UNDERGRADUATE AND GRADUATE UNIVERSITY STUDY

OF CIVIL ENGINEERING

Study programmes with learning outcomes

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INTRODUCTION

HISTORY

The Faculty of Civil Engineering in Zagreb is the oldest and largest institution of higher education in civil engineering in the Republic of Croatia. The Faculty has been integrated into the University of Zagreb which was established in 1669.

The history of civil engineering study in Croatia started when the Polytechnic College was founded in Zagreb, enrolling its first students in 1919. The Civil Engineering Department, at the time one of the four departments at the Polytechnic College, had its premises on the first floor of the refurbished former school at 6, Roosevelt Square. The Polytechnic College grew into the Technical Faculty within the University of Zagreb in 1926. In 1940 the Technical Faculty moved to its new building at 26, Fra Andrije Kačića Miošića Street where the instruction on civil engineering is still conducted today.

In 1956 the Technical Faculty branched into the following faculties: architecture, civil engineering, geodesy, electrical engineering, mechanical engineering with ship-building and food technology, biotechnology with mining engineering. In 1962 the Faculty of Architecture, Civil Engineering and Geodesy was separated into three faculties and thus the Faculty of Civil Engineering became an independent institution of higher education within the University of Zagreb. In 1977 the Faculty integrated with the Civil Engineering Institute of Croatia and operated as the Faculty of Civil Engineering within the newly established Civil Engineering Institute. In the same year two civil engineering colleges merged with the Faculty which started offering vocational studies. When the Civil Engineering Institute was dissolved on July 1, 1991, the Faculty of Civil Engineering of the University of Zagreb once again became an independent institution of higher education. It should be noted that in recent decades, after a series of organisational changes (which have always taken into account the latest developments in science), the Technical Faculty has evolved into present technical faculties within the University of Zagreb (the faculties of architecture, electrical engineering, chemical engineering and technology, traffic engineering, mechanical engineering and ship-building, geodesy, geotechnical faculty in Varaždin, civil engineering, graphic art, metallurgy, mining, geology and petroleum engineering and textile technology) which make up the Technical Field Council of the University of Zagreb.

After the polytechnic colleges were established upon the separation of the vocational studies from the University in the academic year 1997-98, the Civil Engineering Faculty founded the Building Department of the Technical Polytechnic of Zagreb. The Building Department was entirely separated from the Faculty of Civil Engineering on July 8, 2003.

Since the very start of the civil engineering studies, the study programs have been innovated and adapted to the real needs of the economy, changing their nominal duration from four to five years. Every new development of study programs has enriched the contents of individual courses, and introduced new courses brought about by the latest scientific achievements and professional knowledge and the practice of the leading European universities.

The first students graduated from the Faculty in 1923. To date, The Faculty has awarded engineer’s degrees to about 7 500 students, bachelor’s degree in engineering to 1 100 and master’s degree in engineering to about 600 students. They have all become highly esteemed engineers, appreciated in Croatia and abroad, of whom many have attained international reputation either by significant construction work or by contribution to science.

The Faculty first offered post-graduate studies in civil engineering in the academic year 1963 - 64. Until the present day 560 master’s degrees in science and 237 doctoral degrees in science have been awarded. The first doctoral dissertation was defended in 1922.

The year of 1919 is considered the founding year of the Faculty. The Day of The Faculty is celebrated on February 21.

THE FACULTY TODAY

The Faculty headquarters are in Zagreb, at 26 Fra Andrije Kačića-Miošića Street. The Faculty also has premises at 16 Savska Street (hydrotechnical laboratory).

The Faculty consists of 10 constitutional units, of which 9 are departments run by heads and 1 administrative department run by the Secretary of the Faculty. For the purpose of efficiency in scientific and teaching work, the departments are divided into chairs which are run by heads. At present there are the following departments:

Department of Geotechnical Engineering
- Chair for Rock Mechanics and Investigation Works
- Chair for Soil Mechanics and Foundations

Department of Water Research
- Chair for Fundamental Hydraulic Engineering
- Chair for Hydraulic Engineering
- Chair for Sanitary and Environmental Engineering

Department of Structural Engineering
- Chair for Concrete and Masonry Structures
- Chair for Timber Structures
- Chair for Steel Structures
- Chair for Bridges

Department of Materials
- Chair for Materials Research
- Chair for Materials Technology

Department of Mathematics
- Chair for Mathematics
- Chair for Geometry
- Chair for Physics

Department of Construction Management and Economics
- Chair for Construction Management
- Chair for Technology in Construction
- Chair for Social Studies

Department of Transportation Engineering t
- Chair for Roads
- Chair for Railways

Department of Engineering Mechanics
- Chair for Statics, Dynamics and Stability of structures
- Chair for Mechanics of Materials and Testing Structures

Department of Buildings

Administrative units are as follows: Students' office, Secretary's office, Accounting office, Library and Computer room.

The Faculty has 191 employees: 63 lecturers in science teaching positions (assistant professors, associate professors, full professors), 5 lecturers in teaching positions (lecturers, senior lecturers), 30 junior researchers, 19 scientific assistants and senior scientific assistants, 13 expert associates and 61 non-teaching staff.

In order to keep a high standard of tuition the Faculty occasionally hires visiting lectures, top scientists and professionals in their fields.

There are 1500 full time students at the Faculty. The Student Union and the Association of Civil Engineering Graduates of The Faculty operate within the Faculty.

The Faculty has six fully equipped laboratories for scientific, teaching and professional work (geotechnical laboratory, hydrotechnical laboratory, IT laboratory, structural testing laboratory, materials laboratory and transportation engineering laboratory). A local computer network was set up, and the equipment in lecture rooms and classrooms offers multimedia teaching. Ten computer rooms (three for undergraduate and seven for graduate students) are equipped with more than 170 state of the art computers. Through Croatian Academic Network CARNET the Faculty is linked to the Internet.

The library houses 8 9000 titles in 25 000 volume and is subscribed to 36 domestic and foreign journals. A number of foreign scientific journals is available on-line through the centre of on-line data bases of the Croatian Ministry of Science, Education and Sports.

For years the Faculty has encouraged sports activities. The students of the Faculty of Civil Engineering have repeatedly won Zagreb University sports competitions.

ABOUT INSTRUCTION AT THE FACULTY

In the late 1990s a reform of higher education, known as Bologna Process, was started in Europe. Croatia soon joined the reform. The purpose of the reform is to create an attractive, efficient and market tailored higher educational system. Due to the technological and economic domination of the USA the central European system of higher education has been abandoned. According to the new, Bologna system, university studies are divided into undergraduate and graduate levels, usually lasting three and two years (postgraduate doctoral or specialised studies follow graduate degree).

While the central European higher education system traditionally offered students freedom to organise their own time in fulfilling their duties, the Bologna system defines the timetable and the deadlines much more strictly. However, we would like to emphasize that some procedures have been conducted at the Faculty since the 1970s: from continuous monitoring and evaluation of student activities (including lecture attendance, student participation in tuition and independent solution of tasks in exercises), program and seminar paper writing to periodical knowledge testing in pre-exams during semester (so students were exempt from the parts of exams).

The undergraduate program was introduced by the Faculty of Civil Engineering in academic year 2005 – 2006, and in 2008-2009 the first generation of bachelors in engineering enrolled in the graduate program. (The accreditations for undergraduate and graduate programs were issued by the Minister of Science, Education and Sport on June 2, 2005, according to the article 51, paragraph 2, *Act on Science and Higher Education*, on the proposal of the National Council for Higher Education. Following the re-accreditation procedure conducted by the Agency for Science and Higher Education, the accreditations were renewed in November, 2012).

Curricula of undergraduate and graduate university study programs of the most prominent universities in EU (Delft University of Technology, the Netherlands, ETH Zurich, Switzerland, Technical University, Hannover and Stutgart University, Germany, University in Trieste and Polytechnic University of Milan, Italy, Imperial College in London and University in Glasgow, Great Britain),the guidelines for drawing curricula by two large European projects related to the definition of the goals of higher education in engineering (SOCRATES and

ERASMUS Thematic Networks: EUCEET – European Civil Engineering Education and Training i E4 – Enhancing Engineering Education in Europe) and the guidelines by German associations for accreditation of higher education curricula in civil engineering (ASBau – Akkreditirungsverbund für Studinengänge des Bauwesens: Akkreditirung und Qualitätssicherung zeitgemässer Studiengänge des Bauingenieurwesens an deutschen Hochschulen. ASBau e.V., Berlin, 2003) served as models for creating undergraduate and graduate study programs at the Faculty of Civil Engineering.

Undergraduate university program takes three years. Upon its completion students earn 180 ECTS credits and the academic title of bachelor -*baccalaureus* in civil engineering for men, and *baccalaurea* in civil engineering for women (abbrev. *univ. bacc. ing. aedif*.). It is an integrated program, without specialisations, and comprises the fundamental (natural science-mathematical and fundamental technical courses),and the main part (professional courses that cover all civil engineering branches and a number of non-engineering courses related to civil engineering) with field work and graduation exam. It offers students scientific and professional basis for continuing education at graduate level, and for the ones who decide to find employment, gives professional knowledge necessary for managing small scale construction projects, dimensioning small scale building structures with regard to static loads and participation in planning, designing, construction and supervising major construction works and maintain complex buildings.

Knowledge required for performing highly professional activities in various branches of civil engineering (planning, designing, construction, supervision and maintaining complex building structures, facilities and systems) and foundations for development and scientific research is acquired in one of the seven specialisations at graduate university program level: geotechnics (G), water research (W), structures (S), materials (M), construction management (CM), transportation engineering (TE) and theory and modeling of structures (TMS). Graduate program takes two years, 120 ECTS credits are earned and the academic title of *master* of civil engineering is awarded (abbrev. *Mag.ing.aedif*.). Together with mathematical and humanities and social courses students attend fundamental scientific and professional courses which they specialise in. Besides compulsory courses, depending on their interests, students enrol in elective ones which can expand their professional knowledge (and not only in their chosen field), and also their knowledge in mathematics, physics and foreign languages (for civil engineering).

After the instruction was conducted once for all years of undergraduate and graduate programs, the analysis of identified problems, deficiencies and necessary changes was carried out. In regular meetings of the Faculty Council in April and May, 2011, the proposals of changes and amendments to undergraduate and graduate curricula were accepted. As of academic year 2012-2013 the instruction in the first year of study, and as of 2013-2014 the instruction in the second year of study is conducted according to the changed and amended graduate curriculum, while the “new” curriculum for the undergraduate program was started in academic year 2013-2014.

One of the goals of the reform, according to the guidelines of Bologna Declaration, is the harmonisation of studies in different European countries and achieving comparability of academic degrees while respecting differences between them. It should diminish administrative barriers, facilitate employment abroad and enrolment in other universities in the entire European area. The important step in this direction is the international accreditation label with European-Accredited Engineering Program (EUR-ACE) which was awarded to the undergraduate and graduate programs at the Faculty of Civil Engineering by German accreditation agency for study programs in the field of technical sciences, information science, natural science and mathematics, ASIIN (Akkreditierungsagentur für Studiengänge der Ingenieurwissenschaften, der Informatik, der Naturwissenschaften und der Mathematik e.V.), in March, 2012.

Undergraduate university study

GENERAL

Duration of study

Three years, 180 ECTS credits.

Enrolment requirements

All secondary school programs lasting four years, state graduation exam.

Study system

Organized and conducted in semesters as a full time study.

Criteria and transfer requirements of ECTS credits

Students earn ECTS credits according to the Faculty regulations of study curriculum regardless of the value of credits at the main study program.

Requirements that have to be met by students who interrupted their studies or lost the right to study if they want to continue

Students who have interrupted their studies, can continue if they comply with the program they are enrolling in.

Students who have lost the right to study at some other study program are allowed to continue if they conform the ECTS credits they have earned to the Faculty's study program.

Academic title awarded upon graduation

Bachelor (baccalaureus) in civil engineering (for men) / bachelor (baccalaurea) in civil engineering (for women).

Document on completed study

Upon graduating undergraduate students are issued with a degree certifying their graduation and their academic title.

Students are also issued with a diploma supplement certifying the exams passed, grades achieved and ECTS credits earned.

Graduate studies offered upon graduation

– graduate university study in civil engineering at the Faculty or a similar study at other universities in Croatia and abroad,

– graduate study in civil engineering at institutions offering thereof,

– with major or minor additional study obligations a university graduate or professional graduate studies in other technical professions in Croatia or abroad.

PROGRAMME'S LEARNING OUTCOMES

Accomplished learning outcomes upon the competition of undergraduate studies:

(ACQUIRING KNOWLEDGE AND UNDERSTANDING)

- ability to recognize and describe engineering issues
- ability to recognize the interaction between design, construction, marketing, clients' demands and removal of structures
- understanding of the impact of civil engineering on society and the environment

(APPLYING KNOWLEDGE AND UNDERSTANDING)

- application of acquired knowledge of mathematics, science and technology to civil engineering
- ability to prepare and carry out experiments, and to analyse and interpret their results
- application of current computer tools to execute calculations and simulations
- basic structure design
- static load dimensioning for medium-sized building structures

(MAKING INFORMED JUDGEMENTS AND CHOICES=

- critical assessment of arguments, hypotheses, abstract concepts and data in reaching decisions and solving engineering issues creatively

(COMMUNICATING KNOWLEDGE AND UNDERSTANDING, WORKING AS PART OF A TEAM)

- participation in planning, design, realisation, supervision and maintenance of large-scale construction work
- supervision of small-scale construction work
- exchange of information, ideas, problems and solutions with experts and non-experts
- participation in expert groups and adaptability to the work environment
- application of current computer tools to produce documents, presentations and internet pages

(CAPACITIES TO CONTINUE LEARNING, ETHICS)

- application of acquired knowledge and skills in further professional and academic education
- adaptability to changes in technology and work methods in the process of lifelong learning
- ethical attitude to solving engineering issues

COURSE TIMETABLE BY SEMESTER

1st year, 1st semester

Course			Horus per week		ECTS
			Lecture	Practice	
1	Elective subjects	Introduction to Civil Engineering History of Building	2	0	3
2	Mathematics 1		4	4	9
3	Descriptive Geometry		2	3	6
4	Basics of Construction Informatics		1	2	3
5	Mathematical Programmes for Engineers		1	1	2
6	Geodesy		2	2	4
7	Elective subjects	Sociology of Work and Professional Ethics Basics of Civil Engineering Law Business Economics English in Civil Engineering 1 German in Civil Engineering 1	2	0	3
	Total		14	12	30

1st year, 2nd semester

Course		Horus per week		ECTS
		Lecture	Practice	
1	Mathematics 2	4	3	8
2	Physics	4	1	6
3	Mechanics 1	2	2	5
4	Building Construction	3	3	7
5	Materials Science	2	1	4
	Total	15	10	30

2nd year, 3rd semester

<table>
<tr><td colspan="3" rowspan="2">Course</td><td colspan="2">Horus per week</td><td rowspan="2">ECTS</td></tr>
<tr><td>Lecture</td><td>Practice</td></tr>
<tr><td>1</td><td colspan="2">Probability and Statistics</td><td>2</td><td>2</td><td>4</td></tr>
<tr><td>2</td><td colspan="2">Strength of Materials 1</td><td>3</td><td>3</td><td>7</td></tr>
<tr><td>3</td><td colspan="2">Fluid Mechanics</td><td>3</td><td>2</td><td>6</td></tr>
<tr><td>4</td><td colspan="2">Mechanics 2</td><td>2</td><td>2</td><td>5</td></tr>
<tr><td rowspan="2">5</td><td rowspan="2">Elective courses</td><td>Construction Materials</td><td rowspan="2">2</td><td rowspan="2">2</td><td rowspan="2">5</td></tr>
<tr><td>Basic of Concrete Technology</td></tr>
<tr><td>6</td><td colspan="2">Hydrology</td><td>2</td><td>1</td><td>3</td></tr>
<tr><td></td><td colspan="2">Total</td><td>14</td><td>12</td><td>30</td></tr>
</table>

2nd year, 4th semester

<table>
<tr><td colspan="3" rowspan="2">Course</td><td colspan="2">Horus per week</td><td rowspan="2">ECTS</td></tr>
<tr><td>Lecture</td><td>Practice</td></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Elective courses</td><td>Applied Geology</td><td rowspan="2">2</td><td rowspan="2">0</td><td rowspan="2">3</td></tr>
<tr><td>Environmental Protection</td></tr>
<tr><td>2</td><td colspan="2">Strength of Materials 2</td><td>3</td><td>2</td><td>5,5</td></tr>
<tr><td>3</td><td colspan="2">Structural Analysis 1</td><td>4</td><td>3</td><td>7,5</td></tr>
<tr><td>4</td><td colspan="2">Introduction to Structural Engineering</td><td>2</td><td>0</td><td>2</td></tr>
<tr><td>5</td><td colspan="2">Soil Mechanics</td><td>3</td><td>2</td><td>6</td></tr>
<tr><td rowspan="2">6</td><td rowspan="2">Elective Courses</td><td>Water Supply and Sewerage 1</td><td rowspan="2">2</td><td rowspan="2">1</td><td rowspan="2">4</td></tr>
<tr><td>Water Protection</td></tr>
<tr><td>7</td><td colspan="2">Law in Construction</td><td>2</td><td>0</td><td>3</td></tr>
<tr><td></td><td colspan="2">Total</td><td>18</td><td>8</td><td>30</td></tr>
</table>

3rd year, 5th semester

	Course		Horus per week: Lecture	Horus per week: Practice	ECTS
1	Concrete and Masonry Structures		4	3	6,5
2	Rock Mechanics		3	2	6
3	Roads		3	2	6
4	Elective courses	Building Technology Technology of Heavy Construction	2	0	3
5	Elective courses	Structural Analysis 2 Numerical Modelling of Structures	2	2	4,5
6	Railways		2	1	3
	Total		16	10	29

3rd year, 6th semester

	Course		Horus per week: Lecture	Horus per week: Practice	ECTS
1	Construction Management 1		3	3	6,5
2	Metal Structures		2	1	4
3	Bridges		2	1	4
4	Elective courses	Timber Structures Lightweight Structures	2	1	4
5	Hydraulic Engineering Structures		3	0	3,5
6	Education on Construction Site		0	3	3
7	Final Assignment		0	0	6
	Total		12	9	31

COURSE CONTENT WITH LEARNING OUTCOMES

1st year, 1st semester

Compulsory courses

MATHEMATICS 1

Credit value (ECTS):9

Number of hours (in semester):

- Lectures:60
- Exercises (auditory):60

Course objectives:

- Acquiring theoretical knowledge in differential and integral calculus,
- Acquiring basic knowledge in linear algebra to be applied by students in future.

