Univerza *v Ljubljani*
Fakulteta *za gradbeništvo in geodezijo*

Presentation of the study programme

2nd CYCLE MASTER STUDY PROGRAMME
CIVIL ENGINEERING (MA)

1. Information about the study programme

The 2nd cycle master study programme *Civil Engineering* consists of 2 years (4 semesters) and amounts to 120 ECTS points. The study programme includes the following divisions: Structural Engineering, Geotechnics – Hydrotechnics, Infrastructural Engineering. Within the division Structural Engineering courses are organised in four modules: Interdisciplinary Project Study of Computer-Aided Design of Structures, Concrete and Masonry structures, Steel Structures, as well as International Master Module of Engineering Modelling, which is foreseen to be carried out within one semester only in foreign language, and it is intended for foreign students. Within the division Infrastructural Engineering courses are organised also in four modules: Traffic, Organisation – Construction IT, Municipal Engineering, and Project.

2. Basic goals of the programme and general competences

2.1 Basic goals of the programme

The basic goal of the 2nd cycle master study programme *Civil Engineering* is to educate experts with in- depth and specific knowledge and skills from the basic areas of civil engineering, and considering the chosen orientation and elective courses also with special in-depth knowledge from the individual area of civil engineering or the areas related to it.

Within the study the student will learn about the traditional principles upgraded by the latest findings. The contents will be delivered in a contemporary way with modern technology. Students will also learn about all specifics in Slovenia and Europe resulting from special historic, socio- economical and geographic characteristics. With group work, project work and problem-oriented tasks they will get accustomed to group work, public appearance and managing customers as well as get actively involved in research. All the acquired theoretic knowledge will be tested to the largest possible extent with appropriate practical work and with solving demanding theoretic or professionally oriented problems and projects, which will facilitate them the inclusion in practical work after the study and to understand the issues related to civil engineering.

Students acquire the necessary in-depth and specific knowledge from the basic natural sciences and computer-information courses, the knowledge from the basic courses related to civil engineering as well as specific knowledge from professional civil engineering courses. Within individual orientations and elective courses students can choose specialisation and prepare for further study within the programmes of the third cycle.

The goal of the programme is to ensure international comparability, mobility and progression, and the graduate can continue study in Europe and get a job within the European Union. The programme is harmonised with the minimum requirements of the FEANI Association, and thus also with the accreditation of the programme for the title Euro-eng. The goal is also to increase the progression of students and to provide better quality by introducing regular study, with the development of general student and teacher tutorship as well as tutorship for specific courses.

Student can test the acquired knowledge in practice within two-weak practical training in construction and similar companies that also represent the target employment areas.

The programme designed in this way results in a graduate with in-depth theoretical and expert knowledge who can find job in construction companies or individually perform the most demanding expert and development tasks from the area of civil engineering in Slovenia and in Europe.

2.2 General competences acquired with the programme

General competences of the graduate of 2nd cycle master study of Civil Engineering are:

- good general information and knowledge about academic areas and scientific methods of work,
- development of abilities to setup, research, understand and creatively solve problems, principles and theories,
- critical reading and understanding of texts, independent search for knowledge and sources,
- development of the ability of critical, analytical and synthetic thinking,
- qualification for the transfer and use of theoretic knowledge into practice and solving of expert and working problems as well as interdisciplinary connections,
- development of professional and ethical responsibility,
- development of scientific literacy, public appearance and communication with customers, delivering and presenting of knowledge and results,
- possibility of using foreign expert language in written and oral communication, communication in international and national scientific circles,
- possibility of using information-communication technology,
- consideration of safety, functional, economical, environmental and ecological aspects at work,
- development of moral-ethical standards (integrity to the work with customers, unbiased advice, independence and expertise according to valid legislation),
- creating objective view to the environment and society.

2.3 Course-specific competences acquired with the programme

With the 2nd cycle master study programme Civil Engineering of the graduate acquires mainly the following course-specific competences:

- basic and specific expert knowledge from the area of civil engineering, mainly from the areas of design, organisation, management and execution of construction works and construction manufacturing, construction informatics, ecology, spatial planning and spatial policy,
- independent comprehensive design of demanding structures,
- independent project management in the area of civil engineering,
- understanding interaction of technical and environmental issues with the ability to conceptualise and design environment friendly structures,
- performing demanding tasks from the area of civil engineering independently and within work groups for the activities described in the first indent,
- organisation, management and performance of development activity in the area of civil engineering,
- managing the basic knowledge from the area of civil engineering (natural sciences, mathematics, informatics, mechanics, materials), ability to connect knowledge from different areas and ability for the application of the acquired knowledge,
- use of knowledge in specialised areas of civil engineering (hydraulic engineering, building structures, municipal engineering, organisation – informatics and traffic engineering),
- understanding the general structure of the basic discipline and interconnection of its sub-disciplines,
- use of information-communication technology and systems, most frequently used in practice in the area of civil engineering
- managing construction and similar companies and offices.

3. Conditions for enrolment and selection criteria when enrolment is restricted

The 2nd cycle master study programme Civil Engineering is according to Articles 38a, 38b and 41 of the Higher Education Act and according to Article 115 of the Statute of UL available to the graduates from:

a) 1st cycle study programme from the area of Civil Engineering, which consists of the whole thematic field of civil engineering,
b) 1st cycle study programme from construction management, traffic or other expert areas, if before the enrolment the candidate completes other study obligations which are essential for the continuation of the study, totalling 10-60 ECTS; these obligations shall be defined according to the nature of expert area, and the candidates may complete them during the 1st cycle study, in programmes for additional education and by passing exams before the enrolment to the master study
c) higher education professional study programme according to the old study programme of civil

engineering

d) higher education expert study programme according to the old study programme of other expert areas if before the enrolment the candidate completes study obligations which are essential for the continuation of the study, totalling 10–60 ECTS, and the candidates may complete them during the 1st cycle study, in programmes for additional education and by passing exams before the enrolment to the master study.

In case of restricted enrolment the following conditions shall be considered: grade obtained in the first cycle study (100%).

The number of places is determined in the Call for enrolment into second cycle study programmes of the University of Ljubljana individually for each academic year.

4. Criteria for recognising knowledge and skills acquired before enrolment in the programme

The student can be acknowledged the knowledge that matches the contents and scope of the study in the programme Civil Engineering. The Study Board of the Department of Civil Engineering UL FGG takes decisions regarding the acknowledgement of knowledge and skills acquired before the enrolment, based on the student's written application, the enclosed certificates and other documents evidencing the successfully acquired knowledge and contents of this knowledge, and in accordance with the Rules on the procedure and criteria for the acknowledgement of informally acquired knowledge and skills, adopted on 29 May 2007 at the 15th meeting of the Senate of UL.

For the acknowledgement of knowledge and skills the following shall be considered:

- certificates and other documents evidencing finished courses and other forms of education,
- evaluation of finished products, services, publications and other original works of the student,
- evaluation of knowledge acquired by the student based on self-education or learning from experiences (possibility of completing study obligations without participation at lectures, practical work, seminars),
- adequate work experiences.

Shall the Study Board of the department establish that the acquired knowledge may be acknowledged, this shall be evaluated with the same number of points according to ECTS as the number of points in the subject.

5. Conditions for progression through the programme

Conditions for the progression from one year to another

Students may enrol to subsequent year, if they complete by the end of the study year the obligations foreseen by the study plan, amounting to at least 45 ECTS.

Exceptionally students may enrol to subsequent year if they have not achieved this criterion, if they have justifiable reasons as defined by Article 153 of the Statute of UL (maternity, longer disease, exceptional family and social circumstances, certified status of a person with special needs, active cooperation at top expert, cultural and sports events, active cooperation in the bodies of the University).

Under the conditions from the above paragraph the student may enrol to subsequent year with at least 30 ECTS points collected. The Study Board of the Department of Civil Engineering of UL FGG adopts the decisions about the enrolment from the above paragraph.

Students with above average study results will be allowed faster advancement. Based on the student's application and justified opinion of the Study Board of UL FGG the final decision about such advancement is adopted by the Senate of UL FGG. With its decree the principles of faster progress shall be defined.

Conditions for repeated enrolment in the same year

Failing to meet all the obligations defined by the study program for the advancement in the subsequent year, students may enrol in the same year for the second time, provided that they have obtained at least 30 credit points according to ECTS.

6. Requirements for completion of the study

Students finish the study by accomplishing all the prescribed obligations totalling 120 points according to ECTS, including practical training and submission and defence of the Master thesis.
According to the Professional and Academic Titles Act the graduate is awarded with the title: magister inženir gradbeništva, abbreviated as mag. inž. grad., level 7.
In compliance with the Professional and Academic Titles Act (Official Gazette No. 61/2006) professional and scientific titles as well as titles acquired by education shall not be translated to foreign languages. However, as reference only, the title acquired according corresponds to the English title Master Engineer of Civil Engineering.

7. Transfers between study programmes

Transfer involves suspension of the student's educational process in the study programme of the original choice and continuation of education in another 2nd cycle master study programme of Civil Engineering (second programme), where all or part of student's successfully completed work in the original study programme is accepted as completed work.

Transfers are possible from 2nd cycle study programmes and also from undergraduate academic study programmes, until the last year of validity, adopted before 11. 06. 2004 that provide comparable competences and which cover, according to the recognition criteria, at least half of ECTS budgets from the first study programme, related to obligatory courses of the second study programme. Considering the scope of obligations recognised from the first study programme finished in the Republic of Slovenia or abroad, student may enrol to the same or higher year in the second study programme. Students changing their study programme shall comply with the conditions for the enrolment to the second study programme.

Applications of candidates changing their 2nd cycle master study programme of Civil Engineering and their study obligations in the second study programme will be discussed individually by the Study Board of the Department of Civil Engineering. If the candidate is approved at least the number of credit points that represent the condition for the enrolment to a higher year of the 2nd cycle master study programme of Civil Engineering, such candidate is allowed to enrol to a higher (second) year of the 2nd cycle master study programme of Civil Engineering.

