University of Zagreb
Faculty of Civil Engineering

University graduate study programme Civil Engineering

with learning outcomes for courses offered in English

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Contents

1 INTRODUCTION

The Faculty of Civil Engineering, University of Zagreb, welcomes Erasmus+ incoming students and offers a selection of courses taught in English within its graduate study programme in Civil Engineering.

The courses presented in this catalogue are organized according to the year of study and semester (Winter and Summer Semester), making it easier for students to identify the courses available during their planned mobility period. Each course description includes the number of ECTS credits, workload, learning outcomes, course content and recommended literature to assist students in selecting courses that best match their academic interests.

The courses are available to international exchange students, subject to the availability of teaching staff and a sufficient number of enrolled students.

Incoming students are encouraged to consult their academic coordinator at their home institution and the Erasmus+ coordinator at the Faculty of Civil Engineering (ects-coordinator@grad.unizg.hr) when preparing their Learning Agreement. The final selection of courses should be appropriate to the student's prior knowledge, study level and academic background.

We look forward to welcoming you to the Faculty of Civil Engineering and wish you a successful and rewarding Erasmus+ experience in Zagreb.

2 COURSES OFFERED IN ENGLISH WITH LEARNING OUTCOMES

2.1 First study year

2.1.1 Winter semester

Courses	Total hours			ECTS
	Lectures	Seminar	Practice	
Building Maintenance Management	30	0	15	4,5
Optimization Methods in Construction	30	0	30	6
Study of Work	30	0	15	4,5
Durability of Construction Materials	30	4	26	6
Special Concrete and Technologies	45	0	30	7,5
Applied Soil Mechanics	45	0	30	7,5
Geotechnical Engineering	30	0	30	6
Numerical modelling in geotechnics	30	0	45	7,5
Hydrology 2	30	0	30	6
River Training	45	0	30	7,5
Prestressed Concrete	30	0	30	6
Mechanics of Material	30	0	15	4,5
Mathematics 3	45	0	30	7,5
Stochastic processes	45	0	30	7,5

BUILDING MAINTENANCE MANAGEMENT

Credits (ECTS): 4.5

Hours (total per semester):

- Lectures: 30
- Exercises: 15 (auditory: 3, design: 12)

Course objectives:

- Train the student to create a building maintenance project,
- Train the student to use methods for creating a list of priorities in building maintenance.

Entry competences (prior knowledge, descriptive):

- It is necessary to know the calculation of the bill of quantities and the bill of costs.

Learning outcomes:

- Understanding the parts of the building maintenance project,
- Application of damage identification methods,
- Application of the multi-attribute method for deciding on the priority list of maintenance works,
- Application of the analytic hierarchy process for deciding on the priority list of maintenance works,
- Application of the "Expert Choice" computer software,
- Understanding the position of building maintenance in the context of managing a company's real estate portfolio.

Course content (by course schedule):

- Lectures:
    1. Introduction and general concepts
    2. State of regulations in the field of building maintenance
    3. Regular maintenance, preventive and reactive maintenance, reconstructions, repairs and emergency interventions
    4. Maintenance cost structure
    5. Building maintenance in the context of the entire construction process
    6. Building maintenance management: short-term and long-term maintenance plans
    7. Structure of the building maintenance project
    8. Planning and organization of maintenance works: Information technologies in maintenance; BIM and maintenance
    9. Maintenance and contracting strategies; Analysis of the life cycle cost of the building
    10. The place and role of building maintenance in facilities management
    11. Maintenance of old and legally protected buildings;
    12. Monument annuity and modality of annuity collection
    13. The impact of climate change on building maintenance
    14. Maintenance and renovation of buildings in accordance with energy efficiency
    15. Management of the company's real estate portfolio (Corporate Real Estate Management) with an emphasis on the management and maintenance of buildings
- Exercises:

1. Defining project tasks
2. Inspection of the selected building and creation of photo documentation of damage to the building
3. Inspection of the building and completion of standardized forms for the maintenance of the building
4. Creating a list of damage to the building
5. Creation of a detailed description of damage to the building with photo documentation
6. Creation of a proposal to repair damage for the selected building
7. Creation of a proposal to repair damage for the selected building
8. Defining criteria for multi-criteria analyses and creating a list of priorities for maintenance plans
9. Creating a list of maintenance priorities using the analytic hierarchy process with the Superdecisions software
10. Creating a list of priorities with a multi-attribute approach
11. Estimate of costs for all planned works on building maintenance/renovation
12. Creation of a time plan for damage repair
13. Simulation of building maintenance costs with @Risk - DecisionTools Suite
14. Program presentations and defences
15. Program presentations and defences

OPTIMIZATION METHODS IN CONSTRUCTION

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 30
- Exercises: 30 (auditory: 15, design 15)

Course objectives:

- Acquisition of knowledge about operational research methods and their application in problems of optimization of organization and of construction technology.

Entry competences (prior knowledge, descriptive):

- Knowledge of the basics of organization and construction technology,
- Understanding the basics of linear algebra and mathematical statistics.

Learning outcomes:

- Demonstrate the ability to solve linear programming problems using the graphical and simplex method,
- Demonstrate the ability to solve dynamic deterministic and probabilistic programming problems,
- Demonstrate the ability to use the methods of decision-making in certainty, decision-making with risk and decision-making in uncertainty,
- Demonstrate the ability to create Monte Carlo simulation models.

Course content (by course schedule):

- Lectures:

1. Introduction
2. Linear programming models with two variables, graphical solution, graphical sensitivity analysis
3. Transition from graphical to algebraic solution, simplex method
4. Artificial initial solution, special cases in the application of the simplex method
5. Definition of dual problem, relationship between primal and dual, interpretation of duality
6. Postoptimal analysis and sensitivity analysis
7. Transport models
8. Network models
9. Deterministic dynamic programming
10. Deterministic models of inventory
11. Non-linear programming
12. Decision-making in certainty, decision-making with risk, decision-making in uncertainty
13. Probabilistic dynamic programming, probabilistic models of inventory, queuing systems
14. Monte Carlo simulation, random number generators
15. Simulation languages

- Exercises:

1. Graphic solution
2. Simplex method
3. Graphical solution and simplex method with the help of a computer
4. Artificial initial solution, special cases in the application of the simplex method
5. Definition of dual problem, relationship between primal and dual, interpretation of duality
6. Postoptimal analysis and sensitivity analysis
7. Transport models, network models
8. (1st mid-term exam)
9. Deterministic dynamic programming, deterministic models of inventory
10. Non-linear programming
11. Decision-making in certainty, decision-making with risk, decision-making in uncertainty
12. Probabilistic dynamic programming, probabilistic model of inventory, queuing systems
13. Monte Carlo simulation, random number generators, simulation languages
14. (2nd mid-term exam)
15. Corrective exam

STUDY OF WORK

Credits (ECTS): 4.5

Hours (total per semester):

- Lectures: 30
- Exercises: 15 (auditory: 10, on the computer: 5)

Course objectives:

- Based on a detailed analysis of the construction productivity, the student will master methods and techniques for studying work, with the support of which they can impact work design and increase efficiency in construction processes, along with acquiring detailed theoretical knowledge such as:

- Work organization,
- Theories of organizations,
- Development of general management,
- Construction productivity,
- Application of information technology (IT) in construction,
- Execution of construction projects
- Managerial approach to project management,
- Human resources,
- Rationalization of construction productivity,
- Organization of preparation of construction productivity and
- design organization

Entry competences (prior knowledge, descriptive):

- Knowledge of the main construction technological processes:
  - Earthworks,
  - Carpentry works,
  - Concrete works,
  - Reinforcement works,
  - Reinforced concrete works,
  - Masonry works,
  - Asphalt works and
  - Hydrotechnical works.
- Understanding the application and use of computers.

Learning outcomes:

- Knowledge of the methodological procedure in the preparation of the Elaborate of study of work and process management,
- Mastery of calculating construction norms through the application of work study methods;
- application of simulation methods in the construction industry.,

Course content (by course schedule):

- Lectures:

1. A short refresher and introduction
2. Organization of work and production: Historical development of work organization; Construction development; Organization of work; Four (4) Taylor principles; Principles of work organization; The future of studies of work; Two (2) fundamental areas of development of labour science. Concept of production; Production goals; Scientific disciplines of production organization; Five (5) characteristic stages of production development
3. Work study. Objectives, methods, content and results.
4. Labour force classification, norms and normatives. Vocational and educational degrees. Official classifications of competency levels.

5. Time and material measurement. Development of time and material normatives (standards) in construction.
6. Process determinants of production, storage and installation of materials. Parameters on the basis of which coordination of workers in groups and organization of work processes is carried out.
7. Coordination of workers and machines in early groups. Rules of coordination in work operations and work processes. Regard for quantities and units of work.
8. Practical maxima of the amount of work in time and space. Organizational and technological limitation of work efficiency.
9. Connection of work processes and project activities. Analytics of processes and activities. Static and dynamic process planning.
10. Determination of working groups. Optimal use of resources on activities.
11. Human resources in production and construction works. Productivity of workers and their optimal grouping. Labour productivity factors; Physiological impacts on workers; Sociological influences on persons; Influences of the working environment on construction professionals.
12. Application of material and time standards. Normatives and standards. International differences and applicability. Presentation and explanation of the application of normatives in the construction industry of the Republic of Croatia and the world; Review of the practice of applying standard norms and those specific to individual organizations; Creation and use of norms and normatives in EU practice; Comparison of EU and Croatian best practice; Trends in the study of work and the use of modern technologies.
13. Studying construction work in the context of the economy. Social dialogue, safety and the right to work.
14. Industrialization 4.0 in the context of labour studies. Robotization and the impact of industrialization on production processes.
15. Production simulation. Definition of the term simulation; Application of the best-known simulation methods (Queueing theory, Monte Carlo method, discrete event method)

- Exercises:

1. Introduction and division of students into groups
2. Mathematical basis for the study of work
3. Breakdown of elements of work processes and working hours at the operational and market level.
4. A digital approach to dynamic process modelling.
5. A digital approach to dynamic process modelling.
6. Tasks of work organization in different conditions.
7. Coordination of workers and machines in workgroups.
8. Tasks of the organization of work processes - conditions and variant solutions.
9. Tasks of the organization of work processes - conditions and variant solutions.
10. Students are introduced to the possibilities of using IT software packages for simulations and solving concrete examples.

11. Students are introduced to the possibilities of using IT software packages for simulations and solving concrete examples.
12. Students are introduced to the possibilities of using IT software packages for simulations and solving concrete examples.
13. Students are introduced to the possibilities of using IT software packages for simulations and solving concrete examples.
14. Students are introduced to the possibilities of using IT software packages for simulations and solving concrete examples.
15. Conclusion of the course and final consultations with students; Integration of what has been learned.

DURABILITY OF CONSTRUCTION MATERIALS

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 30
- Exercises: 26 (auditory: 12, construction: 10; laboratory: 4)
- Seminar: 4

Course objectives:

- Acquisition of extended theoretical and practical knowledge about the behavior of structures under environmental loads during their service life,
- Training for distinguishing different mechanisms of the deterioration of construction materials and linking the causes and consequences of individual environmental loads with the help of own knowledge and modern scientific trends.

Entry competences (prior knowledge, descriptive):

- Knowledge of the basic properties and composition of construction materials,
- Knowledge of the basic mechanisms of transport and exchange of substances within the material,
- Knowledge of the basics of chemical reactions between materials and the environment.

Learning outcomes:

- Deepened and expanded knowledge about degradation processes (chemical, physical, mechanical and biological) of construction materials and special permanent loads from the environment,
- Independent creation of a project for the assessment of the condition and maintenance of the structure depending on the type of construction material and the calculation of the service life of the construction materials,
- Recommend to target groups new methods of preventive protection with construction materials depending on the type of construction and environment,
- Ability for cross-professional/interdisciplinary research (civil engineering, chemistry, electrochemistry, wood technology, mechanical engineering, etc.).

Course content (by course schedule):

- Lectures:

1. Introduction, classification and properties of construction materials, generally about mechanics of the durability of structural materials [2]
2. Mechanism of metal corrosion [2]
3. Protection of metals from corrosion [2]
4. Strategy for designing the durability of materials with metal structures [2]
5. Mechanism of degradation and protection of stone and polymer [2]
6. Degradation mechanism and protection of wood [2]
7. Mid-term exam
8. Mechanism of degradation and protection of glass [2]
9. Mechanism of degradation and protection of masonry [2]
10. Mechanics of durability of concrete [4]
11. Protection of concrete and reinforced concrete [2]
12. Strategy for design of durability of materials in RC structures [2]
13. Sustainable construction materials [2]
14. Mid-term exam

- Exercises:

1. Fundamentals of electrochemical corrosion of metals, methods for corrosion testing [2]
2. Specific forms of corrosion in construction and other engineering branches [2]
3. Metal protection methods - Example of galvanizing [2]
4. Examination of the surface protection system of metal structures [2]
5. Examples of wood damage in construction and other engineering branches [2]
6. Degradation of materials in soil [2]
7. Examples of masonry damage in construction [2]
8. Condition assessment of the concrete [2]
9. Application of methods for the condition assessment of concrete [2]
10. Methods of testing reinforcement corrosion in concrete (electrochemical tests, corrosion monitoring) [2]
11. Examples of reinforced concrete protection (inhibitors, cathodic and anodic protection, stainless steel) [2]
12. Calculation of service life using computer software [2]
13. Application of computer software for calculating the service life of structures under specific environmental loads [2]

- Seminars:
    1. Recognition of different mechanisms of degradation based on test results, chemical and microscopic analyses of materials [2]
    2. Final presentations of project assignments with discussion and oral assessment of acquired knowledge [2]

SPECIAL CONCRETE AND TECHNOLOGIES

Credits (ECTS): 7.5

Hours (total per semester):

- Lectures: 45
- Exercises: 30 (auditory: 10, laboratory: 16, fieldwork: 4)

Course objectives:

- Understanding of different special concrete technologies,
- Acquisition of knowledge about the selection of constituent components depending on the type of concrete,
- Understanding the dependence between the properties, structure and technology of individual types of concrete,
- Familiarization with the technology of production, transport, laying and curing,
- Acquisition of knowledge about the quality proof method in the concrete plant and on the construction site,
- Acquisition of knowledge about designing compositions for different types of concrete,
- Familiarization with the application of special concrete technologies.

Entry competences (prior knowledge, descriptive):

- Knowledge of the basic properties of components for making concrete,
- Knowledge of concrete composition calculations,
- Knowledge of the basics of concrete technology.

Learning outcomes:

1. Develop an application technology for different types of concrete,
2. Design the composition of concrete for different types of concrete,
3. Make designed concrete at a concrete plant,
4. Create a quality assurance plan for concrete structure performance,
5. Carry out quality control at the construction site,
6. Interpret the results of testing concrete properties.

Course content (by course schedule):

- Lectures:
    1. Introduction to the development directions of concrete technology [3]
    2. Self-compacting concrete [3]
    3. Architectural concrete [3]
    4. Micro-reinforced concrete [3]
    5. Lightweight concretes. Heavyweight concretes [3]
    6. Shotcrete [3]
    7. Concrete with high performance properties. High strength concrete [3]
    8. Hydrotechnical concretes. Massive concrete. Rolled concrete [3]
    9. Concrete pavement structures. Concrete in tunnels [3]
    10. Polymer-modified concretes and mortars. Concrete and mortar for rehabilitation and strengthening [3]
    11. Concrete from recycled aggregate [3]
    12. Mortars. Injection mixtures. [3]
    13. Technology of concreting at high and low temperatures [3]
    14. Special concrete installation technologies [3]

15. Examples of buildings made with special concrete and technologies [3]

- Auditory exercises:
  1. Achievements in the field of special concrete and technologies [2]
  2. Self-compacting concrete [2]
  3. Micro-reinforced concrete [2]
  4. Thermal calculation of massive concrete [2]
  5. Examples of practical application of special concrete and technologies [2]
- Laboratory exercises:
  1. Self-compacting concrete [2]
  2. Micro-reinforced concrete [2]
  3. Lightweight concrete [2]
  4. Testing the properties of hardened self-compacting concrete [2]
  5. Testing the properties of hardened microreinforced concrete [2]
  6. Testing the properties of hardened lightweight concrete [2]
  7. Ultra high strength concretes [2]
  8. Testing the properties of ultra-high-strength hardened concrete [2]
- Laboratory exercises:
  1. Examples of application in practice [4]

APPLIED SOIL MECHANICS

Credits (ECTS): 7.5

Hours (total per semester):

- Lectures: 45
- Exercises: 30 (12 auditory + 18 construction)

Course objectives:

- Familiarization with the mechanical behaviour of fine-grained and coarse-grained water-saturated soils,
- Familiarization with simple analytical models of soil mechanical behaviour,
- Familiarization with the procedures for determining the parameters of simple analytical models of soil mechanical behaviour from the results of common laboratory and field experiments.

Entry competences (prior knowledge, descriptive):

- Application of the basic concepts of the mechanics of continuous media (stresses, deformations, equilibrium, linear elasticity, elastic and plastic deformations, strength),
- Understanding of the basic concepts and application of the finite element method in the mechanics of continuous media,
- Application of basic concepts of soil mechanics (soil classification, index indicators, principle of effective stresses, stiffness and strength of soil, soil consolidation, common laboratory and field geotechnical experiments, calculation of settlement and bearing capacity of shallow foundations, soil pressures on walls, seepage of groundwater, slope stability).

Learning outcomes:

- Recognize important factors that influence the mechanical behaviour of the soil,
- Interpret and analyse the results of usual geotechnical laboratory and field experiments,
- Analyse, compare and connect the results of geotechnical investigation works,
- Evaluate and select the parameters of simple analytical models of soil behaviour relevant to the considered geotechnical problem,
- Choose a calculation model of the geotechnical soil profile relevant to the considered geotechnical problem,
- Basic handling of computer programs for solving problems of boundary conditions on examples of modelling oedometer and triaxial experiments with a linear-elastic soil model and triaxial experiments with an elasto-plastic soil model.

Course content (by course schedule):

- Lectures:
  1. Introductory lecture
  2. Phase relations in soil
  3. Stresses in the soil
  4. Phase relations in soil – student presentations
  5. Behaviour of the soil in the oedometer experiment
  6. Soil behaviour in direct shear tests
  7. Soil behaviour in drained triaxial experiments
  8. Stresses in soil – student presentations
  9. Soil behaviour in undrained triaxial tests
  10. Soil behaviour during compaction
  11. Soil stiffness at small deformations [2]
  12. Laboratory experiments – student presentations [2]
  13. Final presentations and submission of final program assignments
- Exercises:
  1. Introduction
  2. Phase relations in soil [3]
  3. Stresses in soil [4]
  4. Laboratory experiments [5]
  5. Phase relations in the soil, stresses in the soil, laboratory experiments [2]

Contributions to the final grade:

- Written exam 100%.

GEOTECHNICAL ENGINEERING

Credits (ECTS): 6.0

Hours (total per semester):

- Lectures: 30
- Exercises: 30 (11 auditory + 19 construction)

Course objectives:

- Familiarization with the basic principles of Eurocode 7 and their application to geotechnical structures,
- Acquiring basic knowledge about the types and roles of basic geotechnical structures and measures (shallow and deep foundations, retaining structures, protection of construction pits, cuttings, earthfill structures) and understanding design situations related to them,
- Acquisition of knowledge on the calculation of simpler geotechnical structures (shallow foundations on soil and rock, piles, retaining structures, stabilization of cuttings and excavations in the rock) from the aspect of serviceability and ultimate limit states.

Entry competences (prior knowledge, descriptive):

- Knowledge of the basic physical and mechanical properties of soil and rock mass (stiffness, strength),
- Application of basic concepts of soil mechanics (soil classification, index indicators, principle of effective stresses, soil consolidation, settlement and bearing capacity of shallow foundations, soil pressures on walls, groundwater seepage, slope stability).