Entry competences (foreknowledge, descriptive):

- Secondary school mathematics, basic knowledge on vectors, sequences and functions.

Learning outcomes:

- Knowledge on basic facts and theorems on vectors and analytical geometry in space,
- Acquiring basic knowledge on matrix calculus, with the emphasis on linear systems of equations and relevant values,
- Knowledge about the basic facts on sequences and series,
- Understanding the basics of differential calculus and its applications,
- Understanding the basics of integral calculus and its applications.

Course content (according to timetable):

- Lectures:
  1. Vectors [6]
  2. Analytic geometry in space [4]
  3. Matrices, linear systems of equations, eigenvalues [10]
  4. Sequences and series [4]
  5. Real functions of real variable [10]
  6. Differential calculus, continuity, limes, derivations, applications [10]
  7. Integral calculus with applications [16]
- Exercises (auditory):
  1. Vectors [4]
  2. Analytic geometry in space [6]
  3. Matrices [10]
  4. Sequences and series [4]
  5. Functions, introduction [10]
  6. Differential calculus [10]
  7. Integral calculus [16]

Student responsibilities:

- Lecture and exercise attendance,
- 1 mid-term exam– minimum 25% score, a make-up exam.

Grading and evaluation of student work over the course of instruction:

- Mid-term exam – students who achieve a 60% score are exempt from the written part of the exam.

End of semester grading:

- Written and oral exam.

Contributions to the final grade:

- Students with a 60% score in pre-exams, pre-exam 60%, oral exam 40%,
- Other students: written exam 50%, oral exam 50%.

Required literature:

1. Došlić, T., Sandrić, N.: Internal mimeographed notes available at: `http://www.grad.unizg.hr/_download/repository/T._______Doslic%2C_N._Sandric%3B_Matematika_1.pdf`

Optional literature:

1. Kurepa, S.: *Matematička analiza I*, Zagreb: Tehnička knjiga, 1989
2. Kurepa, S.: *Matematička analiza II*, Zagreb: Tehnička knjiga, 1990
3. Kurepa, S.: *Uvod u linearnu algebru*, Zagreb: Školska knjiga, 1978
4. Pauše, Ž.: *Matematički priručnik*, Zagreb: Školska knjiga, 2003

DESCRIPTIVE GEOMETRY

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises: 45 (auditory – 15, design –30)

Course objectives:

- Expansion of theoretical knowledge on geometric objects and their relations,
- Development of spatial visualisation skills and spatial imagination,
- Interpretation of spatial situations based on plane views (2D representations),
- Development of problem-solving abilities of various spatial relationships of 2D representations.

Entry competences (foreknowledge, descriptive):

- Secondary school mathematics.

Learning outcomes:

- Acquiring theoretical knowledge on several methods of projection (orthogonal, parallel, projection with elevations),
- Ability to visualise, identify and interpret relationships between spatial objects given by their plane projections,
- Using computer CAD software for 3D modelling and solving geometric problems,
- Ability to apply geometric knowledge to civil engineering.

Course content:

- Lectures:
  1. Plane curves and transformations [4]
  2. Monge's method (12)
  3. Axonometric projection [2]
  4. Computer CAD software [2]
  5. Cross sections [2]
  6. Intersection of surfaces [2]
  7. Projection with elevations – Terrains [6]
- Exercises (auditory):
  1. Plane curves and transformations [2]
  2. Monge's method [6]
  3. Axonometric projection [1]

4. Computer CAD software [1]
5. Cross sections [1]
6. Intersection of surfaces [1]
7. Projection with elevations – Terrains [3]

- Exercises (design – drawing room or computer room):
  1. Planar curves and transformations [4]
  2. Monge's projection method [14]
  3. Axiomatic image of an object [2]
  4. Cross sections [2]
  5. Intersection of surfaces [2]
  6. Projection with elevations – Terrains [6]

Student responsibilities:

- 100% attendance at lectures and exercises,
- 8 short homework assignments,
- 5 projects,
- 2 pre-exams - minimum 25% score in each exam,
- Written and oral exam.

Grading and evaluation of student work over the course of instruction:

- Grading homework assignments and projects,
- Mid-term exams - students achieving minimum 60% score are exempt from the written exam.

End of semester grading:

- Written exam - minimum 60% score,
- Oral exam.

Contributions to the final grade:

- Homework assignments + projects 25%
- Pre-exams or written exam 50-60%
- Oral exam 15-25%

Required literature:

1. I. Babić, S. Gorjanc, A. Sliepčević, V. Szirovicza: *Nacrtna geometrija – zadaci*, HDGG, Zagreb, 2007
2. S. Gorjanc: *Predavanja iz Deskriptivne geometrije*, (web mimeographed notes) http://www.grad.hr/sgorjanc/Links/deskriptiva/plan.html

Optional literature:

1. V. Szirovicza, E. Jurkin: *Deskriptivna geometrija*, CD-ROM, HDGG i GF, Zagreb, 2005
2. I. Babić, K. Horvat-Baldasar: *Nacrtna geometrija*, Sand, Zagreb, 1997
3. V. Niče: *Deskriptivna geometrija*, Školska knjiga, Zagreb, 1997

BASICS OF CONSTRUCTION INFORMATICS

Credit value (ECTS): 3

Number of hours (in semester):

- Lectures: 15
- Exercises (auditory): 15
- E-learning: 15

Course objectives:

- Basic computer literacy,
- Basic computer knowledge and skills in order to carry out educational tasks in other courses where work with computer is needed.

Learning outcomes:

- Mastering the basic use of operational systems, e-mail and the Internet,
- Developing basic 2D techniques of CAD tools,
- Learning basic functionalities of office tools,
- Understanding the role of information and communication technologies in construction industry and their development trends.

Course content:

- Lectures:
  1. Introduction [1]
  2. Construction informatics – What is it? [1]
  3. Engineering software [1]
  4. Basics of computer graphics [3]
  5. Communication revolution [1]
  6. Intro into the Internet [1]
  7. Internet security [2]
  8. Business and social networking [1]
  9. Methods of modeling [1]
  10. Building Information Model [1]
  11. New forms and architecture of digital age [1]
  12. Trends of development and implementation of information and communication technologies in construction industry [1]
- Exercises (auditory):
  1. AutoCAD entrance exam [1]
  2. Introduction into AutoCAD [1]
  3. AutoCAD 2D [6]
  4. AutoCAD colloquium [1]
  5. e-learning entrance pre-exam (all modules) [1]
  6. e-learning: Hardware, software, Internet and MS Word [1]
  7. e-learning: MS Excel [1]
  8. e-learning: MS Powerpoint [1]
  9. e-learning: MS Access [1]
  10. e-learning pre-exam (all modules) [1]

Student responsibilities:

- 75% lecture attendance,
- 100% exercise attendance,
- AutoCAD 2D pre-exam pass,
- 60% score in e-learning pre-exam.

Grading and evaluation of student work over the course of instruction:

- AutoCAD entrance exam – if passed students are not obliged to attend AutoCAD excerices,
- AutoCAD pre-exam – making a blueprint of a simple house using basic tools,
- e-learning entrance exam (all modules) – if passed, students are not obliged to attend e-learning exercises in particular (passed) modules,
- Make up pre-exam in AutoCAD,
- Make up pre-exam in e-learning modules.

Required literature:

1. D. Gookin: *PC For Dummies, Windows 7 Edition*, Willey Publishing Inc., 2010
2. P. Weverka: *Office 2010 All-In-One For Dummies*, Willey Publishing Inc., 2010
3. B. Fane: *AutoCAD 2014 For Dummies*, Willey Publishing Inc., 2013

Optional literature:

1. T. Dzambazova, E. Krygiel, G. Demchak: *Introducing Revit Architecture 2010*: BIM for Beginners, Willey Publishing Inc., 2009
2. G. Freund: Network Security For Dummies, Willey Publishing Inc., 2003

MATHEMATICAL PROGRAMMES FOR ENGINEERS

Credit value (ECTS): 2

Number of hours (in semester):

- Lectures: 15
- Exercises (design): 15

Course objectives:

- Training in the application of computer software in solving mathematical tasks,
- Developing logical skills,
- Acquiring basic knowledge in computer programming.

Entry competences (foreknowledge, descriptive):

- Secondary school mathematics.

Learning outcomes:

- Ability to solve mathematical tasks using computers,
- Understanding computer programming and ability to write a simple computer program,
- Ability to apply acquired knowledge and skills in further study.

Course content:

- Lectures:
  1. Introduction into computer algebra systems (CAS) [1]
  2. Numerical and symbolic calculus using computer software [5]
  3. Visualisation of functions and data using computer software [2]
  4. Basics of computer programming [7]
     4.1 Data types, variables, constants, commands,
     4.2 Looping and branching,
     4.3 Functions,
     4.4 Containers (lists, sequences, dictionaries). Derived types,
     4.5 Programming paradigms
- Exercises (in the computer room):
  1. Arithmetic operations, elementary functions [1]
  2. Polynomials, functions, graphs [1]
  3. Equations, systems of equations, inequalities [2]
  4. Vectors and matrices [1]
  5. Limits, derivatives and integrals [1]
  6. 2D and 3D graphics [2]
  7. Data types, variables, commands [2]
  8. Looping and branching [2]
  9. Functions, containers [2]
- Pre-exams cover:
  1. Numerical and symbolic calculus and visualisation,
  2. Basic computer programming.

Student responsibilities:

- Regular attendance in lectures and exercises,
- Two pre-exams – 40% score required in each,
- One make up pre-exam.

Grading and evaluation of student work over the course of instruction:

- Grading pre-exams:
  - 40-59% score – sufficient (2),
  - 60-74%score – good [3],
  - 75-89% score – very good [4],
  - 90-100% – excellent [5].

Required literature:

1. Course materials: `http://sage.grad.hr`
2. *Sage PREP Tutorials*, `http://sagemath.org/doc/prep/index.html.`
3. M. O'Sullivan, R. Rosenbaum, D. Monarres: *Sage Tutorial*, `http://www-rohan.sdsu.edu/~mosulliv/Courses/sdsu-sage-tutorial/index.html`.

Optional literature:

1. *Sympy Tutorial*, `http://docs.sympy.org/latest/tutorial/index.html`
2. G. van Rossum: *The Python Tutorial*, `http://docs.python.org/2/tutorial/index.html`

GEODESY

Credit value (ECTS): 4

Number of hours (in semester):

- Lectures: 30
- Exercises: 30 (auditory - 10, design - 10, field - 10)

Course objectives:

- Applying the acquired knowledge to project implementation – cooperation of construction and surveying experts,
- Training for team work.

Entry competences (foreknowledge, descriptive):

- Knowledge of basic properties of trigonometric functions,
- Basic knowledge about infinitesimal calculus (derivations and integrals),
- Basic knowledge about working on computer: text processing, grid computing, basic graphic programs.

Learning outcomes:

- Ability to analyse and use geodetic maps: maps and plans of different scales,
- Understanding the role of the geodetic works in construction in various design phases,
- Application of acquired knowledge in preparation of project documentation and realization of concrete project tasks,
- Analysing and recognising the importance of geodetic works in various design tasks and the need to involve geodetic experts,
- Ability to obtain geodetic documentation necessary for the design and transfer of the project into field,
- Implementing simple geodetic task in field.

Course content:

- Lectures:
  1. The shape and size of the Earth and its mapping on maps and plans [2]
  2. Geodetic instruments. Basic geodetic measurements: length, angles and altitude differences [2]
  3. The basic theory of errors and adjustments [2]
  4. Coordinate systems in geodesy. National coordinate system [2]
  5. Basic geodetic works. Positional geodetic networks [2]
  6. Altitude geodetic maps. Methods of height determination [2]
  7. Cartography. Scale geodetic plans and maps. Cartometry [2],
  8. Calculating areas and volumes based on measured values and data obtained from surveying: from plans and maps of various scales [2]
  9. Land surveying methods; classic, photogrammetric, satellite [2]
  10. Spatial databases. Geoinformation systems – GIS [2]

11. Cadastral contents and land registry [2]
12. Surveying in design and construction [2]
13. Surveying in various construction branches [2]
14. Surveying in design and route design of traffic routes [2]
15. Determination of displacements and deformations of objects using different geodetic methods [2]

- Exercises (auditory):
  1. Coordinate calculus. Calculating direction angles, horizontal angles, lengths, areas and volumes from the coordinates of points. First and second geodetic task [2]
  2. Determining the altitude differences by geometric and trigonometric precise levelling,
  3. Surveying methods of capturing details. Practical examples [2]
  4. The theory of errors and adjustment calculus. Examples of direct and indirect measurements [2]
  5. Special databases. Examples of GIS based on geodetic data [2]
- Exercises (field):
  1. Measuring horizontal and vertical angles and slanting lengths (theodolite, measuring station) in triangle [5]
  2. Determining altitude differences using geometric and trigonometric precise levelling. Determining the heights of objects based on measured values [5]
- Exercises (design):
  1. Calculating angles and lengths in a triangle using trigonometric functions. Calculating area by analytic and trigonometry method. Calculating altitude differences and altitude of points by geometric and trigonometric precise levelling [5]
  2. Cartometry: reading the coordinates of four points from a map, scale 1: 5000. Numerical calculations of directional angles, horizontal angles, lengths, areas and volumes from coordinates of points on a map. Creating a longitudinal profile and transverse profiles for a section of a traffic route marked on a map, based on the lengths and heights from the map. Calculating the terrain inclination for route sections [5]

Student responsibilities:

- Regular attendance in lectures and exercises,
- Doing 2 design assignments.

Grading and evaluation of student work over the course of instruction:

- Two pre-exams: students achieving 60% score are exempt from the written exam,
- Requirement for pre-exams - doing 2 design assignments.

End of semester grading:

- Written exam - 60% score,
- Oral exam.

Contributions to the final grade:

- Attendance in lectures and exercises 5%,
- Two pre-exams (or written exam) 60%
- Oral exam 35%.

Required literature:

1. Cigrovski-Detelić, B.: Repozitorij – *Geodezija, predavanja*: `www.grad.unizg.hr`, Građevinski fakultet Sveučilišta u Zagrebu, Zagreb, 2012
2. Cigrovski-Detelić, B.: *Topografija*, mimeographed copy, Geodetski fakultet Sveučilišta u Zagrebu, Zagreb, 2009
3. Kapović, Z.: *Geodezija u niskogradnji*, Geodetski fakultet Sveučilišta u Zagrebu, Zagreb, 2010
4. Pribičević, B., Medak, D.: *Geodezija u građevinarstvu*, V.B.Z. d.o.o., Zagreb, 2003

Optional literature:

1. Benčić, D., Solarić, N.: *Mjerni instrumenti i sustavi u geodeziji i geoinformatici*, Školska knjiga, Zagreb, 2008

2. Frančula, N.: *Kartografske projekcije*, skripta, Geodetski fakultet Sveučilišta u Zagrebu, Zagreb, 2000.
3. Roić, M.: *Upravljanje zemljišnim informacijama: katastar*, Geodetski fakultet Sveučilišta u Zagrebu, Zagreb, 2012.