8. Methods of assessment

Knowledge is examined and evaluated in individual courses. Accordingly, the teaching process in each course finishes with the examination of knowledge and acquired skills. The forms of knowledge testing (oral or written examinations, preliminary examinations, seminar works, work logs, practical assignments, projects, portfolios, peer evaluation) are defined in the study plans of individual courses. General rules of knowledge testing are regulated by the Rules on testing and evaluation of knowledge at UL, FGG, adopted by the Senate of FGG. The details are defined by the Study Regulations.

The student receives a single grade of the exam, consisting of foreseen required obligations in each course. Each obligation shall be evaluated with a positive grade.

Knowledge from lectures, tested based on written or oral examinations, seminars, home projects, etc., amounts up to 30% of the total grade.

Knowledge from seminars, seminar works, laboratory works and field works as well as any other knowledge may be tested with written or oral exams, seminars, home projects, homework and similar, and such testing amounts to at least 70% of the total grade.

According to the Statute of the University of Ljubljana the following grading scale is used:

10 – (91-100 %: excellent: exceptional results with negligible mistakes),

9 – (81-90 %: very good: above average knowledge with few mistakes),

8 – (71-80 %: very good: sound outcomes),

7 – (61-70 %: good: good knowledge, but with significant shortcomings)

6 – (51-60 %: sufficient: performance meets the minimum criteria),

5 to 1 – (50 % and less: unsatisfactory: performance does not meet minimum criteria).

The candidate's performance is considered successful for grades from satisfactory (6) to excellent (10).

9. Study programme courses, Syllabus

	Contact hours								
	L	**S**	**ST**	**LT**	**FW**	**OW**	**ΣCH***	**ΣSO***	**ECTS***
DIVISION STRUCTURAL ENGINEERING									
1st YEAR									
1st semester									
Mathematics 3	45		30				75	150	5
Numerical Methods	30			30			60	120	4
Building Physics	30		15				45	90	3
Nonlinear Continuum Mechanics	45		30	15			90	180	6
Conceptual Design of Building and Civil Engineering Structures	30	15					45	90	3
Structural Analysis	30	15		30			75	150	5
Elective course 1	30		15	15			60	120	4
Total	**240**	**30**	**90**	**90**			**450**	**900**	**30**
2nd semester									
Geotechnics of Buildings	60		15	30			105	210	7
Retrofitting and Experimental Analysis of Structures	30	15		30			75	150	5
Non-linear Analysis of Structures	45			30			75	150	5
Computer-Integrated Construction	45		15	15			75	150	5
Probability Theory and Statistics	30		30				60	120	4
Practical Training	6					80	34	120	4
Total	**216**	**15**	**45**	**120**		**80**	**424**	**900**	**30**

	Contact hours								
	L	**S**	**ST**	**LT**	**FW**	**OW**	**ΣCH***	**ΣSO***	**ECTS***
2nd YEAR									
3rd semester									
Project Management	30		15	15			60	120	4
Structural Dynamics and Earthquake Engineering	60			45			105	210	7
Selected Chapters from Concrete and Masonry Structures	45		30	15			90	180	6
Steel Structures	45			30			75	150	5
Probabilistic Methods and Reliability of Structures	30			30			60	120	4
Elective course 2	30		15	15			60	120	4
Total	**240**		**60**	**120**			**450**	**900**	**30**

	Contact hours								
	L	**S**	**ST**	**LT**	**FW**	**OW**	**ΣCH***	**ΣSO***	**ECTS***
4th semester									
Master module of STRUCTURAL ENGINEERING									
Module INTERDISCIPLINARY PROJECT STUDY OF COMPUTER-AIDED DESIGN OF STRUCTURES									
Interdisciplinary Seminar on Computer-Aided Design of Structures		90		60			150	300	10
ICT for Building Project Work	20	10	30				60	120	4
Elective course from the area of Structural Engineering	30		30				60	120	4
Master thesis						150	150	300	10
Total	**65**	**100**	**75**			**150**	**450**	**900**	**30**
TOTAL 2nd YEAR	**305**	**100**	**135**	**210**		**150**	**900**	**1800**	**60**

Module CONCRETE AND MASONRY STRUCTURES									
Design of Concrete and Masonry Structures - Seminar		90		60			150	300	10
Elective course SE 1	45			45			90	180	6
Elective course SE 2	30			30			60	120	4
Master thesis						150	150	300	10
Total	**75**	**90**		**135**		**150**	**450**	**900**	**30**

Module STEEL STRUCTURES									
Design of Steel Structures - Seminar		90		60			150	300	10
Elective course SE 1	45			45			90	180	6
Elective course SE 2	30			30			60	120	4
Master thesis						150	150	300	10
Total	**75**	**90**		**135**		**150**	**450**	**900**	**30**

INTERNATIONAL MASTER MODULE ENGINEERING MODELLING (COMPUTATIONAL ENGINEERING)**									
Numerical Modelling of Solids	45			45			90	180	6
Coupled Problems	30			30			60	120	4
Numerical Modelling of Geotechnical Structures	45			30			75	150	5
Numerical Methods in Fluid Dynamics	45			30			75	150	5
Master thesis						150	150	300	10
Total	**165**			**135**		**150**	**450**	**900**	**30**
TOTAL 2nd YEAR	**315**	**90**	**60**	**285**		**150**	**900**	**1800**	**60**
GRAND TOTAL							**1800**	**3600**	**120**

** module is available in the English language

DIVISION GEOTECHNICS - HYDROTECHNICS									
1st YEAR									
1st semester									
Mathematics 3	45		30				75	150	5
Numerical Methods	30			30			60	120	4
Geotechnics of Infrastructural Facilities	30		15	15			60	120	4
Hydraulic Modelling	45	15		45			105	210	7
Hydrological Modelling	30			60			90	180	6
Elective course 1	30		30				60	120	4
Total	**240**	**30**	**10**	**75**			**450**	**900**	**30**
2nd semester									
Earthquake Engineering	45			30			75	150	5
Numerical Modelling of Geotechnical Structures	45		15	30			90	180	6
Numerical Modelling of Solids	45			45			90	180	6
Design of Building Structures	30		30				60	120	4
Probability Theory and Statistics	30		30				60	120	4
Elective course 2	45		30				75	150	5
Total	**240**		**105**	**105**			**450**	**900**	**30**
TOTAL 1st YEAR	**450**	**15**	**180**	**255**			**900**	**1800**	**60**
3rd semester									
Project Management	30		15	15			60	120	4
River Engineering	60	30	15		15		120	240	8
Hydraulic Structures	60		60				120	240	8
Experimental Methods in Geotechnical Engineering	45	10		30	5		90	180	6
Elective course 3	30		15	15			60	120	4
Total	**225**	**40**	**120**	**45**	**20**		**450**	**900**	**30**
4th semester									
Practical training	6					80	34	120	4
Torrent, Erosion, Rockfall and Avalanche Control	45		30		15		90	180	6
Slope Processes	35		15		10		60	120	4
Rock Mechanics and Underground Structures	45		15	30			90	180	6
Master thesis						150	150	300	10
Total	**210**	**30**	**80**	**130**			**450**	**900**	**30**
TOTAL 2nd YEAR	**341**	**60**	**165**	**105**	**40**	**230**	**874**	**1800**	**60**
GRAND TOTAL	**791**	**60**	**345**	**360**	**40**	**230**	**1774**	**3600**	**120**

DIVISION INFRASTRUCTURAL ENGINEERING									
1st YEAR									
1st semester									
Mathematics 3	45		30				75	150	5
Numerical Methods	30			30			60	120	4
Geotechnics of Infrastructural Facilities	45		15	15			75	150	5
Quality Assurance and Quality Control	60		30	30			120	240	8
Operative Planning and Monitoring of Projects	45		15	15			75	150	5
Elective course 1	30		30				60	120	4
Total	**240**		**135**	**75**			**450**	**900**	**30**
2nd semester									
Real Estate Management	45		30				75	150	5
Design of Building Structures	30		30				60	120	4
Intelligent Transport Systems	30		15		15		60	120	4
Optimisation Methods in Civil Engineering	30		15	15			60	120	4
Computer-Integrated Construction	45		15	15			75	150	5
Probability Theory and Statistics	30		30				60	120	4
Practical Training	6					80	34	120	4
Total	**216**		**135**	**30**	**15**	**80**	**414**	**900**	**30**
TOTAL 1st YEAR	**456**		**270**	**105**	**15**	**80**	**874**	**1800**	**60**
3rd semester									
Project Management	30		15	15			60	120	4
Road Construction Machinery and Technology	60		15	30			105	210	7
Urban Roads	45		15	15			75	150	5
Building Information Modelling	30	15	15	30			90	180	6
Elective course 2	30		30				60	120	4
Elective course 3	30		30				60	120	4
Total	**225**	**15**	**120**	**90**			**450**	**900**	**30**
4th semester									
Master module MUNICIPAL ENGINEERING									
Municipal and Housing Economics	30	15	45				90	180	6
Water Supply and Drainage	60	30		60			150	300	10
Project from Municipal Infrastructure	30		30				60	120	4

Master thesis						150	150	300	10
Total	**120**	**45**	**75**	**60**		**150**	**450**	**900**	**30**
Master module ORGANISATION – BUILDING INFORMATICS									
Process Modelling and Information Systems	30		15	15			60	120	4
Selected Chapters from Building Informatics	45			45			90	180	9
Management in Civil Engineering	30		30				60	120	4
Organisational Planning of Construction	30	30	15	15			90	180	6
Master thesis						150	150	300	10
Total	**135**	**30**	**60**	**75**		**150**	**450**	**900**	**30**
TOTAL 2nd YEAR	**360**	**45**	**180**	**165**		**150**	**900**	**1800**	**60**
Master module TRAFFIC ENGINEERING									
Road Design	30		15				45	90	3
Roads Seminar		60		45			105	210	7
Railway Design	30		15				45	90	3
Railway Seminar		45		60			105	210	7
Master thesis						150	150	300	10
Total	**60**	**105**	**30**	**105**		**150**	**450**	**900**	**30**
TOTAL 2nd YEAR	**285**	**120**	**150**	**195**		**150**	**900**	**1800**	**60**
Master module PROJECT									
Construction Informatics Project		60					60	120	4
Project from Traffic Infrastructure		120					120	240	8
Project from Municipal Economics		60	15				60	120	4
Project from Construction Organisation and Contracting	30	30					60	120	4
Master thesis						150	150	300	10
Total	**30**	**270**				**150**	**450**	**900**	**30**
TOTAL 2nd YEAR	**255**	**285**	**120**	**90**		**150**	**900**	**1800**	**120**
GRAND TOTAL							**1800**	**3600**	**120**

