific road construction project using the VESTRA CAD road planning program. It begins with the three-dimensional site survey, after which all planning tasks relating to the alignment, gradient and cross-section design are processed and solved with computer support.

[Digitalization in the road sector (VÜ)]

The course "Digitalization in the road sector" provides basic knowledge and practical methods for digital transformation in the field of road infrastructure. The focus is on current technologies and strategies that are used to optimize the planning, construction, operation and maintenance of roads. Students are introduced to the challenges and potentials of digitalization and learn how digital systems and smart technology approaches can change traditional work processes in the transport and road sector in the long term. This includes, for example, sensor technologies for condition monitoring (Pavement Monitoring System) or the methods of Building Information Modeling (BIM) in the planning of infrastructure projects.

Objective qualification

The qualification objective is the independent planning of road projects from project initiation, variant planning, dimensioning of the road structure, structural design through to the preparation of tender documents including the documentation of technical and economic decisions. Students understand the holistic plan-

ning process in its individual planning stages (preliminary planning, design planning, approval planning) and recognize the legal, financial and environmental framework conditions of public road projects. On the basis of a realistic example of a road project, students combine their specialist knowledge with application, creating specifications, cost and schedule plans, variant studies and tender documents. They take into account economic, ecological and social criteria as well as the contents of a life cycle analysis. In the area of structural design and computational dimensioning, they are proficient in the modeling and dimensioning of multi-layer road structures, can apply building material and load-bearing behavior models and are proficient in the use of planning software (e.g. VESTRA CAD). They can create terrain models, develop route variants and optimize gradient and cross-section constructions with the aid of computers. The project-oriented group work sharpens their team and communication skills and prepares them to work on road projects independently and in a solution-oriented manner.

Literature
Richtlinien und Empfehlungen Vorlesungsskripte

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture/Exercise	german
	2,0	Lecture/Exercise	german
	2,0	Exercise	german

Title			
Number	3320000020	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Straßenwesen
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Michael Wistuba
Workload (h)	180		
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			

Contents

[Road construction materials (VÜ)]

The course begins with the question of the requirements for road construction materials (skid resistance, crack resistance, ageing resistance) and then explains how these can be met through the targeted selection, formulation and mix design of construction materials. The quality of aggregates, binders and construction material mixtures, binder modification, reuse of construction materials, determination of the layer structure and prediction of the service life of road pavements are discussed in more detail.

[Road construction technology (VÜ)]

The course deals with the technical handling and implementation of road construction projects. The transportation, paving and quality assurance of road pavements are dealt with in a practical manner. Road maintenance is then discussed. The methods for recording and assessing the condition of surface and layer properties, structural and operational road maintenance (especially winter road maintenance) and the recovery and reuse of road construction materials are explained in detail. Numerous application examples are used to prepare students for construction site-related and operational issues in road construction.

[Road construction technology in practice VÜ)]

Using selected examples from the design and production of building materials and building material components, from road construction and from the testing of new/innovative construction equipment or construction methods, the course offers an insight into the current and future practice of road construction technology. This is supported by excursions and specialist lectures by people from the construction industry.

Objective qualification

Students learn that the sustainability of road constructions depends largely on the formulation of the construction material mixtures and their composition to form a layered load-bearing system. They will be able to assess the basic suitability of building materials for road construction, for example, to recognize rocks for road construction or to interpret the quality of bituminous binders on the basis of results from laboratory tests. Students learn how to produce and test typical road construction specimens. They will be able to estimate the costs and benefits of standard test methods and correctly evaluate and interpret test results. They will acquire in-depth theoretical and practical knowledge of the methods used to test the suitability and quality of raw materials, construction material mixtures and additives as well as the technical implementation of

asphalt recycling. Students also gain in-depth knowledge of the life cycle of road constructions, starting with the delivery of construction materials, through installation and use, to reuse.

Literature

Richtlinien und Empfehlungen

Vorlesungsskripte

↑

Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
Road Construction Materials	2,0	Lecture/Exercise	german
Road Construction Technology	2,0	Lecture/Exercise	german
Road Construction Technology in Practice	2,0	Lecture/Exercise	german

Title			
Number	3320000000	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Straßenwesen
Hours per Week / ECTS	2 / 6,0	**Module owner**	Prof. Dr. Michael Wistuba
Workload (h)	180		
Class attendance (h)	28	**Self studying (h)**	152
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			

Contents

The seminar provides insight into research in the field of road pavement engineering in general (including topics, boundary conditions, internationality, interdisciplinarity, scientific language) and imparts knowledge of scientific working methods in the subject area. Students work independently on a sub-question within one of the research topics by studying sources, write a short paper on the topic and give a short presentation. In this way, they are introduced to scientific work and acquire essential core competencies for a targeted, methodologically sound and comprehensible preparation and summary of selected research topics as preparation for independent scientific work and publication (e.g. also as part of a dissertation).