Elective courses

INTRODUCTION TO CIVIL ENGINEERING

Credit value (ECTS): 3

Number of hours (in semester):

- Lectures: 30
- Seminars: 15

Course objectives:

- Introducing students with their future profession – civil engineering,
- Clarifying basic terms and various fields of civil engineering.

Learning outcomes:

- Thorough knowledge about an extensive and pervasive profession -civil engineering,
- Learning to distinguish between the different areas of civil engineering,
- Theoretical knowledge on basic civil engineering terms,
- Ability to assess specific achievements and evaluate them in the context of the worldwide achievements in the field of civil engineering.

Course content:

- Lectures:
  1. Introduction [2]
  2. History of civil engineering [2]
  3. Professions in building construction; Structures in nature [2]
  4. Bearing systems [1]
  5. Materials; Construction methods [3]
  6. Structures [2]
  7. Traffic infrastructures [2]
  8. Hydraulic Engineering Structures; Building from concept to construction [2]
  9. Sustainable development; Management of structures [2]
  10. Regulations and codes; Ethics in civil engineering [2]
  11. World achievements in civil engineering [2]
  12. Croatian achievements in civil engineering [2]
- Seminars:
  1. Technical description of a chosen building, description of the present state of the building [15]

Student responsibilities:

- Regular attendance in lectures,
- Writing a seminar paper.

Grading and evaluation of student work over the course of instruction:

- Evaluation of the seminar,
- 2 pre-exams - students who achieve minimum 60% score in each pre-exam, are exempt from the exam.

End of semester grading:

- Written exam - 60% score required,
- Oral exam.

Contributions to the final grade:

- Seminar 10-20%,
- Written exam or pre-exams 80-90%

Required literature:

1. J. Radić: *Introduction to Civil Engineering*, mimeographed notes published on the website: http://www.grad.unizg.hr/predmet/uug

Optional literature:

1. Pech, A., Kolbitsch, A., Zach, F., Pauser, A., Zeininger, J.: *Tragwerke*, Springer-Verlag, Wien, 2007

HISTORY OF BUILDING

Credit value (ECTS): 3

Number of hours (in semester):

- Lectures: 30 hours

Course objectives:

- To follow literature on subject matter and apply the acquired knowledge in further training,
- To apply the acquired knowledge in engineering analysis,
- To differentiate between the assumptions, arguments and solutions in engineering work,
- To shape and creatively use the acquired knowledge in the real world,
- To present professional topics.

Course content:

- Lectures:
  1. Introduction –the art of construction and history of building [2]
  2. Construction as primary process, constructive elements, history of shaping [2]
  3. Construction in Mesopotamia [2]
  4. Construction in Egypt [2]
  5. Construction in the Aegean area and Greece [2]
  6. Construction in Ancient Rome [2]
  7. Construction in late Antiquity and early Christianity [2]
  8. Construction in the middle Ages: Pre-romanesque, Romanesque and Gothic styles [2]
  9. The modern era – Humanism and Renaissance [2]
  10. The modern era – Baroque and Classicism [2]
  11. The modern era – Foundation of new Architecture [2]
  12. The modern era – the present, trends and tendencies [2]

Student responsibilities:

- Course attendance,
- 2 pre-exams, minimum 25% score in each, one make up pre-exam.

Grading system during the semester:

- Pre-exams.

Grading at the end of the semester:

- Written exam.

Required literature:

1. Basic S.,Senjak I., Vezilić Strmo N.: *Internal mimeographed notes*

Optional literature:

1. Muller W., Vogel G.: *Architectural Atlas1&2,* Golden marketing, Zagreb, 1999

SOCIOLOGY OF WORK AND PROFESSIONAL ETHICS

Credit value (ECTS): 3

Number of hours (in semester):

- Lectures: 30

Course objectives:

- This course prepares students for solving social problems connected with work,
- Students learn how to apply basic knowledge of sociology and psychology in work surroundings,
- The course should train civil engineers for effective leadership and team work,
- The course gives basic knowledge about professional and business ethics.

Learning outcomes:

- Effective leadership abilities and knowledge about business ethics.

Course content:

- Lectures:
    1. Course introduction [2]
    2. Basic definitions, subject and methods of investigation [2]
    3. History of work [2]
    4. Classical theories of work [2]
    5. Modern theories of work [2]
    6. Selection of employees [2]
    7. Work motivation [2]
    8. Awards and punishments [2]
    9. Work in construction industry [2]
    10. Professionalism [2]
    11. Professional and business ethics [2]
    12. Ethics of studying, scientific ethics, sexual harassment [2]
    13. Ethics of civil engineers [2]
    14. Business ethics and profit [2]
    15. Final lecture [2]

Student responsibilities:

- Attendance in lectures,
- Pre-exam,
- Final exam.

Grading and evaluation of student work over the course of instruction:

- Pre-exam,
- Activities in the class.

End of semester grading:

- Final exam.

Contributions to the final grade:

- Discussions in class and class attendance 10 %,
- Mid-term exam 20 %,
- Final exam 70 %.

Required literature:

1. Antić, Miljenko, *Sociology of work and professional ethics*, Textbook, 2012

Optional literature:

1. Grint, Keith, *The Sociology of Work*, Polity Press, Cambridge, 2005
2. Jennings, Marianne M.*Business Ethics: Case Studies and Selected Readings*. Eagan, USA: Thomson West, 2006

3. Dienhart, John W., *Business, Institutions and Ethics: A Text with Cases and Readings,* Oxford University Press, 2000
4. Vecchio, Robert P., *Organizational behaviour: core concepts***,** Mason, Ohio: Thomson/South-Western, 2003
5. Dessler, Gary. *Human Resource Management*. Upper Saddle River, USA: Pearson Education, 2005
6. Kendall, Dina., *Sociology in Our Times: The Essentials*. Belmont, USA: Wadsworth, 2002
7. Vecchio, Robert P., 2003, *Organizational behavior: core concepts***.** Mason, Ohio: Thomson/South-Western, 2003

BASICS OF CIVIL ENGINEERING LAW

Credit value (ECTS): 3

Number of hours (in semester):

- Lectures: 30

Course objectives:

- Introducing the basics of public (planning and construction) and private law (property and obligation law).

Learning outcomes:

- Knowledge of and understanding the basics of legal system,
- Knowledge of and understanding the basics of property law,
- Knowledge of and understanding the basics of obligation law,
- Knowledge of and understanding the basics of spatial planning,
- Knowledge of and understanding the basics of construction.

Course content:

- Lectures:
    1. Introductory lecture [2]
    2. Basic questions related to the structure of law [4]
    3. Status issues – natural and legal persons [2]
    4. Legal affairs [2]
    5. Property law – possession [2]
    6. Property law – right of ownership [2]
    7. Land registry [2]
    8. Property rights on other people's possession [2]
    9. Obligation law [2]
    10. Obligation law – agreements [2]
    11. Cadastre, spatial planning, construction [6]

Student responsibilities:

- Regular attendance and pre-exam pass.

Grading and evaluation of student work over the course of instruction:

- Pre-exam.

End of semester grading:

- Written exam.

Contributions to the final grade:

- Pre-exam results.

Required literature:

1. Rajčić, D., Nikšić, S.: *Uvod u građevinsko pravo*, university textbook, HSN, Zagreb, 2008

Optional literature:

1. Relevant regulations.

BUSINESS ECONOMICS

Credit value (ECTS): 3

Number of hours (in semester):

- Lectures: 30
- E-learning: 2nd level

Course objectives:

- Gaining theoretical knowledge about the history and development of economics,
- Understanding the concept of companies, business activities, business results and the environment in which a company operates.

Learning outcomes:

- Description of the development of economics as a scientific discipline and the list of the most prominent economic theorists throughout history,
- Definition of company types, restrictions and principles of business companies and business operations through the process of reproduction and business assets,
- Definition of the key elements of production; input & output, working capital; basic assets, capacity, amortization, costs and price calculation; price, purchase price, supply price;
- Interpretation of business success measures; cost-effectiveness, productivity, profitability;
- Analyses of business environment; concept of earning, indicators of economic development, factors of economic development, technical structure of economy,
- Evaluation of the contribution of factors affecting the performance of an enterprise.

Course content:

- Lectures:
  1. History of economics [2]
  2. Basics of reproduction process[2]
  3. Business assets [2]
     3.1. Basic asset
     3.2. Working assets
  4. Costs, price and price calculation[4]
     4.1. Costs (direct/indirect; fixed/variable)
     4.2. Price (purchase price/supply price; law of supply and demand; elasticity of demand)
     4.3. Price calculations (calculation methods; calculations in construction)
  5. Business results[2]
     5.1. Financial reports
     5.2. Business success measures (cost-effectiveness, productivity, profitability
  6. Company and its environment[2]
     6.1. Company types
     6.2. Restrictions in company operations
     6.3. Principles of company operations
  7. Business environment[2]
  8. Factors affecting company performance[4]

Student responsibilities:

- Attendance in more than 75% lectures,
- Achieving minimum25% score in every pre-exam,
- Written paper,
- Using *Merlin*.

Grading and evaluation of student work over the course of instruction:

- Written paper,

- Three pre-exams (students who earn in all pre-examsminimumgrade3, will be exempt from the written part of the exam, students who earn in all pre-exams grade4or5, will be exempt from taking the exam).

End of semester grading:

- Written exam,
- Oral exam.

Contributions to the final grade:

- Pre-exams 80%,
- Paper 15%,
- *Merlin* 5%.

Required literature:

1. Mariza Katavić*,Osnove ekonomike za graditelje*, Hrvatska sveučilišna naklada, Zagreb, 2009
2. Lecture notes (hand outs on *Merlin*)

ENGLISH IN CIVIL ENGINEERING 1

Credit value (ECTS): 3

Number of hours (in semester):

- Lectures: 30

Course objectives:

- Systemic overview of basic grammatical structures,
- Acquiring general civil engineering vocabulary from the fields of construction materials, transportation, geotechnical, hydro-engineering, structural engineering.
- Obtaining key terms through the survey of the history of civil engineering,
- Mastering translation techniques in professional vocabulary,
- Giving short presentations, focusing on sentence structuring, style and most common mistakes.

Entry competences (foreknowledge, descriptive):

- Intermediate or B1 according to the European Language Framework

Learning outcomes:

- Mastering skills and competences involving the key terms in civil engineering, Independent and fluent acquisition of basic vocabulary,
- Reinforcement of basic grammar categories used in technical language - passive, tenses, modal verbs,
- Gaining fluency in structuring sentences and developing skills of individual presentation and writing technical reports.

Course content:

1. Civil engineering as a profession [2]
2. What is cool about being an engineer [2]
3. Go where the action s [2]
4. Principal construction materials [2]
5. Environmental engineering [2]
6. The birth of modern structures [2]
7. Up in the air [2]
8. Bridges [2]
9. Skyscrapers [2],
10. Revision of tenses [2],
11. Revision of vocabulary [2]

12. Domes [2]
13. Aswan high dam [4]
14. Term preliminary exam [2].

Student responsibilities:

- Attendance 75%,
- Taking 3 pre-exams.

Grading and evaluation of student work over the course of instruction:

- Through regular attendance and continuous work the student can be exempt from a part of exam or the entire exam,
- Checking acquired knowledge in written or oral form is conducted regulary,
- The skills required include comprehension of engineering texts, summary writing, giving presentation on technical topics, mastering grammar categories most applied in technical reports.

End of semester grading:

- The credits earned through all the testing and pre-exams make up the final grade.
- Grading is as follows
  - 50-62% score – sufficient [2],
  - 63-75% score – good [3],
  - 76-88% score – very good [4],
  - 89-100% score – excellent [5].

Contributions to the final grade:

- Grading is based on the following: results achieved through regular work in class involving homework assignments, presentations, active listening, grammar check.

Required literature:

1. Kralj Štih: *English in Civil Engineering,* Hrvatska sveučilišna naklada, 2004

Optional literature:

1. D. Bonamy: *Technical English 3,* Pearson Longman, 2011
2. Vulelija, *Ilustrirani rječnik arhitekture i građevinarstva* – hrvatsko engleski i englesko hrvatski, Masmedia, Zagreb, 2010
3. Prager, *Trojezični građevinski rječnik*, Masmedia, Zagreb, 2002
4. Internet pages Building Big, Brantacan, ASCE

GERMAN IN CIVIL ENGINEERING 1

Credit value (ECTS): 3

Number of hours (in semester):

- Lectures: 30

Course objectives:

- Systemic overview of basic civil engineering topics and grammatical structures.
- Acquisition of general civil engineering vocabulary in the fields of construction materials, transportation, geotechnical, hydro-engineering, structural engineering.
- Acquiring key terms through the survey of the history of civil engineering.
- Mastering translation techniques in professional vocabulary.
- Giving short presentations, focusing on sentence structure, style and most common mistakes.

Entry competences (foreknowledge, descriptive):

- Intermediate – B1 level

Learning outcomes:

- Mastering skills and competences involving key terms in civil engineering. Independent and fluent application of basic vocabulary,

- Understanding technical vocabulary,
- Reinforcement of basic grammar categories used in technical language - passive, tenses, modal verbs.

Course content:

1. Was ist Bauingenieurwesen? (2)
2. Wie wird man Bauingenieur(in)? (2)
3. Bauingenieure haben ein weites Feld….. (3)
4. Bauingenieure gestalten die Umwelt (2)
5. Wie entstehen Ingenieurbauten – die Arbeitsweise des Bauingenieurs (3)
6. Geschichte der Baustoffe (2)
7. Wie haben Erfindungen das Aussehen von Bautenverändert? (3)
8. Die Baustoffe für Ingenieurbauten (2)
9. Die Entwicklung der ersten Wolkenkratzer (3)
10. Vokabelübungen (Dialogübungen) (2)
11. DieBrücken I (3)
12. DieBrücken –II /
13. Ein Mann der Perfektion – G. Eiffel I (3)
14. Turmbau
15. Kolloquium

Student's responsibilities:

- Attendance 75% ,
- Taking 3 pre-exams.

Grading and evaluation of student work over the course of instruction:

- Through regular attendance and continuous work a student can be exempt from a part of the exam or from the entire exam,
- Checking acquired knowledge in written or oral form is conducted regularly,
- The skills required include comprehension of engineering texts, summary writing, giving presentation on technical topics, mastering grammar categories most applied in technical reports.

End of semester grading:

- The credits earned through all the testing and pre-exams make up the final grade.
- Grading is as follows
  - 50-62% score – sufficient [2],
  - 63-75% score – good [3],
  - 76-88% score – very good [4],
  - 89-100% score – excellent [5].

Contributions to the final grade:

- Grading is based on the following: results achieved through regular work in class involving homework assignments, presentations, active listening, grammar check.

Required literature:

1. A. Kralj Štih: *Deutsch im Bauingenieurwesen*, Hrvatska sveučilišna naklada, 2004

Optional literature:

1. A. Prager: *Trojezični građevinski rječnik*, Masmedia, Zagreb, 2002
2. www. bau.dewww.leo.org

1st year, 2nd semester

Compulsory courses

MATHEMATICS 2

Credit value (ECTS): 8

Number of hours (in semester):

- Lectures: 60
- Exercises (auditory): 45

Course objectives:

- Application of theoretical knowledge on differential and integral calculus for the functions of several variables,
- Acquiring basic competences in differential equations,
- Acquiring basic competences in line and surface integrals.

Entry competences (foreknowledge, descriptive):

- Basic knowledge of differential and integral calculus and analytic geometry in space.

Enrolment requirements (correlated courses):

- Teachers signatures: Mathematics 1

Requirements for examination taking (correlated courses):

- Examinations passed: Mathematics 1

Learning outcomes:

- Knowing basic facts and theorems about differential equations, recognizing types and understanding methods for their solving,
- Recognizing the problems which lead to solving differential equations,
- Understanding the basics of differential and integral calculus for the functions of several variables together with applications,
- Understanding the basics of line and surface integrals and their applications.

Course content:

- Lectures:
  1. Differential equations, introduction [2]
  2. Method of the separation of the variables [2]
  3. Linear differential equation of the first order [2]
  4. Linear differential equation of the second order [4]
  5. Functions of several variables, introduction [2]
  6. Continuous functions and limit [2]
  7. Differential of functions of several variables, derivations of higher order [4]
  8. Taylor's theorem [2]
  9. Extreme value of the function of several variables [4]
  10. Multiple integrals [6]
  11. Method of substitution in multiple integrals [4]
  12. Application of multiple integrals [4]
  13. Scalar and vector fields, gradient [2]
  14. Divergence and rotation, special fields [4]
  15. Curves and line integrals, line integral of the first kind [4]
  16. Line integral of the second kind [4]
  17. Surfaces, surface integral of the first kind [2]
  18. Surface integral of the second kind [2]
  19. Divergence theorem, Stokes theorem [2]

- Exercises (auditory):
  1. Differential equations [7]
  2. Function of several variables [11]
  3. Multiple integrals, applications [12]
  4. Scalar and vector fields [3]
  5. Line integrals [6]
  6. Surface integrals [6]

Student responsibilities:

- Regular attendance,
- Minimum 25% score in pre-exam.