ELECTIVE PROFESSIONAL COURSES FROM STRUCTURAL ENGINEERING									
Technology of Material with Mineral Binders	45		15	30			90	180	6
Advanced Construction and Building Materials	15	15		30			60	120	4
Advanced Materials	30		15	15			60	120	4
Smart House	30		30	30			90	180	6

Fire Safety	45		15	30			90	180	6
Prestressed Concrete	45		30	15			90	180	6
Composite Structures	30		30				60	120	4
Engineering Timber Structures	30		15	15			60	120	4
Shell Structures	30			30			60	120	4
ELECTIVE PROFESSIONAL COURSES FROM GEOTECHNICS – HYDROTECHNICS									
Hydraulic Machines and Devices	30			30			60	120	4
Hydroelectric Power	30		30				60	120	4
Numerical Methods in Fluid Dynamics	45			30			75	150	5
Environmental Geotechnics	30			30	15		75	150	5
ELECTIVE PROFESSIONAL COURSES FROM INFRASTRUCTURAL ENGINEERING									
Traffic Flow Theory and Capacity Analysis	45			15			60	120	4
Traffic Ecology	30		15	15			60	120	4
Planning of Construction and Maintenance of Transport Infrastructure	30		15	15			60	120	4
Real Estate Valuation	30		30				60	120	4
Urban Planning	30		30				60	120	4
Design and Construction of Steel Buildings	30		30				60	120	4
Property Law	30		30				60	120	4

* student obligations total 60 ECTS/year, which agrees with 1800 hours/year; hours include contact hours + independent work

L – lectures; S – seminar; SP – seminar practicals; LP – laboratory practicals; FW – field work; OW – other work; CH – contact hours; SO – study obligations

Crosswise table of courses for individual orientations

Course \ Orientation	GEOTECHNICS - HYDRAULICS	STRUCTURAL ENGINEERING	INFRASTRUCTURAL ENGINEERING
Structural Dynamics and Earthquake Engineering		x	
Geotechnics of Infrastructural Facilities	x		x
Environmental Geotechnics	x		
Experimental Methods in Geotechnical Engineering	x		
Geotechnics of Buildings		x	
Building Physics		x	
Hydraulic Machines and Devices	x		
Hydraulic Modelling	x		
Hydraulic Structures	x		
ICT for Building Project Work		x	
Building Information Modelling			x
Intelligent Transport Systems			x
Interdisciplinary Seminar on Computer-Aided Design of Structures		x	
Engineering Timber Structures		x	
Selected Chapters from Building Informatics			x
Selected Chapters from Concrete and Masonry Structures		x	
Steel Structures		x	
Municipal and Housing Economics			x
Shell Structures		x	
Master thesis	x	x	x
Management in Civil Engineering			x
Mathematics 3	x	x	x
Real Estate Management			x
Rock Mechanics and Underground Structures	x	x	
Road Construction Machinery and Technology			x
Urban Roads			x
Numerical Modelling of Geotechnical Structures	x	x	

Hydrological Modelling	x		
Advanced Materials		x	

Course \ Orientation	GEOTECHNICS - HYDRAULICS	STRUCTURAL ENGINEERING	INFRASTRUCTURAL ENGINEERING
Non-linear Analysis of Structures		x	
Nonlinear Continuum Mechanics		x	
Numerical Methods	x	x	x
Numerical Methods in Fluid Dynamics	x		
Numerical Modelling of Solids	x	x	
Operative Planning and Monitoring of Projects			
Optimisation Methods in Civil Engineering			x
Organisational Planning of Construction			x
Smart House		x	
Planning of Construction and Maintenance of Transport Infrastructure			x
Earthquake Engineering	x		
Coupled Problems		x	
Fire Safety		x	
Practical Training	x	x	x
Prestressed Concrete		x	
Retrofitting and Experimental Analysis of Structures		x	
Process Modelling and Information Systems			x
Project from Municipal Infrastructure			x
Construction Informatics Project			x
Project from Municipal Economics			x
Project from Construction Organisation and Contracting			x
Project from Traffic Infrastructure			x
Road Design			x
Design of Building Structures	x		x
Design and Construction of Steel Buildings			x

Railway Design			x
Torrent, Erosion, Rockfall and Avalanche Control	x		
Traffic Ecology		x	x
Computer-Integrated Construction	x	x	x
Roads Seminar			x
Design of Steel Structures – Seminar		x	
Design of Concrete and Masonry Structures - Seminar		x	

Course / **Orientation**	**GEOTECHNICS - HYDRAULICS**	**STRUCTURAL ENGINEERING**	**INFRASTRUCTURAL ENGINEERING**
Slope Processes	x		
Structural Analysis		x	
Property Law			x
Technology of Material with Mineral Binders		x	
Traffic Flow Theory and Capacity Analysis			x
Urban Planning			x
River Engineering	x		
Probabilistic Methods and Reliability of Structures		x	
Probability Theory and Statistics	x	x	x
Project Management	x	x	x
Real Estate Valuation			x
Hydroelectric Power	x		
Water Supply and Drainage	x		x
Quality Assurance and Quality Control			x
Conceptual Design of Building and Civil Engineering		x	

10. Possibilities of elective courses and mobility

The division Structural Engineering foresees two external elective courses (4+4 ECTS in the second and third semesters), and students shall select a master module consisting of additional professional electives from the area of structural engineering.

The division Geotechnics – Hydraulics foresees three external elective courses (4+5 ECTS in the second and 4 ECTS in the third semester).

The division Infrastructural Engineering foresees three elective courses (4 ECTS in the second and 4+5 ECTS in the third semester). Further on, the division foresees four elective master modules in the fourth semester. Due to large variety of the syllabus at Infrastructural Engineering students are recommended to select only electives from the division Infrastructural Engineering.

Students may choose external elective courses in any study program of the UL or from other universities.

Students may transfer 30 ECTS of the programme (one semester, regardless of obligatory or elective units) from any programme from the area of civil engineering of any faculty in Slovenia or from abroad, provided that the UL FGG has a valid bilateral agreement with such institution.

11. Presentation of individual courses

STRUCTURAL DYNAMICS AND EARTHQUAKE ENGINEERING (7 ECTS)
Introduction to the dynamics of building structures, dynamic response of systems with one degree of freedom, dynamic response of systems with several degrees of freedom (computational models and equations of movement, free and forced oscillation, response spectra, simplified methods), analysis of structures under seismic load, basic terms about earthquakes and seismic load (introduction, general about earthquakes, intensity, earthquakes in space and time, characteristics of ground movements at a location, design spectra), principles of seismic-resistant design (load-carrying capacity and ductility, stiffness, muffling, structural design), behaviour of buildings and bridges during earthquakes, standard Eurocode 8.

EXPERIMENTAL METHODS IN GEOTECHNICAL ENGINEERING (6 ECTS)
Planning of geotechnical investigations. Methods of laboratory tests of soils: macroscopic identification of rocks containing clay and potential pathogenic minerals, tests for the identification of soil behaviour with the emphasis on pathogenic properties (implementation of soil swelling and failure tests), implementation and valuation of direct shear and tri-axial soil test, implementation of suction measurements and elaboration of retention curve, methods of field ground tests, basics of geophysical ground investigation methods, geotechnical field monitoring, geotechnical measurements for earth work control, basics of laboratory and field investigation of rocks, basics of measuring environmental parameters in laboratory and in the field, analysis of laboratory and field investigation results of ground. Assessment of characteristic values. Back analyses, sensitivity analyses.

GEOTECHNICS OF INFRASTRUCTURAL FACILITIES (4 ECTS)
Methods of soil improvement (pre-loading,radial consolidation, dynamic compaction, stone columns, grouting, jet grouting, methodsof surface and deep mixing). Groundwater flow through saturated isotropic and anisotropic soil (buoyancy, critical hydraulic gradient, hydraulic failure, internal erosion, piping). Earthfill dams: flow of water through the dam,measures to reduce the adverse consequences, filter design, stability of earthfill dams under static and dynamic (seismic) conditions. Liquefaction of soil. Use of geosynthetics: sealing, filtration, separation and einforcement. Analysis and management of geotechnical risks.

ENVIRONMENTAL GEOTECHNICS (5 ECTS)
Introduction to environmental geotechnics: history, differences in approaches used in classical and environmental geotechnics. Soil as conductor, barrier or accumulator of pollutants. Introduction to unsaturated soils, soil-water characteristic curve. Sources of radon in nature. Hydrogeology and transport of pollutants in ground. Alternative materials in civil and environmental engineering. Use of alternative materials – secondary

raw materials instead of natural soils and their potential environmental impact. Leaching and percolation test. Use of geosynthetics for environmental protection. Landfills I: types of landfills, choice of location, design and materials for bottom liner system, stability and deformability of landfill, collection and drainage of seepage water. Landfills II: Closure of landfills, design of cover layer, calculation of water balance, lysimeters, control of abandoned landfills. Remediation of polluted land: methods of recognition, strategies and technologies of remediation. Types and properties of structures and devices for groundwater monitoring. Fundamentals of geothermal energy. Regulation in the field of environmental geotecnics, implications of regulations on engineering design, standards.