Objective qualification

Students gain insight into current international research in the field of road pavement engineering (in particular asphalt technology, testing, rheological modeling) and are enabled to grasp the state of the art in selected specific questions from the field of research, to critically analyze it using scientific methods and to formulate new research questions.

Literature

International Journal Papers

Richtlinien und Empfehlungen

Vorlesungsskripte

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
		Seminar	english

Specialisation Transport and Urban Planning

Title	Transport Planning		
Number	4318020	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Verkehr und Stadtbauwesen
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Bernhard Friedrich
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 Min.) or oral exam (30 Min.)		
Course achievement	Homework assignment		

Contents

[Verkehrsplanung (VÜ)]
- Introduction to transport planning
- Planning Methodology
- Behavioural traffic surveys
- Planning of transport networks
- Planning of measures in public transport (external lecturer from the field)
- Decision models
- Traffic models (traffic generation, traffic distribution, traffic allocation)
- Impact models and evaluation procedures
- Traffic safety

Objective qualification

The students gain an overview of the characteristics of mobility, the socio-economic significance of transport that can be derived from this and the resulting legal anchoring of spatial and transport planning. Based on the understanding of the problems and tasks of transport planning, the planning methodology and the instruments of transport network planning in public transport and individual transport are introduced. In this context, the students get to know the requirements of the German guidelines in transport planning and can apply them to planning tasks. Through the in-depth examination of the theory and practice of transport demand modelling, the students are enabled to carry out own planning studies and to quantitatively evaluate planning alternatives. They are thus qualified to make reliable recommendations for the development of the transport infrastructure.

Literature

vgl. Vorlesung

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	german

Title	Research Seminar Traffic Planning and Traffic Engineering		
Number	4398080	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Verkehr und Stadtbauwesen
Hours per Week / ECTS	2 / 6,0	**Module owner**	Prof. Dr. Bernhard Friedrich
Workload (h)	180		
Class attendance (h)	28	**Self studying (h)**	152
Compulsory requirements			
Expected performance/ Type of examination	Presentation		
Course achievement			

Contents

In this seminar, specific questions from the research fields of traffic planning and traffic engineering are dealt with on changing topics. The seminar topics are embedded in the current research work or research content of the Institute of Transport and Urban Engineering. The students gain an insight into current research topics in traffic planning and traffic engineering and have the opportunity to actively participate and shape them.

- introduction, discussion of research topics
- presentation and discussion of first ideas for individual research questions
- literature review methods -overview to methods
- literature review methods -exercise
- intro on how to write a scientific paper
- development and formulation of own, individual research questions
- preparation of a short scientific paper on the individual research topic
- presentation and discussion of individual research questions

Objective qualification

The seminar imparts knowledge in the planning and implementation of research projects and gives an in-depth insight into scientific working methods. The students independently work out a partial question within one of the research topics by studying sources, write a short paper on it and present it in a short presentation. The students are thus guided to in-depth scientific work and acquire essential core competences for a goal-oriented, methodically clean and comprehensible preparation and summary of selected research topics

Literature

Die Recherche der maßgebenden aktuellen Literatur und deren Erfassung ist Bestandteil des Forschungsseminars

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Research Seminar Traffic Planning and Traffic Engineering	2,0	Seminar	english german

Title	Microscopic Traffic Flow Simulation and its Applications		
Number	4301910	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Verkehr und Stadtbauwesen
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Bernhard Friedrich
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	written exam (90 Min.) or oral exam (30 Min.)		
Course achievement			

Contents

- Traffic surveys
- Microscopic traffic flow modelling
- Calibration and validation methods
- Traffic-actuated control methods
- Applications of microsimulation using professional software

Objective qualification

The students acquire basic knowledge of the theoretical principles of microscopic traffic flow models, for the collection of input, calibration and validation data as well as for the statistically correct evaluation of simulation results. They are enabled to plan and carry out traffic surveys and to check traffic and design planning with the help of microsimulation using the collected data.
In the course of the lecture, the students learn how to use a simulation tool and are enabled to independently set up and carry out simulations with the software.

Literature

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	german

Title	Urban Road Design		
Number	3319000000	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Verkehr und Stadtbauwesen
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Bernhard Friedrich
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Portfolio		
Course achievement			

Contents

- Requirements for a sustainable and climate-friendly design of urban roads
- Design principles and utilisation requirements for urban roads
- Guidelines and recommendations for the design and layout of urban roads
- User and mode of transport-specific design elements for road sections and junctions
- Design and layout of facilities for motorised private transport
- Design and layout of facilities for pedestrian traffic
- Design and layout of facilities for bicycle traffic
- Design and layout of facilities for local public transport
- Accessibility
- Project study in collaboration with the city of Braunschweig

Objective qualification

(E) The planning and design of sustainable urban streets is based on objectives derived from the quality of sojourn and functionality. To this end, the existing road users' requirements, aspects of accessibility, traffic safety and ecological compatibility are considered. Students are given a systematic overview of these requirements for a sustainable street space and learn how to take them into account in the design process. They will also be able to apply the state of the art of the relevant recommendations and guidelines. Students acquire practical skills as part of a project study in which they design a real street space, taking appropriate account of all user requirements and boundary conditions. In cooperation with the city of Braunschweig, exemplary streetscapes are selected and worked on in small groups in order to implement, coordinate and finally present what has been learnt in the lecture in a practical exercise.