Learning outcomes of courses (4-8):

- Recognize design situations related to basic geotechnical structures (shallow and deep foundations, retaining structures, slopes, earthfill structures) in accordance with the principles of Eurocode 7,
- Calculate the bearing capacity of shallow and deep foundations in different types of soil and rock,
- Apply simpler methods for assessing the stability of natural and artificial slopes,
- Determine earth pressures on different types of retaining structures and evaluate their stability,
- Perform simpler seismic calculations for basic geotechnical structures.

Course content (by course schedule):

- Lectures:
  1. Introduction to geotechnical engineering [2]
  2. Principles of Eurocode 7 [2]
  3. Types and bearing capacity of shallow foundations in different types of soil and rock [2]
  4. Settlement of shallow foundations [2]
  5. Calculation methods of stability of natural and artificial slopes [2]
  6. Actions on slopes and stabilization procedures [2]
  7. Types of retaining structures and determination of earth pressures [2]
  8. Actions and stability checks of retaining structures [2]
  9. Application of types and bearing capacity of deep foundations [2]
  10. Action and transmission of forces in pile groups [2]
  11. Types of earthfill structures and basics of soil compaction [2]
  12. Construction of earthfill structures and stability checks [2]
  13. Introduction to soil dynamics and the basics of soil cyclic behaviour [2]
  14. Typical problems of seismic geotechnical engineering [2]

15. Simplified seismic geotechnical calculation [2]

- Exercises:
1. INTRODUCTION – revision, syllabus, rules (auditory) [2]
2. EC7 – revision (design situations, project values, part. coeff.), examples for various constructions. (auditory) [2]
3. Pad foundation (bearing capacity + settlement) – example of calculation of bearing capacity for skew eccentric load and settlement Kanny, Steinbrenner, M&P, 1 . PROGRAM – assignment (auditory and construction) [2]
4. 1ST PROGRAM ASSIGNMENT – problem solving (construction) [2]
5. SLOPE – stability calculation in the program GEO-SLOPE, 2. PROGRAM – assignment (auditory and construction) [2]
6. 2ND PROGRAM ASSIGNMENT – problem solving (construction) [2]
7. RETAINING WALL – calculation example for gravity and L wall (pressures according to Rankine), 3RD PROGRAM – assignment (auditory and construction) [2]
8. 3RD PROGRAM ASSIGNMENT – problem solving (construction) [2]
9. SHEET PILE STRUCTURE – example of calculation for anchoring in one row, 4TH PROGRAM – assignment (auditory and construction) [2]
10. 4TH PROGRAM ASSIGNMENT – problem solving (construction) [2]
11. DEEP FOUNDATION ON PILES - example of calculation of bearing capacity (API and DIN) and settlement of piles (DIN), 5TH PROGRAM – assignment (auditory and construction) [2]
12. 5TH PROGRAM ASSIGNMENT – problem solving (construction) [2]
13. SEISMIC CALCULATION - simpler examples of seismic calculations on geotechnical structures from previous programs, 6TH PROGRAM – assignment (auditory and construction) [2]
14. 6TH PROGRAM ASSIGNMENT – problem solving (construction) [2]
15. REVIEW OF PROGRAM ASSIGNMENTS (construction) 2]

NUMERICAL MODELLING IN GEOTECHNICS

Credits (ECTS): 7.5

Hours (total per semester):

- Lectures: 30
- Exercises: 45 (5 auditory + 35 on computers + 5 construction)

Course objectives:

- Acquisition of knowledge required for engineering judgment in modelling in geotechnics,
- Application of acquired knowledge in modelling complex geotechnical problems.

Entry competences (prior knowledge, descriptive):

- Knowledge of working with SIGMA/W, SEEP/W and SLOPE/W software,
- Knowledge of all soil parameters required as input data for the SIGMA/W, SEEP/W and SLOPE/W software,
- Understanding of the basic principles of numerical modelling.

Learning outcomes:

- Recognize the appropriate method of numerical modelling for a particular geotechnical problem,
- Explain the results of numerical modelling,
- Choose relevant soil parameters for numerical modelling,
- Analyse the modelled soil behaviour,
- Plan numerical modelling steps for a specific geotechnical problem.

Course content (by course schedule):

- Lectures:
  1. Introduction [1]
  2. Numerical analyses of water seepage in soil [4]
  3. Stress-strain analysis [5]
  4. Mid-term exam
  5. Stability analyses [4]
- Exercises (auditory in the computer room):
  1. Structured and unstructured networks and the influence of boundary conditions, familiarization with computer programs
  2. Modelling of seepage in saturated soil
  3. Flow through anisotropic and inhomogeneous soil
  4. Modelling of the soil consolidation process [2]
  5. Modelling of seepage in unsaturated soil
  6. Interaction of seepage analysis and stress-strain analysis
  7. Analyses of settlement and bearing capacity of isolated footing, foundation strips and foundation slabs
  8. Modelling of the construction pit and stabilization with anchors
  9. Modelling of the construction pit and stabilization with struts
  10. Embankment and tunnel modelling
  11. Interaction of seepage analysis and stability analysis
  12. Selection of models and parameters for modelling stability analyses
  13. Stability analysis – parametric analysis
  14. Comparison of LEM and phi-c reduction stability analyses

HYDROLOGY 2

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 30
- Exercises: 30 (2 auditory + 10 design + 18 construction)

Course objectives:

- Acquisition of theoretical and practical knowledge in the field of hydrology, which includes analysis of precipitation data, hydrological processes on land: determination of interception and evapotranspiration, seepage into the soil and surface water flow, groundwater, soil moisture, saturated and unsaturated zone, parametric methods for determining processes runoff in the basin – methods for determining direct runoff, and mathematical modelling in hydrology.

Entry competences (prior knowledge, descriptive):

- Knowledge of the basics from hydrology courses, which include: water and water movement in nature, processes in the atmosphere, hydrometry, hydrometric data processing, application of probability and statistics in hydrology,
- Knowledge and understanding of the physical properties of substances (phases of substances, density, specific volume and quantity of substances).

Learning outcomes:

- Explain in more detail terms about: hydrological processes on land and enumerate them, analysis of precipitation data, runoff processes in the basin - methods for determining direct runoff, and mathematical modelling in hydrology,
- Apply the acquired theoretical knowledge of hydrology in the construction industry; in building design, they are able to solve simpler problems and tasks in hydrology,
- Explain terms and apply procedures for basic analysis of meteorological data, hydrological analysis and elaboration of hydrological data,
- Students have the knowledge about the meaning and role of water in the development of society, about the role of hydraulic structures in the management of water resources, about the classification, purpose and definition of hydrological data and analyses when dimensioning hydraulic structures.

Course content (by course schedule):

- Lectures:
  1. Introduction [2]
  2. Revision [2]
  3. Hydrometry: hydrological measurements and observations, measurements of water level, water depth, flow, groundwater, river sediment, ice observation [2]
  4. 1st mid-term exam [2]
  5. Processing of hydrometric data: basic processing, flow curve, sediment transport curve, random variable, frequency and durability curves [2]
  6. Analyses of time series: calculation of flood flows, theoretical distribution functions [2]
  7. Precipitation: precipitation parameters, remote measurements of precipitation, precipitation in Croatia, point data processing, IDF curves, RDF curves, design storm [2]
  8. Morphological characteristics of the watershed: longitudinal fall, stream length, watercourse length, watershed and river network [2]
  9. Modelling and GIS technology: GIS components, spatial analyses, examples of hydrological analyses [2]
  10. Runoff process in the watershed: base runoff, direct runoff, runoff on small watersheds, runoff on large watersheds [2]
  11. Effective precipitation models: index method, NRCS-CN method [2]

12. Direct runoff models: isochron method, unit hydrograph method, synthetic unit hydrograph [2]
13. Continuity equation: water balance, discrete time domain, hydrological year, water balance on Earth [2]
14. Hydrological forecasts: results of the BRIDGE SMS project, results of the MuraDrava-FFS project [2]
15. 2nd mid-term exam

- Exercises:
  1. Analysis of hydrological time series. Frequency curves and durability curves. Flow curve. [4]
  2. Probability of flood flows [6]
  3. Submission and commentary of the 1st program assignment [2]
  4. Basin runoff model [2]
  5. Basic characteristics of the basin [4]
  6. Project precipitation. Effective precipitation model. Surface runoff model. Base runoff model. Model of water wave propagation in a watercourse. [4]
  7. Runoff modelling in HEC-HMS. [6]
  8. Submission and commentary of the 2nd program assignment [2]

RIVER TRAINING

Credits (ECTS): 7.5

Hours (total per semester):

- Lectures: 45
- Exercises (design): 30

Course objectives:

- Learning about the basic know-how about design, construction, maintenance and management of river training works to students,
- Understanding basic morphological characteristics of natural watercourses and interpretation of events that initiate their changes.

Entry competences (prior knowledge, descriptive):

- Knowledge of basic fluid dynamics (momentum equation, general equations for description of the fluid in motion (Saint-Venant and Navier-Stokes equations), the law of conservation of energy, Bernoulli equation for viscous fluid, resistance to flow, determination of local and friction energy losses, pressure and energy grade, measurement of flow velocity, pressure and discharge),
- Knowledge of descriptive and differential geometry, drawing in 2D plane, finding line intersections, placement of circles given by their tangent lines,
- Computer literacy: drawing with CAD based software.

Learning outcomes:

- Definition of basic laws in riverine environment and their representation through use of mathematical tools,
- Understanding dynamics in natural watercourse,
- Modeling free surface flow with 1D models and interpretation of results,
- Application of engineering approaches to river training,
- Placing of horizontal alignment in space and design of river training structures in plane and crosssection,
- Estimating the cost-benefit for particular variant solutions with regard to selected river training works type.
-

Course content (by course schedule):

- Lectures:
  1. Purpose, problems and tasks of river training, the role of river training works in water management. Basic definitions and classifications [3]
  2. Morphology of the river bed [3]
  3. Hydrological properties of natural watercourses, flow regime, sediment regime, ice regime [3]
  4. Hydraulic calculations of natural and artificial watercourses [6]
  5. Flow calculations in open channels [3]
  6. Calculations of channel stability [3]
  7. Morphodynamic analyses of the watercourse channel [3]
  8. Approaches to the problem of local channel instability [3]
  9. River training structures in the main channel [3]
  10. River training structures outside the main channel [3]
  11. Embankments[3]
  12. Other river training structures [3]
  13. Regulating the flow regime [3]
  14. Works on the basin and facilities for regulating the water regime, basic principles of functioning [3]
  15. Hydraulic structures on watercourses [3]
  16. Regulation of small watercourses with a immobile boundary [3]

- Exercises:
  1. Channel axis layout and bank lines [6]
  2. Selection and placement of river training structures [4]
  3. Hydraulic flow calculations for mean water flow[4]
  4. Hydraulic flow calculations for high water [4]
  5. Selection and layout of river training structures [4]
  6. Design of structures [4]
  7. Hydraulic calculations of flow in a channel for mean and high water for a design state [4]

PRESTRESSED CONCRETE

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 30
- Exercises: 30 (design: 15, construction: 15)

Course objectives:

- Acquisition of theoretical knowledge about prestressing systems and technologies, suitable materials, differences in relation to reinforced concrete, the background of the design approach, the application of prestressed concrete in different types of structures for their exploitation, but also in the construction of special types of structures,
- Acquisition of theoretical and practical knowledge about the realization of prestressing force and its losses, calculation of bending, shear and torsion, checking of cracks, deflections, introduction of prestressing force into the structure, tendons/cables layout, and constructing details.

Entry competences (prior knowledge, descriptive):

- Knowledge of reinforced concrete in terms of materials and design of basic elements.

Learning outcomes:

- Knowledge and skills required for designing prestressed structural elements,
- Knowledge and ability to select steel for prestressing and concrete depending on the conditions of use of prestressed structural elements and conditions of aggressive environmental action in accordance with contemporary methods and criteria of European standards,
- Knowledge and skills necessary for analysing the behaviour and to design prestressed structural elements and load-bearing systems according to the ultimate limit states using contemporary methods and criteria of European standards,
- Knowledge and skills necessary for verification of serviceability limit states with the use of contemporary methods and criteria of European standards,
- The ability to shape and design prestressed structural elements.

Course content (by course schedule):

- Lectures:
  1. Basic principles, historical development, types and systems of prestressing [2]
  2. Prestressing materials, systems and technology and the field of application [2]
  3. Prestressing force, immediate and time losses [2]
  4. Axially prestressed elements. Elements exposed to bending (1) [2]
  5. Elements exposed to bending (2 and 3) [4]
  6. Shear and torsion [2]
  7. Deflections and cracking, Transfer of prestressing [2]
  8. Details and constructive rules for prestressed concrete structures [2]
  9. Cantilever beams. Continuous and partially continuous beams (1) [2]
  10. Continuous and partially continuous beams (2). Composite beams [2]
  11. Prestressed slabs [2]

12. Elements in compression. Circular prestressing [2]
13. External prestressing [2]

- Exercises (auditory):
  1. Layout of the structure
  2. Defining appropriate actions/loads, construction phases and usage
  3. Work on structural layout, action analysis and structural calculation
  4. Cable and adhesive prestressing of the main girder
  5. Tendons/cables layout and prestressing force losses
  6. Work on prestressing, tendon layout and losses
  7. Work on prestressing, tendon layout and losses
  8. Dimensioning of the prestressed girder for the ultimate limit state
  9. Work on dimensioning for ULS
  10. Checks of the prestressed girder for the serviceability limit state
  11. Checks of the prestressed girder for the serviceability limit state
  12. Work on checks for SLS
  13. Design and construction of details, creation of a prestressed reinforcement plan for a given girder
  14. Work on the reinforcement plan
  15. Submission of program assignments

MECHANICS OF MATERIAL

Credits (ECTS): 4.5

Hours (total per semester):

- Lectures: 30
- Exercises: 15 (auditory: 4, laboratory: 11)

Course objectives:

- Acquisition of theoretical knowledge about the physical and mechanical properties of materials,
- Acquisition of theoretical and practical knowledge about conducting experiments, ability to analyse and apply results.

Entry competences (prior knowledge, descriptive):

- Knowledge of differential and integral calculus,
- Knowledge of mechanics (statics and kinematics),
- Understanding the concepts of stress and strain analysis,
- Knowledge of stress and deformation calculations in elements loaded with internal forces (longitudinal and transverse, torsional moment and bending moment).

Learning outcomes:

- Become familiar with types of testing of mechanical properties of materials, methods and standards for testing,
- Explain the structure of matter, structurally sensitive and insensitive properties, selective and additive theory,

- Explain and interpret the methods of determining the mechanical properties of materials,
- Explain the strength of materials under cyclic loading,
- Recognize the meaning of rheology and fracture mechanics,
- Explain the concept of material hardness and test methods,
- Explain methods of non-destructive testing of materials and apply them,
- Apply experimental stress and deformation analysis when determining the physical and mechanical properties of materials.

Course content (by course schedule):

- Lectures:
    1. General considerations. Phenomenology. Classification of testing, loading speed of material samples. Interpretation of test results. Norms (standards) for testing. Material properties to be tested: chemical, physical and chemical, physical, and mechanical properties. Structure of solid materials. The influence of the material structure on the mechanical properties of the material. Probabilistic character of mechanical properties. Structural sensitivity and structural insensitivity. Selective and additive theory [2]
    2. Modelling and scale effect. Load, time, temperature. Test methodology. Mechanical properties of materials during stretching. Diagram F-Δl. Determination of the tensile strength of materials in a brittle state. Conventional material flow chart. Characteristics of material deformability. Ductile materials. Brittle materials [2]
    3. The actual working diagram of the material. Mechanical properties of materials under pressure loading. Schematization of the material working diagram. Elastic material, elastoplastic material with hardening, ideally elastoplastic material, rigid plastic material, rigid plastic material with hardening [2]
    4. The influence of various factors on the behaviour of materials under load: speed of load increase, Bauschinger effect, elastic hysteresis, creep, stress relaxation, influence of temperature. Permanent static strength. Basic types of rod breakage. Load types [2]
    5. Material strength under dynamic loading. Types of dynamic load. Impact strength or toughness of materials: Charpy and Föppl's method. External factors affecting the impact strength of materials. Material strength under cyclically variable load. Types of cyclically variable load [2]
    6. Appearance of material fatigue. Permanent dynamic strength, time dynamic strength. Determination of dynamic strength. Presentation of test results. Wohler, Smith, Launhardto-Weyrauch and Haigh diagrams [2]
    7. Influence of various factors on permanent dynamic strength. Calculation of strength under variable stress. Safety factor of permissible stress. Schematization of the Haigh diagram according to Serensen and Kinosošvili. Schematization of the Haigh diagram according to Goodman. Determination of permanent dynamic strength, safety coefficient and permissible stresses [2]
    8. Rheology. Rheological properties of materials and rheological models. Rheological equation of state of the material. The principle of superposition of time and temperature. Complex rheological models: Kelvin, Maxwell and Poynting-Thomson model [2]

9. Bending test. Residual stresses. Testing of plastic properties: bend test and wire twist test. Torsion test. Shear test. [2]
10. Fracture mechanics and material strength. Basic forms of crack development. Stress intensity factor. Fracture criteria. Fracture toughness. Material sensitivity to notch and cracks [2]
11. The hardness of the material. Martens process, Brinell process, Vickers process, Rockwell process, Shor process and Poldi process, sclerometer. Correlation of hardness and strength of materials. Non-destructive testing [2]
12. Acoustic procedures. Determination of material strength and elastic modulus. Application of the ultrasound method in defectoscopy [2]
13. Test by resonance vibration. Devices for measuring deformations. Experimental analysis of stress and deformation. [2]
14. Choice of measurement base and disposition of measurement locations. Interpretation of test results [2]
15. Mid-term exam

- Exercises (auditory):
  1. Material fatigue. Influence of various factors on permanent dynamic strength. Calculation of strength under variable stress. Safety factor of permissible stress. [2]
  2. Rheological properties of materials and rheological models. Rheological equation of the state of the material. Fatigue of the material [1]
  3. Fracture mechanics and material strength. Stress intensity factor. Fracture criteria. [1]
- Exercises (laboratory):
  1. Determination of diagrams for static and dynamic loading. Bauschinger effect. Elastic hysteresis. Creep. Relaxation. [2]
  2. Determination of tensile strength of brittle material. Pressure test. Effect of sample size on material strength. The influence of the rate of increase in load. [2]
  3. Shear test. Bending test. Test of toughness by reverse bend test. [2]
  4. Twisting test of toughness.
  Impact strength according to Charpy and Föppl.
  Material fatigue.
  Material hardness: Martens, Brinell, Vickers, Rockwell, Poldi, sclerometer. [2]
  5. Fracture mechanics [2]
  6. Acoustic procedures.
  Determination of tension in the wire. [1]

MATHEMATICS 3

Credits (ECTS): 7.5

Hours (total per semester):

- Lectures: 45
- Exercises (auditory): 30

Course objectives:

- Acquisition of theoretical knowledge about basic linear models of mathematical physics and their application in civil engineering,
- Acquisition of basic practical knowledge and skills for analytical and numerical solution of such models.

Entry competences (prior knowledge, descriptive):

- Knowledge of differential and integral calculus (including ordinary differential equations) and linear algebra.

Learning outcomes:

- Understanding the conditions and limitations of applicability of linear models,
- The ability to recognize and choose a suitable model,
- The ability to solve simpler models, analytically and/or numerically,
- The ability to qualitatively analyse solutions.