GEOTECHNICS OF BUILDINGS (7 ECTS)
Classification of excavation pits with regard to excavation technique and type of retaining structure. Calculation of earth pressures. Methods for drainage /sealing of excavation pits. Technology of construction. Design of retaining structures. Shallow foundations: preparation of ground for shallow foundation (ground improvements, acceleration ofconsolidation). Analysis and design of shallow foundations. Bearing capacity (shallow foundations). Modulus of subgrade reaction and its application in the design of shallow foundations. Calculation of contact pressures underneath foundations (isolated footings, strip footings). Mat foundations - types and design methods. Deep foundations: Types of deep foundations, purpose and construction methods. Group of piles - load distribution. Bearing capacity of axially loaded piles and groups of axially loaded piles. Transversely (horizontally) loaded piles. Standards related to design and execution of piles (Eurocode 7). Static and dynamic load tests of piles. Construction monitoring and quality control. Construction and design of shafts, caisson and mat foundations supported with piles.

REAL ESTATE MANAGEMENT (5 ECTS)
Basic concepts related to economics of real estate. Real estate life cycle from real estate development to real estate reuse. Urban economics and real estate market analysis. Land development potential. Investing in real estate, role and conceptual definition of certain types of investments, methods of evaluating investment projects on micro and macro-economic level. Importance, legal basis and evaluating methods of public investment efficiency. Taxation of real estate. Real estate brokers' activities, legal and cost aspects of real estate brokers' activities. Property as factor of production. Facility management. Real estate market and real estate valuation. Basics of individual and mass real estate valuation.

BUILDING PHYSICS (3 ECTS)
Distribution of temperature and transfer of heat in matter and with radiation. Basic methods of solving diffusion equation, boundary and initial conditions. Relative and absolute humidity, measuring humidity, moisture in building materials, transfer of heat and vapour in porous materials, influence of moisture on mechanical and thermal properties of building materials. Sources of sound and spreading of sound in a room, reverberation, perception and measuring of sound level, characterisation and control of noise in buildings.

HYDRAULIC MACHINES AND DEVICES (4 ECTS)
Lectures: theoretical bases of turbine machines, Euler turbine equation, laws of similarity, flow in turbine cascade, theoretical bases of hydraulic devices at water structures, design of machine line-ups and operating conditions, experimental modelling and defining of integral characteristics of hydraulic machines and devices according to standards and regulations and verification on structures. Practical work: selection of hydraulic machine and definition of basic geometrical characteristics of rotor in hydraulic machine for freely selected integral hydropower conditions or the same work for a selected hydraulic device and transfer of model results for realisation. Laboratory practical work: measurements of integral characteristics of a hydraulic machine (hydrodynamic, power characteristics) or selected hydraulic devices (hydrodynamics and drive loads) as well as measurements of hydraulic and downstream conditions.

HYDRAULIC MODELLING (7 ECTS)
Permanent non-uniform flow (demanding cases of boundary conditions, software description), physical hydraulic models (dimensional analysis, principles of the theory of similarity, distorted models, process of model design, criteria for the selection of physical or mathematical model), modelling of hydraulic structures (description of hydraulic properties of individual structures or devices, their modelling,

boundary conditions and checking of technical requirements), modelling of demanding piping systems and optimisation of operation with artificial intelligence tools (description of hydraulic properties, characteristics of modelling elements and operating conditions, verification-calibration-validation of hydraulic models), laboratory work (model similarity, basics of measuring technique and simple measuring systems, measurements on physical models of dams, sedimentation basins, etc, hydraulic dimensioning of systems), seminar (elaboration of independent seminar work consisting of: use of 1D or 2D model for the calculation of a advanced example of permanent non-uniform flow in open river or hydraulic modelling of a demanding piping system or hydraulic modelling of demanding hydro technical structure). Nonsteady flow with free surface level (types of waves, basic St. Venant equations, methods of solving – method of characteristics, explicit and implicit methods of final differences, initial and boundary conditions, basics of two-dimensional problems, basics and examples of movement of non-Newton fluids – avalanches, debris flows), water impact in pipes under pressure (description of phenomenon, derivation of dynamic and continuity equation, method of characteristics, initial and boundary conditions, measures to mitigate water impact), surge tanks (description, derivation of continuity and dynamic equation, equation of non-damped oscillations, methods of solving, stability of surge tanks, types of surge tanks, their selection and calculation methods), theory of waves of small amplitudes (analytical solutions of basic equations), practical work (travelling water jump, measurements on a physical model of surge tank, use of computer programs for calculating flood waves, operating and flood waves and water impact – work in computer room).

HYDROLOGICAL MODELLING (6 ECTS)
Models, classification, application, basic theories of systems, basics of using stochastic in hydrology, in-depth knowledge from hydrological processes, in-depth knowledge from hydraulics of underground water, hydrogram of a unit and synthetic hydrogram of a unit, underground water modelling, methods for the estimation of precision of modelling results, regionalisation of hydrological phenomena, floods and hydrological prognoses, impacts of individual structures on the change of water regime, measurements of hydrological phenomena.

HYDRAULIC STRUCTURES (8 ECTS)
Historic overview of the development of dam engineering, basis for the design of dam structures (planning, design, expert bases for the design), design of dam structures (concrete, earth dams), sampling of water from natural flows (ground and surface sampling structures) and water overflow across dam structure (spills, cascades, water rebounds, spilling chutes, stilling basins), barriers and blocking structures (different types of surface and depth barriers), structures for water inflow and outflow (water captures, desanding, canals, shaft structures, compressive pipelines, surge tanks), practical work (design and static stability calculation of gravity dam, hydraulic design of evacuation structures – spill, chute, stilling basin, connection with lower water, hydraulic calculus of derivation for high-pressure PP).

TORRENT, EROSION, ROCKFALL AND AVALANCHE CONTROL (6 ECTS)
Introduction to torrent regulation: historic overview, issues of regulation, concept of integral water regulation, legislation and planning. Basics of torrent control and river regulation: river hydrology, soil erosion, torrent hydraulics, appearance and dynamics of mass flows (debris and mud flows, falling rocks and rock slides), mechanics and dynamics of snow cover and avalanches, gravel balance. Torrent and river regulation: protection against surface erosion, protection against torrent erosion (structures in torrential beds), protection against avalanche effects. Basics of preventive actions: legislation, active and passive measures, concept of risk management and handling in threatening events, documenting of floods and landslides, mapping of phenomena and risks, vulnerability and endangerment. Modelling of dangerous geologically and hydrologically conditioned phenomena and their effects on structures, construction conditions, examples of safe construction.

INFORMATION AND COMMUNICATION TECHNOLOGY FOR BUILDING PROJECT WORK (4 ECTS)
principles of computer-integrated construction, process aspects of cooperation in construction projects, topology of cooperation systems and their use, asynchronous and synchronous systems for project work, methods of the exchange of project documents according to the project phase and size of project team, tools and methods of modelling products and processes for computer-integrated construction, basics of information modelling of buildings for cooperation, practical work (establishment of cooperation systems,

elaboration of digital project documentation), seminar work (elaboration of information model of buildings).

BUILDING INFORMATION MODELLING (6 ECTS)
Introduction to information modelling of buildings, modelling methods for real models and schemes, syntax, structure and semantics of data, planning of data bases, relational and object data model, systems for managing data bases, methods, standards and tools for information modelling in civil engineering and assurance of interoperability, overview of aspect models and tools for modelling buildings, open standards for geometry exchange, open standards for the exchange of STEP information models, standards for information modelling of buildings IFC and CIS2, standards for the exchange of information models of roads LandXML, parametric modelling of information models of buildings, practical work (planning of information model of an application, information modelling of the same building product with several tools, elaboration of parametric models).

INTERDISCIPLINARY SEMINAR OF COMPUTER-AIDED DESIGN OF STRUCTURES (4 ECTS)
Civil engineer prepares a seminar in cooperation with an architect. General introductory lectures deals with: principles of the design of constructional system (first in general, then by considering specifics of individual materials), given are methods of selecting initial dimensions, completed knowledge from the areas of the methods of geotechnical design of shallow and deep foundations, presented are advance methods of analysis and design, which present an upgrading of current knowledge in the area of design, presented are theoretical basics for recommended software equipment and advanced functions in design programs, design programs, given are the principles of computer-integrated construction and basic IT tools necessary for this purpose, given are principles and procedures for the design of load-carrying capacity, for ensuring ductility and especially for the design of seismic safety of supporting structures, relevant requirements in the system of Eurocode standards are presented in more detail, especially those related directly to selected structures. Seminar and laboratory work: architect presents outline design of the structure without proposing solution of the structure, civil engineer creates conceptual design for several possible constructional systems, which may be of different building materials; in discussion with architect they select at least two possible solutions, define initial dimensions and harmonise solutions and dimensions based on simple computational models and analyses; finally they present arguments in written form for the final selection of one constructional systems, which is dealt with in detail and a project is elaborated, including realisation plans for the most important elements; in the end project visualisation is made, used in a public presentation of the project, which is at the same time final exam; students cooperate remotely using adequate IT tools that allow remote design; all developed project documents are filed by them using information-supported procedures.

ENGINEERING TIMBER STRUCTURES (4 ECTS)
Technology for the production of timber building products and specifics in their design (glue-lam timber, layered veneer, plates with oriented splinters, laminated plates), calculation of displacements of timber structures by taking into account deflection of binders (influence of slip, rheological phenomena, compressibility of elements perpendicular to fibres and initial imperfection), design of complex connections, junctures and details of timber structures, plane elements of timber structures (ceilings and walls), limit state of vibrations of timber ceilings, ensuring seismic resistance of timber structures, fire resistance of timber structures (computationally defined fire resistance using simplified and advanced computational methods, measures to ensure fire resistance), timber buildings (design load, basic groups of load-carrying elements of timber buildings, conception and selection of load-carrying structure of a building, modelling and analysis of load-carrying structure, design of elements of load-carrying structure), timber bridges (design, design load, basic members of load-carrying structure of a bridge, translation of actual structure in adequate computational model, design of load-carrying elements).