Literature

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Urban Road Design	4,0	Lecture/Exercise	german

Title	Traffic Management		
Number	3319000010	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Verkehr und Stadtbauwesen
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Bernhard Friedrich
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam+ (90 Min.) or oral examination (ca. 30 Min.) Two assignments can be completed in advance which, if passed, count for 25% of the final grade for the module. The application for an written exam+ must be submitted by the student at the start of the examination. Further information on deadlines for the submission of term papers is provided in the courses of the module.		
Course achievement			

Contents

- Functional and organisational system architectures for the management of road traffic facilities
- Traffic flow theory as the basis for determining the traffic situation and evaluating measures
- Recording, processing and analysing traffic data (practical course)
- Design and traffic engineering dimensioning of road traffic facilities
- Procedures and methods of traffic control for road network, road sections and junctions within (urban roads) and outside built-up areas (motorways)
- Procedures for determining the traffic situation and quality management
- Insights into practice through guest lectures and excursions

Objective qualification

Students gain a comprehensive overview of the responsibilities, tasks and objectives of the management of road traffic facilities inside and outside built-up areas. In this context, system architectures for traffic management in Germany are introduced in their functional and organisational forms. Students learn the basics of traffic data analysis and traffic flow theory in order to be able to competently deal with the tasks of traffic management and, building on this, to apply state-of-the art methods for the dimensioning of road traffic facilities and the various methods of traffic control in accordance with the regulations applicable in Germany. This gives students the skills to develop and evaluate measures that make sense from a traffic flow perspective and are ecologically and economically suitable. Taking into account the existing traffic infrastructure, they will be able to dimension road traffic systems on urban roads and motorways that meet the standards of German guidelines and equip them with the necessary traffic engineering systems (operation).

Literature

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Traffic Management	4,0	Lecture/Exercise	german

Specialisation Hydraulic Engineering

Title	Hydraulic Engineering		
Number	4320030	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Abteilung Wasserbau und Gewässermorphologie
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Jochen Aberle
Workload (h)	180		
Class attendance (h)	62	**Self studying (h)**	118
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 Min.) and presentation and oral exam (approx. 20 Min.)		
Course achievement			

Contents

Hydraulic Engineering (VÜ)
The course deals with the design of hydraulic structures in rivers and streams such as weirs, dams, culverts, stilling basins as well as the hydraulic parts of hydroelectric power plants and hydraulic structures for restoring the longitudinal continuity for ecology and sediments in rivers.

Open Channel Hydraulics – Hydraulic Structures (Ü)
Practical exercises support the contents presented in the course Hydraulic Engineering. This is achieved through the performance of scale model experiments in the teaching and hydraulic engineering laboratory.

Dams (V)
The elective course includes in-depth and supplementary teaching content to the compulsory course "Hydraulic Engineering" with regard to dams. The design and construction principles of reservoirs, retaining walls, dams, flood relief and extraction systems are treated. In addition, the sustainable sediment management of reservoirs is discussed.

Hydraulic Steel Constructions and Offshore-wind turbines (V)
The students acquire knowledge about typical steel constructions in the field of hydraulic engineering and are able to design them. The essential standard regulations are also conveyed.

Experimental Hydraulics (V)
The students acquire in-depth knowledge of experimental hydraulics. hydraulic engineering experiments. This includes dimensional analysis, scaling laws and similarities, scale models, scale models with a movable bed; instrumentation and field measurements.

Objective qualification

The students learn get an in-depth understanding of hydraulic engineering and hydraulic structures. They will be able to explain the functionality of hydraulic structures such as weirs, dams, hydroelectric power

plants, continuity structures and crossing structures and to dimension these structures hydraulically. In addition, they can independently plan and carry out hydraulic scale model tests. Thus, the students are able to develop suitable measures for solving practical problems taking into account special boundary conditions.

Literature

Vorlesungsumdrucke und Fachbücher, wie z.B.:
- Chow, V. T. (1959). Open channel hydraulics. Singapore: McGraw-Hill.
- Giesecke, J.; Heimerl, S.; Mosonyi, E. (2014). Wasserkraftanalagen. Planung, Bau und Betrieb. 6. Auflage. Berlin:
Springer Vieweg.
- Hager, W., Schleiss, A. J. Boes, R. M., Pfister, M. (2021). Hydraulic Engineering of Dams, CRC Press.
- Muste et al. (2017). Experimental Hydraulics: Methods, Instrumentation, Data Processing and Management, Two
Volume Set; Routledge, Taylor and Francis Group.
- Patt, H.; Gonsowski, P. (2011). Wasserbau. 7., aktualisierte Auflage. Heidelberg, Springer.
- Strobl, T.; Zunic, F. (2006). Wasserbau. Berlin, Heidelberg, Springer.