Course content (by course schedule):

- Lectures:
  1. Review of mathematical analysis content.
  2. Review of linear algebra content.
  3. Fourier series.
  4. Boundary problem for wire balance.
  5. Wave equation. A boundary value problem for transverse wire oscillations.
  6. Fourier method for the wave equation.
  7. Heat conduction equation. A boundary value problem for heat conduction through a rod. Fourier method.
  8. Laplace's equation. Harmonic functions and their properties. Boundary-value problems for membrane equilibrium. Fourier method.
  9. Poisson's equation. Boundary problems for membrane oscillations. Fourier method.
  10. Numerical methods for ordinary differential equations - Cauchy problem. Euler's method. The Runge-Kutta method.
  11. Mid-term exam.
  12. Numerical methods for ordinary differential equations - the boundary value problem of the equilibrium of a wire in a medium with resistance. Finite difference method.
  13. Numerical methods for partial differential equations - boundary value problem of wire oscillation and heat conduction through a rod. Finite difference method (network method).
  14. Numerical methods for partial differential equations - membrane equilibrium boundary value problem. Finite difference method.
  15. Finite Element Method
- Exercises:

The exercises follow lectures

STOCHASTIC PROCESSES

Credits (ECTS): 7.5

Hours (total per semester):

- Lectures: 45
- Exercises (auditory): 30

Course objectives:

- Acquisition of theoretical knowledge about the basic features of random processes and their application in civil engineering,
- Acquisition of basic practical knowledge and skills for setting up and solving simple mathematical models of such processes.

Entry competences (prior knowledge, descriptive):

- Knowledge of the elements of differential and integral calculus, probability theory and linear algebra.

Learning outcomes:

- Understanding the general features of random processes,
- Understanding the limitations and conditions of applicability of individual models,
- The ability to recognize and choose a suitable model,
- The ability to pose problems in terms of Markov chains,
- The ability to analyse the behaviour of Markov chains and other types of random processes.

Course content (by course schedule):

- Lectures:
  1. Revision of linear algebra and mathematical analysis content
  2. Revision of probability and statistics content.
  3. Markov chains. Definitions and examples.
  4. Markov chains with a finite set of states.
  5. Markov chain state classification.
  6. Recurrence/transience. Periodicity.
  7. Stationary distributions and boundary behaviour.
  8. Output distributions and times.
  9. Markov chains with a countable set of states.
  10. Simple and complex Poisson processes.
  11. Mid-term exam.
  12. Continuous-time Markov chains.
  13. Queueing theory I
  14. Queueing theory II
  15. Time series
- Exercises:

The exercises follow lectures

2.1.2 Summer semester

Courses	Total hours			ECTS
	Lectures	Seminar	Practice	
Building information modelling	30	0	30	6
Management for Construction Industry	30	11	4	4,5
Management of construction projects	60	5	25	9
Applied Geology	30	0	0	3
Applied Rock Mechanics	30	0	30	6
Embankments and Slopes	30	0	30	6
Foundation Engineering	45	0	30	7,5
Data Analysis for Hydrosciences	30	0	30	6
Drainage and Irrigation 1	45	0	30	8
Environmental Protection	30	0	0	3
Water Supply and Sewerage 1	30	0	15	4
Durability of Structures 1	30	0	30	6
Theory of Composites	30	0	15	4,5
Theory of Elasticity and Plasticity	45	0	30	7,5
Geometry in Civil Engineering	15	0	30	4,5
Numerical Mathematics	30	0	30	6
Perspective	30	0	30	6
Waves and Oscillations	30	0	30	6

MANAGEMENT FOR CONSTRUCTION INDUSTRY

Credits (ECTS): 4.5

Hours (total per semester):

- Lectures: 30
- Exercises 15 (auditory: 4, seminars: 11)

Course objectives:

- Acquiring a theoretical knowledge of management principles, project management, and business decision-making,
- Understanding corporate concepts, construction operations, outcomes, and market concepts.

Entry competences (prior knowledge, descriptive):

- Preferably knowledge of the basics of economics within the Business Economics course (elective course in the first year of undergraduate studies).

Learning outcomes:

- Explain management fundamentals, including development and functions,
- Describe management as a process including planning, organising, motivating, and controlling,
- Explain decision-making styles and processes for businesses,
- Definition of company types, the limitations and principles of business operations, and the business itself through the process of reproduction and business assets,
- Differentiation between business costs, prices and calculations,
- Interpretation of indicators of business results,
- Analyse market types and market exchange participants.

Course content (by course schedule):

- Lectures:
  1. Introduction
  2. 1. Basic principles of management
  3. Managers/techno managers Management functions
  4. Development of Management Schools of management
  5. 2. Management as a process – planning, organizing
  6. Management as a process – motivation, control
  7. 3. Company – concepts, types
  8. Companies – reproduction process, business assets of the company
  9. 4. Costs, prices and calculations
  10. 5. Business results – financial reports, success indicators
  11. 6. Business decision-making – methods and styles
  12. Business decision-making – communication
  13. 7. Market and market operations
  14. Market and exchange participants
  15. Presentation of seminar papers
- Exercises:

  1. Management – Concept/Merlin
  2. How to write a seminar paper?

3. Who are effective leaders?
4. How to prepare a successful presentation?
5. Case study
6. Presentation of the seminar work – discussion
7. 1st mid-term exam
8. Case study
9. Case study
10. Presentation of the seminar work – discussion
11. 2nd mid-term exam
12. Case study
13. Presentation of the seminar work – discussion
14. Seminar Presentation of the seminar work – discussion
15. Seminar 3rd mid-term exam

CONSTRUCTION PROJECT MANAGEMENT

Credits (ECTS): 9

Hours (total per semester):

- Lectures: 60
- Exercises: 30 (auditory: 16, design: 14)

Course objectives:

- Acquisition of theoretical knowledge about planning, managing, leading, organizing and controlling construction projects and other aspects of project management,
- Acquisition of practical knowledge of construction project management tools.

Entry competences (prior knowledge, descriptive):

- Knowledge of the method of additional and direct calculation in construction,
- Theoretical knowledge from the organization of construction, such as: price analysis, network planning, organizational charts, theories of organization, construction regulations, etc.

Learning outcomes:

- Recognize the foundations of project management (Strategies, Goals, Content, Phases, Lifetime, Participants, Limitations, Success Variables, Project Sustainability),
- Recognize management processes in the front end (Project identification, Project concept and definition, Early Project Design, Project execution preparation),
- Recognize the management processes throughout the implementation phases (Starting execution, Execution, Completion of execution) apply the method of planning machine work,
- Apply various the team life cycle and leadership models,
- Apply various risk management methods,
- Apply various quality management methods

Course contents:

- Lectures:
    1. Basic knowledge of project management (Development of project management, Basic knowledge according to IPMA, ISO 21500 and PMI standards)

2. Basics of construction project management (Strategies, Goals, Content, Phases, Lifetime, Participants, Constraints, Success Variables, Project Sustainability)
3. Management in the front end phases (Identification of the project, Definition of the project, Preparation of the execution of the project)
4. Management throughout execution phases (Initiation of execution, Execution, Completion of execution)
5. Construction project manager, Execution management (Required qualifications, Special features of the manager, Job of the manager, Responsibilities of the manager, Project management program)
6. Team work (Definition of a team, Characteristics of an effective team, Team formation – composition and size, Team work, Individual team roles, Team work problems, Examples of project teams, Leadership, Conflicts)
7. Risk management in construction projects (Definitions of risks, Essential characteristics of risks, Effects of risks in construction projects, Identification of sources of risk, Analysis of risks, Response to risks)
8. Change management in Construction (Sources of changes, Deciding on changes, Administration of changes)
9. Human resource management (Importance and functions, Management techniques, Human resource planning)
10. Quality/cost/time management in construction projects (Elements of quality, Standardization of quality, Quality in the project and business system, Quality as a strategic goal, Total quality management, Management methods and techniques)
11. Management of information and communication in construction projects (Information, Communication, Information technologies, Information system planning, Decision making)
12. Documentation of construction project management (Assignment of works and services, Contract documentation, Domestic and foreign sources of documentation, Performance contracts, Concession agreements, Engineering contracts, Documentation for contractual claims and disputes)
13. Information systems (IS) and information technologies (IT) in the context of construction project management

- Exercises:
  1. Project description (SWOT, purpose, strategic and project goals, short-term and long-term)
  2. Project description (SWOT, purpose, strategic and project goals, short-term and long-term)
  3. Interested parties (Internal, external, strength matrix, interest, attitude, their potential influence, their wishes, needs and goals in the project)
  4. Interested parties (Internal, external, strength matrix, interest, attitude, their potential influence, their wishes, needs and goals in the project)

5. Project content (scope, WBS, documentation for all project phases, project concept as a unifying document, management team, team functions, team collaboration)
6. Project content (scope, WBS, documentation for all project phases, project concept as a unifying document, management team, team functions, team collaboration)
7. Project activity planning (WBS, OBS, human and material resources, prices)
8. Project activity planning (WBS, OBS, human and material resources, prices)
9. Risks in the project (identification and register of risks, impact and consequences of risks on the project, risk reduction measures
10. Risks in the project (identification and register of risks, impact and consequences of risks on the project, risk reduction measures)
11. Project communication plan, and project monitoring and control (RAM, communication plan with reference to the WBS-OBS structure, control and reporting system, corrective activities, communication forms)
12. Project communication plan, and project monitoring and control (RAM, communication plan with reference to the WBS-OBS structure, control and reporting system, corrective activities, communication forms)
13. Closing the project - project close out (lessons learned, transfer of knowledge from the project, saving the database, handover and closing the project)
14. Presentation of the project plan (the entire course program)
15. Final defence and submission of the program assignment

BUILDING INFORMATION MODELLING

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 30
- Exercises: 30 (auditory: 11, design 19)

Course objectives:

- Acquisition of theoretical knowledge about building information modelling (BIM),
- Acquisition of theoretical knowledge about planning, management, organization and control of BIM construction projects,
- Acquisition of practical knowledge of BIM tools and processes for planning, preparation and execution of construction projects,
- Acquisition of practical knowledge about the necessary competencies of persons involved in BIM project management,
- Acquisition of practical knowledge about standards, processes and tools for applying the BIM concept in projects.

Learning outcomes:

- Explain the definition, properties and importance of BIM in construction projects.
- Recognize the necessary competencies of persons involved in the BIM project.

- Create and interpret the BIM execution plan and the employer's information requirements (EIR).
- Create a plan for communication, monitoring and quality control in BIM projects.
- Create a BIM model of the building.
- Create and evaluate a 5D construction execution plan.
- Interpret the relationship between the BIM project execution plan and the project management plan.

Course content (by course schedule):

- Lectures:
  1. Modelling and information management in the BIM environment (nD modelling)
  2. Roles and responsibilities of persons involved in BIM projects
  3. Data standards in BIM projects (ISO 16739, ISO 12006-3, ISO 29481, etc.)
  4. Process standards in BIM projects (family of ISO 19650 standards)
  5. Defining model information: BIM objects and libraries, levels of detail (LOD), classification systems (ISO 12006-2 and ISO 17412)
  6. Employer's information requirements (EIR) and BIM execution plan (BEP) in projects (context in project management, purpose and necessary principles in application)
  7. Delivery of digital information and use of information in different phases of the project (PIM, AIM, COBie, Digital Plan of Work, etc.)
  8. Exchange and security of information use in BIM projects (common data environment, UK Government Soft Landing scheme, etc.)
  9. Conditions for contracting the application of BIM on projects (ownership of BIM models, intellectual rights, insurance and exposure to risks, etc.)
  10. The state of BIM application (global and national standards, certificates, professional organizations that promote and support the application of BIM, legal regulations, etc.)
  11. Maturity levels and organizational resistance and changes in BIM implementation
  12. Values from the application of BIM technology in projects (improvement of construction and maintenance processes, reduction of waste, elimination of errors, improvement of the quality of deliveries, improvement of coordination of participants, etc.)
  13. New trends and the future of management in BIM projects
- Exercises (auditory):
  1. 1: Defining the input data for working in the BIM environment
  2. 2: Quality control of the BIM model (original and IFC file)
  3. 3: Creating a 4D BIM model
  4. 4: Creation of 5D BIM model
  5. 5: Creating a dynamic scheme of the construction site
  6. 6: Creating a BIM execution plan
- Exercises (design):
  1. 1: Defining the input data for working in the BIM environment
  2. 2: Quality control of the BIM model (original and IFC file)
  3. 3: Creating a 4D BIM model

4. 4: Creation of 5D BIM model
5. 5: Creating a dynamic scheme of the construction site
6. 6: Creating a BIM execution plan

APPLIED ROCK MECHANICS

Credits (ECTS): 6.0

Hours (total per semester):

- Lectures: 30
- Exercises (auditory): 30

Course objectives:

- Acquisition of advanced theoretical and applied knowledge about the behaviour of rocks due to the performance of geotechnical interventions,
- Application of acquired knowledge in solving more complex problems in the domain of rock mechanics and rock engineering.

Entry competences (prior knowledge, descriptive):

- Understanding the basic concepts of rock mechanics,
- Understanding primary and secondary stress states in rock engineering,
- Knowledge of rock mass classification methods,
- Knowledge of the basic principles of numerical modelling in geotechnics.

Learning outcomes:

- Apply methods of classification and characterization of rock mass and discontinuities in practical operations in rock mass,
- Explain the principles, mechanisms and difficulties in the design, execution and monitoring of interventions in rock in an engineering-adequate manner (verbally, in writing and graphically),
- Formulate and perform appropriate analyses for the needs of evaluating the stability of slopes, foundations and tunnels in the rock mass,
- Select and apply available engineering methods, tools and technologies for the design and execution of operations in the rock mass.

Course content (by course schedule):

- Lectures:

1. Introduction to applied rock mechanics and rock engineering.
2. Secondary state of stress for different interventions in the rock mass.
3. Physical and mechanical properties of rock mass and discontinuities.
4. Advanced discontinuity characterization and stereographic projection.
5. Engineering applications of rock mass classification.
6. Block theory.
7. Constitutional models of rock mass.
8. Rock foundations – failure mechanisms, analytical and numerical models.
9. Foundation on rock – essential aspects of performance.
10. Stability of rock slopes – failure mechanisms, analytical and numerical models.
11. Stability of rock slopes – methods of stabilization.

12. Tunnels in rock – failure mechanisms, analytical and numerical models.
13. Tunnels in rock – construction and rehabilitation methods.
14. Measurements and monitoring in rock engineering.
15. Rheology of rock mass.
16. Rock mechanics and environmental protection.

- Exercises:

1. Introductory exercises
2. Analytical methods in rock engineering
3. Numerical methods based on continuum.
4. Numerical methods based on discontinuity.
5. Parameter selection for rock engineering constitutive models.
6. Analysis and interpretation of stereographic projections.
7. Stability checks of the overlay and laminated roof layers of underground openings.
8. Numerical analyses of the stability of rock wedges in tunnels.
9. Numerical analyses of planar failures of rock slopes.
10. Numerical analyses of wedge failures of rock slopes.
11. Numerical analyses of overturning of blocks of rock slopes.
12. Numerical analyses of rock slides.
13. Numerical analyses of the stability of foundations on rock mass.
14. Probabilistic methods in rock engineering analyses [2].

EMBANKMENTS AND SLOPES

Credits (ECTS): 6.0

Hours (total per semester):

- Lectures: 30
- Exercises: 30 (6 auditory + 20 on computers + 4 construction)

Course objectives:

- Acquisition and application of theoretical knowledge when solving more complex geotechnical problems related to steady-state and transient flow of water through soil and earthfill structures,
- Acquisition of theoretical knowledge about the types of earthfill structures, the choice of materials and the method of installation,
- Acquisition of theoretical knowledge about methods of stabilizing unstable slopes,
- Acquisition of theoretical and practical knowledge about calculations of earthfill structures
- and slopes.

Entry competences (prior knowledge, descriptive):

- Understanding the effective and total stresses and water pressure in still water, and the potential for stationary water flow in the soil
- Understanding soil consolidation,
- Knowledge of the basic physical and mechanical characteristics of the soil (strength, stiffness, seepage coefficient),

- Knowledge of the basic principles of numerical modelling.

Learning outcomes:

- Define all terms related to steady-state / transient flow of water through saturated/unsaturated soil and earthfill structures,
- Understand and define the relevant boundary conditions for the problems of water seepage through earthfill structures and slopes,
- Understand the failure mechanisms of earthfill structures and slopes,
- Explain the functions of the internal structure of earthfill structures,
- Choose project situations related to different types of earthfill dams,
- Understand the basic problems related to the construction and stability of earthfill dams,
- Carry out seepage and stability calculations of different types of earthfill dams and slopes in accordance with relevant national and European standards,
- Analyse and prove the stability of earthfill structures and slopes in saturated and unsaturated conditions,
- Select and apply available engineering methods, tools and technologies for stabilizing unstable slopes.

Course content (by course schedule):

- Lectures:

1. Unstable slopes and their causes.
2. Shear strength parameters in saturated and unsaturated conditions and the method of their selection; drained and undrained strength parameters.
3. Geotechnical calculation of slope stability with an overview of analytical and numerical methods (MGR and MKE).
4. Geotechnical calculations of slope stability for different design situations.
5. Stabilisation of unstable slopes (anchored and nailed slopes, application of geosynthetics, micropiles).
6. Types of earthfill structures (hydraulic embankments and dams, road embankments, waste disposal sites).
7. Selection of soil materials, testing in the field and in the laboratory, methods of installation, properties of compacted material.
8. Mid-term exam.
9. Selection of dam types, zoned embankments, solution variations, presentation of more significant dams.
10. Analyses of the stability of earthfill structures in different design situations.
11. Water seepage through earthfill structures, water flow in saturated and unsaturated conditions, water flow through anisotropic and inhomogeneous soil.
12. Consolidation of soil under earthfill structures / Construction of embankments on undrained and drained foundation soil.
13. Application of Eurocode for earthfill structures and slopes [2].
14. Monitoring and observation of earthfill structures and slopes.

- Exercises:

1. Geotechnical calculations of slope stability [3]
2. Stabilization of unstable slopes with anchors
3. Stabilization of unstable slopes with nails
4. Stabilization of unstable slopes with geosynthetics.
5. First program assignment, analysis of program requirements, selection of the optimal stabilization solution.
6. Geotechnical calculations of the stability of earthfill structures
7. Geotechnical calculations of water seepage through earthfill structures [2]
8. Second program assignment, analysis of program requirements, selection of the optimal project of the earthfill structure.
9. Water seepage through earthfill structures – isotropic / anisotropy and homogeneous / inhomogeneous section.
10. Steady-state / transient flow of water through a saturated / unsaturated structure.
11. Embankment construction in undrained and drained conditions, soil consolidation analysis under the embankment.

End of semester grading:

- Written (theory and tasks on the computer) and oral exam (a total of 60 points).

Contributions to the final grade:

- The final grade is obtained from the sum of the points earned during the semester (up to 40 points) and in the written and oral exam (up to 60 points) as follows: sufficient 60-70 points, good 70-80 points, very good 80-90 points, excellent 90-100 points.

APPLIED GEOLOGY

Credits (ECTS): 3

Hours (total per semester):

- Lectures: 30

Course objectives:

- Acquisition of basic knowledge in general geology, mineralogy and petrology,
- Acquisition of basic knowledge in hydrogeology and engineering geology for application in construction,

Entry competences (prior knowledge, descriptive):

- Knowledge of basic chemical elements and compounds.

Learning outcomes:

- The ability to distinguish igneous, metamorphic and sedimentary rocks,
- The ability to recognize beds, wrinkles, faults and overthrust,
- Knowledge of the process of formation of karst and different karst forms, as well as familiarity with the problems that builders encounter when building tunnels in karst,
- The ability to use geological maps – recognizing geological symbols, reading the geological age of rocks, their composition and other important geological phenomena of a terrain,
- Acquisition of knowledge about basic engineering-geological classifications of rock mass.