INTELLIGENT TRANSPORTATION SYSTEMS (4 ECTS)
Upgrade of general knowledge about the theory of traffic flow and planning of traffic, monitoring of traffic, measuring devices in road traffic, traffic management systems in intercity traffic network, system of communicating traffic information (dynamic management in road network) or active dynamic systems of increasing road permeability, roadside weather information system and winter service, meteorological conditions of carriageway, electronic toll collection systems, traffic management systems in urban

areas, traffic issues in inhabited areas, traffic regimes, traffic signalling and equipment in inhabited areas, traffic calming devices in inhabited areas, parking areas and garage houses, system for managing and paying parking, needs for parking surfaces, systems of managing goods traffic, weighing of vehicles, systems of public traffic services, bus stops, traffic signalling and traffic equipment, systems for managing extraordinary events, road works, traffic and environment.

SELECTED CHAPTERS FROM BUILDING INFORMATICS (6 ECTS)
Basics of software engineering (RUP method, service architectures (SOA), management of the development of web applications), infrastructure (network topologies, network protocols and standards, internet and world wide web), program languages (program languages for making web applications, standards, tools and program languages), high-throughput computing (standards, elaboration of workflows of process applications), formats and safe data exchanges (EDI and XML, safety on the Internet), practical work (programming, elaboration of a system based on SOA technology and web services).

SELECTED CHAPTERS FROM CONCRETE AND MASONRY STRUCTURES (6 ECTS)
Concrete technology (design of concrete composition with special demands, thermal treatment of concrete, concreting in special conditions), optimal design of reinforced and prestressed load-carrying elements (starting points of optimisation, transformation of the problem of optimisation of load- carrying elements to mathematical program, overview of procedures of numerical solving of mathematical programs), calculation and technological process of adhesion-prestressed elements, statically non-defined prestressed linear structures, prefabricated concrete structures (specifics of behaviour of prefabricated concrete structures, efficient design of elements of prefabricated concrete structures with the emphasis on elaboration of nodes and connections), design and execution of plane concrete structures (walls, wall beams, slabs and shells), design and execution of concrete foundations, ensuring fire safety of concrete structures, prestressed masonry structures.

MUNICIPAL AND HOUSING ECONOMICS (6 ECTS)
Public needs, public utility services, public infrastructure (concepts, importance and role of municipal activities), cost aspects of providing public utility services, organisation of public utility services, system of public finance on local level, economic instruments of environmental safety, valuation methods of investment projects on the area of municipal infrastructure, basic concepts from the area of housing economics, property and other rights on apartment, planning of housing construction, market of apartments and residential houses, management of multi-apartment houses, costs of using apartments and residential houses (rents).

SHELL STRUCTURES (4 ECTS)
Motivation for studying shell structures. Differential geometry of surfaces. Curved shell, flat shell, membrane. Curved shells in civil engineering: silos, storage tanks, domes, vaults, tunnels, roofs, arcs, cooling towers, … Membrane and bending theories of shells. Shell buckling. Finite element analysis of shells: Finite element modelling, static analysis, buckling analysis. Design of shells: reinforced concrete shells, steel shells, composite shells, Eurocodes for steel shells.

MANAGEMENT IN CIVIL ENGINEERING (4 ECTS)
Characteristics of construction industry (complexity, composition), definition of operation processes and phases in construction, managing relationships among construction participants, organisation and organisation management (goals and functions of organisation), management in organisations, human resources in organisation (culture in organisation, management and leadership, work in a team, human resource management), strategic planning, measuring and assessment of success of an organisation, decision making process in organisation (multi-criteria decisions, analytical-hierarchical process, quantitative methods), seminar work (computational practice, related mainly to quantitative methods of decision making), study visit to a selected construction company.

MATHEMATICS 3 (5 ECTS)
Linear spaces, linear mapping, Euclidian spaces. Numerical linear algebra: numerical calculation and errors, linear systems, mathematical splits. Ordinary differential equations: LDE of n-th order, linear systems of differential equations, boundary problems. partial differential equations. Basics of the theory of graphs.

ROCK MECHANICS AND UNDERGROUND STRUCTURES (6 ECTS)
Basics of rock mechanics: classification, crack properties, rock investigations, rock strength and stiffness, Hoek's and Brown's failure criteria, structurally conditioned instabilities. Historic overview of underground structures, overview of types and purposes of underground structures. Stability of underground spaces in rocks. Conceptual design of portal tunnel area. Construction technologies of underground spaces: machine excavations (TBM), New Austrian method, supporting measures. Characteristic behaviour of underground spaces considering the ground composition and properties and primary stress states. Principles and methods of tunnel design and design of other underground structures. Stability of tunnel front. Tunnels in soils (construction technologies, supporting measures). Influence on rock anisotropy on deformations during tunnel excavation. Organisational works, measurements during construction, safety and equipment. Calculation of works during tunnel construction (matrix method).

ROAD CONSTRUCTION MACHINERY AND TECHNOLOGY (7 ECTS)
Construction machinery, elements and characteristic cross-sections of road and carriageway, basic road-construction materials, artificial materials, secondary raw materials and chemically stabilised materials, basic tests and investigations according to the conditions of using road-construction materials, characteristic layers in road cross-section, water movement and actions in road element and in carriageway layers, procedures of construction and strengthening of layers and procedures of quality check, practical work (elaboration of a report on the selection of adequate road construction machinery, elaboration of technological report on road construction in excavation, slope, mixed cross-section profile of road and in the transition of earth structure - building structure), seminar (design of carriageway structures).

URBAN ROADS (5 ECTS)
Systematic presentation of urban road network (administrative and functional), design elements of urban roads (in situation, in subbase profile, in cross-section, transparency), design elements of intersections (forms, computational elements, traffic islands, visible field, bus stops), stationary traffic (different forms of parking), traffic calming in inhabited areas (purpose and measures in the network and on the carriageway), cycle surfaces (different forms, design elements), pedestrian surfaces (pedestrian zones, crossovers, underways, level crossings), traffic signals (vertical, horizontal), practical work (preparation of outline design of a certain element of urban traffic surfaces).

NUMERICAL MODELLING OF GEOTECHNICAL STRUCTURES (6 ECTS)
Basics of critical state soil mechanics. Behaviour of soils at small strains. Non-linear elasto-plastic material models: basic principles, Mohr Coulomb model, Cam Clay model, Cap models, Hardening Soil model, the mathematical formulation and determination of material parameters from classic soil tests. FEM in 2D and 3D, finite elements in geotechnical engineering, interaction between structures and ground. Numerical solution of nonlinear problems. Coupled problems: formulation and simultaneous solving of equilibrium and diffusion equations (consolidation), drained and un-drained conditions. Modeling of dynamic problems: mass matrix and damping matrix, time integration.

ADVANCED CONSTRUCTION AND BUILDING MATERIALS (4 ECTS)
Overview of modern development of materials and technologies that allow this development (nanotechnologies, etc.) and special properties of materials, detailed presentation of properties and applicability of advanced materials according to four basic groups (ceramics, metal, polymers and composites), special features of advanced materials' use for the conception of structures from the aspect of design, execution and maintenance; foundations of the life cycle assessment of advanced materials and comparison to conventional materials as well as cost estimate for the use and maintenance of structures, seminar (small groups prepare a proposal of structural element and complex made of advanced material and analyse its properties and compare it to the same element or complex made of conventional material), practical work (learning about material structure based on microscoping, testing of basic mechanical and technological properties of advanced materials compared to classical ones, use of experimentally obtained data in computational tasks that present the basis of the seminar).

ADVANCED MATERIALS (4 ECTS)
Correlation between chemical structure and properties, polymer materials with elevated thermal resistance and resistance to UV radiation, examples of solar energy systems (photovoltaics and solar receivers), protection of polymer materials against overheating (thermotropic and thermochromatic coatings), coatings with low thermal emissivity, coatings with changeable absorption, "cold" colours, radiation cooling, protection against UV radiation (UV absorbers, spectrally selective colour coatings with low thermal emissivity, coatings with added UV absorbers), coatings with nano-composite covers and multifunctional properties for polymer materials (oleophobics and hydrophobics, "hard" nano-composite covers), coatings and nano-composite covers with multifunctional properties for polymer inorganic materials (concrete (antigraffiti), plasters, natural materials (stone), use for building renovation and to protect cultural heritage), optically permeable polymer materials (PTFE, Mylar) and their functionalisation to achieve self-cleaning effects, protection of metals against corrosion by nano-composites (corrosion processes, decay measurements, spectroscopy, etc.), advanced corrosion inhibitors for iron, copper and aluminium, heat storages (PCM), materials for the preparation of solar coolers and solar cooling, overview of test methods for establishing material resistance (accelerated ageing tests), seminar work (overview of experimental procedures to define material properties, learning about processes to prepare nano- composite covers and preparation of coatings), field work (elaboration of model systems with multifunctional properties from the area of advanced materials).

NONLINEAR ANALYSIS OF STRUCTURES (5 ECTS)
The basic goal of the course is to learn methods and phenomena related to nonlinear response of structures that are relevant to modern design of structures. This includes: A) Classical stability analysis: mathematical Definition of stability of structures, classification of instability points (bifurcation and limit points), conservative-nonconservative systems, initial instability problem, buckling forces and buckling shapes, formulation and analytical solution of basic stability problems (elastic and elasto-plastic buckling of columns, lateral buckling, local buckling of plates), imperfection sensitivity. B) Nonlinear analysis: numerical equilibrium path following methods, nonlinear finite element analysis of structures with exercises, introduction to methods for numerical simulation of advanced problems such as: contact problems, multi-scale problems, coupled problems. C) Attendance of an intensive seminar where the theory is put into practice: International Short Course on Experimental and Numerical Modeling of M5 Problems in Engineering.