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Related courses

Rules for the choice of courses

Mandatory courses:
[Hydraulic Engineering] (4 LP), [Open Channel Hydraulics – Hydraulic Structures] (1 LP)

One of the following elective courses: [Dams] (1 LP),
[Hydraulic Steel Constructions and Offshore-Wind Turbines] (1 LP)
[Experimental Hydraulics] (1 LP)

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	1,0	Lecture	german
	4,0	Lecture/Exercise	german
	1,0	Exercise	english german
	1,0	Lecture	german
	1,0	Lecture	english

Title	Eco-Hydraulics		
Number	4320020	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer		**Teaching unit**	
Module duration	1	**Institution**	Abteilung Wasserbau und Gewässermorphologie
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Jochen Aberle
Workload (h)			
Class attendance (h)	66	**Self studying (h)**	114
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 Min.) and oral exam (approx. 30 Min.)		
Course achievement			

Contents

[Near-to-Nature Hydraulic Engineering (Master) (VÜ)]
European Water Framework Directive, River Morphology, Hydraulics of nature-like rivers; Flow resistance of plain river beds composed of different bed material and form resistance of morphological structures; Roughness and resistance coefficients, Sediment transport, Morphological development of rivers, River maintenance and development measures
[Open Channel Hydraulics – Near-to-Nature (Master) (Ü)]
Practical exercises in the field are carried out so that the students learn about the effect of hydraulic, morphological and morphodynamic factors on the flow characteristics of rivers.

[Flow Resistance of Vegetation (Master) (V)]
Approaches are introduced for the determination of parameters to describe riverine vegetation characteristics (rigid, flexible, emergent, submerged) and to determine flow resistance due to vegetation. This is an elective subject serving as an in-depth supplement to the compulsory course "Near-to-Nature Hydraulic Engineering”
[Stream Ecology (Master) (V)]
Introduction into the field of stream ecology and presentation of methods for the determination of water and structural quality of streams.
[Dynamics of Cohesive Sediments (V)]
Introduction into the physical processes governing the dynamics of cohesive sediments in rivers, streams, and estuaries.

Objective qualification

The students learn the basics of essential aspects that are important for near-to-nature hydraulic engineering applications. They will have a basic understanding of flow characteristics, flow resistance and sediment transport in natural rivers and how these are interrelated, also considering the effect of further roughness such as vegetation. The students will be able to define the goals of near-natural revitalization measures, to develop appropriate measures and to evaluate the success of planned and existing revitalization measures. The practical training is underlined by exercises in the field. In addition to hydraulic engineering and environmental hydraulics applications, ecological considerations are also part of the contents to prepare the stu-

dents for the interdisciplinary cooperation with the scientific field of natural sciences that is required in professional life to implement nature-based solutions.
Literature
Literaturhinweise, Fachbücher, und Vorlesungsumdrucke

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Related courses
Rules for the choice of courses
Compulsory: [Near-to-Nature Hydraulic Engineering] (3 LP), [Open Channel Hydraulics – Near-to-Nature] (2 LP) One of the elective courses: [Flow Resistance of Vegetation] (1 LP) [Dynamics of Cohesive Sediments] (1 LP) [Stream Ecology] (1 LP) must be chosen.
Compulsory attendance

Name of the course	**SWS**	**Eventtype**	**Language**
	3,0	Lecture/Exercise	german
	2,0	Exercise	german
	1,0	Lecture	german
	1,0	Lecture	german

Title	Numeric Methods in Ground and Surface Waters		
Number	4320040	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Abteilung Wasserbau und Gewässermorphologie
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Jochen Aberle
Workload (h)	180		
Class attendance (h)	66	**Self studying (h)**	114
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 Min.) and presentation and oral exam (30 Min.)		
Course achievement			

Contents

[Numerical Methods in Groundwater and Open Channel Flow (Master) (VÜ)]
General: Concepts of models, basics of numerical solutions; discretization of space and time; practical introduction of several hydro numerical programmes
Surface flow: basics of hydraulic modelling; modelling of turbulence; setup of computational grid; 1D to 3D computations; basics of sediment transport modelling; hydraulics of subsurface flow
Groundwater flow: fundamental terms; basic hydraulic formulas; methods for determination of conductivity; modelling of groundwater flow

[Open Channel Hydraulics - numerical (Master) (Ü)]
Introduction to several methods and programmes for numerical modelling of open channel flow; tutorials for modelling groundwater flow

[Hydraulics of Dams and Dikes (Master) (V)]
Complementary and deepening knowledge for considering water in dams and dikes construction

[Sediment Transport Modelling (Master) (V)]
Introduction to computational methods for sediment transport processes

[Numerical Computation of Groundwater Flow in Dams and Dikes (Master) (VÜ)]
Basics of the Finite Elements Method und of the differential method; development of programmes for simple 1D systems; exercises for modelling 1D and 2D systems