Course content (by course schedule):

- Lectures:
  1. Introduction [2]
  2. On geoscience. General geology, stratigraphic. Constitution of the Earth. Geoid. Mineralogy. Mineral. Crystal [2]
  3. Isotropic and anisotropic minerals. Pyrogenic, pneumatogenic, hydrothermal, hydatogenic. Axis, plane centre of symmetry. Crystal systems. Properties of crystals, crystal bonds. Tetrahedral coordination. Coordination number. Polymorphism. Isomorphy [2]
  4. Properties of minerals. Mineral groups. Oxides and hydroxides. Carbonates. Sulfates. Silicates [2]
  5. Introduction to petrology. Rocks. Phenocrysts, monomineralic. Eruptive rocks. The way eruptive rocks appear. Structure and texture of eruptive rocks. Magma acidity. Bowen sequence of crystallization. Table of eruptive rocks [2]
  6. Sedimentary rocks. Transport of sediments. Mineral composition of sedimentary rocks. Structures and textures of sedimentary rocks. General overview of sedimentary rocks. Metamorphic rocks. Zones of metamorphism. Divisions of metamorphic rocks [2]
  7. Tectonics. Outcrops, camber, bed thickness. Beds, folds, anticlines and synclines. Faults. Overthrusts. Types of cracks [2]

  (Mid-term exam)

  8. Exodynamics of the Earth. Insolation. Hydrogeology. Water, hydrologic cycle. Porosity, permeability. Laminar and turbulent flow. Types of aquifers. Ghyben–Herzberg law. Ice and snow. Wind, organisms [2]

(Retest)

  9. Karst. External karst forms. Internal karst forms [2]
  10. Types of speleological objects. Speleothems. Groundwater [2]
  11. Landslides. Endodynamics. Orogenesis, epigenesis [2]
  12. Volcanoes. Earthquakes. Earthquake scales, seismicity [2]
  13. Geological maps. RMR and Q classification of rocks in construction. Determining the age of rocks [2]

FOUNDATION ENGINEERING

Credits (ECTS): 7.5

Hours (total per semester):

- Lectures: 45
- Exercises: 30 (auditory: 16, on computers: 14)

Course objectives:

- Interpret legal regulations related to the design and construction of foundations,
- Choose the type of foundation considering the type of soil, the possibility of execution and the given loads,
- Design and calculate the foundations of the building to meet the conditions of mechanical resistance and stability,
- Develop a program of investigative works necessary for designing the foundation.

Entry competences (prior knowledge, descriptive):

- Interpret the results of geotechnical investigation works,
- Recognize the type and essential mechanical properties of the foundation soil,
- Identify the general requirements for risk consideration in the norms for the design of building structures,
- Calculate settlement, time course of settlement and bearing capacity of soil under simple shallow foundations.

Learning outcomes:

- Recognize and explain design situations and limit states relevant for proving the mechanical resistance and stability of basic structures,
- Design a program and interpret the results of geotechnical investigation works for the purposes of designing and executing basic structures,
- Calculate settlement, bearing capacity, stability and internal forces in shallow foundations and piles,
- Devise a calculation procedure and prove the mechanical resistance and stability of shallow and deep foundations in case of structure-foundation-soil interaction,
- Draw up and design suitable foundations considering the requirements of the structure that rests on them and the properties of the soil,
- Develop the necessary communication and agreements with the designer of the building structure that will be supported by the provided foundation.

Course content (by course schedule):

- Lectures:
  1. Introduction to foundations, types of foundations, criteria, legal regulations
  2. Shallow foundations (types, limit states, design situations, design, details)
  3. Soil testing and determination of design parameters for shallow foundations
  4. Settlement of shallow foundations
  5. Bearing capacity of shallow foundations, sliding of shallow foundations
  6. Dimensioning of shallow foundations according to Eurocode 7
  7. Structure-foundation-soil interaction
  8. Deep foundations, types, limit states, design situations
  9. Methods of execution of deep foundations, details
  10. Soil testing and determination of design parameters for deep foundations
  11. Axial load on piles, negative friction
  12. Laterally loaded piles
  13. Dimensioning of deep foundations according to Eurocode 7
  14. Pilot testing, measurements and observations
  15. Complex foundation structures
- Exercises:
  1. Isolated footing: bearing capacity and settlement [4]
  2. Isolated footing group and foundation strip [2]
  3. Ground slab [2]

4. Soil-structure interaction (frame construction on shallow foundations) [2]
5. Bearing capacity and settlement of an axially loaded pile [2]
6. Bearing capacity and settlement of transversely loaded pile [2]
7. Calculation of the pilot group

DATA ANALYSIS FOR HYDROSCIENCES

Credits (ECTS): 6.0

Hours (total per semester):

- Lectures: 30
- Exercises (design): 30

Course objectives:

- Introduce students with methods and tools for analysing temporal and spatial data in hydrotechnics,,
- Train students for independent creation of research and/or projects using software environments for data management, calculation and graphic display.

Entry competences (prior knowledge, descriptive):

- Advanced use of basic computer tools (MS Excel),
- Knowledge of programming syntax and semantics,
- Knowledge of loops and branching: "for" loop, nested loops, "if" branching

Learning outcomes:

- Use the basics of the programming environment for data management, calculation and graphic display (Matlab / Octave, R, QGIS),
- Prepare and process raw time and/or spatial data for use in the calculation of functionality,
- Apply basic statistical analyses and models to the data and evaluate the model results,
- Distinguish basic methods for processing time data in the time and frequency domain,
- Apply a GIS tool for a basic overview of spatial data from hydrotechnics,
- Apply appropriate methods for spatial data analysis for the purpose of processing and use for design,
- Integrate spatial and temporal types of information within one system for the purpose of analysing the basis for hydrotechnical calculations,
- Make decisions based on the analysis of spatial and temporal data within the framework of interdisciplinary design activities.

Course content (by course schedule):

- Lectures:

1. Data preparation and input using the Matlab / Octave software environment, R. [2]
2. Application of descriptive statistics methods. [2]
3. Application of inferential statistics methods. [2]
4. Regression models. Data-based models. [2]
5. Model validation. [2]
6. Introduction to time series analysis. Spectral analysis and filtering. [2]
7. Trend analysis. [2]

8. 1st mid-term exam
9. Basics of GIS. Overview of coordinate systems and projections. Spatial data analysis. Storage of geospatial objects: points, polylines, polygons. [2]
10. Digital relief model. Vector data model. [2]
11. Layers in GIS. Using publicly available WMS layers in QGIS. [2]
12. Analysis of topographical characteristics. The triangulated irregular network (TIN) model. [2]
13. Analysis of topographical characteristics. Raster model. [2]
14. Application of GIS in hydrotechnics. Projects and research on examples. [2]
15. 2nd mid-term exam

- Exercises:

1. Creating variables and saving data in the Matlab software environment/Octave, R. [2]
2. Calculation of basic statistical parameters for a set of hydrological data. [2]
3. Determining the correlation between variables. [2]
4. Creating a regression model. [2]
5. Model validation. [2]
6. Time series analysis and spectrum. [2]
7. Trend analysis. [2]
8. Presentation of the 1st part of the project [2]
9. Project assignment in QGIS. [2]
10. Entering data into the model [2]
11. Creating a digital relief model from vector data [2]
12. Adding data to DTM from WMS layers [2]
13. Creation of the triangulated irregular network (TIN) model. [2]
14. Creating a raster model. Data export [2]
15. Presentation of the 2nd part of the project [2]

DRAINAGE AND IRRIGATION 1

Credits (ECTS): 8

Hours (total per semester):

- Lectures: 45
- Exercises (design): 30

Course objectives:

- Getting to know the laws of the plant-soil-water relationship and the basics of designing, planning and managing hydromelioration systems,
- Development of analytical skills in the field of plant-soil-water relations, planning, designing and management of melioration systems, especially in designing systems for surface and underground drainage.

Entry competences (prior knowledge, descriptive):

- Basics of hydraulics and hydrology,
- Working knowledge of basic computer programs for spreadsheets, text creation and technical drawing.

Learning outcomes:

- Acquisition of knowledge in hydrology, hydraulics, meliorative pedology, climatology, topography, engineering informatics, designing hydromelioration systems for drainage,
- Perform an analysis of the hydrological, pedological, topographical and climatological characteristics of the catchment areas – agricultural areas,
- Define the criteria and measures for choosing the optimal hydromelioration system of the agricultural area,
- Understand the basic parameters of the plant-soil-water relationship related to underground and surface drainage,
- Create a preliminary design of the hydromelioration system of surface and underground drainage,
- Use computer programs in hydrotechnical melioration projects

Course content (by course schedule):

- Lectures:
  1. The importance of hydrotechnical melioration in agriculture, EU common agricultural policy, buildings for basic melioration drainage in accordance with the Water Act, Water Management Plan [3]
  2. Data for creating plans and projects of hydromelioration facilities and systems. Dimensioning criteria [3]
  3. Conceptual solution of surface drainage – determination of channel layout in the drainage network, channel spacing of the 4th order, higher order channel routing [3]
  4. Calculation of runoff from agricultural land – determination of relevant precipitation, concentration time and drainage module [3]
  5. Dimensioning of the channel network – hydraulic calculation of flow in channels and optimization of channel geometry using DrainCAN and HEC-RAS software [3]
  6. Structures on the canal network: floodgate, pipe culvert, plate culvert, culvert, siphon, plug, hydraulic drop structure, threshold, pumping station, crossings and bridges. General technical conditions and examples [3]
  7. Hydraulic drop structures and floodgates: approach to dimensioning; channel connections; hydraulic jump; waterfalls; energy dissipators, examples of built structures [3]
  8. Pumping stations: basic terms and definitions, selection of the optimal pump, dimensioning of the pumping basin, examples of constructed pumping stations. [3]
  9. Maintenance and management of drainage systems [3]
  10. Soil pedology, water constants, excess subsurface water, calculation of groundwater flow [3]
  11. Stationary calculation of underground drainage, drainage through channels, pipe drainage, drainage wells, vertical, horizontal and radial inflow into drains, determination of drain spacing; Hooghoudt's approach; Ernst's approach [3]
  12. Non-stationary calculation of underground drainage [3]
  13. Drainage slope and interception drainage: calculation approach; solution examples [3]
  14. Drainage and soil salinization: the influence of irrigation on drainage; salt balance in the root zone; salt washing; salinization due to capillary rise of water in the soil [3]
  15. Drainage and irrigation as part of agricultural land management [3]

- Exercises (auditory and construction):
  1. Conceptual solution of the surface drainage system [4]
  2. Rainfall - calculation [4]
  3. Hydraulic calculation of flow [6]
  4. Calculation of hydraulic drop structures [4]
  5. Plans - profile grades and cross-sections [4]
  6. Calculation of the underground drainage system [4]
  7. Dimensioning of the pumping station [4]

ENVIRONMENTAL PROTECTION

Credits (ECTS): 3

Hours (total per semester):

- Lectures: 30

Course objectives:

- Acquiring theoretical knowledge about basic ecological terms and processes,
- Knowledge of anthropogenic impacts on the environment, primarily from the field of civil engineering,
- Acquisition of knowledge about environmental protection measures and procedures and legal regulations in the field of environmental protection and water management.

Entry competences (prior knowledge, descriptive):

- Knowledge of basic terms in physics, biology, chemistry and civil engineering.

Learning outcomes:

- Understanding of basic ecological processes,
- Recognize and explain basic ecological principles,
- Explain the basic technological procedures of wastewater treatment,
- Understanding waste management,
- Understanding the concept of "sustainable development".

Course content (by course schedule):

- Lectures:
  1. Introduction [2]
  2. Basics of ecology and environmental protection; basic terms [2]
  3. Environmental problems: air pollution (sources and consequences) [2]
  4. Environmental problems: water pollution [2]
  5. Environmental problems: soil pollution and nature pollution [2]
  6. Renewable and non-renewable energy sources and climate change [2]
  7. Legislation in the field of environmental protection: Environmental impact assessment - identification and classification of impacts [2]
  8. Sustainable development and civil engineering [2]
  9. The impact of cities, roads and water engineering facilities [2]
  10. 1st mid-term exam
  11. Waste and waste management [2]

12. Landfills [2]
13. Waste water and the application of the combined approach methodology [2]
14. Environmental protection measures and procedures [2]
15. 2nd mid-term exam

WATER SUPPLY AND SEWERAGE 1

Credits (ECTS): 4

Hours (total per semester):

- Lectures: 30
- Exercises (design): 15

Course objectives:

- Acquisition of theoretical knowledge about all aspects of managing urban water supply and sewerage systems,
- Acquisition of practical knowledge in hydraulic dimensioning of individual parts of water supply and sewerage systems as well as their design.

Entry competences (prior knowledge, descriptive):

- Knowledge of mathematical analysis,
- Understanding the basic regimes of water flow (flow under pressure, flow with a free water surface),
- Knowledge of the basics of fluid mechanics (momentum conservation equation, Bernoulli's equation for a real fluid, calculation of local and linear energy losses, pressure and energy line).

Learning outcomes:

- Application of acquired knowledge for conceptual development of water supply and sewerage systems,
- Defining relevant parameters and hydraulic design of the water supply and sewage network,
- Dimensioning of the water reservoir,
- Defining the basic parameters for determining the capacity of pumping stations, calculating pump energy consumption, determining the system curve,
- Settling tank sizing.

Course content (by course schedule):

- Lectures:
  1. Water supply - introduction, types of water supply systems [2]
  2. Water consumption [2]
  3. Springs, water intakes [2]
  4. Water intakes, pumping stations [3]
  5. Water conditioning [3]
  6. Water reservoirs, water supply networks [2]
  7. Water supply networks - design [2]
  8. 1st mid-term exam
  9. Drainage - introduction, drainage systems [2]
  10. Relevant amounts of waste water [2]

11. Sewage networks [2]
12. Sewage networks - design [2]
13. Construction of sewage network [3]
14. Treatment of wastewater and discharges [3]
15. 2nd mid-term exam

- Exercises (auditory):
  1. Determination of relevant quantities of water consumption [1]
  2. Dimensioning of water intake structures [1]
  3. Dimensioning of pumping stations [1]
  4. Dimensioning of facilities for water conditioning [1]
  5. Dimensioning of the water tank [1]
  6. Hydraulic calculation of the water supply network [2]
  7. Determination of relevant amounts of waste water [1]
  8. Hydraulic calculation of the sewage network [2]
  9. Dimensioning of facilities on the sewage network [1]
  10. Determining the parameters for the sizing of waste water treatment devices [1]
  11. Hydraulic calculation of settling tank [1]
  12. Additional calculation tasks and preparation for the mid-term exam [2]

DURABILITY OF STRUCTURES 1

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 30
- exercises: 30 (design: 14; construction: 16)

Course objectives:

- Acquisition of theoretical knowledge about
  1. Modern durability design,
  2. Deterioration mechanisms of structures from different structures,
  3. The influence of design, construction and maintenance on durability,
  4. Methods of achieving the durability of structures made of different materials,
  5. Risk management,
  6. Reconstruction methodology after major destructions,
  7. Sustainable construction,
- Acquisition of practical knowledge about
  1. Designing the durability of new structures,
  2. Inspections of buildings, categorization of damage, assessment of the condition of the building.

Entry competences (prior knowledge, descriptive):

- Knowledge of structures in terms of knowledge of material properties and design methods.

Learning outcomes:

- Knowledge about the impacts on durability through the design, construction and maintenance of structures,
- Knowledge about the maintenance of existing buildings and building management,
- Skills of proving durability when designing a new structure,
- Knowledge and skills of collecting data on existing structures in order to evaluate them.

Course content (by course schedule):

- Lectures:
  1. Definitions of basic concepts. A modern approach to the durability of buildings. Durability design [2]
  2. Deterioration mechanisms of concrete, masonry, metal and timber structures. Examples of structural damage [2]
  3. Impact of design on durability. Effect of construction on durability [2]
  4. Effect of maintenance on durability. Management of buildings. Other influences on the durability of structures [2]
  5. Condition assessment and structural health monitoring [2]
  6. Durability of structures and limit states [2]
  7. 1st mid-term exam
  8. Achieving durability of concrete structures. Achieving durability of masonry structures [2]
  9. Achieving durability of timber structures. Achieving durability of steel structures [2]
  10. Failures, accidents and disasters. Risk management [2]
  11. Temporary and auxiliary buildings. Renovation methodology [2]
  12. Aesthetic, ecological and ethical aspects of sustainability [2]
  13. Sustainable construction [2]
  14. 2nd mid-term exam
  15. Retest.
- Exercises:
  1. Inspection and assessment of the building condition [2]
  2. Creating the basic documentation for the inspection of buildings [2]
  3. Inspection of bridges [4]
  4. Inspection of buildings [4]
  5. Types of damages and their graphical representation in the program [6]
  6. Examples of durability verification [2]
  7. Categorisation of damages and the assessment of the structure [6]
  8. Review and submission of program assignments [4]

THEORY OF COMPOSITES

Credits (ECTS): 4.5

Hours (total per semester):

- Lectures: 30
- Exercises: 15 (auditory: 9, on computers: 6)

Course objectives:

- Acquisition of theoretical knowledge about the production, types and properties of composites used in construction,
- Acquisition of practical knowledge about the application, design and quality control of composites used in construction.

Entry competences (prior knowledge, descriptive):

- Knowledge of basic concepts and laws of strength of materials.

Learning outcomes:

- Learn about different types of composites and their properties and production processes,
- Apply theoretical and experimental bases for sizing composites with an emphasis on polymer composites,
- Acquire examples of application of polymer composites in construction,
- Adopt the procedure of quality control and confirmation of the construction product on the example of structural bearings.

Course content (by course schedule):

- Lectures:

1. Introduction; General information about composites; Matrices and reinforcement [3]
2. Production of polymer composites [3]
3. Properties of polymer composites [3]
4. Application of polymer composites in construction [3]
5. Fiber reinforced polymer materials (FRP materials) [3]
6. Macromechanics of composite layer [6]
7. Micromechanics of composite layer [3]
8. Multilayer composites; Classical lamination theory [3]
9. Failure criteria for multilayer composites [3]

- Exercises:
  1. Micromechanics of composites [2]
  2. Macromechanics of composite layer [2]
  3. Classical lamination theory in multilayer composites [3]
  4. Failure criteria for composites [1]
  5. FRP materials in the computer software Abaqus [6]

THEORY OF ELASTICITY AND PLASTICITY

Credits (ECTS): 7.5

Hours (total per semester):

- Lectures: 45
- Exercises: 30 (auditory: 20, laboratory: 4, design: 6)

Course objectives:

- Acquisition of theoretical knowledge about the behaviour of real deformable bodies under load in the elastic and plastic area,
- Acquisition of theoretical knowledge in the field of analysis of displacements, deformations and stresses of real solid bodies,

- Acquisition of knowledge in the field of analytical and numerical procedures for the analysis of real solid bodies.

Entry competences (prior knowledge, descriptive):

- Knowledge of differential and integral calculus, ordinary and partial differential equations, and vector and tensor analysis,
- Good knowledge of the elements of general theoretical mechanics and numerical mathematics,
- Knowledge of the elements of statics, dynamics and resistance of materials.

Learning outcomes:

- Recognize the appropriate boundary-value problem of the theory of elasticity and plasticity,
- Explain the conditions of equilibrium and compatibility in the analysis of deformations and stresses,
- Adequately formulate the boundary-value problem, express its solution through displacement and stress,
- Choose the optimal method of solving the corresponding boundary-value problems,
- Explain certain methods of solving boundary-value problems in plane and space,
- Explain the laws of material behaviour in the elastic and plastic regions.