NONLINEAR CONTINUUM MECHANICS (6 ECTS)
Body as an object having continuously distributed mass. Embedding of the body into the mathematical space. Material and spatial coordinates. Deformation as a regular non-linear map. Deformation gradient as a local linear deformation map. The polar decomposition of the deformation gradient. Local length, area and volume in undeformed and deformed configurations. Deformation of a body. The strain tensor as a measure of the deformation degree. The strain tensor expressed in terms of displacements. The linearized strain tensor. Stretches. The stretch tensor. Principal stretches and directions. Spectral decomposition of symmetric tensors. Spectral decompositions of various material and spatial deformation tensors. Tensor functions. Exponential and logarithmic tensor functions. Generalized strain tensors. Material time derivative of tensors. Displacements, velocity and acceleration. Rotations, angular velocity and angular acceleration. Time derivatives of characteristic tensors: velocity gradient, rate of deformation, spin, the rate of Cauchy-Green tensor, the rate of Green-Lagrange tensor, the rate of Euler-Almansi tensor. Stresses. Surface tractions. The stress vector, the Cauchy postulate, reciprocity and the Cauchy formula. The stress tensor. Material and spatial stress tensors. Conservation laws: conservation of mass, linear and angular momentum in global and local forms. Objectivity of tensors. Material and spatial objectivity. Objectivity of typical tensors of mechanics. Objectivity of time rates of tensors. Corotational and convective time derivatives of tensors. The Jaumann, Truesdell, Oldroyd and Green-Naghdi time rates of the Cauchy stress tensor. Weak form of the dynamic equilibrium equations of bodies. The principle of virtual work (PVW) in material and spatial forms. The derivation of the local dynamic equilibrium equations from PVW. The basic concepts of implementation and application of PVW in the method of finite elements. Constitutive equations. Hyper-elastic materials. Isotropic material model based on an additive specific strain energy function. Isotropic material model using principal stretches or logarithmic principal stretches. Hyper-elastic material model with constraints. Inextensible or incompressible materials. Examples of classical hyperelastic material models: StVenant-Kirchhoff and Neo-Hookean material models. Numerical experiments using FlagSHyP, the computer program based on the non-linear finite element analysis introduced by J. Bonet and R.D. Wood, Swansea, UK, and reprogrammed for the Matlab environment by R. Flajs.

NUMERICAL METHODS (4 ECTS)
Motivation for studying the finite element method (FEM). One-dimensional linear FEM: from a differential equation to a system of linear equations. One-dimensional linear FEM for elasticity and heat and fluid flows Interpolation and numerical integration in FEM. Finite elements for plane stress and plane strain elasticity. Isoparametric finite elements. Finite elements for elastic plates. Finite elements for elastic shells. Solving structural examples with FEM software. Preparation of good numerical models. FEM analysis. Critical evaluation of numerical results.

NUMERICAL MODELLING OF SOLIDS (6 ECTS)
The basic goal of the course is to learn methods for numerical modeling of all phenomena related to mechanical behavior of solids. A) Introduction structure and technology of software systems for numerical simulations in engineering: overview of numerical methods for the simulation of solids (finite element methods, finite volume, boundary element methods). B) Nonlinear analysis of solids: - mathematical definition of stability of structures, classification of instability points (bifurcation and limit points), conservative-nonconservative systems, imperfection sensitivity, numerical equilibrium path following methods, explicit versus implicit analysis, nonlinear finite elements for the analysis of solids and structures (2D, 3D, axisymmetric), numerical implementation of basic and advanced constitutive models of solids (implicit, explicit integration of evolution equations), coupled problems: solution strategies for coupled problems, example: coupled thermohidro-mechanical problem, introduction to advanced methods for the numerical simulation of problems such as: contact problems, multi-scale problems. C) Attendance at an intensive seminar where the theory is put into practice: International Short Course on Experimental and Numerical Modeling of M5 Problems in Engineering.

NUMERICAL MODELLING IN FLUID DYNAMICS (5 ECTS)
Basic equations of fluid dynamics: continuity, dynamic, equation of state, energy, convection, diffusion for transport of matter, original elements for biochemical processes, principle of solving hydrodynamic problems (initial and boundary conditions), non-steady flow with free surface level (types of waves, St.Venant equations, numerical methods of solving, initial and boundary conditions), two-dimensional problems, examples of movements of non-Newton fluids (debris flows, avalanches), calculation of water impact in pipesunder pressure, calculation of mass oscillations in surge tanks, description of three-dimensional numerical models for calculating flows and pollution spreading in surface waters (Reynolds equations, turbulence models, numerical methods of solving).

OPERATIVE PLANNING AND MONITORING OF PROJECTS (5 ECTS)
-Operational planning as element of project management. Critical path methods. Resources required for the construction project execution, inclusion of resources into project model. Optimisation of schedule, from the viewpoint of resources. Costs of construction projects, optimisation of schedule for the viewpoint of costs. Elements of monitoring the execution. Delay analysis, allocation of responsibility. Techniques for planning the location plans (linear plans, cyclograms). Modelling project risks in operational plans (stochastic planning).

OPTIMISATION METHODS IN CIVIL ENGINEERING (4 ECTS)
Linear programming (general problem, graphic methods, simplex method, transport problems, stepping stone method, MODI method, degeneration, integer linear programming). Nonlinear programming (methods for solving problems without constraints, without using derivatives, with using derivatives; methods of solving problems with constraints: Lagrange multipliers, transformation methods, penalty function method), discrete dynamic programming, genetic algorithms, multiple criteria decision making.

ORGANISATIONAL PLANNING OF CONSTRUCTION (6 ECTS)
Project preparation for the organisation of construction in individual phases. Checking of possible solutions. Preparation of technological-economical report. Integration of time plan and financial plan of construction. Preparation of management plan and construction control. Establishment of a monitoring and control system for the work implementation. Preparation of time plan of construction with the help of adequate software tools.

SMART HOUSE (6 ECTS)
Genesis of the relation concept – technology, interactivity of influences at a location, schemes of the smart house system (environment, behaviour systems, management levels, implementation), role of individuality (health, comfort, efficiency in planning, interactivity and relation between space and time with a link of

this principle to information technology), influence of culture and technology, physiology and energy as well as new information technologies on efficiency, communication topology, smart products, subsystems and automated living environment, influence of dynamic opening and facade systems, regulation of daylight/artificial light, overview and critical presentation of interesting cases, seminar work (planning of residential buildings based on starting points of dynamic response to external changes), laboratory work (individual simulations and comparative analyses of selected cases of buildings from practical work).

PLANNING OF CONSTRUCTION AND MAINTENANCE OF TRANSPORT INFRASTRUCTURE (4 ECTS)
Approaches to planning of traffic infrastructure construction, data acquisition (counting, surveys, measurements), mathematical models (four-phase model: generation, distribution, mode choice, assignment), evaluation of alternatives (cost-benefit analysis, multi-criteria analysis), models for pavement management.

EARTHQUAKE ENGINEERING (5 ECTS)
Introduction to dynamics of structures. The dynamic response of the single-degree-of-freedom system under seismic action. The dynamic response of structures with multi-degree-of-freedom. Basics of earthquakes and seismic action (introduction, causes for earthquakes, intensity measures, earthquakes in space and time, characteristics of seismic ground motion, concept of reduction of seismic forces, the design spectrum). Basic concepts and principles of earthquake resistant design of structures (strength, ductility, stiffness, damping, basics for preliminary design). Behaviour of geotechnical and hydrotechnical structures (dams, pipelines, water and sewer system). Simplified seismic analysis.

COUPLED PROBLEMS (4 ECTS)
General about coupled problems, equations of thermal conductivity, humidity transition, chemical influences, mechanical response of structure and interconnection of equations, numerical methods of solving coupled problems (simple integrators according to time, "mid-point" method, solving partial differential equations by FEM, solving nonlinear algebraic equations with iteration methods).

FIRE SAFETY (6 ECTS)
General about fire engineering, overview of basic concepts, European standards and regulations, fire load, models of standard and real fires, measures of active fire protection, escape routes, fire alarm systems and fire fighting, measures of passive fire protection, influence of high temperature on material properties, definition of temperature development in time and place in the structure, specifics of various materials according to structure type, computational identification of fire resistance of load-carrying structures.

PRACTICAL TRAINING (4 ECTS)
Student learns about the work and how to do the work expected of a graduate from the master study programme in practice. Most importantly, they learn about the organisational structure of a construction company with current activity in a construction company, field work – current construction sites, work in office, less demanding works in a project.

PRESTRESSED CONCRETE (6 ECTS)
Prestressed concrete frames, plane prestressed structures (walls, wall girders, slabs, shells), specifics of prestressing with cables without connection and with external cables, analysis and design of prestressed bridge structures built according to special building technologies (launching of beam structures, free cantilever construction), computational definition of fire resistance of prestressed concrete structures and measures for its assurance.

RETROFITTING AND EXPERIMENTAL ANALYSIS OF STRUCTURES (5 ECTS)
General concepts related to durability, repair and strengthening of structures (basic terms, definitions, reasons of decay and changes of structure, reduced applicability, preventive measures, criteria to approach to repair, relevant regulations and standards, specifics of individual structure types), basics of structural diagnostics (tests to determine the state and quality of materials and structural elements, nondestructive and destructive tests), measures to increase residual life cycle of a structure and built-in materials (selection of materials according to foreseen influences on life cycle of a structure, compatibility of different materials in structure, planning of structural details, planning of protective measures against external influences and combination of current and long-term influences), technical regulations from the area of

durability, repair and strengthening of structures (recommendations, standards, regulations including Eurocodes, design and control of execution, quality assurance), experimentally supported development of repair and strengthening methods, repair and strengthening of highway and railway structures as well as buildings with special emphasis on cultural heritage structures, general concepts about tests of building structures (purpose of tests, test samples, loadings, measurements and monitoring, accompanying tests), model tests of building structures (basics of model theory, modelling of structures, model materials, practical examples), equipment for the simulation of static and dynamic loading, measurements and registration of physical quantities (physical quantities, data acquisition and registration, data processing, reporting).