Grading and evaluation of student work over the course of instruction:

- Pre-exam, students with minimum 60% score are exempt from the part of the exam

End of semester grading:

- Written and oral exam.

Contributions to the final grade:

- Written exam 50%
- Oral exam 50%

Required literature:

1. Došlić, T., Filipin, A.: *Internal mimeographed notes*

Optional literature:

1. I. Brnetić, V. Županović: *Višestruki integrali*, Element, Zagreb, 2004,
2. N. Elezović: *Diferencijalne jednadžbe*, Element, Zagreb, 2004,
3. P. Javor: *Matematička analiza 2*, Element, Zagreb, 2004,
4. L. Korkut, M. Krnić, M. Pašić: *Vektorska analiza*, Element, Zagreb, 2007

PHYSICS

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 60
- Exercises: 15 (auditory – 1, laboratory - 14)

Course objectives:

- Lectures: acquiring knowledge in solving special examples and tasks, setting physics experiments for verifying solutions of the problems; developing skills in reducing real life phenomena to physics models, skills in finding equations for physics models, skills in recognising a common physics basics for different real life phenomena.
- Exercises: developing skills in preparation for laboratory work and skills for conducting laboratory experiments in a laboratory, data measuring and processing, gaining knowledge about physical basis of phenomena, and about measuring and processing measures.

Entry competences (foreknowledge, descriptive):

- Competence in applying vector, differential, integral and matrix calculus.

Enrolment requirements (correlated courses):

- Teachers signatures: Mathematics 1

Requirements for examination taking (correlated courses):

- Examinations passed: Mathematics 1

Learning outcomes:

- Competence in solving special examples and tasks, in setting physics experiments which verify the solutions of problems,
- Skills in recognising a common physics basics for different real life phenomena,
- Skills in reducing real life phenomena to physics models, in finding equations for physics models,
- Skills in preparation for laboratory work, skill in laboratory team work, data measuring and processing, knowledge about the physical basis of phenomena, measuring and processing measures.

Course content:

- Lectures:
  1. *Mechanics of material particles and rigid bodies* (with experiments within lectures): dynamics, work, energy, strengths, conservation laws [2]. Oscillation, curvilinear motion, nutation, precession, gravitation, relative systems [4]
  2. *Mechanics of fluids* (with experiments within lectures): Euler's method, statics of fluids [2]. Laminar flows, body motion [4]. Viscosity of fluids, vortices, model testing [4]. Capillarity, surface tension [1]
  3. *Electro-magnetism* (with experiments within lectures): Coulomb's law, energy, potential, voltage, condensers, electric dipole, dielectrics, current [5]. Magnetic field [3]. Alternating current, law of induction, work, power [2]. Transformers, electric resonance, electromagnetic waves [1]
  4. *Optics* (with experiments and computer simulations within lectures): Fermat's principle, plane waves, spherical waves, spreading of waves [2]. Spreading of waves through media, ideal and spheric diopter, spherical aberration, colours, photometry, vision [2]. Geometrical optics, physical optics, interference, diffraction, polarisation, lasers [2]
  5. *Acoustics* (with experiments and computer simulations within lectures): longitudinal waves, creation and spreading of waves in media, supersonic wave fronts, hearing [4]
  6. *Heat* (with experiments and computer simulations within lectures): temperature, kinetic-molecular theory, work [2]. Heat, thermodynamic properties of bodies, calorimeters, mechanical equivalent of heat [2]. Thermodynamics, 1st and 2nd laws [3]. Thermodynamic cycles, Otto cycle, Diesel cycle, Carnot cycle, heat engine, heat pump [3]. Phases [2]. Conduction, convection and radiation and their combinations, properties of substantances [2].
  7. *Atomistics, structure and testing of materials* (with tests and computer simulations within lectures): matterwaves, photoelectric effect, line spectra, Franck-Hertz experiment, Bohr's model [3]. The structure of atoms and molecules, structure of materials, properties of materials, properties of chemical bindings [3]. Testing of material properties, X-rays, electron diffraction [2]

- Laboratory exercises (all students do not participate in all exercises):
  1. Measuring with measuring instruments,
  2. Airy's pendulum,
  3. Density of solid bodies,
  4. Density of alcohol,
  5. Spiral spring law,
  6. Torsional oscillation,
  7. Physical pendulum,
  8. Friction,
  9. Speed of sound in air and in CO_2,
  10. Spherical mirror,
  11. Bessel method for measuring the focal length,
  12. Prism spectrometer,
  13. Photometric laws,
  14. Determining properties of light source,
  15. Young's experiment,
  16. Heat of vaporization,
  17. Joule's law,

18. Heat pump – heat raiser,
19. Ohm's law,
20. The strength of alternating current.

- Auditory exercise: preparation for exam.

Student responsibilities:

- Regular attendance in lectures and exercises,
- 3 pre-exams: minimum 35% score; one make-up pre-exam.

Grading and evaluation of student work over the course of instruction:

- Students with a 60% score in pre-exams are exempt from the part of the final exam (final test is compulsory).

End of semester grading:

- Final test and final exam (final test is the requirement for the final exam).

Contributions to the final grade:

- Final test 20%
- Final exam 80%

Required literature:

1. Kulišić, P.: *Mehanika i toplina,* Školska knjiga, Zagreb, 1991
2. Henč-Bartolić, V.; Kulišić, P.: *Valovi i optika,* Školska knjiga, Zagreb, 1989
3. Pavičić, M.: *Zbirka riješenih za ataka iz fizike,* (2. izdanje), Sveučilište u Zagrebu, Zagreb, 1984
4. Babić, E.; Krsnik, R.; Očko, M.: *Zbirka riješenih za ataka iz fizike,* Školska knjiga, Zagreb, 1988

MECHANICS 1

Credit value (ECTS): 5

Number of hours (in semester):

- Lectures: 30
- Exercises (auditory): 30

Course objectives:

- Acquiring theoretical knowledge of and understanding the physical meaning of a force and a moment equilibrium and the behavior of structures under load and on the modes of transmission of forces,
- Acquiring practical knowledge about the methods in design of statically determined structures.

Entry competences (foreknowledge, descriptive):

- Linear algebra, trigonometry, differential and integral calculus, descriptive geometry and physics.

Enrolment requirements (correlated courses):

- Teachers signatures: Mathematics 1, Descriptive geometry

Requirements for examination taking (correlated courses):

- Examinations passed: Mathematics 1

Learning outcomes:

- Knowledge of vector mechanics, representation of physical quantities by a vector notation. Grasping the meaning of magnitude and direction of a vector, understanding the definition of a unit vector,
- Understanding the physical meaning of a force and a moment equilibrium. Mastering the balance of forces and moments to ensure equilibrium for 2D and 3D structures,

- Students acquire the skill in drawing a correct and complete free body diagram of forces and moments for a structure,
- Understanding the internal forces in structures and learn how to draw the internal forces diagrams for beams, Gerber beams and three-hinged frames,
- Students learn the method of joints and the method of sections for the analysis of trusses. They should also be able to identify the zero force members of a truss by inspection,
- Understanding the concept of friction on surfaces and calculating friction forces,
- Skill in calculing the centroid of lines, areas, volumes and composite bodies,
- Understanding the method of virtual work.

Course content:

- Lectures:
    1. Basic concepts and principles. Statics of particles. Forces in plane and space. Resultants. Resolution of a force into components. Unit vectors. Equilibrium of a particle in plane and space [2]
    2. Vector analysis. Rigid bodies: Equivalent systems of forces. Moment of a force about a point and a given axis. Varignon's theorem. Moment of a couple. Reduction of a system of forces in plane and space to one force and one couple. Reduction of a system of forces to a wrench [4]
    3. Graphic analysis of forces in the plane [2]
    4. Distributed forces: Centroids and centers of gravity [2]
    5. Equilibrium of rigid bodies. Free body diagram. Reactions on supports and connections for two and three dimensional structure [2]
    6. Analysis of structures. Beams. Internal forces in structural members. Various types of loading and support. Internal forces diagrams. Relations among load and internal forces [7]
    7. Gerber beams [1]
    8. Plane trusses: Method of joints, Method of Sections [2]
    9. The three-hinged frames [2]
    10. Method of virtual work [2]
    11. Friction [1]
    12. Cables [1]
- Exercises (auditory):
    1. Examples of vector of force in space and in plane. Resultants. Equilibrium of a particle in plane and space [2]
    2. Moment of a force about a point, a given axis [2]
    3. Reduction of a system of forces in plane and space to one force and one couple [2]
    4. Equilibrium of rigid bodies [2]
    5. Reactions on supports and connections for two and three dimensional structure [3]
    6. Distributed forces: Centroids and centers of gravity [1]
    7. Beams [10]
    8. Plane trusses: Method of joints, Method of Sections [2]
    9. The three-hinged frames [2]

Student responsibilities:

- Lecture and exercise attendance,
- Solving 2 programs,
- 2 pre-exams: 25% score, 1 make-up pre-exam.

Grading and evaluation of student work over the course of instruction:

- 2 pre-exams: students who achieve a 60% score in each pre-exam are exempt from the written part of the exam

End of semester grading:

- Written exam: 50% for a pass,
- Oral exam.

Contributions to the final grade:

- Programs 10%,
- pre-exams or written exam 50-60%,
- oral exam 30-40%

Required literature:

1. Werner, H.*: Mehanika 1 - Statika*, HSGI, Zagreb, 2007,
2. Nikolić, Ž.: *MehanikaI*, SveučilišteuSplitu, Građevinsko-arhitektonskifakultet, Split, 2009,
3. Matejiček, F.; Semenski, D.; Vnučec, Z.: *Uvod u statiku sa zbirkom zadataka*, Golden marketing, Tehnička knjiga, Zagreb, 2005

Optional literature:

1. Beer, F. P.; Johnston, E. R.: *Vector Mechanics for Engineers – Statics*, McGraw-Hill, 1988,
2. Kiričenko, A.: *Tehnička mehanika - Statika*, IGH, Zagreb, 1990,
3. Muftić, O.: *Mehanika 1 (Statika)*, Tehnička knjiga, Zagreb, 1989,
4. Bazjanac, D.: *Tehnička mehanika - Statika*, Tehnička knjiga, Zagreb, 1963

BUILDING CONSTRUCTION

Credit value (ECTS): 7

Number of hours (in semester):

- lectures: 45 hours
- exercises: 45 (auditory – 15, design – 30)

Course objectives:

- Inform students about the elements of construction in buildings and houses. It not only includes the presentation and explanation of each element's properties but also the complete context of their usage as well as the possible functional problems of the building structure.

Learning outcomes:

- Analysis of the structure of construction,
- Description of building structure and its elements,
- Identification of functional problem of a primary structure(structural strong hold) and secondary structure(material support/density of support) in buildings,
- Ability to present expert analyses associated to structure of construction in buildings,
- Applying the acquired knowledge and engineering analyses as well as methodology of work.
-

Course content:

- Lectures:
  1. Introduction. Foundation. Hydro-insulation [3]
  2. Vertical construction [3]
  3. Stone walls [3]
  4. Concrete slabs [3]
  5. Dividing slabs [3]
  6. Stucco [3]
  7. Ceiling construction [3]
  8. Flooring [3]

9. Roof top [3]
10. Roofing materials [3]
11. Staircases [3]

- Exercises:

1. Auditory
   Site Plan M 1:500, Block Plan M 1:200, Floor Plan M 1:100
2. - 4. Constructive
   design - Site Plan M 1:500, Block Plan M 1:200, Floor Plan M 1:100
5. Program completion
   Site Plan M 1:500, Block Plan M 1:200, Floor Plan M 1:100
6. Auditory
   Floor Plan M 1:50
7. - 9. Constructive
   design - Floor Plan M 1:50
10. Program completion
   Floor Plan M 1:50
11. Auditory
   Section drawing M 1:50
12.-14. Constructive
   design - Section drawing M 1:50
15. Program completion
   Section drawing M 1:50

Student responsibilities:

- Regular attendance in lectures and exercises,
- Program development,
- 2 pre-exams with a minimum 25% score, a make-up pre-exam.

Grading and student evaluation during the semester:

- Pre-exams,
- Programs/ exercises.

End of semester grading:

- Written exam.

Required literature:

1. Basic S.,Senjak I., Vezilić Strmo N.: *Internal mimeographed notes of lectures*

Optional literature:

1. Peulić, Đ*.: Konstruktivni elementi zgrada I. i II.*, Tehnička knjiga, Zagreb, 1980,
2. Peulić, Đ.: *Konstruktivni elementi zgrada*, Croatia knjiga, Zagreb, 2002,
3. Neufert, P.: *Elementi arhitektonskog projektiranja*, Golden marketing, Zagreb, 2002

MATERIALS SCIENCE

Credit value (ECTS): 4

Number of hours (in semester):

- Lectures: 30
- Exercises (auditory): 15

Course objectives:

- Learning about materials used in civil engineering. An emphasis is put on the description of structure and physical, chemical and mechanical properties of materials.

Entry competences (foreknowledge, descriptive):

- Basic knowledge of physics and chemistry.

Learning outcomes:

- Information, theoretical and factual knowledge about materials. Cognitive skills about basic testing and properties of construction materials. Competences: integration of knowledge in future study and work.

Course content:

- Lectures:
  1. Introduction [2]
  2. Physical properties of materials [2]
  3. Classification of materials and their properties [2]
  4. Surface properties, capillary absorption, surface stress [2]
  5. Atom bonding; Physical parameters of materials: thermal, acoustic, optical and electrical properties of materials [3]
  6. Chemical properties of materials [3]
  7. Development of microstructure: hardening, changes in phases, diagrams of phases [2]
  8. Reaction of materials to action of external forces [2]
  9. Deformations under short-term and long-term loading [2]
  10. Theories of material failure: mechanics of failure [2]
  11. Rheology of liquids and solid bodies [2]
  12. Fatigue of materials; Durability of materials [2]
  13. Regulatory rules [2]

- Exercises (auditory):
  1. Physical parameters of materials [3]
  2. Permeability properties [3]
  3. Thermal properties of materials [3]
  4. Optical and electrical properties of materials [3]
  5. Mechanical properties of materials [2]
  6. Statistical analysis [1]

Student responsibilities:

- 75 %, attendance in lectures, 100% attendance in exercises,
- 2 programs,
- 2 pre-exams (min 25 % score in each).

Grading and evaluation of student work over the course of instruction:

- Minimum 60 % score in each preliminary exam.

End of semester grading:

- Written examination, minimum 50 % score.

Contributions to the final grade:

- Written examination 100 %,
- Preliminary exams 70%,
- Programs 30%.

Required literature:

1. Bjegović, D., Balabanic, G., Mikulic, D.: *Construction materials – solution manual*, Faculty of civil engineering, University of Zagreb, 2007 (in Croatian)
2. Ukrainczyk, V.: *Introduction to construction materials*, Institut građevinarstva Hrvatske, Alcor, Zagreb, 2001 (in Croatian)
3. Young, J.F., Mindess, S.,Gray, R.J., Bentur, A.: *The Science and Technology of Civil Engineering Materials*; Prentice Hall, 1998,
4. Beslac, J.: *Materials in architecture and civil engineering*, Školska knjiga, Zagreb, 1989 (in Croatian)

Optional literature:

1. Ashby, M. F.; Jones, D. R.: *Engineering Materials 1*, Butterworth Heinemann 1996,
2. Illston, J. M., Domone, P. L. J. (ed.): *Construction materials – their nature and behavior*, 4th edition, SPON Press, 2010

2nd year, 3rd semester

Compulsory courses

PROBABILITY AND STATISTICS

Credit value (ECTS): 4

Number of hours (in semester):

- Lectures: 30
- Exercises (auditory): 30

Course objectives:

- Acquiring basic theoretical knowledge about descriptive and inferential statistics and theory of probability,
- Acquiring basic statistical culture.

Entry competences (foreknowledge, descriptive):

- Secondary school mathematics.

Enrolment requirements (correlated courses):

- Teachers signatures: Mathematics 2
- Examinations passed: Mathematics 1

Requirements for examination taking (correlated courses):

- Teachers signatures: Mathematics 2
- Examinations passed: Mathematics 1

Learning outcomes:

- Understanding and availability of the interpretation of descriptive statistical data,
- Availability of the presentation of descriptive statistical data,
- Understanding random variables,
- Knowing basic theoretical facts and fields of the applications of the most common probabilistic distributions,
- Understanding relations of statistical variables in the population and model,
- Knowledge of and ability to apply elementary methods of inferential statistics – interval estimates, tests.