Objective qualification

Students gain competent knowledge of the theoretical background for calculating surface and groundwater flow. Thus, they achieve the ability for understanding implications of boundary conditions, assumptions, and simplifications required for hydraulic computational modelling. Consequently, they are able to assess which method/model is appropriate and required, resp., to numerically solve a hydraulic problem. In practical applications the students are introduced to several hydro numerical programmes with emphasizing the critical

discussion of results. The students are, finally, able to handle a hydraulic question by compiling required information, selecting an appropriate programme and analysing and discussing the results.
Literature
Script

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Related courses
Rules for the choice of courses
Mandatory: Numerical Methods in Groundwater and Open Channel Flow (3 LP), Open Channel Hydraulics-Numerical (2 LP) Obligatory choice (1 out of 3): Hydraulics of Dams and Dikes (1 LP), Sediment Transport Modelling (1 LP) or Numerical Computation of Groundwater Flow in Dams and Dikes (1 LP)
Compulsory attendance

Name of the course	**SWS**	**Eventtype**	**Language**
	3,0	Lecture/Exercise	german
	2,0	Exercise	german
	1,0	Lecture	german

Title	Project Management in Waterways Engineering		
Number	4398790	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	2	**Institution**	Abteilung Wasserbau und Gewässermorphologie
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Jochen Aberle
Workload (h)	180		
Class attendance (h)	72	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	3 Examinations: 2 Written exams (each 60 Min.) or 1 Written exam (60 Min.) and 1 oral exam (15 Min.) and a presentation		
Course achievement			

Contents

[Inland Waterways Engineering (VÜ)]
Inland navigation; administration of the federal waterways; canals and inland vessels; dynamics of inland vessels; river training; sluices

[Project Management in Waterways Engineering (V)]
Planning and implementation of projects in waterways engineering; responsibilities; planning stages; scheduling and resource planning; tenders and tender models; risk management; consideration of interest groups; process optimization options

Objective qualification

Projektmanagement im Bauwesen kann entweder im Modul Realisierung und Finanzierung oder im Modul Projektmanagement im Verkehrswasserbau eingebracht werden.
The students acquire in-depth knowledge of inland navigation, the required waterway engineering infrastructure and project management for the construction, maintenance and rehabilitation of infrastructure elements from the point of view of the waterways and shipping administration. They will be able to understand the functionality of hydraulic structures used in waterways engineering and to design hydraulically these structures. They will gain in-depth insights into the methods and tools that can be used in waterways engineering projects and how such projects can be carried out in a goal-oriented manner from an organizational, legal, technical, economic and scheduling point of view.

Literature

Präsentationsfolien der Vorlesungen

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture/Exercise	german
	2,0	Lecture	german
	2,0	Seminar	german

Additional Modules

Title	Design of High-Rise Buildings		
Number	3303000010	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration		**Institution**	Institut für Tragwerks-entwurf
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Harald Kloft
Workload (h)	180 h		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written Exam (60 min) and Design Project		
Course achievement			
Module grade composition	The grade for the module is composed of the grade for the written exam (50%) and the grade for the Design Project (50%)		

Contents
1. Introduction to High-Rise Buildings, 2. Structural Systems and Design, 3. Foundation Systems, 4. Wind Engineering and Aerodynamics, 5. Seismic Design, 6. Construction Techniques and Management, 7. Construction Techniques and Management, 8. Case Studies, 9. Digital Tools and Software (e.g., ETABS, SAP2000, SAFE)
Objective qualification
Students will acquire a solid foundation in the design and analysis of high-rise buildings, learning to evaluate and apply criteria for various types of loads, including dead loads, live loads, wind loads, and seismic forces. They will gain hands-on experience with industry-standard software such as ETABS and SAFE, enabling them to analyze diverse building structures, including renowned skyscrapers and their foundation systems. The course will also cover advanced techniques for damping dynamic forces, such as those caused by storms and seismic activity, including the use of mass dampers and base isolation systems. Theoretical knowledge will be complemented with practical examples and case studies to ensure students can translate their learning into real-world applications effectively.
Literature

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Design of High-Rise Buildings	4,0	Lecture/Exercise	english

Title	Digital Models and Methods in Construction and Real Estate Industry		
Number	4398570	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Bauwirtschaft und Baubetrieb Institut für Geodäsie und Photogrammetrie
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Patrick Schwerdtner
Workload (h)	180 h		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Writte exam (60 Min.) or oral exam (approx. 15 Min.)		
Course achievement	Presentation		

Contents

The module consists of three parts:

[Foundations and Applications of digital models in the construction process]
First of all, basic knowledge concerning the methodology BIM will be taught (Schwerdtner): Basic knowledge of the methodology should be presented with specific reference to possible applications in the design and construction process. Based on this, recording methods for existing buildings and during the construction process will be explained (Gerke): Topics covered include the principles of building survey with an overview of modern detection methods (laser scanning, photogrammetry) and the challenges associated with the verification of tolerances. Finally, geodetic (pre-) services are linked with construction applications (Schwerdtner): In addition to the assessment and monitoring of performance, the focus will also be on issues of invoicing. There will be accompanying exercises in which a building is captured with modern methods and modeled for an application case.