PROCESS MODELLING AND INFORMATION SYSTEMS (4 ECTS)
Introduction to process modelling and its use. Tools and methods for process modelling. Micro and macro process modelling. Process model reuse in collaboration. Business process re-engineering:- Modelling of AS-IS and TO-BE process models. Modelling of material process models based on building information models (BIM) - The development of 4D process models. The development of 5D process models.

CONSRUCTION INFORMATICS PROJECT (4 ECTS)
Course within master module Project (direction Infrastructural Engineering), preparation of information support within the project individually or in a group. Contents: Principles of computer-integrated construction in engineering structures. Topology of systems for the cooperation and their application in infrastructural projects. Asynchronous and synchronous project systems. Structural, organisational and process models of exchanging project communication. Systems for product management. Methods of simultaneous cooperation in the development of construction products.

PROJECT OF MUNICIPAL INFRASTRUCTURE (4 ECTS)
Expert report by individual student or a group of students, including at least the following: analysis of existing condition and needs, definition of goals, proposals of alternatives to realise the goals, analysis of alternatives considering costs and benefits, locations, influences on environment, feasibility, proposal of most favourable alternative, financial structure of project, time plan of project execution.

PROJECT FROM MUNICIPAL ECONOMICS (5 ECTS)
Course within master module Project (direction Infrastructural Engineering), preparation within the project individually or in a group: Presentation of existing situation and development needs for municipal infrastructure in local community with the description of reasons for the proposed investment; Definition of development possibilities and investment goals and checking of harmonisation with strategic documents; Description and analysis of investment alternatives (location, investment costs, environment protection, foreseen sources of financing), economic justification of a project; Proposal of the most favourable alternative of financial structure of a project; Definition of sensibility and possibilities of further preparation of investment, project, technical and other documentation with time plan.

PROJECT FROM CONSTRUCTION ORGANISATION AND CONTRACTING (4 ECTS)
Each student prepares a techno-economical expert report or project of construction organisation based on designer inventory, the contents of each such project (study of different alternative solutions, building calculation, time plan, plan of use of sources, plan of use and delivery of material, plan and diagram of construction site arrangement), expert field trip (interesting construction sites, design departments in large companies), seminar consists of several accompanying lectures with participation of experts from practice (experiences in construction site organisation, monitoring and harmonisation of construction, alternative production methods).

PROJECT FROM TRAFFIC INFRASTRUCTURE (8 ECTS): Course within master module Project (direction Infrastructural Engineering), preparation of project documents of a road within the project individually or in a group: conceptual design, traffic predictions, outline scheme, intersection design, carriageway design, assessment of environment impacts, bill of quantities and cost estimate.

ROAD DESIGN (3 ECTS)
Road construction and its characteristics. Sub-disciplines: road planning, road design, road construction and operations. Road design procedures: process and documentation. Contents of project and technical design documentation. Spatial and structural road characteristics: classification of roads, traffic loads, factors and principles for Typical Cross Section (TCS) definition. Geometrical and technical elements of the road: speed terminology, sight distances and alignment (summary), elements of roadway drainage, bridges, retaining walls and other structures, traffic signalisation and equipment, planimetric quantities and calculation support. Road safety (impact assessment and audit) and road safety measures. Environmental issues in road design (measures, arrangements). Comparative and pre-investment studies of road infrastructure investments (principles and process of comparison). Technical design documentation for new road construction (conceptual design, preliminary design, building permit documentation, documentation for execution). Technical design documentation for reconstruction and renovation of roads. At-grade intersections and graded interchanges (design, criteria, conditions, signs and equipment). From roadway design to terrain and cadastral study.

DESIGN OF BUILDING STRUCTURES (4 ECTS)
Design procedure of building structures, specifics of the behaviour of timber, concrete and masonry structures, principles of rational structural system in dependence of selected material, design load, basics for the design of timber structures (mechanical and rheological properties of material, design of linear timber elements, basic rules of connections between timber structures), design of concrete structures (design and structural execution of linear structures, slabs and walls as well as foundations), basics for the design of masonry structures (mechanical properties of bricks, mortar and walls, design of non-reinforced concrete structures to axial-bending and shear loading, execution of seismically safe simple masonry structures).

DESIGN AND CONSTRUCTION OF STEEL BUILDINGS (4 ECTS)
Global analysis of steel structures (methods, initial imperfections, modelling, design of elements, assessment of results); basics of the design of seismically resistant steel structures (design, ductility, measures to provide seismic resistance); corrosion protection of steel structures, fire protection of steel structures; tolerances of production and assembly of steel structures; technology of production and assembly of steel structures with the emphasis on buildings; maintenance of steel structures. Seminar: Elaboration of a project of simple steel building (static design, loads, calculation of internal forces, design of elements and connections, drawing of structure and data for the elaboration of a structure).

RAILWAY DESIGN (3 ECTS)
General concepts of traffic infrastructure – substructure and superstructure of railway tracks (definition, contents, basic characteristics, subsystems, components and elements of railway infrastructure, essential demands …).

TRAFFIC ECOLOGY (4 ECTS)
Basic concepts of environmental protection (historic overview, the term of environmental protection, environmental protection and spatial planning, forms of activities within environmental protection, influences of traffic on environment), components of environment and space (air and climate, ground, waters, plants, fauna, protected areas, noise loads, cultural heritage, landscape quality, forestry and forests, agriculture and agrarian surfaces, settlements, tourism), environmental impact study (concept and importance, historic overview, forms of impact studies, legal framework and procedure, execution of impact study), arrangement of road-side landscape (positioning of road into space, relief, use of vegetation, arrangement of accompanying structures, water regulation, arrangements for animals), mitigation measures (traffic noise, animals), seminar work (placement of road alignment into space by taking into account all previously acquired knowledge), laboratory work (demonstrational work at computer models).

COMPUTER INTEGRATED CONSTRUCTION (5 ECTS)
Role of building informatics, what is building informatics and its history, specific problems of building informatics, models and paradigms of design and planning and the role of IT, technological, scientific and development-cyclical frameworks of IT. Introduction of informatics into companies, strategic aspects of informatisation in the area of civil engineering, role and place of informatics in a construction company and in society, reengineering of business processes and introduction of IT, building

informatics as business opportunity. Thematic map of building informatics. Modelling as method for solving problems, Computer-integrated construction, communication integration, information integration, process integration, connection of knowledge. Results: computer integrated construction, concurrent engineering, virtual companies, eWork, eBusiness. What computers cannot do.

ROADS SEMINAR (7 ECTS)
Design, prediction of traffic, outline scheme, design of intersections, pavement design, environmental impact study, inventarisation and design cost estimate.

DESIGN OF STEEL STRUCTURES - SEMINAR (10 ECTS)
Each student makes a project of steel building and engineering structure (bridge, reservoir, antenna tower…) in the scope of a project for building permit, the contents of each project (structure concept. loads, computational model, calculation of internal forces and displacements, assessment and control of computational results, design of elements and connections, concept of key structural details), preparation of project contents (technical report, static calculation and design), for one of both project plot of workshop plans with the help of adequate software (shorter scope of project for execution), expert field trip (interesting building sites, workshops for the production of steel structures), seminar consists of several accompanying lectures with the participation of lecturers from practice (design and elements of different types of steel structures, corrosion protection, fire resistance of steel structures, dimension tolerances for the elaboration of steel structures, technology for the production and assembly of steel structures, control of production and assembly of steel structures, presentation of interesting finished structures).

DESIGN OF CONCRETE AND MASONRY STRUCTURES - SEMINAR (10 ECTS)
Principles of conceptualisation and design of concrete structures, design load of concrete structures, key criteria for rational selection of structural system type, translation of load-carrying system of a structure to adequate computational model, overview of basic groups of elements of load-carrying elements of concrete buildings and bridges with adequate characteristics according to the load-carrying capacities and deformabilities as well as structural specifics. Elaboration of part of project for building permit and project for execution of an office, residential or any other building of larger dimensions. Elaboration of part of project for building permit and project for execution of reinforced or prestressed concrete bridge.

RAILWAYS SEMINAR (7 ECTS)
Detailed insight into the design of railway structure - substructure and superstructure of railway tracks (characteristics of subsystems, interoperability components, elements of railway infrastructure, essential demands, technical specifications about interoperability, procedures to start construction and to acquire operating permit …).

COMPOSITE STRUCTURES (4 ECTS)
Basics (types and special characteristics of composite buildings and bridges, basic assumptions for calculations and design), global analysis of composite structures (methods, influence of cracks, influence of concrete shrinkage and creep), bending girders (elastic and plastic load-carrying capacity of cross-sections, binders, partial composite action, vertical and longitudinal shear, bending failure, continuous systems and rheological influences), ceiling structures (types, design methods), columns (types of cross-sections, compressive, bending and compressive-bending load-carrying capacity, characteristic interaction diagrams moment-axial force, buckling, influence of second order theory), connections (specifics, load-carrying capacity, ductility), limit states of applicability (basics, crack control, displacement control), construction technology (overview of technological procedures of construction, gradual construction and its influence on design).

SLOPE PROCESSES (4 ECTS)
Forms of slope processes, causes of their formation, triggering factors, field research. Hydrotechnical and geotechnical measures for mitigation and stabilisation of landslides and rockfalls. Basics of handling natural risks: legislation, arrangements, active and passive measures, documentation of landsliding, mapping of phenomena and hazards.

STRUCTURAL ANALYSIS (5 ECTS)
Engineering modelling of temperature actions according to relevant standards. Engineering modelling of traffic load on bridges according to relevant standards. 3D modelling of more complex building structures and bridges with beam column elements. Influence lines. Analysis of structures subjected to moveable load. Envelopes of the effects of movable actions. 3D finite element analysis of structures subjected to temperature actions, settlements, and moving load using beam-column elements. Shear stiffness in FEM. Advanced use of the computer programme: analysis of structures subjected to temperature actions, settlement, and moveable load. Calculation of the influence lines and envelopes.