Course content:

- Lectures:
  1. Descriptive statistics [8]
  2. Theory of probability [4]
  3. Random variables and their distribution [4]
  4. Basic methods of inferential statistics [12]

- Exercises (auditory):
  Same as lectures

Student responsibilities:

- Regular attendance,
- Minimum 25% score in mid-term exam.

Grading and evaluation of student work over the course of instruction:

- Pre-exam, students with a minimum 60% score are exempt from the part of the exam.

End of semester grading:

- Written and oral exam.

Contributions to the final grade:

- Written exam 50-60%,
- Oral exam 40-50%

Required literature:

1. Internal mimeographed notes.

STRENGTH OF MATERIALS I

Credit value (ECTS): 7

Number of hours (in semester):

- Lectures:45
- Exercises: 45 (auditory – 39, laboratory – 6)

Course objectives:

- Acquisition of theoretical knowledge about the behavior of deformable bodies under the action of external loads,
- Acquisition of theoretical knowledge about the mechanical properties of materials, and the calculation stresses and deformations of structural elements and whole construction,
- Practical knowledge about the procedures for evaluation of the strength and stiffness of construction elements.

Entry competences (foreknowledge, descriptive):

- Knowledge of differential and integral calculus (including ordinary differential equations) and linear algebra,
- Knowledge of solid body statics. Understanding the concepts of internal forces.

Enrolment requirements (correlated courses):

- Teachers signatures: Mechanics 1, Mathematics 1

Requirements for examination taking (correlated courses):

- Examinations passed: Mathematics 1, Mechanics 1

Learning outcomes:

- Applying differential equations of balance and transformation equations to the analysis of stresses and strains,
- Using physical equations and Hooke's law to determine the characteristics of deformable solid bodies,
- Calculating the stresses of straight rods with torsion,
- Distinguishing pure straight bending, bending forces and biaxial bending strength and calculate the base element in bending,
- Identifying and calculating the stresses in bending compound and composite girders,
- Defining and calculating the stresses in the fastener elements loaded in shear,
- Using differential equations elastic line carriers in calculating the deflection and rotation angle girders,
- Calculating the stress and deformation of thin walled vessel.

Course content:

- Lectures:
  1. General assumptions and basic design elements. External and internal forces [3]
  2. General approach to solving problems in the science of resistance of a material. Stress analysis. Stress tensor. Differential equations of balance and transformation equations [3]
  3. Major stresses. Stress ellipsoid. Mohr's stress circle. Octahedral stresses [3]

4. Strain analysis. Concepts of displacement and strain. Strain tensor. Transformation equations. Major strains [3]
5. Continuity condition. Deformability characteristics of rigid bodies – physical equations[3]
6. Hooke law. Material elasticity constant. Law on superposition, Saint Venant principle [3]
7. Permitted stresses, safety coefficient and recent explanation of structure safety [3]
8. Axial beam loading - extension and pressure. Stress concentration. Structurally indeterminate beam systems. Heat and initial stresses [3]
9. Extension of catenary cable. Stress and strain of thin walled vessel. Shear (cutting force) [3]
10. Design of elements under thrust load. Geometric characteristics of flat beam cross sections – moment of inertia. Torsion of flat beams [3]
11. Prandtl's membrane analogy. Statically indeterminate tasks with torsion [3]
12. Bending of flat beams. Pure bending. Bending under forces. Strength design under bending [3]
13. Bending of compound and composite girders. Skew bending [3]
14. Differential equations of second and fourth order of girders elastic line and solving procedure.
15. Deflections due to transverse force. Influence of temperature on deflection [3]

- Auditory exercises:
  1. Numerical solving examples. Stress analysis. Strain analysis [6]
  2. Hooke law [3]
  3. Axial beam loading - extension and pressure [3]
  4. Stress and strain of thin walled vessel. Shear (cutting force) [3]
  5. Design of elements under thrust load [6]
  6. Geometric characteristics of flat beam cross sections – moment of inertia [3],
  7. Torsion of flat beams. Prandtl's membrane analogy. Statically indeterminate tasks with torsion. Bending of flat beams [6]
  8. Pure bending. Bending of compound and composite girders [6]
  9. Skew bending. Differential equations of second and fourth order of girders elastic line and solving procedure [3]

- Laboratory exercises:
  1. Determination of mechanical properties of materials. Examination of the normal rod, determine the stress-strain diagram. Determination of elastic constants. Saint Venant principle [3]
  2. The impact of sudden changes in the behavior of the cross sections of elastic and elastoplastic materials. Torsion rods of circular cross-section. The principle of superposition [3]

Student responsibilities:

- Regular attendance in and exercises,
- Two pre-exams, in each minimum 25% score; 2 makeup exams.

Grading and evaluation of student work over the course of instruction:

- Pre-exam: students with 50% score are exempt from the written part of the exam.

End of semester grading:

- Students who have scored 50% in written exam are allowed to take the oral exam.

Contributions to the final grade:

- Pre-exams, written exam 50%,
- Oral exam 50%.

Required literature:

1. V. Šimić: *Otpornost materijala I*, Školska knjiga, Zagreb, 2002

Optional literature:

1. I. Alfirević: *Nauka o čvrstoći I*, Tehnička knjiga, Zagreb, 1989,
2. D. Bazjanac: *Nauka o čvrstoći,* Tehnička knjiga, Zagreb, 1973,
3. J. Brnić, G. Turkalj: *Nauka o čvrstoći I*, Tehnički fakultet Sveučilišta u Rijeci, Rijeka, 2004

FLUID MECHANICS

Credit value (ECTS): 6

Number of hours (in semester):

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

Course objectives:

- Acquiring basic theoretical and practical knowledge in the field of fluid hydrostatics, kinematics, potential flow theory, the dynamics of ideal and real fluids, hydraulic structure flows, open channels flow, groundwater flow and physical modelling.

Entry competences (foreknowledge, descriptive):

- Knowledge of differential and integral calculus (including ordinary differential equations) and linear algebra,
- Knowledge and understanding of the particle mechanics (speed, acceleration, Newton's laws, the change of momentum, energy, force, work, power),
- Knowledge and understanding of the substance physical properties (material phases, density, specific volume and the amount of substance),
- Understanding of the stress and pressure, transmission of forces through the material,
- Knowledge of basic theology principles, velocity of compressible phenomena propagation, the speed of sound, thermal expansion of solids and liquids, phase change, latent heat, specific heat, thermal conductivity, surface tension and capillarity, adsorption and absorption,
- Knowledge of the laws of thermodynamics.

Enrolment requirements (correlated courses):

- Teachers signatures: Mathematics2, Mechanics 1, Physics
- Examinations passed: Mathematics1

Requirements for examination taking (correlated courses):

- Examinations passed: Mathematics2, Mechanics 1, Physics

Learning outcomes:

- Understanding the basic concepts of fluid(field of physical quantities, the physical properties of liquids, liquid rheological diagram),
- Understanding and implementing the procedures of fluid statics calculation (equilibrium equations, pressure forces on surfaces, buoyancy, stability of floating body),
- Understanding concepts and procedures used in the calculation of fluid kinematics (the fluid particle motion, streamline, trajectory, stationarity, uniformity, conservatism, total derivative of speed),
- Understanding the concepts and applying procedures and calculation sin fluid dynamics (momentum equation, the general law of real fluids (Saint-Venant and the Navier-Stokes equation), kinetic energy budget, Bernoulli's equation for ideal and viscous fluid, laminar flow, turbulent flow, boundary layer, linear and local energy losses, piezometer and energy line, measurements of speed and pressure within the flow field,
- Application of those finding stopractical hydraulic problems(pipe flow, pump, turbine, spill, overflowing, channel flow, potential flow, groundwater flow, hydrodynamic forces on the immersed body, dynamically stable and unstable forms, physical modelling).

Course content:

- Lectures:
    1. Introduction: basic concepts of fluid and physical quantities fields, the physical properties of liquids, Rheological diagram, forces exerted on fluids [3]
    2. Fluid statics: Euler equilibrium equations and its solving, relative motion [3]
    3. Fluid statics: Forces acting on the surface, buoyancy and lift force, swimming body stability [3]

2. Fluid kinematics: motion of fluid particles, streamline, trajectory, stationarity, uniformity, conservatism, total derivative of velocity [3]
3. Conservation laws for physical quantities field: law of mass conservation (continuity) [3]
4. Fluid dynamics: momentum equations, general law of real fluid flows (Saint-Venant and Navier-Stokesova equations)[3]
5. Kinetic energy equation, Bernoulli equations for ideal and real fluids, laminar flow, turbulent flow, boundary layer theory [3]
6. Flow resistance, linear and local energy losses, piezometric and energy line, measurement of speed, pressure and discharge within the flow field [3]
7. Application to hydraulic problems: pipe flow including pumps and turbines [3]
8. Application to hydraulic structures: small and large orifice, culverts, overflows [3]
9. Open channel flow: specific energy diagram, flow regimes, uniform flow [3]
10. Open channel flow: non-uniform flow, constriction and elevation of the riverbed, water jump, initiation of sediment transport [3]
11. Potential flow: potential flow equations, boundary condition, source-sink, dipole [3]
12. Groundwater flow: Darcy flow equation, hydrodynamic 3D theory, hydraulic 2D theory, Dupuit assumption, groundwater capture objects [3]
13. Fluid forces on the immersed body, dynamically stable and unstable forms, physical modeling [3]

- Exercises:
  1. Fluid Statics: The Governing Equations, Pressure Due to Gravity [2]
  2. Hydrostatic Pressure in a Compressible Fluid [2]
  3. Hydrostatic forces on submerged planar and curved surfaces and bodies, buoyancy [2]
  4. “Solid-Body” acceleration of liquids (linear acceleration, solid-body rotation of a fluid), stability of floating objects [2]
  5. Law of mass conservation (continuity), potential flow and vortices, uniform andnon-uniform flow, steady and unsteady flow [2]
  6. Law of momentum conservation, examples of dynamically stable systems [2]
  7. Law of kinetic energy conservation, Bernoulli equation for ideal fluid, piezometric and energy line [2]
  8. Bernoulli equation for real fluid, generally approach, determination of local and line energy losses, discharge, speed and pressure measurement [2]
  9. Bernoulli equation for real fluid, pipe flow with pumps and turbines [2]
  10. Free discharge (small and large orifice and culverts), sharp crested overflow, Venturi flume, broad crested overflow, specific energy of open channel flow, critical depth and slope, determination of the flow regime according to the bottom slope [2]
  11. Open channel flow: application of Chezy equations calculation of hydraulic parameters [2]
  12. Non-uniform flow, hydraulic jump and calculation of conjugate depths, stilling basin, influence of flow profile changes on water surface elevation [2]
  13. Potential flow in ground water flow analysis, Darcy flow equation, hydrodynamic 3D theory, hydraulic 2D theory, apply of Dupuit assumption in engineering problems of groundwater flow [2]
  14. Groundwater flow field, confined and unconfined well, group of wells, calculating the water table depression, open channel flow as boundary condition [2]
  15. Fluid forces on the immersed body, Froude and Reynolds partial similarity in physical modeling, dimensional analysis [2]

Student responsibilities:

- Attendance in75% of lectures and 100% of exercises,
- Two pre-exams.

Grading and evaluation of student work over the course of instruction:

- Two pre-exam.

End of semester grading:

- According to success achieved in two pre-exams over the course of instruction:
  50% -65% - sufficient [2],
  66% – 80% - good [3],
  81% – 90% - very good [4],
  91% – 100% - excellent [5].
- Students with the score under 50% in pre-exams are required to do the written part of the exam and the oral exam.

Contributions to the final grade:

- Attendance in lectures and success achieved in pre-exams.

Required literature:

1. Jović, *Osnove hidromehanike*, Element, Zagreb, 2005
2. Public domain: (http://www.grad.unizg.hr/predmet/mehtek)
3. Mimeographed notes (pdf, word)
4. Weekly lecture notes (ppt, pdf)
5. Previous exams with a key (pdf, word)

Optional literature:

1. Fancev, *Mehanika fluida*, Tehnička enciklopedija (Technical encyclopedia), vol. 8
2. Agroskin, *Hidraulika*, Tehnička knjiga, 1969.

MECHANICS 2

Credit value (ECTS): 5

Number of hours (in semester):

- Lectures: 30
- Exercises: 23 auditory, 7 design

Course objectives:

- Acquire knowledge of basics kinetics lows of particle, rigid bodies and simple systems of rigid bodies. The abilities of applications and expansion the learned in other courses are expected.
- Acquire knowledge of the analytic approach to formulation and solving dynamic equilibrium problems (loading and motions influence on internal force and reactions).

Entry competences (foreknowledge, descriptive):

- Well knowledge of trigonometry, basics of vector calculus is expected.
- Knowledge of the differential and integral calculus as well as the meaning of differentials and integrals is expected.
- Well knowledge of basics static lows of particle, rigid bodies and simple systems of rigid bodies, as the understanding of forces transmission to reactions at supports and connections.

Enrolment requirements (correlated courses):

- Teachers signatures: Mathematics 2, Mechanics 1

Requirements for examination taking (correlated courses):

- Teachers signatures: Mathematics 2
- Examinations passed: Mechanics 1

Learning outcomes:

- Learn to apply mathematic and informatics knowledge on different problems of particle, rigid bodies and simple systems of bodies motions solving,
- To explain kinematics constrains of different supports and connections,
- To explain and apply the knowledge of analytical procedure for solving velocities and accelerations problems particle motions depending on various way of setting task,
- To explain and apply the knowledge of analytical and graphical procedure for solving velocities and accelerations problems rigid bodies motions depending on various way of setting task,
- To explain and apply the knowledge of graphical procedure for determination a displacement and velocities fields of mechanisms,
- To explain the motion problem formulation of rigid bodies and systems of bodies due to external force actions,
- To identify and explain the motion ways of particle, rigid bodies and simple systems of rigid bodies due to different supports and connections,
- To explain a single degree of freedom vibrations problem and apply it to find out a simplified response to some specific loadings in civil engineering,

Course content:

- Lectures:
    1. Kinematics of particles: Introduction to kinematics. Determination of the motion of a particle: position, velocity and acceleration. Coordinate system selection, the relation existing between various systems [1]
    2. Selected methods on determination of the particle motion: vector functions, parametric and natural way. Determination of the kinematics properties of the various motion laws [1]
    3. Particular way of the motions, angular velocity, angular acceleration. Analytical and graphical solution methods of rectilinear-motion problems [1]
    4. Absolute and relative motion. Composed motion. Coriolis acceleration explanation [1]
    5. System of particles motion. General laws application. Motion of a connected particles system [1]
    6. Introduction to Kinematics of a rigid body. Translation, rotation, motion in a plane [1]
    7. Analysis of a rigid body motion in a plane. Central axis. Selection of the degrees of freedom. The generalized coordinates [1]
    8. Analysis of a joined bodies systems. Mechanisms degrees of freedom [1]
    9. Constrained plane motion of rigid bodies systems. Kennedy's theorem [1]
    10. Fields of velocities and the displacement fields definitions. Graphical methods in solutions [1]
    11. Application of the field of velocities and the displacement fields on the theory of structures. Principle of virtual work [1]
    12. Introduction to dynamics of particle. Fundamental laws and principles of dynamics overview [1]
    13. Motion of a particle under the action of force: Newton's laws. Free and constrained plane motion [1]
    14. D'Alembert principle. Theorem of momentum [1]
    15. The law of moment of momentum [1]
    16. The law of relative motion of a particle. Moment of momentum with respect to a moving reference plane [1]
    17. Work of a force. Function of a force, conservative forces and proper laws [1]
    18. Potential energy. Kinetic energy of a particle. Principle of work and energy. Conservation of energy [1]
    19. Dynamics of a system of particles (free and constrained)..The point of a centre of mass [1]
    20. Motion of the center of mass. Theorem of momentum. The moment of momentum. Kinetic

energy of a system of particles [1]

21. Systems of particles motion analysis, application of fundamental dynamic laws [1]
22. Impact of two particles. Principle of impulse and momentum. Impact several particles [1]
23. Rigid body dynamics: Mass moments of inertia, major axis, Steiner's item [1]
24. General plane motion of a rigid body. Translation of a rigid body. Equations of a rigid body translation motions [1]
25. Rotation about a fixed axis. Equations defining the rotation of a rigid body about a fixed axis [1]
26. Inertial force. Reactions exerted by the rotation of a rigid body about a fixed axis [1]
27. Plane motion of a rigid body: Equations of motion, D'Alembert's principle, momentum and moment of momentum [1]
28. Application of the principle of momentum and the law of moment of momentum to the analysis of the plane motion of a rigid body [1]
29. Introduction to mechanical vibrations: Free vibrations of particles. Simple harmonic motion without damping. Damped free vibrations [1]
30. Introduction to simple forced mechanical vibrations without damping [1]

- Exercises (auditory, design): Follows the lectures

Student responsibilities:

- class attendance (exercises 100%, lectures 75%)
- 2 mid-term exam

Grading and evaluation of student work over the course of instruction:

- Student is exempt from first part of exam if both mid-term exams are solved more than 55%
- Student activity during the course add up 5% to mid-term exams or first part of exam credits

End of semester grading:

- First part of written exam (problems only) – 55% is necessary to access a second part of exam
- Second part of written exam (problems solving and explaining lows of Kinematics and Dynamics) – 50% is necessary to access grade

Contributions to the final grade:

- Middle grade value of both exams

Required literature:

1. V. Andrejev: *Kinematika, dinamika*, Tehnička knjiga, Zagreb, 1973.
2. A. Kiričenko: *MehanikaII*, PBI d.o.o., 1976
3. A. Kiričenko: *Mehanika III*, PBI d.o.o., 1996
4. V.Raduka: Lectures (on line)
5. V.Raduka: Solved problems, examples for exercises (on line)

Optional literature:

1. F.P.Beer, E.R. Johnston: *Vector Mechanics for Engineers – Dynamics*, 1988

HYDROLOGY

Credit value (ECTS): 3

Number of hours (in semester):

- Lectures: 30
- Exercises (auditory): 15

Course objectives:

- Acquisition of theoretical and practical knowledge in the field of hydrology, including water and the water cycle, processes in the atmosphere, hydrometry, processing of hydrometric data, the application of probability and statistics in hydrology, and parametric methods for the estimation of runoff processes in the basin.