[Development and integration of digital methods]
First, current developments in research with regard to the digitalisation of the design and construction process are presented. In this context, knowledge of the basics of scientific research is a requirement for a successful degree. Afterwards individual presentations will be elaborated with reference to one of the presentations that will take place in the companying seminar for digital design and construction. Participants search for suitable literature, read it critically and summarize it scientifically in the form of a presentation.

[Seminar for digital design and construction]
Representatives of companies and offices will explain the possibilities and limits of digital design and construction in different lectures.

Objective qualification

[Fundamentals and Applications of digital models in the construction process]
The participants get to know basic, methodological and technical knowledge of the methodology Building Information Modeling (BIM) in accordance with the guideline VDI/buildingSMART-MT 2552 Sheet 8.1 “BIM – Foundation Basics”. The (geometric) recording of buildings will play a major role. These competences conduce to in-depth understanding of the interfaces in model construction as well as geodetic and construction

applications. After successful completion, participants are able to evaluate and apply relevant applications of the BIM methodology.

[Development and integration of digital methods]
The aim of this course is to get to know and work on topics related to digitalisation in the building and real estate industry. After successful completion, participants of this course will have the following competencies:

- Knowledge of current developments in research on the digitalisation of the design and construction process
- Structure and procedure of a literature search and correct citation
- Critical reading of scientific articles
- Summarising of scientific articles

[Seminar for digital design and construction]
Based on presentations given by representatives with practical experience students learn about selected fields of application for digital methods in design and construction.

Literature

Will be announced during the course.

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	2,0	Lecture/Exercise	german
	1,0	Lecture	german
	1,0	Seminar	german

Title	Public Building Law		
Number	4318260	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	2	**Institution**	Institut für Verkehr und Stadtbauwesen
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Bernhard Friedrich
Workload (h)	180 h		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 Min.) or oral exam (approx. 30 Min.)		
Course achievement			

Contents

[Bauplanungsrecht(VÜ)]
- Fundamentals and objectives of building planning law
- Legal bases: BauGB, BauNVO, BauPlZVO
- Urban land use planning: stages and preparation procedures
- Privatization and security instruments in urban land use planning
- Admissibility of projects
- Consideration and protection of neighbors
- Secured development

[Bauordnungsrecht(VÜ)]
- Fundamentals and goals of the building code
- Legal bases
- Landesbauordnung
- Musterbauordnung
- Implementing ordinance
- special building regulations
- ancillary building regulations
- Types of procedures and approvals
- building documents and responsibilities
- material requirements in the building code
- Regulatory content of the building permit
- protection of neighbors
- ancillary building law
- monument protection law
- immission control law
- Law governing places of assembly
- Workplace law

Objective qualification

Students receive basic knowledge of public building law. This includes the teaching of basic knowledge of building planning law as well as building regulations and ancillary building law (including special regulations). The overarching goal is to teach the relevant sources of law and how to apply them to selected

examples. The students thus acquire the competence to comprehend and understanding basic legal system interrelationships in relation to public construction.
Literature

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture/Exercise	german
	2,0	Lecture/Exercise	german

Title	Sustainability in Construction		
Number	3303000000	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Tragwerks-entwurf
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Harald Kloft
Workload (h)	180 h		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Term paper		
Course achievement			

Contents

Exploring sustainable construction practices focused on reusing old structural elements, retrofitting, and advanced
structural techniques, emphasizing architectural design and creating eco-friendly environments.

1. Introduction to Sustainability in Structural Engineering, 2. Initial Tests for Evaluation of Old Elements, 3. Structural
Materials and Resource Efficiency, 4. Innovative Reutilization of Old Structural Elements (e.g., Transforming Concrete Shear
Walls into Beams or Furniture), 5. Retrofitting Existing Structures for Sustainability, 6. Architectural Aspects in Design of
New Constructions, 7. Connection Developments for Enhanced Structural Performance of Reconstructed Structures, 8.
Mitigating Progressive Collapse in Building Structures, 9. Source and Waste Management in Construction

Objective qualification

By the end of this seminar, students will have acquired a comprehensive understanding of sustainable construction
practices, focusing on both innovative reutilization of old structural elements and the retrofitting of existing structures.
Participants will gain hands-on knowledge in evaluating and repurposing materials, thereby minimizing waste and
optimizing resource efficiency. They will explore advanced topics such as mitigating progressive collapse, developing
connections for enhanced structural performance, and integrating architectural considerations into new and reconstructed
buildings. This includes appreciating aesthetic design, functional space planning, and creating sustainable, healthy indoor
environments. Armed with this expertise, students will be well-equipped to lead the industry toward more sustainable and
innovative building practices that will make a tangible impact on the built environment.