PROPERTY LAW (4 ECTS)
Concept of law and division into public and private law, concept of real estate, legal sources regulating real estates, principles of property law, ownership right (acquisition, termination, contents), ownership right for several persons, easements (material easements, personal easements, right of way), mortgage and land debt, building right, real estate records, cadastre (border arrangement procedure and land allotment), land cadastre (concept, principles, types of entries, procedure of entry), border dispute and border arrangement in legal procedure, strata-title unit, building cadastre and entry of strata-title unit in land cadastre, limitations of ownership rights in public interest.

TECHNOLOGY OF MATERIALS WITH MINERAL BINDERS(6 ECTS)
Microstructure and properties in hardened state, constitutive materials, design of mixes and properties in early age, historic materials based on mineral binders, special types of concretes, provisions of SIST EN 206-1 standard, provisions of SIST 1026 standard, seminar work (design examples of different mixes with mineral binder), laboratory work (elaboration of different mixes with mineral binder, checking of their strength and existing characteristics, material analysis using microscope).

TRAFFIC FLOW THEORY AND CAPACITY ANALYSIS (4 ECTS)
Basics about traffic flow theory (historic overview, basic purpose and problems dealt with by this area of science, areas of use), movement of individual vehicle, basic traffic flow parameters, traffic flow characteristics, theoretical and empirical relations between traffic flow parameters, mathematical models of interdependencies in traffic flow, mathematical models for the description of vehicle flow laws in different traffic flow conditions, basic theories of queuing theory in traffic engineering, capacity of different traffic solutions (areas of hindered traffic flows – road intersections, areas of partially hindered traffic flows – freeway facilities, areas of unhindered traffic flow – road sections).

URBAN PLANNING (4 ECTS)
Introduction, basic concepts and terminology in the planning of urban space; sustainability principles of urban development. Development of urban areas, typology of settlements, urban system. Urban documentation and administrative services. Development of urban land: land allotment for construction purposes, acquisition of land, urban planning. Implementation of urban documents. Data bases, urban information systems and their use. Urban renovation. Lectures on settlement, production, central use of ground, on green, traffic and communal surfaces and on infrastructural systems. Based on an urban plan or regulation, a plan of execution is designed (textual or graphic report).

RIVER ENGINEERING (10 ECTS)
Introduction to river regulation (historic overview, regulation problems, legislation and planning), basics of river regulation (river hydraulics, river mechanics, river morphology, erosion and sedimentation), classical river regulation (safety measures against floods, river bed regulations, design and maintenance of individual water structures), sustainable river regulation (river corridor, hydromorphological condition of rivers, basics of engineering biology, catalogue of sustainable arrangements, planning and maintenance of sustainable arrangements), seminar work (calculations from river hydraulics and mechanics), laboratory work (demonstration work from river mechanics in laboratory model, structure and application of one-dimensional mathematical hydraulic model in computer room), seminar (hydraulic calculation of real river section), field work (grain structure analysis of river sediments, measurements of flow velocities with tracer, hydromorphological mapping of river transects).

PROBABILITY METHODS AND RELIABILITY OF STRUCTURES (4 ECTS)
Theory of probability (review): definition of probability, random variables and vectors, moments, derived distributions. Statistical distributions: log-normal distribution, extreme value distributions, beta and gamma distributions. Characteristic values, definition; determination by the ranking method and by assumed distribution, Bayesian approach. The basic problem of reliability of structures, generalization for arbitrary distribution, generalization for multidimensional space and non-linear limit function. FOSM – first order second moment method. Monte Carlo method, random sample generation. System reliability, parallel and series systems.

PROBABILITY THEORY AND STATISTICS (4 ECTS)
Algebra of events, definitions of probability. Bayes formula. Random variables: discrete and continuous. Rrandom vectors: discrete and continuous. Basics in stochastic processes. Limit theorems. Basics in statistics: ampling, estimation of parameters, hypothesis testing.

PROJECT MANAGEMENT (4 ECTS)
Project as system, project goals, components and relations in project, relationship with environment, organisation of project implementation, permanent and non- permanent project organisation, areas of project management, specifics and phases of civil engineering projects, project structuring, matrix of responsibility, project planning and monitoring, forming a project team, risk management, practical work (elaboration of own project from conceptualisation to general plan, risk modelling in civil engineering projects and simulation of influences).

HYDROELECTRIC POWER (4 ECTS)
Lectures: production of electrical power in Slovenia and role of water energy, basics of planning energy use of water sources (design of accumulations, economical and financial basis of valuation, definition of specific investment indicators, legal regulation for planning hydro power plants and placement into electricity system), equipment of water power plants (turbines, generators, energy transfer), types of water power plants (accumulation, run-of-river, pumping, chains of power plants, small hydro power plants), hydraulic optimisation models of HPP operations (accumulation power plants, run-of-river chain power plants), optimisation of HPP operations and role of HPP in electricity system, environmental aspects of planning and operation of water power plants. Practical work: calculation of energy production for accumulation power plant, economic optimisation of derivation structures, feasibility study of a water power plant project.

WATER SUPPLY AND DRAINAGE (10 ECTS)
Introduction to historic development of this field of science, hydraulic modelling of pipeline systems (knowledge of hydraulic properties of different system elements, common cases of their use and extraordinary events, calculation and selection of adequate tools for demanding cases of use), use of hydraulic models (planning, checking of operation, rehabilitation and modernisation of systems, etc.), water sources (appearance, characteristics, exploitation, protection), needs for water, planning of use and exploitation of water sources, types of waste waters, appearance and methods of waste water and atmospheric water drainage, water losses (types, corrections, rehabilitation of pipelines), design, planning, construction and operation of water supply and drainage systems, precipitation in Slovenia and analysis of heavy rainfalls, discharge and retention of polluted water, estimation of influences of discharged canal waters and quality of detention tanks of discharged waters, influence of hinterland waters on flood safety of urbanised surfaces, static evaluation against pipe failure and water tightness of a system, structures on pipelines and drainage systems, practical work (hydraulic calculation of systems for water drainage with detention tanks, overflows, static estimation of pipes against failure, pumping station design, learning about mathematical models for the design of water supply and drainage systems), seminar (calculation of hydraulic properties and characteristic operating conditions of the selected demanding system, verification-calibration-validation and use of hydraulic models in planning, operation and typical events during life cycle).

REAL ESTATE VALUATION (4 ECTS)
Market and market valuation of real estate (subject of valuation, evaluated value and principles of real estate valuation, land evaluation, real estate value in the procedure of land consolidation, real estate valuation in the cases of material easement and in cases of other limitations of property right, valuation

in specific cases), procedure of individual real estate valuation and elaboration of a valuation report, mass real estate valuation, data acquisition, real estate market analysis and elaboration of valuation models.

QUALITY ASSURANCE AND QUALITY CONTROL (4 ECTS)
Historical overview of quality management development, fundamental terms (control, assurance, management of quality, aspects of quality, importance of quality of a structure). Relevant legislature and standardisation (importance and relevance, application of standards, preparation of standards). Statistical process control in serial production of construction products. Conformity assessment for construction products (overview of construction products, accompanying legislature, standards for construction products, conformity assessment systems). Relationship between quality and business success, costs of quality. Quality assurance in all stages of construction project (with special emphasis to quality of design), quality management in construction project. Integrated management systems (QMS, EMS, OHSAS). Qualitative methods for quality assurance.

CONCEPTUAL DESIGN OF BUILDING AND CIVIL ENGINEERING STRUCTURES (4 ECTS)
Lectures are based on the thesis that the key task of a structural engineer is to bridge the span and cover the space. The success in this objective (i.e. to increase the span considering the optimal technological solution and costs) depends on the understanding of the load transfer within the structure and the knowledge of the advantages of different structural materials and technological solutions. Therefore the lectures address the following topics: 1) The outlined thesis is first illustrated by the (historical) development of structural systems of buildings and bridges. The key milestones in the progress of structural engineering are illustrated by the case studies of specific structures and typical use of different materials and technologies. 2) The possibilities in the choice of the structural systems for buildings and bridges are systematically analysed. Indicative guidelines are provided when it is possible and reasonable to choose a specific structural system, taking into account specific characteristics of different materials (reinforced/concrete, pre-stressed concrete, steelconcrete composite, timber and masonry). 3) The existing knowledge about the actions/loads on structures is expanded and improved. 4) The methods for preliminary sizing are given. 5) Optimization of the load transfer into the foundation soil as well as the systems and applicability of different solutions for shallow and deep foundations are presented. 6) Structural integrity at permanent and variable actions as well as at accidental (i.e. fire) and earthquake actions are discussed. The importance of the ductility and robustness are explained. 7) The conceptual design of buildings in seismic regions is outlined. The principles of the capacity design, ductility and detailing of the earthquakeresistant structures are explained. 8) All topics are closely connected with the adequate requirements in the structural Eurocodes.

GEOTECHNICS OF INFRASTRUCTURAL FACILITIES (8 ECTS)
Methods of soil improvement (pre-loading,radial consolidation, dynamic compaction, stone columns, grouting, jet grouting, methodsof surface and deep mixing). Groundwater flow through saturated isotropic and anisotropic soil (buoyancy, critical hydraulic gradient, hydraulic failure, internal erosion, piping). Earthfill dams: flow of water through the dam,measures to reduce the adverse consequences, filter design, stability of earthfill dams under static and dynamic (seismic) conditions. Liquefaction of soil. Use of geosynthetics: sealing, filtration, separation and einforcement. Analysis and management of geotechnical risks. Fundamentals of rock mechanics (classification of rock, mechanical properties of rock, Hoek&Brown failure criterion, structurally controlled instability of blocks and wedges, Schmidt's projection, Markland test, analytical and numerical methods). Basics of design and construction of tunnels (technology, machinery, support measures, primary and secondary stress states, principles and methods for the design, geotechnical monitoring). Fundamentals of numerical methods in geotechnics (nonlinear elasto-plastic models for soils, principles of non-linear numerical analysis).