Entry competences (foreknowledge, descriptive):

- Knowledge of basic statistical principles and methods, both empirical and theoretical,
- Knowledge of and understanding the physical properties of substances (phase material, density, specific volume and quantity of the substance).

Enrolment requirements (correlated courses):

- Teachers signatures: Physics, Probability and statistics

Requirements for examination taking (correlated courses):

- Teachers signatures: Physics, Probability and statistics

Learning outcomes:

- Understanding the basic concepts of water, the water cycle, the atmosphere, and atmospheric processes and measurements,
- Understanding and implementation of procedures in the application of probability and statistics in hydrology (empirical and compromising probability, application of theoretical probability distributions in hydrology, forming a statistical collection of hydrological data, tests of homogeneity and adjustment, errors in statistical parameters),
- Understanding the concepts and application of basic analysis of meteorological data, hydrological analysis and elaboration on hydrological data,
- Ability to detect, observe and define the problem of water in civil engineering,
- Detecting and describing the problems of the runoff process in the basin and the runoff components, of the methodology for determining runoff, and of the extreme conditions of runoff occurrence in the basin.

Course content:

- Lectures:
  1. Water and its natural properties, global distribution and circular motion of water in nature - the hydrologic cycle. The atmosphere and the processes in the atmosphere , composition and properties of the atmosphere [2]
  2. Meteorological measurements (temperature, pressure, humidity, condensation, precipitation, evapotranspiration), processing of the measured meteorological data [2]
  3. Water in the soil, runoff processes, underground and surface runoff, hydrography, basin, river valleys, river channels [2]
  4. Hydrometry, hydrometric stations, hydrometric measurement: water temperature, river ice, water level, depth and velocity of water [2]
  5. Measurements of flow, sediments and sediment measurement in streams [2]
  6. Processing hydrometric data: stage discharge curve, stage and flow hydrograph [2]
  7. Frequency and duration of water levels and flows, low, mean and high flows [2]
     (Pre-exam I.)
  8. Trend analysis, the application of linear and nonlinear correlation in hydrology [2]
  9. Probability and statistics in hydrology: empirical and compromise probability, theoretical probability density distribution curve in hydrology [2]
  10. The cumulative probability and the return period, the time series of hydrological and meteorological data, forming a statistical collection of hydrologic data [2]
  11. Tests of homogeneity and adjustments, confidence intervals, errors of statistical parameters, data processing on precipitation - IDF curves [2]
  12. Parametric hydrology: parametric methods of runoff estimation, runoff coefficient, rational method. Empirical methods for calculation of runoff by various authors [2]
  13. Modeling in hydrology [2]
      (Pre-exam II.)

- Exercises (auditory):
  Exercises accompany lectures

Student responsibilities:

- 2 pre-exams: each pre-exam should earn minimum 15 points,
- Regular attendance in exercises,
- Fulfilling assignments,
- One make up pre exam at the end of semester.

Grading and evaluation of student work over the course of instruction:

- Minimum 50 points must be earned in pre-exams to be exempt from the exam.

Contributions to the final grade:

- Minimum 50 points must be earned in pre-exams earn a grade in the exam.

Required literature:

1. Husno Hrelja: *Inženjerska hidrologija*, Univerzitet u Sarajevu – Građevinski fakultet, Sarajevo, 2007,
2. Ranko Žugaj: *Hidrologija*, Sveučilište u Zagrebu – Rudarsko-geološko-naftni fakultet, Zagreb, 2000,
3. Stevan Prohaska, Vesna Ristić: *Hidrologija* – kroz teoriju i praksu, Univerzitet u Beogradu – Rudarsko-geološki fakultet, Beograd, 2002,
4. Živko Vuković: *Osnove hidrotehnike* – prvi dio – prva knjiga, Sveučilište u Zagrebu – Građevinski fakultet, Zagreb, 1996,
5. Dionis Srebrenović: *Primijenjena hidrologija*, Tehnička knjiga, Zagreb, 1986,
6. Eugen Čavlek: *Osnove hidrologije*, Geodetski fakultet, Zagreb, 1992,
7. Ognjen Bonacci: *Oborine, glavna ulazna veličina u hidrološki ciklus*, Split, 1994

Optional literature:

1. Ven Te Chow: *Book of Applied Hydrology*, Mc Graw-Hill Book Company, INC New York, Toronto, London.

Elective courses

CONSTRUCTION MATERIALS

Credit value (ECTS): 5

Number of hours (in semester):

- Lectures: 30
- Exercises : 30 (auditory – 12, laboratory - 18),

Course objectives:

- Learning about materials used in civil engineering, and the technology of their production. Emphasis is put on description of mechanical, physical and chemical properties of materials.
- Acquiring knowledge about the basic methods of engineering materials testing according to domestic and international regulations and standards of their production and quality control.

Entry competences (foreknowledge, descriptive):

- Basic knowledge of materials science.

Enrolment requirements (correlated courses):

- Teachers signatures: Materials science

Requirements for examination taking (correlated courses):

- Examinations passed: Materials science

Learning outcomes:

- Theoretical and factual knowledge about construction materials,
- Cognitive and practical skills in basic testing and properties of construction materials,
- Competences: integration of knowledge in future study and work. Students will be able to determine basic physical and mechanical properties of construction materials, make aggregate grading curves and concrete mix design.

Course content:

- Lectures:
  1. Introduction [2]
  2. Stone [2]
  3. Aggregate [2]
  4. Ceramics [2]
  5. Inorganic binders [2]
  6. Mortar [2]
  7. Concrete [2]
  8. Organic binders [2]
  9. Metals [2]
  10. Timber [2]
  11. Polymers[2]
  12. Glass [2]
  13. Adhesives, colours and varnishes, Insulation materials [2]
  14. Concrete admixtures [2]
  15. Quality control [2]

- Auditory exercises:
  1. Stone [2]
  2. Aggregate [2]
  3. Ceramics [2]
  4. Inorganic binders [2]
  5. Mortar [2]
  6. Fresh concrete [2]
  7. Hardened concrete [2]
  8. Strength [2]
  9. Non-destructive testing methods [2]

- Laboratory exercises:
  1. Physical and mechanical properties of stone [2]
  2. Physical and mechanical properties of ceramics [2]
  3. Aggregate properties for concrete [2]
  4. Fresh concrete testing [2]
  5. Mechanical properties of construction materials [2]
  6. Non-destructive testing methods [2].

Student responsibilities:

- Minimum 75% attendance in lectures,
- 100% attendance in exercises,
- 2 programs,
- 2 preliminary exams (min 25 % score in each).

Grading and evaluation of student work over the course of instruction:

- Minimum 60 % score in each preliminary exam,
- Positively graded laboratory exercises and programs.

End of semester grading:

- Minimum 60% score in written exam,
- Oral exam.

Contributions to the final grade:

- Written examination 50 %
- Oral examination 50 % or preliminary exams 50 %,
- Laboratory exercises and programs 40 %
- Participation in lectures and exercises 10 %

Required literature:

1. Young, J.; Mindess, S.; Gray, R. J., Bentura: *The Science and Technology of Civil Engineering Materials*, Prentice Hall, 1998,
2. Ukrainczyk, V.: *Introduction to construction materials*, InstitutgradevinarstvaHrvatske, Alcor, Zagreb, 2001 (in Croatian),
3. Ukrainczyk, V.: *Concrete – Structure, Properties and Technology*, Alcor, Zagreb, 1994 (in Croatian),
4. Bjegovic, D., Balabanic, G., Mikulic, D.: *Construction materials – solution manua*l,, Faculty of civil engineering, University of Zagreb 2007, (in Croatian),
5. Beslac, J.: *Materials in architecture and civil engineering*, Skolskaknjiga, Zagreb, 1989 (in Croatian),
6. Durekovic, A.: *Cement, cement composites and additives for concrete*, Skolskaknjiga, Zagreb, 1996 (in Croatian),

Optional literature:

1. Ashby, M. F.; Jones, D. R.: *Engineering Materials 1,* Butterworth Heinemann 1996,
2. Illston, J. M., Domone, P. L. J. (ed.): *Construction materials – their nature and behavior*, 4th edition, SPON Press, 2010,
3. Taylor, G. D.: *Materials in Construction*, second edition, Longman Group UK Limited, 1994

BASICS OF CONCRETE TECHNOLOGY

Credit value (ECTS): 5

Number of hours (in semester): 60

- Lectures: 30
- Exercises: 30 (auditory – 15, laboratory - 15),
- E-learning: optional

Course objectives:

- Learning about concrete components and concretes used in different areas of civil engineering, and about the production technology and construction methods. An emphasis is put on description of physical, mechanic, and durability properties of concrete.
- Acquiring knowledge about the basic methods of concrete testing according to domestic and international regulations and standards of their production and quality control.

Entry competences (foreknowledge, descriptive):

- Basic knowledge of physics, chemistry and materials science.

Enrolment requirements (correlated courses):

- Teachers signatures: Construction materials, Physics, Mathematics 2

Requirements for examination taking (correlated courses):

- Examinations passed: Construction materials, Physics

Learning outcomes:

- Basic knowledge about concrete properties in fresh and hardened state and concrete mix design,
- Knowledge about the properties of concrete components(cement, aggregates, additives) and their influence on concrete design and properties,
- Practical skills in the application of certain concrete technology depending on the type of structure,
- Theoretical and factual knowledge of concrete degradation processes and concrete durability in different environmental conditions,

- Understanding the process of concrete quality control in concrete production plant and on-site by using laboratory and field test methods,
- Knowledge about special concrete types and special concrete technology
- Integration of knowledge in future study and work.

Course content:

- Lectures:
  1. Introduction [2]
  2. Cement [2]
  3. Aggregate, Water, Admixtures [2]
  4. Fresh Concrete and Concrete Mix Design [2]
  5. Strengths of Concrete [2]
  6. Concrete Deformation Properties [2]
  7. Durability of Concrete [2]
  8. Concrete Production [2]
  9. Basics of Concrete Technology, Concrete in Extreme Conditions [2]
  10. Special Concrete types [4]
  11. Special Concrete types II [2]
  12. Advanced Concrete Technology [2],
  13. Concrete Testing Methods and Quality Control [2]
  14. Technical Regulations for Concrete Structures [2]

- Auditory exercises:
  1. Physical Parameters of Construction Materials, Cement [2]
  2. Aggregate [2]
  3. Concrete Mix Design [2]
  4. Concrete properties in hardened state [2]
  5. Concrete deformations [2]

- Laboratory exercises:
  1. Physical Parameters of Construction Materials [2]
  2. Cement [2]
  3. Aggregate [2]
  4. Fresh Concrete and Concrete Mix Design [2]
  5. Hardened concrete [2]

Student project: Seminar on concrete mix design

Student responsibilities:

- Minimum 75% attendance in lectures,
- 100% attendance in auditory exercises,
- 100% attendance in laboratory exercises,
- Concrete mix design paper, 2 preliminary exams (min 25 % score in each)

Grading and evaluation of student work over the course of instruction:

- Exemption from written exam: minimum 60 % score in each preliminary exam,
- Minimum 75% score in preliminary exams on laboratory exercises,
- Positively graded paper.

End of semester grade:

- Written examination (minimum 60 % score) and oral examination

Contributions to the final grade:

- Written examination 50 %
- Oral examination 50 % or
- Preliminary exams 50 %,
- Laboratory exercises and programs 40 %
- Participation in lectures and exercises 10 %.

Required literature:

1. Bjegovic, D., Balabanic, G., Mikulic, D.: *Construction materials – solution manual*,, Faculty of civil engineering, University of Zagreb 2007 (in Croatian)
2. Ukrainczyk, V.: *Concrete: structure, properties and technology*, Institut gradevinarstva Hrvatske, Alcor, Zagreb, 2001 (in Croatian)
3. Young, J.F.; Mindess, S.;Gray, R.J.; Bentur, A.: *The Science and Technology of Civil Engineering Materials*; Prentice Hall, 1998,
4. Beslac, J.: *Materials in architecture and civil engineering*, Skolska knjiga, Zagreb, 1989 (in Croatian)
5. Krstulović, P., *Properties and technology of concrete*, ISBN 953-6116-20-0, Faculty of civil engineering, University of Split. (in Croatian)

Optional literature:

1. Mehta P.K., *Concrete, Structure, Properties and materials*, New Yersey: Prentice Hall, Inc., Englewood Cliffs,1986.
2. Neville, A.M., *Properties of concrete*, fourth edition. Essex: Longman Group Limited,1995,
3. Žarnić, R., *Osnove lasnosti gradiv*, Ljubljana: Univerza v Ljubljani, Fakulteta za gradbeništvo in geodezijo, Katedra za preskušanje materialov in konstrukcij, 1999,
4. Muravljov, M. *Basics of concrete theory and technology*. 3 edition. Građevinska knjiga, Beograd, 2005,
5. Zoran Grdić, *Concrete technology*, GAF, Niš, 2011

2nd year, 4th semester

Obligatory courses

STRENGTH OF MATERIALS 2

Credit value (ECTS): 5.5

Number of hours (in semester):

- Lectures: 45
- Exercises: 30 (auditory – 28, laboratory - 2)

Course objectives:

- Acquisition of theoretical knowledge about the laws of strength science in the field of the theory of structures,
- Acquisition of practical knowledge needed to understand and solve minor engineering problems related to dimensioning and verification f the strength of elements of engineering structures.

Entry competences (foreknowledge, descriptive):

- Knowledge about differential and integral calculus,
- Knowledge about mechanics (statics and kinematics), stress and strain analysis and calculation of stresses and strains of flat beams caused by individual internal forces(longitudinal and transversal forces, torsion and bending moments).

Enrolment requirements (correlated courses):

- Teachers signatures: Strength of materials1

Requirements for examination taking (correlated courses):

- Examinations passed: Strength of materials1

Learning outcomes:

- Recognizing static indetermination and solving simple statically indeterminate systems,
- Solving simple cases of girders on an elastic base,
- Using the basic theories of strength that dimensioning of structural elements loaded with multi-axial stress state,
- Analyzing complex stress-loaded beams, determining the cross section core and applying it in biaxial bending and eccentric load,
- Determining and understanding the importance of the shear center in thin-walled cross-sections,
- Calculating the stress and strain in curved beams and perceiving the difference between the flat beams,
- Explaining and applying the principle of minimum potential energy of deformation,
- Explaining the problem of stability loss(buckling) of flat beams and dimension beams loaded to buckling,
- Calculating simple statically determined and statically indeterminate structures using theory of plasticity.