Course content (by course schedule):

- Lectures:
  1. Introduction, classification and definition of real deformable body in continuum mechanics. Euclidean vector space E3 . Bases, space metrics and coordinate systems [3]
  2. Linear and homogeneous transformations in E3 space. Covariant and contravariant coordinates. Direct and inverse mapping within databases with the same origin. Definition of tensor. General tensors. Operations with tensors and their properties. Differential operators in tensor form. Stokes and Gauss theorem in tensor form [3]
  3. Models of material continuum deformation. Material and spatial coordinates. Lagrange's and Euler's approach to the problem of deformation of the material continuum. [3]
  4. Deformation gradients. Displacement gradients. Green's and Cauchy's metric tensor. Finite deformation tensors according to Lagrange and Euler and geometric nonlinearity. [3]
  5. Linearization of tensors of finite deformations and restriction to small deformations. Transformational properties of strain tensors. Eigenvalues of the tensor of small deformations. Additive decomposition of small deformations and compatibility equations. [3]
  6. The concept of external and internal forces on a solid body. Principal vector and principal moment of forces. Stress field around a point of a deformed body. Cauchy stress tensor and its definition. [3]
  7. Static admissibility and differential balance equations. Transformation properties of the stress tensor. Eigenvalues and stress tensor decomposition [3]
  8. Laws of state and thermodynamic processes on a real solid body. Energy function of a real deformable body. Tensor of material stiffness and tensor of material flexibility of a solid body. Anisotropic, orthotropic and isotropic real solid. Lame's and technical constants. [3]
  9. Definition of marginal tasks in the theory of elasticity. Formulation of the solution of boundary value problems of a solid body. Statement of the solution of the boundary value problem by

displacements (Lame-Navier). Statement of the solution of the boundary value problem by stresses (Beltrami-Michell). [3]

10. The virtual work equation. Energy principles and theorems. The principle of minimum total potential energy of deformation of a solid deformable body. The principle of minimum total complementary energy of deformation of a solid body. Other principles and theorems. [3]
11. Application of analytical and numerical procedures in solving marginal problems of elasticity theory. Infinite trigonometric series, variational methods, discretization methods of differential equations and residue methods. (Ritz method. Galerkin method. The least squares method. Collocation method. Finite difference method. Finite element method, etc.). [3]
12. State of plane strain and plane stress. Boundary-value problems on the plane and half-plane in rectangular and polar coordinates. Airy function. Harmonic and biharmonic partial differential equation as a solution of plane boundary value problems. Harmonic and biharmonic functions in solving boundary-value problems of the theory of elasticity and plasticity. [3]
13. Potential functions. Boundary value problems on space and half-space (Kelvin's, Boussiness's and Cerruti's problems). Torsion of a straight rod with a general cross-section shape (St. Venant's problem). Theory of rectangular thin plates in Cartesian coordinates. Theory of circular thin plates in polar coordinates. [3]
14. Introduction to plasticity theory and plasticity theory models. Basic material flow criteria. Rules of yielding. Drucker's postulates on the yield surface of materials. Material stability criteria during yielding. Equations of the theory of plasticity and the relationship between stress and deformation in the theory of plasticity. [3]
15. Basics of the theory of viscoelasticity and viscoplasticity. Viscoelastic and viscoplastic models. Creep and relaxation functions. The relationship between stress and deformation in the theory of viscoelasticity and viscoplasticity. [3]

- Exercises (auditory):
  1. Linear and homogeneous transformations in E3 space. Operations with tensors and their properties. Transformation properties of the stress tensor. Eigenvalues and stress tensor decomposition [2]
  2. Airy function of plane tasks in rectangular coordinates. [4]
  3. Airy function of plane tasks in polar coordinates. [2]
  4. Airy's function of plane problems [2]
  5. Torsion solution of a straight rod with a general cross-section and a multiply connected region [2]
  6. Torsion of a straight rod with a general cross-section and a multiple connected region [2]
  7. Rectangular thin plates in rectangular coordinates. [2]
  8. Circular thin plates in polar coordinates. [2]
  9. Thin plates [2]
  10. The Ritz method. Galerkin method. [2]
  11. Finite difference method. [2]
  12. Planar problems [4]
  13. Problems from the theory of plasticity. [2]

GEOMETRY IN CIVIL ENGINEERING

Credits (ECTS): 4.5

Hours (total per semester):

- Lectures: 15
- Exercises: 30 (design: 30)

Course objectives:

- Deepening theoretical knowledge about curves and surfaces of Euclidean space,
- Application of geometric knowledge in computer CAD modelling,
- Acquire a complete picture of the creation process of an object, starting with knowledge of geometry, through parametric modelling in the programs Rhinoceros and Grasshopper, to the final stage of model making, i.e. digital fabrication (BIM methodology).

Entry competences (prior knowledge, descriptive):

- Knowledge acquired from undergraduate mathematics courses (Descriptive Geometry, Mathematics 1 and Mathematics 2)

Learning outcomes:

- Acquire basic knowledge about curves and surfaces of Euclidean space,
- Recognize and evaluate the geometric properties of different types of surfaces,
- Use acquired knowledge in geometry in construction,
- Apply geometric concepts in parametric modelling,
- Apply parametric modelling in the creation of curves and surfaces in a CAD program and prepare a model for digital production.

Course content (by course schedule):

- Lectures:

1. Introduction to CAD modelling (Rhino/Grasshopper)
2. Extended Euclidean space. Curves in plane and space. Parametrization of the curve with a general parameter, analytical processing of curves
3. Surfaces. Analytical processing of surfaces. Surface representation in the CAD software.
4. Surfaces of the 2nd degree - quadrics.
5. Line space. Rectilinear surfaces of the 2nd degree.
6. One-plane hyperboloid and hyperbolic paraboloid.
7. Formation of rectilinear surfaces. Modelling of rectilinear surfaces in the CAD software
8. Rotational and translational surfaces
9. Surfaces obtained by a combination of rotation, translation and homothety (spiral, trans-scale surfaces).
10. Surface coverings – computer modelling
11. Shell grids. Surface approximations with grids of planar polygons
12. Lamella - surfaces.
13. Free-form surfaces. Discrete representations of surfaces
14. Preparation of CAD models for digital fabrication and creation of cardboard models with a laser cutter
15. Presentation of programs and models.

- Exercises:
  1. Introduction to CAD modelling (Rhino/Grasshopper). Solving problems.
  2. Plane and spatial curves. Graphics and modelling in Rhino and Grasshopper.
  3. Surfaces. Surface modelling in Rhino and Grasshopper. Solving problems. Project assignment
  4. Solving problems (Surfaces of the 2nd degree - cone, cylinder).
  5. Solving problems (Level 2 surfaces - ellipsoids, paraboloids, hyperboloids)
  6. Solving problems (one-plane hyperboloid)
  7. Solving tasks (hyperbolic paraboloid)
  8. Solving problems (translational and rotational surfaces)
  9. Solving problems (surfaces obtained by translation, rotation and homothety)
  10. Overlays - computer modelling
  11. Solving problems. Approximation of surfaces by polygons.
  12. Solving problems (Lamella surfaces).
  13. Solving problems (Free-form surfaces).
  14. Preparation of CAD models for digital fabrication and creation of cardboard models with a laser cutter
  15. Design submission

NUMERICAL MATHEMATICS

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 30
- Exercises (auditory): 30

Course objectives:

- Acquisition of theoretical knowledge about the basic types of numerical methods and their application in civil engineering,
- Acquisition of basic practical knowledge and skills for setting up and numerically solving simple problems.

Entry competences (prior knowledge, descriptive):

- Knowledge of the elements of differential and integral calculus and linear algebra.

Learning outcomes:

- Understanding of general features of numerical methods,
- Understanding the limitations and conditions of applicability of individual methods,
- The ability to recognize and choose an appropriate method,
- The ability to set up and numerically solve simpler engineering problems.

Course content (by course schedule):

- Lectures:
  1. Introduction
2. Methods of solving nonlinear equations – bisection and fixed point method
3. Methods of solving nonlinear equations – Newton-type methods
4. Interpolation – interpolation polynomials

5. Interpolation – splines
6. Numerical integration – Newton-Cotes formulas
7. Numerical integration – Gaussian formulas
8. Numerical integration – cubature formulas
9. Numerical methods for ODE – one-step methods
10. Numerical methods for ODE – multistep methods
11. Numerical methods for solving linear systems I
12. Numerical methods for solving linear systems II
13. Numerical methods for the eigenvalue problem I
14. Numerical methods for the eigenvalue problem II
15. Analysis of the program assignment

- Practice

The exercises follow lectures.

PERSPECTIVE

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 30
- Exercises: 30 (construction 8, design 22)

Course objectives:

- Expansion of theoretical knowledge on geometric objects and their relations,
- Developing the ability to favourably determine perspective parameters and read a perspective image,
- Application of knowledge in computer CAD modelling.

Entry competences (prior knowledge, descriptive):

- Knowledge of parallel projection methods.

Learning outcomes:

- Mastering basic constructive procedures in perspective,
- Knowledge of perspective image construction methods,
- Knowledge of geometric properties of higher-order surfaces,
- The ability to construct a perspective image of construction objects.

Course content (by course schedule):

- Lectures:
    1. Central projection. Perspective. [10]
    2. Surfaces: quadrics, rotational and translational surfaces. [2]
    3. Surface modelling in the CAD program. [4]
    4. Surface coverings, domes and vaults.[4]
    5. Line space. Rectilinear surfaces of the 2nd degree. [2]
    6. Rectilinear surfaces of the 3rd and 4th degrees. [4]
    7. Coil and coil surface. [2]
    8. Road in fieldwork. [2]

- Exercises (construction and design):
    1. Solving problems - perspective. [10]
    2. Body modelling in Rhino. [4]
    3. Domes and vaults – computer modelling. [4]
    4. Rectilinear surfaces of the 2nd degree – computer modelling. [2]
    5. Rectilinear surfaces of the 3rd and 4th degree – computer modelling. [2]
    6. Covering with rectangular surfaces – computer modelling. [4]

WAVES AND OSCILLATIONS

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 30
- Exercises: 30 (auditory: 15, laboratory: 15)

Course objectives:

- Master the skill of finding equations of physical models of vibrations, oscillations and deformations,
- Gain knowledge of setting up physical tests and computer simulations of physical problems,
- Master the skills of computer setup and problem solving.

Entry competences (prior knowledge, descriptive):

- Undergraduate mathematics including differential equations,
- Basics of programming

Learning outcomes:

- Mastering the equations from the given problems: free vibrations of simple systems – wires, plates; waves and wave propagation in one, two and three dimensions; deformations;
- Understanding the physical basis of equations processed in specialized and mathematical courses;
- Possibility of finding equations through the physical properties of the problem: coupled oscillations and vibrations, propagation of acoustic waves, acoustic insulation;
- Harmonic oscillator modelling;
- Computer modelling of individual physical models of problems dealt with in specialized and mathematical courses;
- Understanding the physical properties of forced oscillations and Interference;
- Understanding the physical basis of certain measurements in the profession.

Course content (by course schedule):

- Lectures:
    1. Free oscillations of simple systems. Examples.
    2. Free oscillations of a system with several degrees of freedom.
    3. Forced vibrations.
    4. Waves. Wave propagation in one and more dimensions. Sound.
    5. Reflection and transmission of waves. Pulses and wave packets.
    6. Polarization of waves.
    7. Electromagnetic vibrations and waves.

8. Interference and diffraction of waves.

2.2 Second study year

2.2.1 Winter semester

Course	Total hours			ECTS
	Lectures	Seminar	Practice	
Human Resource Management	30	0	30	6
Investment Appraisals in Construction	30	0	30	6
Organization and Structure of Construction Companies	30	0	30	6
Planning and Scheduling Methods	30	0	30	6
Hydrogeology and Engineering Geology	30	0	0	3
Retaining Structures	30	0	30	6
Flood Protection	28	2	30	6
Modelling in Hydraulic Engineering	30	0	30	6
Nature-Based River Restoration	30	0	30	6
Polymers	30	6	9	4,5
Structural Testing	30	0	30	6
Drainage of Transportation Facilities	30	0	15	4,5
Transport Systems	45	0	0	4,5

HUMAN RESOURCE MANAGEMENT

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 30
- Exercises: 30 (auditory: 8, design: 22)

Course objectives:

- Understanding the concept and importance of human resource management in companies,
- The ability to apply acquired knowledge for the development of human resource management strategies in companies.

Entry competences (prior knowledge, descriptive):

- Knowledge of the basics of management.

Learning outcomes:

- Application of methods for planning the needs and structure of employees,
- Application of selection methods for selecting employees,
- Strategic planning of employee development,
- Understanding the importance of communication between project participants,
- Understanding multicultural teams,
- Application of motivational techniques.

Course content (by course schedule):

- Lectures:
  1. Introduction to human resources management
  2. Development of human resources management
  3. The meaning, content and functions of human resources
  4. The importance of human resource management for the success of the company
  5. Characteristics of human resource management in construction companies
  6. The relationship between company strategy and human resources strategy
  7. Techniques and strategies of human resource management in construction companies
  8. The role of communication between project participants
  9. Communication risks and the role of trust in construction projects
  10. Human resource planning in construction companies; Forecasting needs
  11. Selection of job candidates
  12. Team building; International projects and multicultural teams
  13. Motivation and reward of employees
  14. Safety and health protection of employees; professional ethics
  15. New trends and challenges in human resource management in construction
- Exercises:
  1. Defining project tasks
  2. Description of the elements for creating a case study
  3. Creation of program content proposals
  4. Analysis of existing human resource management strategies in construction companies in the world

5. Selection of a construction company for the case study
6. Analysis of the organizational structure of the company
7. Creation of a proposal for a human resource management strategy for a selected construction company
8. Creation of a proposal for a human resource management strategy for a selected construction company
9. Application of candidate selection methods and techniques
10. Application of candidate selection methods and techniques
11. Creation of proposals for motivating and rewarding employees
12. Writing a resume
13. Situational interviews
14. Program presentations and defences
15. Program presentations and defences

INVESTMENT APPRAISALS IN CONSTRUCTION

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 30
- Exercises: 30 (auditory: 6, computer: 24)

Course objectives:

- Acquisition of theoretical knowledge about company development strategy, investment policy and types of investments,
- Creation of an investment study.

Learning outcomes:

- Explain fundamentals of investing strategy in a company and the types of investments,
- Analyse the investor and the investment,
- Analyse the market and create a technical and technological analysis,
- Prepare the main financial statements, the economic and financial flow of the project,
- Check the profitability of the project,
- Carry out a sensitivity analysis of the project.

Course content (by course schedule):

- Lectures:
  1. BASICS OF INVESTMENT PLANNING - Introduction to Investment Studies
  2. Systematization and types of investments – Joint venture, concessions (BOT)
  3. Foreign investments in the Republic of Croatia
  4. Company development strategy and investments; T1. Investor analysis and investment analysis
  5. INVESTMENT PROJECT PLANNING T2. Environment/location analysis
  6. T3. Market analysis – sales market research, procurement market analysis, competition analysis
  7. T4. Technical and technological analysis of the project - technical aspects for creating an investment program / environmental protection

8. T5. Economic and financial analysis
9. T5. Economic and financial analysis
10. EVALUATION OF INVESTMENT PROJECT T6. Project evaluation - static/dynamic
11. T7. Sensitivity analysis
12. T8. Probability analysis and risk analysis
13. Final assessment of the Investment
14. Presentation of the program
15. Presentation of the program

- Exercises:
  1. Overview of Investment Studies / Content Structure of Investment Studies
  2. Systematization and types of investments – Joint venture, concessions (BOT) - example 187
  3. Foreign investments in the Republic of Croatia – an example
  4. T1. Investor analysis and investment analysis
  5. T2. Environment/location analysis
  6. T3. Market analysis – analysis of sales, procurement, competition analysis
  7. T4. Technical and technological analysis of the project
  8. 1st mid-term exam
  9. T5. Economic and financial analysis
  10. T6. Project evaluation - static/dynamic
  11. T7. Sensitivity analysis
  12. T8. Probability analysis and risk analysis
  13. Final assessment of the Investment
  14. 2nd mid-term exam
  15. Presentation of the program

ORGANIZATION AND STRUCTURE OF CONSTRUCTION COMPANIES

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 30
- exercises (auditory: 15, design: 15)

Course objectives:

- Acquisition of knowledge about the basics of organization theory, and methods and techniques of organization design and their application in business systems in construction.

Entry competences (prior knowledge, descriptive):

- Understanding the basics of construction technology,
- Knowledge of the basics of construction regulations.

Learning outcomes:

- Explain the basic concepts from the theory of organization,
- Explain the organization design process,
- Explain the characteristics of individual functions in the construction business system,

- Demonstrate the process of designing an organization using the example of a construction business system.

Course content (by course schedule):

- Lectures:
  1. Typology of business systems in construction
  2. Basics of organization and theories of organization
  3. Organizational structure, demonstrating the elements of the organizational structure. Elements of the organizational structure of the construction business system: human resources, machines and equipment
  4. Elements of the organizational structure of the construction business system: material, information
  5. Business functions of the construction business system: research and development, human resources management
  6. Business functions of the construction business system: procurement, sales, marketing
  7. Business functions of the construction business system: information management, knowledge management
  8. Business functions of the construction business system: improvement of the organization, quality management
  9. Business functions of a construction company: production function
  10. Business functions of the construction business system: planning
  11. Business functions of the construction business system: finances and accounting,
  12. Factors of organization formation. Designing the organizational structure of a construction company.
  13. Organizational changes. Re-engineering
  14. Legal forms of companies.
  15. Forms of cooperation and integration between business systems in construction
- Practice
  1. Organization of classes and selection of seminar topics
  2. Distribution of literature for the seminar and familiarization with the BPM tool
  3. Business systems in construction
  4. Organization theory
  5. Organizational structure
  6. Elements of organizational structure
  7. Business functions of the construction business system
  8. 1st mid-term exam
  9. Creation of business process schemes for certain functions of the construction business system
  10. Characteristics of the business process for certain functions of the construction business system
  11. Optimization of business processes for certain functions of the construction business system

12. Organizational design, organizational changes
13. Forms of cooperation of business systems
14. 2nd mid-term exam
15. Retest

PLANNING AND SCHEDULING METHODS

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 30
- Exercises: 30 (auditory: 8, on the computer: 22)

Course objectives:

- Acquisition of advanced theoretical knowledge about planning, monitoring and control for construction projects,
- Acquisition of advanced practical knowledge of planning methods and techniques,
- Acquisition of knowledge about the use of computer tools for planning and monitoring construction projects.

Entry competences (prior knowledge, descriptive):

- Knowledge of basic planning methods for construction projects,
- Theoretical knowledge about construction organization, such as: network planning, resource planning, organization charts, organization theories, construction regulations, price analysis, etc.

Learning outcomes:

- Explain and apply project planning and control methods,
- Create a detailed basic time plan of activities,
- Create a resource and cost plan,
- Analyse the basic plan of the project,
- Optimize the use of resources and shorten the duration of the project,
- Design a project monitoring and control system,
- Evaluate the progress of the project,
- Identify the essential elements of the multi-project planning system.

Course contents:

- Lectures:
    1. Introduction to planning
    2. Planning by management levels
    3. Basic techniques of network and line planning
    4. Resource planning
    5. Cost planning
    6. Joint time and cost planning
    7. Project monitoring and control
    8. Company project planning
    9. Planning and BIM
    10. Planning with uncertainty

11. AI and planning in construction
12. Mid-term exam
13. Planning with uncertainty
14. Critical chain method
15. Mid-term exam

- Exercises:
  1. Creation of the basic plan, MS Project
  2. Creation of the basic plan, MS Project
  3. Creation of the basic plan, MS Project
  4. Resource and cost planning using MS Project
  5. Resource and cost planning using MS Project
  6. Resource and cost planning using MS Project
  7. Project execution monitoring and reporting using MS Project
  8. Project execution monitoring and reporting using MS Project
  9. Company project planning
  10. Company project planning
  11. Creating a basic plan using an alternative program
  12. Creating a basic plan using an alternative program
  13. Planning with uncertainty and the critical chain method with the help of computers
  14. Planning with uncertainty and the critical chain method with the help of computers
  15. Final review and evaluation

HYDROGEOLOGY AND ENGINEERING GEOLOGY

Credits (ECTS): 3

Hours (total per semester):

- Lectures: 30

Course objectives:

- Acquisition of knowledge in hydrogeology and engineering geology for application in construction,
- Understanding the groundwater regime in karst, getting to know good and bad examples,
- Acquisition of theoretical knowledge about methods of researching rock properties for the purposes of rock mass classification.

Entry competences (prior knowledge, descriptive):

- Knowledge of basic geological concepts.

Learning outcomes:

- Understanding the influence of the groundwater regime on construction interventions in karst,
- Getting to know the methods of determining water protection areas,
- Understanding the influence of geological structures on the bearing capacity of the foundation structure and on the stability of slopes in the rock mass,
- The influence of geological structures on the stability of the underground opening in the rock mass,

- The ability to determine the geological parameters necessary to classify the rock mass.