Literature

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Sustainability in Construction - Seminar	4,0	Seminar	english

Title			
Number	3303000030	**Module version**	
Shorttext	3303000030-E-FK3	**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Tragwerks-entwurf
Hours per Week / ECTS	6 / 6,0	**Module owner**	Prof. Dr. Norman Hack
Workload (h)	180 h		
Class attendance (h)	70	**Self studying (h)**	110
Compulsory requirements			
Expected performance/ Type of examination	Portfolio (with Presentation)		
Course achievement			

Contents

Teaching of digital design theory, computer-aided design, robotic fabrication, and additive manufacturing.

Objective qualification

The set of online available materials consisting lectures and tutorials cover topics related to digitalisation across all phases from design and planning to execution. The focus includes the following aspects: 3D modelling, computational geometry, digital simulation and analysis tools (such as structural optimisation, lighting simulation, and thermal simulation), parametric and generative design methods, Building Information Modelling (BIM), robot-based fabrication processes and additive manufacturing, 3D scanning, virtual and augmented reality, big data, and the application of artificial intelligence in planning.

In the accompanying exercises, students are introduced to the basics of programming in Grasshopper and Python. For this purpose, the widely used 3D NURBS modelling software Rhino 3D is employed, as it offers interfaces to many of the digital design, planning, and execution tools discussed in the lectures.

The independent teaching is supported with personal consultations with lecturers, to support the students and provide additional resources and explanations.

Literature

Recommended literature is optional and corresponds to the continuously updated course content each semester. Detailed information on the specific courses and topics offered is provided in the respective semester programme.

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Related courses			
Rules for the choice of courses			
Students who have attended the module “Digital Construction (4198440)” in the Bachelor's program in Architecture cannot attend this module.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Foundations of Digital Design and Fabrication		Lecture/Exercise	english

Title	Structural Design for Additive Manufacturing in Construction		
Number	3303000020	**Module version**	
Shorttext	3303000020-E-FK3	**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Tragwerks-entwurf
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Harald Kloft
Workload (h)	180 h		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Recommended requirements	It is strongly recommended that students possess preliminary and broad knowledge of Additive Manufacturing in Construction. This should be documented by the successful completion of both: 1. *Angewandte Additive Fertigung* (M.Sc.) and 2. *Foundations of Digital Design and Fabrication* (M.Sc.) / *Digital Construction* (B.Sc.), or an equivalent set of courses completed at another university. The two courses mentioned above may also be taken in parallel with the current course in order to acquire the required background knowledge.		
Expected performance/ Type of examination	Written Exam (60 min) or Oral Exam (30 min) and Term Paper		
Course achievement			
Module grade composition	50% Writte Exam or Oral Exam, 50% Term Paper		

Contents

Strategies and concepts for safety and durability verification in Additive Manufacturing for Construction (AMC), including existing norms and standards, and practical approach based on selected examples.

A series of lectures will introduce 1) relevant existing norms, standards, and guidelines, including: DIN EN ISO/ASTM 52939 and ICC-ES AC509, as well as 2) selected examples of design assisted by testing of additively manufactured structures.

The homework is a written report from design and validation plan of a selected structural element (e.g. a beam, a wall) produced with selected additive manufacturing method, including: 1) design and validation plan, 2) fabrication method selection, 3) design for fabrication and structural calculation, 4) planning of testing for validation and/or quality control.

Objective qualification

Upon successful completion of the module, students will be familiar with the relevant standards and codes applicable in Europe and internationally for the structural and durability verification of additively manufactured structures, with a particular focus on Digital Fabrication with Concrete. They will be prepared to participate in the structural design and execution of projects involving additive manufacturing—especially concrete 3D printing—and to operate effectively in international contexts, including normative environments beyond

Germany. This will also involve the ability to draw analogies from standards and codes not directly valid in Germany.

To this end, students will learn to apply fundamental physical principles and engineering laws to navigate within the currently unregulated domain of structural design using novel materials and fabrication processes. They will gain an understanding of the underlying concepts and logics behind existing design formulas (e.g., those found in the Eurocodes) and will be capable of using them appropriately in situations where the materials or methods lie outside the scope of current normative documents. This ability will enable them to assess and design using a variety of materials, including advanced cementitious composites, and reinforcement types from both structural performance and durability perspectives.

Finally, students will be introduced to the fundamentals of design assisted by testing—a methodology that is not only crucial in the context of Digital Fabrication with Concrete, but also broadly applicable in structural engineering practice, for instance in the verification and assessment of existing structures through physical testing.