Course content:

- Lectures:
  1. Simple statically indeterminate systems [3]
  2. Girder on an elastic base [3]
  3. Equivalent stress according to strength theories. Comparison and application of strength theories. [4]
  4. Complex loading of flat beams. Bending and axial load. Bending and torsion. [3]
  5. Eccentric loading of the short beams. Cross section core. [3]
  6. Application of cross section core. Stresses in cross section with exclusion of tension zone. Bending and axial loading of composite beams. [3]
  7. Thin-walled cross-sections. Shear center. [3]
  8. Curved beams theory. Stress and strain due to longitudinal and transversal forces. Bending. The general case of bending. Rational shapes of curved beam cross section under bending. [3]
  9. Potential energy of deformation. Theorem of reciprocity effect of work and displacements, Castigliani's theorems , Crotti - Engesser's theorem. [4]
  10. Principle of strain minimum potential energy. Principle on stationary condition of potential energy system. [3]
  11. Buckling, elastic stability loss. Beam buckling in the elastic area. Euler's critical force [3]
  12. Beam buckling in the plastic area (extension of Euler's expression for the critical force by introducing a tangent module). Slender beam under the action of longitudinal and transverse loads. Dimensioning of beams under buckling load stability condition [4]
  13. Design of structures according to plasticity theory. The model of ideal elastoplastic material. The condition of plasticity. Plastic torsion and plastic bending of a flat beam. Influence of load release, residual stresses[3]
- Exercises (auditory, laboratory):
  1. Simple statically indeterminate systems[2]
  2. Beam on an elastic base[2]
  3. Comparison and application of theories of strength[3]
  4. Cross-section core [2]
  5. Application of the cross-section core to biaxial bending and eccentric load[2]
  6. Shear center[2]
  7. Curved beams [2]
  8. Application of Castiglian's theorems and the principle of minimal potential energy of strain in solving static systems[3]
  9. Beam buckling in the elastic area[3]
  10. Design of structures according to plasticity theory[3]
  11. Laboratory exercise[2]
- Pre-exams:
  1. Statically indeterminate beams. Beam on an elastic base. Cross-section core. Shear center. Strength theories.

2. Curved beams. Potential energy. Buckling. Design of structures according to the theory of plasticity.

Student responsibilities:

- Attendance in lectures and exercises,
- Attendance in laboratory exercises,
- 2 pre-exams: in each pre-exam students are required to do a minimum25% score, 2 make up tests.

Grading and evaluation of student work over the course of instruction:

- Attendance in lectures and exercises,
- Pre-exams: students with minimum 60% score in each pre-exam are exempt from the written exam.

End of semester grading:

- Written part of the exam: to pass students are required to achieve minimum 50% score,
- Oral exam.

Contributions to the final grade:

- Attendance in lectures and exercises 10% ,
- Pre-exams or written exam 50-60% ,
- Oral exam 30-40%.

Required literature:

1. Šimić, V.: *Strength of Materials II*, Školska knjiga, Zagreb, 2002
2. Bazjanac, D.: *Science of Strength*, Tehnička knjiga, Zagreb, 1967

Optional literature:

1. Alfirević, I.: *Science of Strength II*, Golden marketing, Zagreb, 1999
2. Timošenko, S.: *Strength of Materials I i II*, Građevinska knjiga, Beograd, 1965
3. Brnić, J.; Turkalj, G.: *Science of Strength II*, Zigo, Rijeka, 2006

STRUCTURAL ANALYSIS 1

Credit value (ECTS): 7.5

Number of hours (in semester):

- Lectures: 60
- Exercises (auditory): 45

Course objectives:

- Acquiring theoretical knowledge about the behavior of structures under various loads and other influences and about the modes of force transmission,
- Acquiring practical knowledge about methods of linear analysis of statically determinate and statically indeterminate rod structures.

Entry competences (foreknowledge, descriptive):

- Knowledge of differential and integral calculus (including ordinary differential equations), and linear algebra,
- Knowledge of the statics of particles, particle systems, rigid bodies and connected systems,
- Understanding the concept of stress and strain and internal forces.

Enrolment requirements (correlated courses):

- Teachers signatures: Strength of materials 1, Mathematical programs for engineers
- Examinations passed: Mechanics 1

Requirements for examination taking (correlated courses):

- Teachers signatures: Strength of materials 1, Mathematical programs for engineers

- Examinations passed: Mechanics 1

Learning outcomes:

- Recognising geometric invariability and statical determinacy or indeterminacy of rod structures,
- Interpreting conditions of equilibrium in the plane and in the space and applying them when calculating external and internal forces,
- Explaining and applying analytical and graphical methods in calculating statically determinate planar and spatial structures,
- Explaining the concept of virtual work and comparing it with the equlibrium conditions and kinematic conditions,
- Explaining variational theorems and comparing them with the equilibrium conditions and kinematic conditions,
- Explaining and applying analytical procedures in calculating statically indeterminate structures,
- Explaining and applying analytical and graphic procedures in determining displacement and deflection lines,
- Applying influence function in calculating the influence of moving load.

Course content:

- Lectures:
  1. The scope, objectives and methods of structural analysis. Model of structure. Basic assumptions and principles [1]
  2. Differential and integral equations of equilibrium. Simple beams [2]
  3. Multi-span statically determinate beams: analytical and graphical methods [3]
  4. Trusses: statical determination and geometric invariance; analytical and graphical methods [3]
  5. Three-hinged and similar beams
     - 5.1 Graphical methods [4]
     - 5.2 Analytical methods [3]
     - 5.3 Methods based on superposition[4]
  6. Elastic systems. Displacements and deflection lines [4]
  7. Work. Virtual displacements. Virtual work for elastic bodies. Application [6]
  8. Variational methods [3]
  9. Statically indeterminate structures. Methods of analysis [3]
  10. Force method:
      - 10.1 Transformation into determinate structures [2]
      - 10.2 Equations of the force method. Flexibility matrix [6]
      - 10.3 Forced displacement and the influence of heat. Calculation of displacement [4]
  11. Introduction to deflection method. Equilibrium equations. Matrix formulation [6]
  12. Introduction to the finite element method [3]
  13. Influence functions and influence lines – application [2]
  14. Spatial stastically determinate systems [2]

- Exercises (auditory):
  1. Multi-span statically determinate beams and trusses [6]
  2. Three-hinged and similar girders [12]
  3. Elastic lines [4]
  4. Application of the virtual forces theorem [4]
  5. Force method [14]

- Pre-exams:
  1. Covers parts 1. and 2. in exercises
  2. Covers parts 4. and 5. In exercises

Student responsibilities:

- Regular attendance in lectures and exercises,
- Doing 3 programs and the discussion with an assistant lecturer,
- 2 pre-exams: each requires a 25% score, one make up pre-exam.

Grading and evaluation of student work over the course of instruction:

- Evaluation of students' programs,
- Pre-exam: students with a 60% score in each pre-exam are exempt from the written exam and can take (optional) theoretical pre-exam which renders them exempt from the part of the oral exam.

End of semester grading:

- Written exam: 50 % score,
- Oral exam.

Contributions to the final grade:

- Programs 10%
- Pre-exams or written exam 50 – 60%
- Oral exam 30-40 %

Required literature:

1. V. Simović: *Građevna statika* , Građevinski institut, Zagreb, 1988.
2. M. Anđelić: *Građevna statika 2*, Građevinski fakultet, Zagreb, 2005.
3. K. Fresl: *GS – Bilješke i skice s predavanja*, `http://master.grad.hr/nastava/gs`

Optional literature:

1. M. Sekulić: *Teorija linijskih nosača*, Građevinska knjiga, Beograd, 2005.
2. L. P. Felton, R. B. Nelson: *Matrix Structural Analysis*, Wiley, New York, 1997.

INTRODUCTION TO STRUCTURAL ENGINEERING

Credit value (ECTS): 2

Number of hours (in semester):

- Lectures: 27
- E-learning: 3

Course objectives:

- Gaining theoretical knowledge related to global stabilisation of structures built out of various materials,
- Gaining knowledge in the field of structural reliability,
- Acquiring skills for synergic approach to design in cooperation with architects,
- Gaining theoretical knowledge on determination of basic structural actions and their effects.

Entry competences (foreknowledge, descriptive):

- Knowledge of statics of rigid body and connected systems,
- Understanding and ability to apply equilibrium conditions in plane and space,
- The ability of structure spatial perception,
- Knowledge about building construction basic elements.

Enrolment requirements (correlated courses):

- Teachers signatures: Mechanics 2, Building construction,
- Examinations passed: Mechanics 1

Requirements for examination taking (correlated courses):

- Teachers signatures: Mechanics 2, Building construction,
- Examinations passed: Mechanics 1

Learning outcomes:

- Ability to make layout solutions of simpler structures made of various materials – concrete, steel and timber,
- Adentifying key factors related to structural reliability,
- Ability to determine actions on structures and their design situations for various limit states,
- Ability to use European structural standards for actions.

Course content:

- Lectures:
  1. Basic structural elements and ways of transferring forces [4]
  2. Fundamentals on creating building layout solutions [4]
  3. Typical building disposition solutions for different building materials [6]
  4. Modes of action transfer [2]
  5. Fundamentals of structural reliability [6]
  6. Reliability concept built into European standards Eurocode [2]
  7. Methods of action determination [2]
  8. Design situations for various limit states [4]

Student responsibilities:

- Attendance in lectures,
- 2 pre-exams : minimum 25% score in each; makeup pre-exam for students who did not achieve minimum 25% score in one or both pre-exams for students who want to improve the score achieved in regular pre-exam.

Grading and evaluation of student work over the course of instruction:

- Class participation, achievement in two pre-exams and achievement in on-line knowledge test.

End of semester grading:

- Written exam: minimum 60% score.

Contributions to the final grade:

- Class participation 10%,
- Achievement in pre-exams 70%,
- On-line knowledge test 20%.

Required literature:

1. Schultz, Sobek, Habermann: *Steel structures atlas*, Građevinska knjiga, 2010.(In Croatian)
2. Bjelanović, Rajčić: *Timber structures according to European standars*, GF Zagreb, 2005. (In Croatian)
3. Milčić, Peroš: *Introduction to reliability of structures*, Građevinski fakultet Split, 2003. (In Croatian)
4. Radić: *Concrete structures*, Hrvatska sveučilišna naklada, Zagreb, 2006. (In Croatian)
5. Džeba et al.: WEB materials

Optional literature:

1. Eurocode EN 1990, EN 1991

SOIL MECHANICS

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures:45
- Exercises (design):30

Course objectives:

- Students should acquire elementary knowledge on soil mechanics, and will be able to solve simple practical problems in geotechnical engineering

Entry competences (foreknowledge, descriptive):

- Subject matter of Mechanics 1, Strength of materials 1 and Fluid mechanics

Enrolment requirements (correlated courses):

- Examinations passed: Mechanics 1

Requirements for examination taking (correlated courses):

- Examinations passed: Mechanics 1

Learning outcomes:

- Understanding the classification of soils into groups of similar properties; basic elements of seepage in soil and can interpret flow nets; basic elements about soil stiffness and strength; essential features and use of laboratory and field testing equipment in geotechnical engineering.
- Ability to classify soils related to basic engineering properties; to calculate bearing capacity and settlement of shallow foundations; estimating safety of simple slopes in soils; to calculate lateral pressures on simple retaining structures.
- Ability to integrate the acquired knowledge about general mechanical behavior of solids and fluids with particular aspects of mechanical properties of soils; application of acquired knowledge in solving typical problems in design of simple geotechnical structures.

Course content:

- Lectures:
  1. Introduction to soil mechanics [3]
  2. Basic soil properties and phase relationships, granulometric composition of the soil, border consistency of fine grained soil [3]
  3. Capillarity, soil classification, soil compaction [3]
  4. Seepage in soils [3]
  5. Strain and stress, effective stress, stiffness of the soil, potential flows in calm water [3]
  6. The flow of water through the soil [3]
  7. Drained and und rained condition, soil consolidation [3]
  8. Shear strength of soil [3]
  9. Application of the plasticity method and the method of limit equilibrium [3]
  10. Immediate and time dependent settlement of shallow foundations [3]
  11. Eurocode 7 [3]
  12. Slope stability [3]
  13. Shallow foundations [3]
  14. Supporting structures [3]
  15. Geotechnical field investigations [3]

- Exercises (design):
  1. Images of geotechnics, field work, laboratory [2]
  2. Phase relationships and grain size distribution [2]
  3. Soil classification [2]
  4. Effective stress, stiffness of the soil [2]
  5. The flow of water through the soil [2]
  6. Soil consolidation [2]
  7. Shear strength of soil, bearing capacity of shallow foundations [2]
  8. Settlement of shallow foundations [2]
  9. Applications of Eurocode 7 [2]
  10. Infinite slope [2]
  11. Slope stability [2]
  12. Shallow foundations [2]
  13. Supporting structures [2]

Student responsibilities:

- Attendance in lectures (3points),
- Attendance in exercises (2points),
- Two homework assignments (10points),
- Pre-exam (30points),
- Final exam (60 points).

Grading and evaluation of student work over the course of instruction:

- Students should earn 25 points (excluding the final examination) for the teacher's signature.

End of semester grading:

- Students should earn minimum 55points (including the final examination) for a pass.

Contributions to the final grade:

- As stated above.

Required literature:

1. Roje-Bonacci, Tanja: *Mehanika tla,* Građevinski fakultet Sveučilišta u Splitu, (in Croatian).

Optional literature:

1. Craig, R. F. (1997).*Soil Mechanics,* Sixth Edition. E & FN Spon, London.

LAW IN CONSTRUCTION

Credit value (ECTS): 3

Number of hours (in semester):

- Lectures: 30
- E-learning: teaching hours ar not limited during semester

Course objectives:

- Theoretical knowledge about the basics of law (terms and meanings), disciplines of Law (with the emphasis on constitutional and administrative law, commercial and contract law),
- Theoretical and practical knowledge in the professional area of construction industry law: The Special Planning Act and Building Act,
- Information on the relevant national and international professional associations in the construction industry.

Enrolment requirements (correlated courses):

- Examinations passed: Building construction, Materials science, Geodesy
- Optional: Sociology of work and professional ethics, Outlines of civil engineering legislation, Business economics.

Requirements for examination taking (correlated courses):

- As stated above.

Learning outcomes:

- Understanding the role and the provisions of the law as well as the applicable regulations which determine the concept, design and realization of construction projects in the area of the rights and obligations of their main parties.

Course content:

- Lectures:
  1. Legal elements, basic terminology, legal norms, legal system, origin of law & subjects of law, legal relationships and procedures [2]
  2. Basic contents of Building Act, multidisciplinary elements in a construction project, control systems [2]
  3. Direct and indirect factors in construction projects [2]

4. The role of construction law in construction projects, Building Act, professional norms, life-cycle of construction projects, feasibility studies [2]
5. Urban planning, types of urban documents, drawings and projects. Location permit, building site preparation. Regulation models and key activities in construction projects, preparation for the project and the project documentation. Conceptual design, project design, detailed design. Internal and external control of project documentation [2]
6. Construction tendering, constructing. Complete final account. Building operation and maintenance [2]
7. Demolition of buildings, project of building demolition [2]
8. The participants in construction project and their legal obligations. Investor, designer, reviewer, building contractor, supervisor [2]
9. Tender documents, bill of quantities, drawings. Technical conditions Obligatory site documentation. All types of legal solutions for building activities. The building permit, the building diary book. Design details. The bill of quantity. Certificates about the quality of performed works, and products [2]
10. Basic legal documents. Purposes, ways and methods of obtaining a building permit [2]
11. Plan extract. The building pre-permit. The general building permit. The building permit for the part of the building, or for the whole building [2]
12. Use permits, permit for building demolition and evacuation. Government inspections [2]
13. Professional associations. Croatian chamber of architects and engineers in construction. FIDIC. Basic goals, documents, manner of operation [2]
14. Basics of commercial law, the corporation. Types of safety and their uses [2]
15. Contracts in: construction, concession, selling and leasing, patents, investments, transport, deposit, guarantees [2]

Student responsibilities:

- Attendance in lectures,
- Minimum 3 written papers (a critical review and a personal reflection on the lectures).

Grading and evaluation of student work over the course of instruction:

- Evaluation of students' reports every three weeks as evidence of their presence in lectures,
- Two pre-exams evaluation during semester.

End of semester grading:

- Students with minimum 60% score in their reports and pre-exams are exempt from the written and oral exams,
- Students who have achieved less than 60% score in 2 pre-exams are obliged to take the written and/or oral examination upon the completion of the course, regardless of the pre-exam scores.