Course content (by course schedule):

- Lectures:
  1. Introduction. Hydrogeology [2]
  2. The role of hydrogeology in civil engineering [2]
  3. Classification of groundwater [2]
  4. Groundwater regime [2]
  5. Research methods [2]
  6. Water in karst [2]
  7. Karst [2]

  (Mid-term exam)

  8. Determination of protection zones, Interpretation of hydrogeological research [2]
  9. Engineering geology and its role in civil engineering [4]
  10. Engineering geology and its role in civil engineering. Landslides [2]
  11. Rock classification for geotechnical engineering [2]
  12. Methods of investigating rock properties for construction purposes [2]

RETAINING STRUCTURES

Credits (ECTS): 6.0

Hours (total per semester):

- Lectures: 30
- Exercises: 30 (20 auditory + 4 on computers + 6 construction)

Course objectives:

- acquisition of theoretical knowledge about types of retaining structures,
- Acquisition of theoretical and practical knowledge about the design of
- retaining structures,
- Acquisition of theoretical and practical knowledge about design, execution and
- monitoring of retaining structures.

Entry competences (prior knowledge, descriptive):

- Knowledge of the basic physical and mechanical properties of the soil (strength, stiffness),
- Knowledge of the basics of Mohr's stress circles,
- Understanding the seepage of water in the soil,
- Knowledge of the basic principles of numerical modelling.

Learning outcomes:

- Describe and understand the basic concepts of the behaviour of rigid and flexible retaining structures,
- Understand earth pressures on retaining structures and become familiar with the method of their calculation,
- Determine the relevant actions on the retaining structure, including earth pressures, the structure's own weight, external actions and earthquakes,
- Understand the mechanisms of failure and deformation of retaining structures,

- Select relevant project situations related to retaining structures,
- Analyse and prove the mechanical resistance and stability of retaining structures in accordance with relevant national and European standards,
- Select and apply available engineering methods, tools and technologies to ensure the resistance and stability of retaining structures,
- Acquire basic knowledge and skills of calculation and dimensioning of structural elements and assemblies of retaining buildings.

Course content (by course schedule):

- Lectures:

1. Application and types of retaining structures.
2. Selection of project parameters and relevant design situations.
3. Basics of earth pressure calculation - concepts of earth pressure description, strength parameters.
4. Basics of earth pressure calculations - Rankine states, Coulomb's method and accuracy.
5. Basics of calculation of earth pressures - additional load on the surface of the terrain, action of earthquakes.
6. Retaining walls (gravitational and cantilever).
7. Calculation methods of retaining walls (gravity and cantilever).
8. Reinforced earthen structures.
9. Calculation methods of reinforced earthen structures.
10. Buried supporting rocks, anchoring of retaining structures, elements of calculation of geotechnical anchors.
11. Calculations of buried retaining rocks (design and theoretical requirements).
12. Calculations of buried retaining rocks (calculation procedures)
13. Application of Eurocode for retaining structures.
14. Monitoring and observation of retaining structures.

- Exercises:

1. Examples of calculation of retaining structures - soil pressures (active, passive, at rest, Rankine, Coulomb).
2. The influence of additional loads on retaining structures (additional load on the surface, seismicity: Mononobe - Okabe expressions).
3. Analysis of the relevant limit states of retaining structures - overturning, sliding, bearing capacity, settlement.
4. Calculation of the gravity retaining wall – analytical solutions.
5. Calculation of cantilever retaining wall – analytical solutions.
6. Calculation of a retaining wall made of reinforced soil – stress-deformation analysis and stability analysis.
7. Calculation of buried support structures – analytical solutions.
8. Calculation of anchored buried retaining structures – stress deformation analysis, seepage analysis, stability analysis.
9. Calculation of braced buried support structures – stress-deformation analysis and seepage analysis, stability analysis.
10. Dimensioning of anchors and bracing structures.

11. Completing the program assignment - solving examples of retaining structures. [8]
12. Submission of program assignments.

FLOOD PROTECTION

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 30
- Exercises (design): 30

Course objectives:

- Convey knowledge about flood protection issues and the risks of their occurrence,
- Introduce students to the mechanisms of global and local instability of watercourses and mathematical tools for their description,
- Convey knowledge about dimensioning of structures on flood protection systems

Entry competences (prior knowledge, descriptive):

- Knowledge of differential and integral calculus (including ordinary differential equations) and linear algebra,
- Knowledge of the basics of fluid dynamics (equation of conservation of momentum, general law of real fluid flow (Saint-Venant and Navier-Stokes equation), equation of conservation of kinetic energy, Bernoulli equation for real fluid, flow resistance, calculation of local and linear energy losses, geodesic, pressure and energy line, speed, pressure and flow measurement),
- Knowledge of descriptive geometry, drawing in 3D space, intersection of lines with a digital elevation model,
- Computer work: basics of drawing using CAD software, advanced operations on raster and vector type data,
- Knowledge of working with the HEC-RAS software.

Learning outcomes:

- Define flood risk maps on the terrain model and estimate the water damage from the flood and the approximate number of the population at risk,
- Define the elements of the flood protection system,
- Dimensioning of structures on the flood protection system and their functional relations,
- Assessment of the erosive effect of the flow on submerged elements of structures over watercourses,
- Distinguish between individual approaches used in empirical assessments of the erosive capacity of flow,
- Assess the extent of flow action due to the construction of structures in different aquatic environments.

Course content (by course schedule):

- Lectures:
  1. Introduction, watercourses as an element of the water management system [2]
  2. Two-dimensional hydrodynamic numerical models for water flow modelling [2]
  3. Types of floods and examples of typical damages [2]

4. Tasks during the implementation of the EU Directive on flood risk assessment and management [2]
5. FEH (Flood Estimation Handbook) approach for flood hazard calculation [2]
6. Creation of flood risk maps in Croatia [2]
7. Damage assessment and creation of flood risk maps [2]
8. Passive flood protection approach: Dimensioning of embankments [2]
9. Calculation of percolation through the embankment and drainage system [2]
10. Unreliability in the calculation of relevant water levels [2]
11. Mobile systems for passive flood protection [2]
12. The active flood protection approach: the impact of retention on the water regime [2]
13. The active flood protection approach: the impact of reservoirs on the water regime [2]
14. The active flood protection approach: the influence of flood relief channels on the water regime [2]
15. The appearance of ice on watercourses [2]

- Exercises (auditory):
  1. Creation of a floodplain terrain model [4]
  2. Flow calculation using a 2D numerical model [2]
  3. Creation of flood hazard maps [4]
  4. Creation of flood risk maps [4]
  5. Calculation of the functionality of the embankment [6]
  6. Dimensioning of retention/accumulation/ flood relief channel and intake structure [6]
  7. Dimensioning of filter drainage at embankments [4]

MODELLING IN HYDRAULIC ENGINEERING

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 30
- Exercises (laboratory): 30

Course objectives:

- Acquisition of practical knowledge about physical and numerical modelling of flow in open watercourses and systems under pressure and the transport of substances,
- Gaining insight into the possibilities of applying modern numerical models.

Entry competences (prior knowledge, descriptive):

- Knowledge of differential and integral calculus,
- Knowledge of the general conservation law for field and the dynamics of fluid movement of a material point,
- Understanding the concepts of initial and boundary conditions.

Learning outcomes:

- Understanding the concept of a model,
- Recognizing the advantages and disadvantages of physical and numerical modelling and adopted assumptions and imperfections of each of them,

- Recognizing the appropriate description of boundary and initial conditions,
- Noticing the dimensionality of the problem and the possibility of applying appropriate simplifications,
- Recognition of problems in the numerical discretization of partial differential equations,
- Application of the results of the numerical model in the calculations of pressures and forces on the structure,
- Gaining insight into recent modelling techniques and possibilities of modern free and commercial models,
- Acquiring knowledge about the possibilities of hybrid modelling.

Course content (by course schedule):

- Lectures:
  1. Concept of models and fluid motion modelling. Physical models (laws of similarity, limitations and advantages, types of models). Numerical models (numerical solution methods, limitations and advantages). Hybrid models. Significance in design, construction and use. [2]
  2. Concept of models and fluid motion modelling. Defining the dimensionality of the problem for the implementation of model analyses. Foundations for establishing a physical and/or numerical model. [2]
  3. Flow and transport in a continuous aquatic environment. Fluid flow and heat transfer equations. (law of conservation of mass, momentum and energy in three dimensions, equations of state). [2]
  4. Flow and transport in a continuous aquatic environment. Navier-Stokes equation for Newtonian fluid (conservative form of fluid flow equations). [2]
  5. Flow and transport in a continuous aquatic environment. Differential and integral form of the general transfer equation. Classification by physical characteristics. [2]
  6. Turbulence models. Reynolds averaging of the Navier-Stokes equations for incompressible fluids. Calculation of turbulent flows, "RANS mixing length" turbulence model, "RANS k-" turbulence model). [2]
  7. Flow and transport in a continuous aquatic environment. Model of three-dimensional flow in an open watercourse. A model of two-dimensional flow in an open watercourse. Heat exchange with atmosphere for 2D and 3D model. [2]
  8. Flow and transport in rock with intergranular porosity. Basic laws and process equations (mass conservation law, transport components, generalization of Fick's law, diffusion, dispersion, transport equation). [2]
  9. Flow and transport in rock with intergranular porosity. Reactive processes (influence of dying and decomposition, exchange of substances between solid and liquid phases, retardation). [2]
  10. Modelling of processes in the ecosystem Population model. Michaelis–Menten kinetics. Ecosystem model with two members (predator – prey), with three members (npz) and with four members (npzd). Link to hydrodynamic model of convective dispersion. [2]
  11. Modelling of wave generation. Mechanism of wind wave generation. (theories of wind energy transfer to waves - model implementation). [2]

12. Modelling of wave generation. Non-linear interaction of waves (spectral dissipation in the deep water area, dissipation due to wave breaking). Non-linear interaction in the shallow water area (dissipation at the bottom). [2]
13. Modelling of pressurized systems. [2]
14. Examples of the application of numerical modelling for the purpose of solving problems in hydraulic engineering. [2]
15. Examples of comparison of numerical and physical modelling results in hydraulic engineering (model-nature correlation). [2]

- Exercises (auditory, construction):
  1. Model of flow in an open watercourse. Establishing a model of stationary and non-uniform flow due to a change in the geometry of the flow bed. [2]
  2. Model of flow in an open watercourse. Case analysis of sudden widening and narrowing of the riverbed (definition of boundary and initial conditions). [2]
  3. Model of flow in an open watercourse. Case analysis of sudden deepening and elevation of the bed (definition of boundary and initial conditions). [2]
  4. Model of flow in an open watercourse Comparison with the calculation based on the theoretical elaboration of the problem. [2]
  5. A model of flow in an open watercourse forced by a wind field with variation of wind speeds. [2]
  6. Model of flow in an open watercourse. Case analysis of variation of horizontal dimensions. [2]
  7. Model of flow in an open watercourse. Case analysis of variation of vertical dimensions. [2]
  8. Model of flow in an open watercourse. Case analysis of density variation in the vertical profile. [2]
  9. Model of flow through intergranular porosity rock. Establishment of seepage model (2D in vertical plane), definition of boundary and initial conditions. [2]
  10. Model of flow through intergranular porosity rock. Analysis of the influence of the change in the width of the barrier profile, the depth of immersion of the dam and the thickness of the aquifer on the velocities and total seepage flows. [2]
  11. Model of flow through intergranular porosity rock. Analysis of the influence of isotropy and anisotropy. [2]
  12. Model of wave generation. Establishment of the model (generation of design network, definition of boundary and initial conditions). [2]
  13. Model of wave generation. Sensitivity analysis of model constants and adoption of model parametrization based on measurement results at the wave recording station. [2]
  14. Model of wave generation. Comparison with calculation based on semi-empirical approach. [2]
  15. Ecosystem dynamics model. Establishment of a numerical model presented with two members (prey-predator). [2]

NATURE-BASED RIVER RESTORATION

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 30

- Exercises (design): 30

Course objectives:

- Learning about the theoretical knowledge on the ecological restoration of watercourses as a key element of ecosystem revitalization. Acquisition of practical knowledge on river training through the application of Nature-based Solutions (NbS).

Entry competences (prior knowledge, descriptive):

- Knowledge of the basics from the course River Training, which include: basic morphological features of watercourses, conditions of bed instability, regime bed theory, interaction of geometrical elements of the bed and hydraulic calculations of natural and artificial watercourses.

Learning outcomes:

- Define the causes of the degradation of the ecological status of watercourses.
- Develop a numerical flow representing the existing conditions prior to watercourse restoration.
- Design Nature-based Solutions (NbS) structures for watercourses.
- Describe the advantages and limitations of Nature-based Solutions (NbS) in watercourses compared with conventional river training methods.

Course content (by course schedule):

1. Loss of river habitats, causes of watercourse degradation, and the importance of ecological watercourse restoration (4 hours)
2. River channel and bank stabilization using Nature-based Solution methods (4 hours)
3. Hydraulic flow conditions in areas with flexible vegetation: dynamics of riffles and pools (4 hours)
4. Target flow velocities in restored watercourses: flood protection and ecological aspects (4 hours)
5. Comparison of the performance of Nature-based Solutions (NbS) and conventional river training methods (4 hours)
6. Monitoring and evaluation of the effectiveness of watercourse restoration projects (4 hours)
7. Implementation of watercourse restoration projects: project phases and stakeholders (6 hours)

POLYMERS

Credits (ECTS): 4.5

Hours (total per semester):

- Lectures: 30
- Exercises: 15 (fieldwork: 6, laboratory: 6, computer: 3)

Course objectives:

- Acquisition of theoretical knowledge about the production, types and properties of polymer materials and composites used in construction,

- Acquisition of practical knowledge about the application, design and quality control of polymer materials and composites used in construction.

Entry competences (prior knowledge, descriptive):

- Knowledge of basic concepts and laws of strength of materials.

Learning outcomes:

- Get to know different types of polymer materials and composites and their properties and production processes,
- Differentiate between the field of application of polymer materials and composites in construction in relation to conventional materials,
- Adopt examples of application of polymer materials and composites in construction with an emphasis on bridge construction,
- Adopt the procedure of quality control and confirmation of the construction product on the example of structural bearings.

Course content (by course schedule):

- Lectures:
  1. General information about polymers [6]
  2. More significant types of polymer materials in construction [3]
  3. Processing and reshaping of polymers [3]
  4. Properties of polymeric materials and products [3]
  5. Fiber reinforced polymer materials (FRP materials) [3]
  6. Foamed polymer materials [3]
  7. Application of polymer materials in construction: Bridge construction; Maintenance and renovation [3]
  8. Application of polymer materials in construction: Seismic isolation [3]
  9. Construction products from polymeric materials in the harmonized area [3]
- Exercises:
  1. Field teaching: Tour of companies and plants engaged in the production of polymer and composite products
  2. Laboratory exercises: Testing of polymer materials and composites (e.g. structural bearings, expansion joints, plastomer pipes, etc.) in the Structural Testing Laboratory
  3. Computer exercises: Modelling of Polymer Materials in the Abaqus Software

STRUCTURAL TESTING

Credits (ECTS): 4.5

Hours (total per semester):

- Lectures: 30
- Exercises (laboratory): 15

Course objectives:

- Deepening of theoretical and practical knowledge about the behaviour of structures under real loads,

- Learning about modern measuring equipment and methods in the field of testing building structures.

Entry competences (prior knowledge, descriptive):

- Knowledge of procedures for determining forces in structures,
- Knowledge of stress and deformation calculations due to longitudinal and transverse forces, torsion moment and bending moment,
- Knowledge of basic procedures for analysis and dimensioning of structures (concrete, metal, wood).

Learning outcomes:

- Analysing the behaviour of structural elements and load-bearing systems based on the conducted tests,
- Understanding the behaviour of structures under static and dynamic loading, environmental influences and rheological changes in the material,
- Selection and application of equipment, procedures and methods in structural testing,
- Planning procedures for proving the safety of structures,
- Assessment of the condition of structures and structural elements based on the conducted tests,
- Proving the ability of structures and structural elements to take on the expected loads.

Course content (by course schedule):

- Lectures:
  1. Introduction. The purpose of structural testing. Classification of tests. Scientific and research. Control. Laboratory. Static and dynamic. Short-term and long-term [2]
  2. Mechanical and geometric quantities that are measured during structural testing. Absolute displacement of the point of structure. Change in the spacing of points of structure (deformation). Angle of rotation. Curvature. Relative deformations [2]
  3. Measurement of mechanical and geometric quantities. Elements of accessories. Enlargement. Accuracy. Reliability. Hysteresis. Sensitivity. Measurement area [2]
  4. Measurement of mechanical and geometric quantities. Accessories for measuring: displacements, length changes (tensiometers), angle changes, curvature changes. Calibration of accessories [2]
  5. Tensometry. Classification of tensiometer types: mechanical, optical-mechanical, optical, acoustic, electrical [2]
  6. Electrical resistance strain gauges (ERSG) Types. Method of installation and connection. Sets of measuring instruments. Creation of auxiliary devices for measuring displacement, acceleration, pressure forces, etc. [2]
  7. Analysis of plane state of stress by measuring deformations. Uniaxial state of stress. Biaxial state of stress. Biaxial stress state with known principal stress directions. General biaxial stress state. Rosettes. Triaxial state of deformation and stress [2]
  8. Methods of analysing the state of deformation and stress of structures and their elements. Photoelasticity. Moire method. Process with brittle lacquers [2]
  9. Methods of analysing the state of deformation and stress of structures and their elements. Holographic methods. Geodetic surveying. Modelling [2]

10. Material verification procedures and characteristics of the tested structure. Core extraction. Ultrasound. Sclerometer. Radiographic imaging [2]
11. Static testing of structures. Design. Execution [2]
12. Static testing of structures. Loading mode. Result evaluation. Norms and conditions of construction validity [2]
13. Dynamic testing. Design. Execution. Loading mode and dimensions to be measured [2]
14. Dynamic testing. Dynamic parameters of structures. Assessment of measurement results [2]

- Exercises (laboratory):

1. Presentation and description of instruments for static and dynamic tests [1]
2. Measurement of the same quantity with a portable comparator (determining the accuracy of the instrument). Dose calibration for force measurement (determining the instrument constant). Calibration of the inductive sensor (LVDT) for displacement measurement (determining the instrument constant) [3]
3. Measurement of deformations and deflections on grids and walls with openings (plexiglass models) [2]
4. Photoelastic method [2]
5. Display and description of instruments for static and dynamic tests. [2]
6. Determination of dynamic parameters (natural frequencies, damping coefficients and modal shapes) on models and structures. [2]
7. Description and presentation of examples of structural testing in the Laboratory and data processing and analysis. [3]

DRAINAGE OF TRANSPORTATION FACILITIES

Credits (ECTS): 4.5

Hours (total per semester):

- Lectures: 30
- Exercises: 15 (construction: 12, design: 3)

Course objectives:

- Acquisition of theoretical and practical knowledge about the principles of surface and underground transportation infrastructure drainage,
- Knowledge of the advantages and disadvantages of using different types of drainage devices,
- Acquisition of basic practical knowledge required in design practice for the selection of transportation infrastructure drainage elements.

Entry competences (prior knowledge, descriptive):

- Knowledge of the rules and criteria for transportation infrastructure design,
- Understanding the significance of the optimal design of the cross-section elements.

Learning outcomes:

- To apply professional literature in the field of transportation infrastructure drainage and to apply acquired knowledge in further training,
- To design surface and underground urban and suburban transportation infrastructure drainage systems,

- To solve simpler urban and suburban transportation infrastructure drainage problems,
- To analyse the effect of water on the traffic surface from the aspect of safety, load-bearing capacity and stability of the elements of the subgrade and traffic surface structure, taking into account the ecological parameters of water protection,
- To use computer programs specialized for transportation infrastructure design to develop drainage elements,
- To evaluate assumptions, arguments and design solutions related to the choice of transportation infrastructure drainage devices,
- To manage construction and maintenance of transportation infrastructure drainage elements and at the same time solve engineering problems in a creative way.