Literature

Additive Manufacturing for construction – Qualification principles – Structural and infrastructure elements (ISO/ASTM 52939:2023)

Acceptance Criteria 509 - 3D Automated Construction Technology for 3D Concrete Walls (ICC-ES AC509)

Kloft, H., Sawicki, B., Bos, F., Dörrie, R., Freund, N., Gantner, S., Gebhard, L., Hack, N., Ivaniuk, E., Kruger, J. and Kaufmann, W., 2024. Interaction of reinforcement, process, and form in digital fabrication with concrete. Cement and Concrete Research, 186, p.107640. Available at: https://doi.org/10.1016/j.cemconres.2024.107640

F.P. Bos, C. Menna, M. Pradena, E. Kreiger, W.R. Leal da Silva, A.U. Rehman, D. Weger, R.J.M. Wolfs, Y. Zhang, L. Ferrara, V. Mechtcherine, The realities of additively manufactured concrete structures in practice, Cement and Concrete Research, Volume 156, 2022, 106746, https://doi.org/10.1016/j.cemconres.2022.106746

V. Mechtcherine et al.‘Additive Fertigung mit Beton – Leitfaden für die Planung und die Durchführung von Projekten’, Beton- und Stahlbetonbau, 119.4 (2024), pp. 290–310, doi:10.1002/best.202400005

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
Structural Design for Additive Manufacturing in Construction	4,0	Lecture/Exercise	english

Title	Structural Reliability		
Number	4310750	**Module version**	Erstellt am 07.08.2024 17:05
Shorttext		**Language**	english
Frequency of offer		**Teaching unit**	
Module duration	1	**Institution**	Fachgebiet Brandschutz
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Jochen Zehfuß
Workload (h)	180 h		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (120 Min.) or oral exam (approx. 45 Min.)		
Course achievement	Homework The homework can be prepared in advance and can contribute 10 % of the final grade for the module. Exam+ has to be requested by the student before the beginning of the exam. Further information for deadlines for the homework will be announced in the lectures of this module.		

Contents

[Reliability Theory(V)]
Discussion of typical sources of insecurity in constructions and description of probability distributions; Discussion of First Order Reliability Method; Application for limit states in the computation of partial safety factors for common design problems; Discussion of the basics of system reliability theory and application of First Order Reliability Method for structural systems; Description of systems with fault trees and event trees and preparation for reliability analysis; Implementation of system reliability in risk analysis
Presentation of and exercises with commercial reliability analysis software for limit states and systems; independent study under supervision with typical scenarios of structural systems.

[Structural Reliability Assessment of Existing Structures (S)]
Students apply the reliability analysis methods to determine the reliability and residual service life of existing structures and identify measures for sustainable service life management.

[Risk Assessment Methods for Fire Safety (V)]
Following the basics of reliability theory, students apply the internationally recognized quantitative and qualitative risk assessment methods to establish the risk of fire in construction, especially existing buildings, and perform cost-benefit analysis for different fire protection provisions.

Objective qualification

Students know about safety and dangers to constructions and learn how to record them with reliability theory based safety concepts. They understand the basics of reliability theory, reliability methods in the 1st and 2nd order (FORM/ SORM), know MC-simulations and can apply those to establish or check semi-probabilistic safety concepts for the ultimate limit state and serviceability limit state. Students can also use these methods to perform risk analysis for structural frames or complex technical systems.
For the application of reliability computations of structural elements and structures, students get to know available software and learn how to use it independently for real-case scenarios.

Literature
Klinzmann, C.; Zehfuß, J. et al: Zuverlässigkeitstheorie im Bauwesen, Vorlesungsskript ANSYS optiSLang, Users Manual. www.ansys.com/de-de/products/platform/ansys-optislang

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Structural Reliability	1,0	Internship	english
Structural Reliability	1,0	Lecture	english
Risk Methods in Fire Protection	1,0	Lecture	english
Reliability Assessment of Existing Buildings	1,0	Seminar	english

Title	City and Society		
Number	3307000010	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Bauklimatik und Energie der Architektur
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Henriette Bertram
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Contents			
Objective qualification			
Literature			
Wird zu Beginn des jeweiligen Semesters bekannt gegeben			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	german

Key Qualifications

Title	Key Qualifications		
Number	4301040	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	Fakultät Architektur, Bauingenieurwesen und Umweltwissenschaften
Module duration	1	**Institution**	
Hours per Week / ECTS	6 / 6,0	**Module owner**	
Workload (h)			
Class attendance (h)	84	**Self studying (h)**	96
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Contents			
Objective qualification			
Literature			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

Study Project

Title	Study Project		
Number	4310800	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	Fakultät Architektur, Bauingenieurwesen und Umweltwissenschaften
Module duration	1	**Institution**	
Hours per Week / ECTS	0 / 10,0	**Module owner**	
Workload (h)	300		
Class attendance (h)	1	**Self studying (h)**	300
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Contents			
Objective qualification			
Literature			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

Title	Study Project		
Number	4310810	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	Fakultät Architektur, Bauingenieurwesen und Umweltwissenschaften
Module duration	1	**Institution**	
Hours per Week / ECTS	0 / 6,0	**Module owner**	
Workload (h)	180		
Class attendance (h)	1	**Self studying (h)**	180
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Contents			
Objective qualification			
Literature			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

Master's Thesis

Title	Master's Thesis		
Number	4399360	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	Fakultät Architektur, Bauingenieurwesen und Umweltwissenschaften
Module duration	1	**Institution**	
Hours per Week / ECTS	0 / 20,0	**Module owner**	
Workload (h)			
Class attendance (h)		**Self studying (h)**	600
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Contents			
Objective qualification			
Literature			
abhängig von der konkreten Aufgabenstellung			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**