Course contents:

- Lectures:
  1. Introduction to the course. Hydrological concepts and data
  2. Hydrological data
  3. The relationship between transportation infrastructure and water in the environment
  4. Drainage systems
  5. Surface drainage of traffic areas
  6. Devices for surface drainage [2]
  7. Groundwater drainage
  8. Storm sewers and inspection shafts
  9. Culverts
  10. Drainage buildings
  11. Intersection drainage
  12. Urban drainage solutions [2]
  13. Ecological parameters of water protection and an integral approach to the drainage of traffic areas
- Exercises (design, construction):
  1. Normal cross-section [2]
  2. Details of surface drainage devices
  3. Details of underground drainage devices
  4. Drainage solution in plan view and longitudinal section
  5. Devices for surface drainage (gutters, protective ditches)
  6. Elaboration of catch basins
  7. Elaboration of storm sewers and inspection manholes
  8. Culverts - location and type
  9. Culverts - longitudinal sections
  10. Longitudinal section of the storm sewer
  11. Characteristic cross-section and textual description
  12. Characteristic cross-sections [2]
  13. Creating a text description

TRANSPORT SYSTEMS

Credits (ECTS): 4.5

Hours (total per semester):

- Lectures: 45

Course objectives:

- Multidisciplinary approach to planning, designing and maintaining an integral transport system.

Entry competences (prior knowledge, descriptive):

- Practical knowledge in the field of traffic flow theory,
- Practical knowledge in the field of transportation engineering.

Learning outcomes:

- The ability to determine the main features of the basic elements of the transport system and different types of transport,
- Participation in analysing the development of the overall transport system and its individual parts,
- The ability to design various elements of the transport system,
- The ability to analyse the basic principles of the functioning and development of the road transport system,
- The ability to assess and research existing data on the road transport system and their application in practice,
- Participation in the creation of the concept of the functioning of the transport system,
- Participation in the creation and maintenance of the transport system.

Course contents:

- Lectures:
  1. Traffic system: definitions, categorization, historical development
  2. Traffic-spatial planning and documents
  3. General technical characteristics of traffic infrastructure
  4. Main features of traffic users and travel
  5. Main traffic characteristics of infrastructures
  6. Urban spaces
  7. Urban transportation facilities
  8. Traffic flows and regulation
  9. Traffic loads
  10. Pedestrian traffic
  11. Bicycle traffic
  12. Public urban transport - development and elements of the system
  13. Public city transport - system features and levels of service
  14. Paratransit and traffic safety
  15. Traffic studies

2.2.2 Summer semester

Courses	Total hours			ECTS
	Lectures	Seminar	Practice	
Business Strategies for Construction Companies	45	0	0	4,5
Supervision and Monitoring of Construction Projects	30	0	0	3
Energy renovation of buildings	15	0	45	6
Green Building	15	15	15	4,5
Geotechnical Design	30	0	30	6
Underground Structures	30	0	30	6
Hydrosystems	45	0	15	6
River Channel Stability	30	0	30	6
Design and Construction of Water and Wastewater Infrastructure	30	0	30	6
Urban Hydrology	30	0	30	6
Vegetative Water Facilities	30	0	30	6
Earthquake Engineering	30	0	0	3
Numerical Modelling of Railway Track Structures	30	0	15	4,5
Railway track Maintenance	45	0	0	4,5
Urban Railways	30	0	15	4,5
English in Civil Engineering 2	0	0	45	4,5
German in Civil Engineering 2	0	0	45	4,5

BUSINESS STRATEGIES FOR CONSTRUCTION COMPANIES

Credits (ECTS): 4.5

Hours (total per semester):

- Lectures: 45

Course objectives:

- Introduce students to the concept of strategy, present the business environment and factors that influence construction company operations, analyse business ethics in construction, analyse the environment in which construction companies operate, and introduce students to different types of strategies.

Entry competences (prior knowledge, descriptive):

- Preferably knowledge of the basics of economics within the Business Economics course (elective course in the first year of undergraduate studies).

Learning outcomes:

- Explain the concept of a company's business strategy, the process of formulating a strategy and define the levels of strategy,
- Formulate the mission, vision and goals of the company,
- Describe the business environment and factors that influence the operations of construction companies,
- Create a SWOT analysis and Stakeholder analysis,
- Formulate the company's business strategy – corporate, generic, functional, and marketing strategy.

Course contents:

- Lectures:

1. Introduction
2. Definition of strategy
3. Mission, vision and goals of the company
4. Business environment of construction companies
5. Factors influencing the operation of construction companies
6. Analysis of the environment of construction companies
7. Socially responsible operations of construction companies
8. 1st mid-term exam 2 Formulating the strategy of construction companies
9. Corporate strategy and portfolio analysis
10. Generic/business strategies
11. Functional strategies
12. Marketing strategies
13. Strategies for construction companies entering foreign markets
14. Strategy implementation and control
15. 2nd mid-term exam

SUPERVISION AND MONITORING OF CONSTRUCTION PROJECTS

Credits (ECTS): 3

Hours (total per semester):

- Lectures: 30

Course objectives:

- Acquisition and connection of knowledge in the field of construction regulations, quality management and organization theory in order to monitor and control construction.

Entry competences (prior knowledge, descriptive):

- Basics of construction regulations,
- Basics of construction technology.

Learning outcomes:

- Explain the normative and contractual bases of monitoring and control of the construction process,
- List and describe the duties of expert supervision in the phases of the project,
- Describe the principles of quality, cost and time control in the construction process,
- Explain the activities of technical consulting of investors.

Course content (by course schedule):

- Lectures:
    1. Normative bases of professional supervision over the execution of works, laws and regulations
    2. Contractual basis of professional supervision. Professional supervision and other participants in the project. Structure of the supervisory team and relations within it
    3. The role and duties of professional supervision in the project phases: appointment, introduction of the contractor to the work, verification of technical documentation, geodetic survey
    4. Control of quantities, methods of measurement and calculation
    5. Quality control
    6. Control of the dynamics of work execution
    7. Financial control. Evaluation of extra-cost works
    8. Calculation situations. Completed situation and costing
    9. Technical inspection, handover of the building
    10. Official communication and documentation
    11. Normative bases of technical consulting. Selection of consultants and elements of the technical consultancy contract
    12. The function of a consultant in project phases: preparation and implementation of tenders, contracting of individual phases of project execution
    13. Monitoring project performance in terms of time, quality and costs. Consulting of investors
    14. Contract annexes and supporting documentation
    15. Responsibility of the consultant. Professional associations and norms

ENERGY RENOVATION OF BUILDINGS

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 15

- Exercises: 45 (auditory: 15, construction: 30)

Course objectives:

- Acquisition of advanced and highly specialized knowledge for evaluating the energy efficiency of existing buildings and selecting suitable methods for sustainable energy renovation of buildings.
- Acquisition of advanced and highly specialized knowledge to raise the level of energy efficiency and thermal comfort of the existing building stock by applying proven and economically justified renovation measures.
- Introducing students to advanced and specialized approaches in the analysis and assessment of energy efficiency of buildings.
- Mastering advanced and specialized methods for proper assessment of the condition of the building envelope, with the aim of restoring all damaged areas before installing systems that affect energy efficiency.
- Familiarity with advanced and highly specialized materials, technical systems and their properties, related to durability, safety and fire protection and energy efficiency.
- Developing group work skills by applying the team learning method.

Entry competences (prior knowledge, descriptive):

- Knowledge of basic material properties.
- Basic knowledge of building physics.
- Basic knowledge about the durability and maintenance of buildings.
- Knowledge of the basic procedures for assessing the condition of buildings.
- Basic knowledge about the origin and spread of fire in buildings.
- Knowledge of basic structural elements and building construction systems.

Learning outcomes:

- Create a program assignment for assessing the condition of existing buildings in terms of the condition of materials and structure, energy efficiency and fire protection.
- Apply advanced and highly specialized knowledge about the properties of building materials, products and systems, with an emphasis on durability, fire behaviour and energy efficiency during renovation.
- Analyse the types of applicable systems and their design methods in energy renovation of buildings.
- Create a project for the energy renovation of existing buildings, taking into account measures to renovate the existing structure and fire protection.
- Show that the applied measures of renovation and thermal comfort of the building are simple, provable and cost-justified.
- Create a maintenance program for applied renovation systems.
- Demonstrate the ability to take responsibility during design and the ability to work in a team.

Course content (by course schedule):

- Lectures

1. Introduction to energy renovation, Legal framework – recommendations and obligations (1)
2. Overview of possible strategies for in-depth energy renovation of existing buildings (2)
3. Technical systems in buildings, lighting, control systems (2)
4. Environmental impacts, damage and durability of building materials (2)

5. Deficiencies and needs in the renovation of the existing building stock (2)
6. Models of sustainable building renovation (2)
7. Proper selection of materials and technical systems for the energy renovation of the existing building stock (2)
8. Proper selection of materials and technical systems for energy renovation respecting fire protection requirements (2)

- Auditory exercises

1. Energy properties and characteristics of the existing building stock (2)
2. The use of renewable energy sources in the energy renovation of buildings (2)
3. Energy renovation and rehabilitation of structural elements of buildings under cultural monument protection (2)
4. Cost optimum of energy renovation of buildings (2)
5. Energy renovation in several steps (step by step renovation) (2)
6. Comfort parameters in buildings (2)
7. Evidence of the quality of installed materials during energy renovation of buildings (1)
8. Case studies (2)

- Construction exercises

1. As part of the construction exercises, groups of students will assess the state of the building from the building stock, conduct a design

GREEN BUILDING

Credits (ECTS): 4.5

Hours (total per semester):

- Lectures: 15
- Exercises: 15
- Seminars: 15

Course objectives:

- The aim of the course is to familiarize the students with the concept of green construction so that they can explain and apply methods of reducing the impact of construction on the environment, create a life cycle analysis of a construction product, determine the parameters of energy consumption in buildings and analyse the data needed to create a certificate for green construction.
- Green construction is explained through all three parts of the 7th fundamental requirement, through theoretical bases and examples from practice. The exercises in the course are based on the method of socially useful learning.
- During the course, students create a student project in groups, the aim of which is that students apply the knowledge and skills acquired through their studies to the development of a project that solves a specific social problem in the field of construction and sustainable use of natural resources.

Entry competences (prior knowledge, descriptive):

- Knowledge of basic material properties.
- Knowledge of basic ecological terms.

Learning outcomes:

- Explain and apply the principles of green construction.
- Create a construction product life cycle analysis.
- Determine parameters of influence on energy consumption in buildings.
- Explain and apply methods of reducing the impact of construction on the environment.
- Analyse the data needed to create a green building certificate.

Course content (by course schedule):

- Lectures:

1. Introduction to the concepts of linear and circular economy and the role of civil engineering, key aspects of green construction: ecological, economic, sociocultural and technological aspects.
2. Legislative and normative framework for sustainable use of natural resources in construction
3. Construction waste management strategies, recycling and reuse of buildings, their materials and parts after demolition
4. Sustainable construction and building management strategy, property-based design approaches, prefabricated and modular construction, design for removal, the building as a service
5. Industrial waste and secondary materials management strategy, use of ecological raw materials and secondary materials
6. Tools for comparing the ecological footprint of construction products, second generation certificates
7. Examples of sustainable use of natural resources in construction. International certificates for green construction (LEED, BREEAM, DGNB)
8. Green building management; Examples of green construction

- Exercises:

1. Key features of LCA and LCT
2. LCA - definition of the goal and area of application, data analysis, environmental impact assessment
3. Definition of system boundaries, functional unit and input data, interpretation of LCA
4. Creation of LCA (construction exercises)

GEOTECHNICAL DESIGN

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 30
- exercises: 30 (2 auditory + 28 design)

Course objectives:

- Acquisition of knowledge and skills for integral geotechnical design of geotechnical structures or procedures,
- Integrating previously acquired knowledge and skills when solving more complex geotechnical procedures.

Entry competences (prior knowledge, descriptive):

- Using Software for numerical modelling in geotechnics,

- Knowledge of the basic physical and mechanical properties of soil and rock necessary for design,
- Knowledge of laboratory and field investigations,
- Determination of project situations for simpler geotechnical operations.

Learning outcomes:

- Defining given geotechnical problems and planning geotechnical investigation works,
- Analysis and interpretation of geotechnical investigation works, and determination of the characteristic geotechnical model of the foundation soil,
- Selection of relevant parameters for the design based on investigative works,
- Choosing the appropriate design solution for a given type of geotechnical problem,
- Analysis and interpretation of the results obtained by numerical modelling,
- Evaluation and verification of the selected technical solution for serviceability and ultimate limit states,
- selection and description of performance technology for the selected design solution,
- Drawing up the entire project with attached drawings, cost list, technical description, budgets and technical conditions for the implementation of the selected design solution.

Course content (by course schedule):

- Lectures:
  1. General principles and specifics of geotechnical and structural design [2]
  2. Presentation of the relevant regulations and general provisions of Eurocode 7 - Geotechnics procedures

for designing and proving mechanical resistance and stability) [2]

  3. Eurocode 7 – Geotechnics (limit states, geotechnical data) [2]
  4. Eurocode 7 – Geotechnics (characteristic geotechnical structures) [2]
  5. Eurocode 7 – Geotechnics (seismic geotechnical engineering) [2]
  6. Quality management and quality assurance in geotechnical design and execution [2]
  7. Development of field and laboratory investigative works for typical cases (selection of Methods, schedule and depth of research, sampling density) [2]
  8. Reports of investigation works, geotechnical models of the soil, selection of relevant geotechnical parameters [4]
  9. Variant technical solutions, choice of materials and characteristics of performance technologies [4]
  10. Presentations of more complex geotechnical structures and works from practice [6]
  11. Discussion about projects [2]
- Exercises:
  1. Geotechnical design of typical geotechnical structures (design) [2]
  2. Work on a geotechnical design – preparation of geotechnical data, geotechnical model of the foundation ground (design) [4],
  3. Work on a geotechnical design – creation of a geotechnical model of the foundation ground, selection of parameters (design) [2]
  4. Work on geotechnical design – selection of technical solutions (design) [4]

5. Work on geotechnical design – geotechnical calculations (design, work on computer) [8]
6. Work on geotechnical design – graphical part, technical terms of execution and costs (design, work on computer) [8]
7. Submission of geotechnical design (design)[2]

UNDERGROUND STRUCTURES

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 30
- Exercises: 30 (auditory: 12, construction: 18)

Course objectives:

- Acquisition of theoretical knowledge about the state of stress around openings in the rock mass due to the construction of underground structures,
- Acquisition of theoretical knowledge about the interaction of underground systems and rock mass,
- Acquisition of theoretical knowledge about the design and construction technology of underground structures,
- Mastering more complex problems in the field of underground construction.

Entry competences (prior knowledge, descriptive):

- Knowledge of the basic physical and mechanical properties of soil and rock mass (stiffness, strength, etc.),
- Knowledge of rock mass classifications,
- Understanding of the basic principles of numerical modelling.

Learning outcomes:

- The ability to calculate the relevant soil/rock parameters required for numerical modelling based on the results of laboratory and field tests and on the basis of rock mass classifications,
- The ability to choose a system for ensuring the stability of an underground structure depending on the environment in which it is located,
- The ability to perform more complex two-dimensional and three-dimensional stress-deformation analyses when assessing the stability of support units of underground buildings,
- Knowledge of the principles of interactive design in underground construction using observations and measurements during execution.

Course content (by course schedule):

- Lectures:
  1. Basic concepts and development of underground structures [2]
  2. Traditional methods of tunnel excavation [2]
  3. Theory of a self-supporting vault [3]
  4. New Austrian tunneling method [2]
  5. Norwegian method of tunneling [2]
  6. Primary partition, secondary partition [3]
  7. Waterproofing, ventilation [2]

8. The role of rock mass classification in underground construction [2]
9. Analytical methods in underground construction [3]
10. Numerical methods in underground construction [3]
11. Monitoring of underground buildings [2]
12. Designing of underground structures [4]

- Exercises:
  1. Elements of the primary underground system [8]
  2. Load on the support unit: Theories of self-supporting vault [2]
  3. Load on the support unit: Elastically supported ring [2]
  4. Designing the underground system based on the RMR classification [2]
  5. Designing the underground system based on the Q classification [2]
  6. Characteristic curves of rock mass and support unit [2]
  7. Stress-deformation analyses of underground structures [6]
  8. Long-term deformations of underground structures [4]

HYDROSYSTEMS

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 45
- Exercises: 15 (design)

Course objectives:

- Acquisition of practical and theoretical knowledge in the process of solving complex hydrosystems,
- Acquisition of basic knowledge about water management.

Entry competences (prior knowledge, descriptive):

- Knowledge and understanding of hydrological processes in nature,
- Knowing and distinguishing the application of hydraulic structures,
- Knowledge of the technical characteristics and way of functioning of hydraulic structures.

Learning outcomes:

- Explain basic concepts in the field of water management,
- Know the basic legal regulations,
- Analyse the elements in the technology of solving complex problems, recognize the necessary steps and design the problem-solving procedure,
- Present hydrosystems to a wider audience,
- Compare hydrosystems based on basic financial indicators,
- Participate in team work.

Course content (by course schedule):

- Lectures:
  1. Water and water resources. Basic concepts. [3]
  2. Legal regulations [6]
  3. Problem solving technology [6]

4. Objectives, criteria and measures [3]
5. Changes in the environment due to the construction of hydrosystems [3]
6. Assessment of benefits and costs. [6]
7. Decision making procedures [3]
8. Management of multifunctional hydrosystems [3]
9. Integrated water management [9]
10. Examples of hydrosystems [3]

- Exercises:

1. Creation of a project assignment according to the selected topic from the content of the lectures

RIVER CHANNEL STABILITY

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 30
- Exercises (design): 30

Course objectives:

- Learn how to assess the sediment equilibrium of natural river channels.
- Differentiate sediment transport mechanisms.
- Interpret methods of sediment transport measurement.

Entry competences (prior knowledge, descriptive):

- Knowledge of basic fluid dynamics (momentum equation, general equations for description of the fluid in motion (Saint-Venant and Navier-Stokes equations), the law of conservation of energy, Bernoulli equation for viscous fluid, resistance to flow, determination of local and friction energy losses, pressure and energy grade, measurement of flow velocity, pressure and discharge),

Learning outcomes:

- Assess the sediment transport equilibrium of river reaches and identify critical sections.
- Develop a coupled flow-sediment numerical model.
- Interpret and evaluate the results of a numerical sediment transport model.

Course content (by course schedule):

- Lectures:
  1. Incipient sediment motion and methods for estimating the threshold conditions for sediment entrainment (4 hours)
  2. Types of sediment, sediment transport processes, and bedforms in sand-bed rivers (4 hours)
  3. Identification of the causes of sediment transport disequilibrium in local river reaches (4 hours)
  4. Bed-load transport modelling: methods and current challenges (4 hours)
  5. Suspended sediment transport modelling: sediment rating curves (4 hours)

6. Application of numerical flow and sediment transport models for assessing the sediment transport capacity of river flows (4 hours)
7. Analysis and evaluation of numerical model results (4 hours)
8. Sediment transport measurement methods and guidelines for different sampling approaches (2 hours)

URBAN HYDROLOGY

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 30
- Exercises: 30 (16 auditory + 14 design)

Course objectives:

- Acquisition of theoretical and practical knowledge about the impact of urbanization on hydrological processes, processing of precipitation data and methods of determining runoff using an empirical approach and mathematical modelling.

Entry competences (prior knowledge, descriptive):

- Knowledge of the basics from the courses Hydrology and Hydrology 2, which include: water and water movement in nature, processes in the atmosphere, hydrometry, hydrometric data processing, application of probability and statistics in hydrology, and parametric methods for determining processes,
- Knowledge of the basics from the course Hydrology 2, which include knowledge and understanding of: hydrological processes, analysis of precipitation data, runoff processes in the basin – methods for determining direct runoff, and mathematical modelling in hydrology.

Learning outcomes:

- Define and explain: hydrological processes in urban watersheds, methods for processing precipitation data and methods for calculating runoff in urban basins,
- Create IDF curves and project rain based on precipitation data and the corresponding project hydrogram
- Differentiate and choose the appropriate method of calculating the design rain and runoff hydrograph,
- Apply the acquired theoretical knowledge of urban hydrology in the construction industry; in designing buildings, students are able to solve simpler problems and tasks from urban hydrology.

Course content (by course schedule):

- Lectures:
  1. Hydrological processes in urban basins, hydrologic balance, hydrometeorological network of stations, hydrological information system, impact of urbanization on hydrological processes. [2]
  2. Precipitation, interception, infiltration, retention of water in depressions, surface flow, flow and retention in collecting gutters, gutters and canals. [2]

3. Hydrological and hydraulic characteristics of urban systems, characteristics of elements of rainwater and mixed sewage systems, open stormwater drainage systems. [2]
4. Flat and sloping roofs, asphalted surfaces, parks and unasphalted surfaces, gutters and side ditches, catch basins and manholes, water culverts under roads and other structures, sewage network, rain overflows, retention and expansion basins, inlet and outlet structures. [2]
5. Calculation of runoff from heavy rains, empirical formulas and rational method, time of concentration of runoff and lag time of maximum runoff for rains shorter than the time of concentration. [2]
6. Effective precipitation and runoff coefficient, precipitation-runoff correlation, snowmelt runoff. [2]
7. 1st mid-term exam
8. Creation and meaning of IDF curves of rain in urban areas, formation of relevant sets of rain gauge data for creation of IDF curves. [2]
9. Los Angeles method, Chicago method, SCS Method (Soil Conservation Service Method), other methods. [2]
10. Determining the relevant rain for designing the sewage system, flooding in urban areas, economic aspects of determining the design rain. [2]
11. Determination of the design hydrograph based on runoff modelling and the implementation of an economic analysis of the relationship between the costs of the drainage system and damage from urban floods due to heavy rains. [2]
12. Calculation of runoff from individual buildings, industrial and office buildings, residential blocks and city roads. [2]
13. Contemporary principles of urban drainage and water quality in urban basins. Mitigation of flood waves and the role of urban retention. [2]
14. Collection and use of rainwater, discharge into the underground, management of the urban drainage system based on the application of mathematical runoff modelling. [2]
15. 2nd mid-term exam

- Exercises (auditory and construction):
  1. Formation of relevant sets of rain gauge data for the calculation of IDF curves (auditory) [2]
  2. Formation of relevant sets of rain gauge data for calculation of IDF curves (construction) [2]
  3. Calculation of IDF curves [4]
  4. Determination and application of the unit and current unit hydrograph method in the urban area [4]
  5. Application of HEC-HMS modelling to determine urban runoff. [2]
  6. Application of HEC-HMS modelling to determine urban runoff. [2]
  7. Application of the unit and current unit hydrograph method and the kinematic wave method in the urban area. [2]
  8. Application of the unit and current unit hydrograph method and the kinematic wave method in the urban area. [2]
  9. Change in land use due to urbanization. Introducing elements of sustainable urban drainage systems. [2]

10. Change in land use due to urbanization. Introducing elements of sustainable urban drainage systems. [2]
11. Runoff simulations in HEC-HMS. [4]
12. Determination of the design hydrograph. [2]

DESIGN AND CONSTRUCTION OF WATER AND WASTEWATER INFRASTRUCTURE

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 30
- Exercises: 30

Course objectives:

- Acquisition and application of practical knowledge related to the administrative procedures involved in the preparation and approval of engineering design documentation, the design and construction of water supply and wastewater infrastructure, the preparation of bills of quantities and engineering drawings, and the application of computer software in water engineering

Entry competences (prior knowledge, descriptive):

- Understanding and knowledge of the urban water supply and sewerage systems.

Learning outcomes:

- Explain and apply the relevant legal and regulatory framework governing the preparation and approval of engineering design documentation.
- Apply engineering knowledge to the preparation of design documentation of varying levels of complexity, including engineering drawings and bills of quantities.
- Apply engineering knowledge to the processing and analysis of measured and published data.
- Apply engineering knowledge to the modelling of processes and the design of water supply and wastewater infrastructure.

Course content (by course schedule):

- Lectures:

1. Introduction to the course and the legal and regulatory framework.
2. Administrative procedures and permitting processes.
3. Structure and content of engineering design documentation.
4. Geodetic survey data and site layout drawings; preparation of design base maps.
5. Definition of design criteria: spatial planning, environmental, functional, and structural requirements.
6. Functional design: development of the design concept, including estimated capacity, preliminary structural dimensions, and site layout.
7. Engineering analyses for verification or revision of the proposed design concept, including hydraulic, technological, environmental, and other relevant calculations.
8. Longitudinal and cross-sectional profiles of pipelines and channels.

9. Design of water distribution networks and associated facilities – detailed design.
10. Design of wastewater collection systems and associated facilities – detailed design.
11. Design of water and wastewater treatment facilities – detailed design.
12. Preparation of the technical report describing the proposed design solution.
13. Bills of quantities and project cost estimation.
14. Construction organization and technology, construction supervision, and project management for water infrastructure projects.
15. Presentation of student projects and design solutions.

WATER RESOURCES SYSTEMS MODELLING

Credits (ECTS): 6

Hours (total per semester):

- Lectures: 30
- Exercises: 30

Course objectives:

- Acquire and apply a methodological framework for solving hydraulic engineering problems through purpose-oriented modelling of hydraulic systems, including problem formulation, model selection, and interpretation of modelling results to support decision-making.
- Analyse and apply modelling approaches according to the spatial and temporal scales of hydraulic engineering problems, taking into account the influence of local, microscale, and macroscale processes.
- Distinguish between and apply different modelling paradigms (physics-based, conceptual, data-driven, and hybrid) within simulation and decision-support models.
- Integrate simulation and optimization approaches to support decision-making in hydraulic engineering systems.

Entry competences (prior knowledge, descriptive):

- Understanding and knowledge of basic Hydraulics and Hydrology.

Learning outcomes:

- Analyse the structure and functioning of hydraulic engineering systems and identify the key system inputs, outputs, and state variables.
- Apply methods for estimating system inputs (e.g., precipitation and inflow) using appropriate models and datasets.
- Develop and apply a simulation model of a hydraulic engineering system appropriate to the spatial and temporal scale of the problem.
- Distinguish between and select appropriate modelling approaches (deterministic or stochastic, lumped or distributed, physics-based or data-driven) for a given engineering problem.
- Formulate and solve a simple optimization problem for the operation of a hydraulic engineering system by defining the objective function and constraints.
- Integrate simulation and optimization approaches to support engineering decision-making.

- Interpret and critically evaluate modelling results in the context of hydraulic engineering analysis and decision-making.

Course content (by course schedule):

- Lectures:
  1. Introduction to hydraulic engineering systems modelling.
  2. Data and supporting datasets for hydraulic engineering applications.
  3. Fundamentals of simulation modelling and model classification.
  4. Estimation of system inputs: forecasting methods.
  5. Application of different modelling paradigms for estimating system inputs.
  6. Development of simulation models.
  7. Influence of spatial and temporal scales on modelling.
  8. Model calibration and validation.
  9. Optimization of hydraulic engineering systems.
  10. Fundamentals of decision-support models and model classification.
  11. Modelling of operational decisions and system outputs.
  12. Application of different modelling paradigms for modelling decisions and system outputs.
  13. Development of decision-support models.
  14. Simulation–optimization approaches to hydraulic systems modelling.
  15. Selection of optimal solutions and engineering decision-making.

EARTHQUAKE ENGINEERING

Credits (ECTS): 3

Hours (total per semester):

- Lectures: 30

Course objectives:

- Learning about seismic activity,
- Acquisition of basic knowledge about seismic design of buildings and bridges,
- Acquisition of practical knowledge about seismic design of concrete, steel, masonry and composite structures,
- Acquisition of basic knowledge about the analysis and design of seismically isolated structures.

Entry competences (prior knowledge, descriptive):

- Understanding and ability to apply design of concrete and steel structures,
- Knowledge of basic construction systems,
- Understanding and knowledge of the static calculation of various static systems.

Learning outcomes:

- The ability to conceptually design various structural systems (concrete, steel, masonry and composite structures),
- The ability to observe and analyse seismic effects on buildings by applying modern European standards,
- The ability to conceptually design structures with passive energy dissipation systems,

Course content (by course schedule):

- Lectures:

16. Nature of earthquakes and basics of seismology [4]
17. Structural response, basic terms and ductility [2]
18. Seismic spectrum [2]
19. Energy concept of earthquake engineering [2]
20. Conceptual design [4]
21. Seismic design according to Eurocode 8 [2]
22. Mid-term exam
23. Design methods [2]
24. Special rules for concrete and masonry structures [4]
25. Special rules for steel, timber and composite structures [2]
26. Research in earthquake engineering [2]
27. Mid-term exam

NUMERICAL MODELLING OF RAILWAY TRACK STRUCTURES

Credits (ECTS): 4.5

Hours (total per semester):

- Lectures: 30
- Exercises: 15 (auditory: 3, construction: 12)

Course objectives:

- Acquisition of knowledge about the application of computer simulations in railway design using numerical methods (finite element method and discrete element method),
- Acquisition of theoretical knowledge about numerical modelling of static systems in the field of railways, as well as the problems accompanying the creation and calculation of numerical models,
- Acquisition of knowledge about the discretization of the calculation model for various numerical methods,
- Acquisition of practical knowledge in the interpretation of calculation results obtained by calculation on a computer using various numerical methods,

Entry competences (prior knowledge, descriptive):

- Knowledge of the basics of the permanent way,
- Knowledge of differential and integral calculus (including ordinary and partial differential equations) and linear algebra,
- Understand the theoretical foundations of variational procedures and the concept of area discretization

Learning outcomes:

- Apply knowledge of finite and discrete element methods to the assessment of railway structure behaviour,
- Analyse the impact of the implementation of elastic elements on increasing the elasticity of the system

- Formulate the problems of interaction of elements and load transfer within different types of track structures,
  - Calculate the elements of the ballasted track structure and the slab track structure using specialized computer software for the calculation of stresses and deformations of structures,
  - Analyse and evaluate the results of the modelled behaviour of the segments of the track structure, as well as the permanent way as a whole,
  - Create a stress and deformation project of the track structure with all elements (rails, sleepers, fastening systems, ballast bed)
  - Elaborate the steps of numerical modelling for a particular track problem

Course content (by course schedule):

- Lectures:
  1. Calculation elements of ballasted track structure [2]
  2. Guidelines and calculation methods of track structure [2]
  3. Analysis of the effect on the track structure [2]
  4. Initial and boundary conditions [2]
  5. Finite element method, discrete element method [2]
  6. Ballasted track structure - elements of the numerical model [2]
  7. Slab track structure - elements of the numerical model [2]
  8. Experimental tests for obtaining boundary conditions in numerical calculation [2]
  9. Numerical calculation of the rail as a continuum [2]
  10. Numerical calculation of track sleepers - dimensioning of concrete and wooden sleepers [2]
  11. Numerical model of a rail clip - design of elements of fastening accessories [2]
  12. Numerical model of a ballast bed- dimensioning of elements [2]
  13. Interactions between elements of the track structure as an integrated system [2]
  14. The influence of temperature on the behaviour of the track structure [2]
  15. The influence of incorporating elastic elements into the track structure on the improvement of the elastic properties of the track [2]
- Exercises (auditory, construction):
  1. Basics of design and calculation. [1]
  2. Calculation of traffic load, determination of excitation function [1]
  3. General information on numerical calculation of track structure (FEM, DEM) [1]
  4. Initial and boundary conditions of the numerical model of the track structure [1]
  5. Contact stresses and deformations. Hertz formulas for contact stresses and deformations [1]
  6. Calculation of the basic elements of the track structure using the finite element method in a computer software and comparison of the structure of a ballasted track and a slab track [1]
  7. Checking the stress in the rails of the track structure with a computer software; rail bending, stress concentration [1]
  8. Checking the stress in the sleepers of the track structure with a computer software [1]
  9. Checking the tension of the fastening system of the track structure with a computer software [1]
  10. Checking the stress inside the ballast bed with a computer software [1]

11. Calculation of different types of track structure foundations [1]
12. Integrate the track elements into a track structure [1]
13. Calculation of track structure deflection [1]
14. Modelling the behaviour of the track structure under temperature effects [1]
15. Modelling of elastic elements (elastic pads under the rail, sleeper, ballast) and their influence on the change of elastic properties of the track structure on firm subbase (bridge, viaduct) [1]

RAILWAY TRACK MAINTENANCE

Credits (ECTS): 4.5

Hours (total per semester):

- Lectures: 45

Course objectives:

- Acquisition of theoretical and practical knowledge about track maintenance,
- Acquisition of theoretical knowledge about the railway track condition assessment,
- Acquisition of practical knowledge about manual and mechanized track maintenance,
- Acquisition of theoretical knowledge about the maintenance of turnouts,
- Acquisition of theoretical knowledge about the maintenance of the track substructure,
- Acquisition of knowledge about the condition assessment and maintenance of railway infrastructure facilities.

Entry competences (prior knowledge, descriptive):

- Knowledge of types of permanent way structures,
- Knowledge of how switches work,
- knowledge of the track substructure.

Learning outcomes:

- Explain the track maintenance system,
- Explain track condition assessment,
- Explain the maintenance of the permanent way,
- Explain the maintenance of the track substructure,
- Explain the maintenance of switches,
- Explain the condition assessment and maintenance of railway infrastructure facilities,
- Explain track maintenance for high speed railways.

Course content (by course schedule):

- Lectures:
  1. General terms about railway maintenance
  2. Track condition assessment: track and rail geometry
  3. Track condition assessment: clearance profile, ballast bed
  4. Types of track maintenance works: regular maintenance (current, investment), track overhaul
  5. Maintenance of the permanent way: manual maintenance, mechanized maintenance
  6. Maintenance of the permanent way: mechanical maintenance
  7. Track maintenance for high speeds

8. Regeneration of track material: rails, switches, fastening system, sleepers, ballast bed
9. Maintenance of switches: maintenance of the switch rails, maintenance of rail frog
10. Maintenance of the substructure of the track: railway subgrade, sub-ballast layer, drainage
11. Condition assessment of railway track structures: bridges, culverts, tunnels, level crossings
12. Maintenance and renovation of railway infrastructure facilities
13. Management of the railway maintenance system using modern geographic information systems

URBAN RAILWAYS

Credits (ECTS): 4.5

Hours (total per semester):

- Lectures: 30
- Exercises (construction): 15

Course objectives:

- Acquisition of knowledge about the tram systems, light rail transit (LRT), metro systems, and suburban railways,
- Acquisition of knowledge about rail vehicles, track structure types, and elements of horizontal and vertical alignment geometry,
- Acquisition of knowledge about the basic requirements for designing and locating underground and above-ground tram, LRT, and metro stops,
- Acquisition of knowledge about technical solutions for rail and road traffic intersections at grade and grade-separated,
- Acquisition of knowledge about construction methods and the specifics of track maintenance in urban conditions.

Entry competences (prior knowledge, descriptive):

- Knowledge of railway design and construction,
- Knowledge of the permanent way,
- Knowledge of public city transport.

Learning outcomes:

- Explain the role of public city transport,
- Explain the tram transport system,
- Explain the metro system,
- Explain the urban light rail system,
- Explain the suburban transport system,
- Explain the types of track constructions for urban areas,
- Explain ways to reduce noise and vibrations from rail traffic in urban areas.

Course content (by course schedule):

- Lectures:
  1. General information about urban railways

2. Tram tracks
3. Light rail
4. Metro
5. Suburban railway
6. Types of rail vehicles in the urban environment
7. Types of track structures
8. Track construction in urban areas – tram
9. Track construction in urban areas – metro
10. Track construction in urban areas – light rail
11. Noise and vibrations from rail traffic in an urban environment
12. Revitalization of the city railway - route planning
13. Revitalization of the city railway - arrangement of stops
14. Basics of track monitoring in operation

- Exercises (construction):

1. Reconstruction of the stops (extension, displacement, modernization) [2]
2. Preliminary design of pedestrian underpasses for the needs of rail traffic in urban areas [2]
3. Preliminary design of new rail traffic lines [3]
4. Preliminary design for the revitalization of rail transport in urban areas [2]
5. Preliminary design of unevenness of the intersection of road and rail traffic [2]
6. Analysis of the influence of rail traffic in urban areas on noise level and vibration intensity [2]
7. Creating a segmented track database [2]

ENGLISH IN CIVIL ENGINEERING 2

Credits (ECTS): 4.5

Hours (total per semester):

- Exercises: 45

Course objectives:

- Acquisition of vocabulary in the field of transport facilities and geotechnical engineering, developing functional literacy in writing technical reports,
- Independent communication using technical terms,
- Developing the ability to translate from English into Croatian and vice versa.

Entry competences (prior knowledge, descriptive):

- Upper-intermediate (B1).

Learning outcomes:

- Acquisition of language competences that include use of professional terminology in the field of roads and geotechnical engineering,
- Independent reading of specialized literature,
- Reinforcement of basic grammatical categories in professional language – use of the passive voice, past tenses, modal verbs,
- Gaining fluency in structuring sentences and developing skills of delivering individual presentation and writing technical texts.

Course content (by course schedule):

1. A Career in Transportation Engineering [2]
2. Road Structure [2]
3. Construction of a Road [2]
4. A Career in Geotechnical Engineering [3]
5. Tunnels and Tunneling Tools [2]
6. How to write a CV? [3]
7. The CV and Job Interview Questions [3]
8. Preparing for the Interview Skills – Techniques, Tips and Advice [3]
9. Single presentations on Transportation Issues [3]
10. Transportation System Issues and Challenges [3]
11. The Light at the End of the Tunnel – Revision of vocabulary [4]
12. What's so Special About Geotechnical Engineering? [3]
13. General Considerations in Foundation Design [2]
14. Special Foundation Problems [2]
15. Deep Foundations [3]
16. Presentations [3]

GERMAN IN CIVIL ENGINEERING 2

Credits (ECTS): 4.5

Hours (total per semester):

- Exercises: 45

Course objectives:

- Help the student to independently use professional literature by developing comprehension, conversation and translation skills,
- Mastering all forms of oral communication of technical content, from participation in discussions to independent presentations.

Entry competences (prior knowledge, descriptive):

- Intermediate and upper-intermediate knowledge of German (B1, B2).

Learning outcomes:

- Comprehension and interpretation of technical texts,
- Confidence and independence in oral expression in the technical field and when explaining professional terms,
- Writing a resume and job application.

Course content (by course schedule):

1. Die Geschichte des Kuppelbaus [3]
2. Wie schreibt man einen Lebenslauf? [3]
3. Bewerbungsschreiben [3]
4. Wie man sich auf ein Interview vorbereitet [3]
5. Die größte Drehbrücke der Welt [3]
6. Bewerbungsschreiben [3]

7. Die Geschichte der Tunnelkonstruktion [3]
8. Kräfte und Gegenkräfte [3]
9. Einige Festigkeitsarten [3]
10. Elastizität und Verformung [3]
11. Der Straßenbau [3]
12. Gebäude im Erdbeben [3]
13. Der Flughafen [3]

3 MASTER THESIS RESEARCH AT UNIZGGF

If you plan to write your Master's thesis or conduct research related to your Master's thesis at the Faculty of Civil Engineering, you must have a supervisor at GF.

A list of potential supervisors, together with links to their personal webpages, is provided below. You are encouraged to review their research interests and the ongoing research projects at the Faculty to help you identify the most suitable supervisor.

Once a supervisor at GF has agreed to supervise your thesis, you should include the thesis title, the name of your GF supervisor, and the name of your home institution supervisor in your Learning Agreement.

The proposed thesis topic and the Learning Agreement must be approved by the ECTS coordinators at both your home institution and the Faculty of Civil Engineering before your mobility begins.

Please note that any research carried out during your mobility must be directly related to your Master's thesis. Independent research projects that are not connected to the thesis cannot be approved.

Construction Management module

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Theory And Modelling of Structures module

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