Contributions to the final grade:

- Positive assessment of written reports (essays) can contribute to the overall assessment (final grade) up to 10%

Required literature:

1. Radujković, J.; Izetbegović, J.; Nahod, M. M.: *Osnove građevinske regulative*, GF Sveučilišta u Zagrebu, Zagreb, 2008
2. Izetbegović, J., Predavanja *(E-learning)* na sustavu Merlin u SRCU: Dostupni su studentima s osobnom lozinkom
3. Gorenc, V.: *Trgovačka poduzeća*, ŠK, Zagreb, 1992
4. Gorenc, V.: *Trgački ugovori*, ŠK, Zagreb, 1993
5. Zakon o prostornom uređenju (Spatial planning act) ((published by NN in 2013)
6. Zakon o gradnji (Building Act)(published by NN in 2013)
7. Zakon o građevinskoj inspekciji (Law on building inspection) (published by NN in 2013)
8. Important web-links:
   a. `http://www.nn.hr` (Narodne novine; National Gazette)
   b. `http://www.mzopu.hr` (Ministarstvo zaštite okoliša, prostornog uređenja i gradnje)
   c. `http://www.iusinfo.hr` (Pravni informacijski sustav IUS-INFO)
   d. `http://www.cadial.hr` (Tražilica na hrvatskom ili engleskom jeziku)

Optional literature:

1. Bienenfeld, J., Blažević-Perušić, J., Rajčić, D.; Sudarević, N.: *Prikaz Zakona o izmjenama i dopunama Zakona o prostornom uređenju i gradnji i Zakona o postupanju sa nezakonito izgrađenim zgradama*, Građevinski fakultet Sveučilišta u Zagrebu, 2011.
2. Loboja, A.; Bačurin, N.; Flam, D.; Pandžić, Z.; Pranjić, I.; Rajčić, D.: *Novi propisi o javnoj nabavi*, Građevinski fakultet Sveučilišta u Zagrebu, 2012.
3. Zakon o prostornom uređenju i gradnji (Publshed in 2007)

Optional courses

APPLIED GEOLOGY

Credit value (ECTS): 3.0

Number of hours (in semester):

- Lectures:30

Course objectives:

- Gaining basic knowledge in general geology, mineralogy and petrology,
- Gaining basic knowledge in hydrogeology and engineering geology for the application to construction.

Entry competences (foreknowledge, descriptive):

- Kowledge of basic chemical elements and compounds.

Learning outcomes:

- Ability to distinguish between igneous, metamorphic and sedimentary rocks,
- Ability to identify layers, faults and overthrust,
- Knowledge about the process of the formation of karst and various karst formations and learning about the problems which constructors encounter during construction of tunnels in karst,
- The ability to use geological maps – recognition of geological symbols, determination of the geological age of rocks, their composition and other important geological phenomena of a terrain,
- Knowledge of basic engineering-geological rock mass classification.

Course content:

- Lectures:
  1. Introduction [2]
  2. General information about the geosciences, Geology general, stratigraphic; Constitution of Earth; Geoid; Mineralogy; Mineral; Crystal [2]
  3. Isotropic and anisotropic minerals; pyrogenic, pneumatogenic, hydrothermal, hydatogenic; Axis, center plane of symmetry; crystal systems; properties of crystals, crystal connection; tetrahedral coordination, coordination number; Polymorphism; Isomorphism [2]
  4. The properties of minerals, Mineral groups; oxides and hydroxides, carbonates, sulfates, silicates [2]
  5. Introduction to Petrology; Rock phenocrysts, Monomineral; igneous rocks; types of igneous rocks, structure and texture of igneous rocks; Acidity of magma; Bowen series of crystallization; Table of igneous rocks [2]
  6. Sedimentary rocks, sediment transport, mineral composition of sedimentary rocks , structures and textures of sedimentary rocks; General overview of sedimentary rocks, metamorphic rocks, metamorphic zones; types of metamorphic rocks [2]
  7. Tectonics, rock exposures, outcrops, thickness of layers, anticlines and synclines, faults, over thrust, types of cracks [2]

8. Pre-exam [2]
9. Egzodynamic processes; insolation, hydrogeology, water, the hydrologic cycle, porosity, permeability, laminar and turbulent flow; types of aquifers; Ghyben Herzberg law; Ice and Snow, Wind, organisms [2]
10. Pre-exam [2]
11. Karst; external karst formations; interior karst formations [2]
12. Types of caves, speleothems, groundwater [2]
13. Landslides; Endodynamics; orogeny, epirogensis [2]
14. Volcanoes, Earthquakes; Earthquake scales, seismicity [2]
15. Geological maps, RMR and Q classification of rocks in the construction domain; determining the age of rocks [2]

Student responsibilities:

- Attendance in 75% lectures,
- Minimum 25% score in the pre-exam.

Grading and evaluation of student work over the course of instruction:none.

End of semester grading:

- Written and oral exam.

Contributions to the final grade:

- In order to continue to the oral part of the exam students must have a minimum 60% score in the written part.

Required literature:

1. Herak, M., *Geology*, 1990
2. Šestanović, S., *Basics of Geology and Petrology*, 2001

Optional literature:

1. West, T.,*Geology Applied to Engineering*, 1994
2. Monroe, J. & Wicander, R., *Physical geology*, 2006
3. Plummer,C., McGeary,D. & Carlson, C., *Physical Geology*, 2010

ENVIRONMENTAL PROTECTION

Credit value (ECTS): 3

Number of hours (in semester):

- Lectures: 30

Course objectives:

- Acquisition of basic knowledge about the ecological concepts,
- Knowledge about the athropogenic influences on the environment, primarily in the field of civil engineering,
- Environmental sustainability, and measures and environmental protection procedures.

Entry competences (foreknowledge, descriptive):

- Basic knowledge in physics, biology, chemistry and civil engineering.

Learning outcomes:

- Understanding basic ecological processes,
- Recognising and explaining basic ecological principles,
- Explaining basic technological procedures of wastewater treatment,
- Understanding waste management,
- Understanding the concept of “sustainable development“.

Course content:

- Lectures:
  1. Introduction [2]
  2. Basic ecological concepts (ecology, biotop, biocenose, ecosystem, biodiversity) [3]
  3. Global changes in biosphere –changes in atmosphere [2]
  4. Pedosphere pollution [2]
  5. Hydrosphere pollution [3]
  6. The impact of cities [3]
  7. The impact of landfills [3]
  8. Impact of hydraulic structures [3]
  9. Transportation facilities impact [3]
  10. Environmental sustainability and sustainable development [3]
  11. Measures and environmental protection procedure (political and sociological approach, legal measures, environment planning, economic and financial measures, scientific approach and technological measures, institutional measures [3]

Student responsibilities:

- Attendance in lectures and exercises,
- Two pre-exams.

Grading and evaluation of student work over the course of instruction:

- Students with minimum 60 % score in each pre-exam are exempt from the final exam.

End of semester grading:

- Oral exam.

Contributions to the final grade:

- Oral exam 100 %.

Required literature:

1. Vuković, Ž.: *Environment Protection*, Manuscript, 2014, Zagreb (in Croatian).

Optional literature:

1. Raven, P. H., Berg, L. R., Hassenzahl, D. M.: *Environment*, 7th Edition, Wiley, 2010.
2. Miller, G. T.: *Living in the Environment: Principles, Connections, and Solutions*, 15th Edition, Thomson Books, 2007.

WATER SUPPLY AND SEWERAGE 1

Credit value (ECTS): 4

Number of hours (in semester):

- Lectures:30
- Exercises (auditory):15

Course objectives:

- Acquisition of theoretical and practical knowledge about the basic aspects of the management (planning, design, construction and operation) of water supply and sewerage systems,
- Acquisition of basic knowledge about hydraulic analysis of water supply and sewerage systems.

Entry competences (foreknowledge, descriptive):

- Prior knowledge in Fluid mechanics.

Enrolment requirements (correlated courses):

- Teachers signatures: Fluid mechanics.

Requirements for examination taking (correlated courses):

- Teachers signatures: Fluid Mechanics.

Learning outcomes:

- Planning, design, construction and operation of water supply and sewerage systems facilities: water intakes, pumping station, water conditioning plants, water tanks, water supply networks, sewerage networks, sewerage facilities, waste water treatment plants, outlets, house water supply and sewerage networks.

Course content:

- Lectures:
  1. Water supply – introduction, water supply systems [2]
  2. Water consumption [2]
  3. Springs, water intakes [2]
  4. Pumping stations, water intakes [3]
  5. Water conditioning [3]
  6. Water tanks, water supply networks [2]
  7. Water supply networks – calculation [2]
  8. Waste disposal facilities – introduction, waste disposal facilities systems [2]
  9. Design waste water quantities [2]
  10. Sewerage networks [2]
  11. Sewerage networks– calculus [2]
  12. Sewerage facilities [3]
  13. Waste water treatment and drainage [3]

- Exercises (auditory):
  1. Numerical examples of water consumption [1]
  2. Dimensioning water intake facilities [1]
  3. Dimensioning pumping stations [1]
  4. Dimensioning water conditioning facilities [1]
  5. Dimensioning water tanks [1]
  6. Hydraulic calculus of water supply networks [3]
  7. Determining the hydrostatic and hydrodynamic force pressure within water supply networks [1]
  8. Determining the quantities of waste water [1]
  9. Hydraulic calculus of sewerage networks [3]
  10. Dimensioning facilities in a sewerage network [1]
  11. Determining parameters for dimensioning the facilities for waste water treatment [1]

Student responsibilities:

- Attending lectures and exercises,
- Two pre-exams.

Grading and evaluation of student work over the course of instruction:

- Students with minimum 60 % score in each pre-exam are exempt from the final exam.

End of semester grading:

- Written and oral exam.

Contributions to the final grade:

- Written exam 50 %,
- Oral exam 50 %.

Required literature:

1. Vuković, Ž.: *Water Supply and Sewerage 1*, Manuscript, 2014, Zagreb (in Croatian).

Optional literature:

1. Ratnayaka, D. D., Brandt, M. J., Johnson, K. M.: *Twort□s Water Supply*, 6th Edition, Elsevier, 2009
2. Trifunović, N.: *Introduction to Urban Water Distribution*, Taylor & Francis Group, London, 2008
3. Margeta, J.: *Vodoopskrba naselja: planiranje, projektiranje, upravljanje, obrada vode*, AG fakultet, Split, 2010

WATER PROTECTION

Credit value (ECTS): 4

Number of hours (in semester):

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

Course objectives:

- Acquiring knowledge about basic properties and processes in natural water bodies,
- Technologies of wastewater treatment, water quality modeling and legal water protection.

Entry competences (foreknowledge, descriptive):

- General knowledge from secondary school, the basics of mathematical modeling.

Learning outcomes:

- Acquiring basic knowledge about natural and wastewater properties, anthropogenic impacts on water quality,
- Legal measures on water protection, water quality modeling and wastewater treatment.

Course content:

- Lectures:

  1. Basic ecological principles: biotic and abiotic factors, biotopes, biocenosis, ecosystems. Water properties: structure, physical, chemical, biological [3]
  2. Water quality: physical, chemical and biological indicators. Changes in water quality: pollution sources, wastewater types, water auto-purification [1]
  3. Water quality models: empirical models, numerical models, QUALL, WASP [2]
  4. Aquatic systems degradation: eutrophication, chronic and acute pollution ([2],
  5. Water quality management: political and sociological issues, legal measures, physical planning, financial and economic measures, scientific and technological measures, institutional measures, water protection plans and programs [2]
  6. Wastewater treatment: general principles, mechanical treatment, physico-chemical treatment [2]
  7. Wastewater treatment: biological – conventional treatment with active sludge [2]
  8. Wastewater treatment: biological – extended aeration, SBR [2]
  9. Wastewater treatment: biological – nitrogen and phosphorus removal [2]
  10. Wastewater treatment: sludge treatment [2]
  11. Wastewater treatment: alternative wastewater treatment [2]
  12. Wastewater treatment: alternative procedures [2]
  13. Mixing models in lakes and seas: (VISUAL PLUMES, CORMIX) [2]
  14. Best management practices in runoff treatment [2]
  15. Non point pollution control: phenomenon, sources, control techniques [2]

- Exercises (auditory:

  1. Waste water analyses: physical, chemical, biological [1]
  2. Streeter-Phelps oxygen sag curve calculation [1]
  3. River water quality modeling (QUAL, WASP) [1]
  4. River water quality modeling (QUAL, WASP) [1]
  5. River water quality modeling (QUAL, WASP) [1]
  6. Dynamics of wastewater generation and inflow [1]
  7. Mechanical treatment dimensioning [1]
  8. Kinetics equations of biological treatment [1]
  9. Conventional biological treatment dimensioning [1]
  10. Attached microorganisms systems dimensioning [1]
  11. Primary and secondary settling dimensioning [1]

12. Facilities for sludge treatment dimensioning [1]
13. Alternative WWTP dimensioning [1]
14. Long sea outfalls dimensioning [1]
15. Mathematical modeling of pollution transport and dilution (VISUAL PLUMES, CORMIX) [1]

Student responsibilities:

- Regular attendance in lectures and exercises,
- Exercise attendance 100%
- Lecture attendance 75%

Grading and evaluation of student work over the course of instruction:

- 2 pre-exams, each maximum 100 points
- 1 additional pre-exam, for students who achieved less than 25% score in one or both pre-exams.

End of semester grading:

- 120 – 140 points = satisfied [2]
- 140 – 160 points = good [3]
- 160 – 180 points = very good [4]
- ≥ 180 points = excellent [5]

Contributions to the final grade:

- Bonus for regular attendance, maximum 20 points.

Required literature:

1. Mimeographed notes of lectures
2. Tedeschi, S.: *Zaštita voda*, Zagreb university textbook, 1997

Optional literature:

1. Metcalf & Eddy: *Wastewater Engineering, Treatment, Disposal and Reuse*, McGraw-Hill International Editions, 2003

3rd year, 5th semester

Obligatory courses

CONCRETE AND MASONRY STRUCTURES

Credit value (ECTS): 8

Number of hours (in semester):

- Lectures: 60
- Exercises: 45 (auditory – 15, design - 30)

Course objectives:

- Acquisition of theoretical knowledge about the basics of reinforced concrete and masonry elements and structures design,
- Acquisition of practical knowledge about the basics of reinforced concrete and masonry elements and structures design and making reinforcement and formwork design plans for these elements and structures.

Entry competences (foreknowledge, descriptive):

- Theoretical and practical knowledge acquired in the course Structural analysis 1 (behavior of structures under applied loading and determining of internal forces for that structures),

- Theoretical and practical knowledge acquired in the courses Strength of materials 1 and 2 and Materials science,
- Knowledge about basic structural elements.

Enrolment requirements (correlated courses):

- Teachers signatures: Strength of materials 2, Structural analysis 1
- Examinations passed: Mathematics 2, Physics, Descriptive geometry, Building construction, Materials science.

Requirements for examination taking (correlated courses):

- Examinations passed: Mechanics 2

Learning outcomes:

- Students will acquire basic knowledge and skills needed for designing basic structural systems of reinforced concrete and masonry structures and they will know basic principles of conceptual designing,
- Students will gain basic knowledge about basic bearing reinforced concrete and masonry structural elements,
- Students will have knowledge and skills needed to analyse behavior and to design basic bearing system of reinforced concrete and masonry structures according to ultimate limit states using modern methods and European norms criteria,
- Students will be able to make design plans for simple reinforced concrete structures and their elements,
- Students will have necessary knowledge for designing simple masonry building in areas where no stronger seismic activities are expected.

Course content:

- Lectures:
  1. General information about concrete and masonry structures – the meaning and usage, history and development, advantages and disadvantages. CONCRETE STRUCTURES - Codes, literature. Physical and mechanical properties of concrete and steel reinforcement [4]
  2. Bending of reinforcement. Concrete cover. Reinforcement bar spacing. Tables of reinforcement. Design spans. Bond-slip behavior of reinforcement, anchoring, lap-splicing of reinforcement. Durability and concrete cover. Basic assumptions for reinforced concrete structures design according to ultimate limit states. Global and partial safety factors [4]
  3. Actions on structures. Singly reinforced cross sections [4]
  4. Minimum reinforcement. Double-reinforced cross sections. One way slabs [4]
  5. Staircases. Two way slabs. Minimum and maximum reinforcement [4]
  6. Beams – rectangular and T- cross section – design [4]
  7. MIDTERM EXAM no. 1 – Design of reinforced concrete one-way slabs [4]
  8. MASONRY STRUCTURES – history. Introduction [4]
  9. Masonry structures materials. Masonry elements. Mortar. Concrete infill [4]
  10. Material characteristics: masonry units, mortar, masonry, reinforcement [4]
  11. Unreinforced masonry. Stability and behavior of structures [4]
  12. MIDTERM EXAM no. 1 – Design of vertically loaded unreinforced masonry wall according to European norm EN 1996-1-1 [4]
  13. Walls subjected to concentrated load. Confined masonry. Laterally loaded masonry. Reinforced masonry walls. CONCRETE STRUCTURES –Principles and methods of centrically and eccentrically loaded reinforce concrete structural elements (columns and walls) [4]
  14. Design of reinforced concrete short columns according to method by Ehlers and interaction diagrams [4]
  15. Reinforced concrete foundations. Revision of the course content [4]
- Exercises (auditory, design):
  1. Introduction (auditory) [3]
  2. Layout and dimensions of elements (auditory) [2], (design) [1]
  3. Design of slabs position numbers from 100 and up (auditory) [2], (design) [1]

4. Reinforcement layout for slabs position numbers from 100 and up (auditory) [2], (design) [1]
5. (design) [3]
6. Beam 207-208-207 (auditory) [2] , (design) [1]
7. Reinforcement plan for beam 207-208-207 (auditory) [2], (design) [1]
8. (design) [3]
9. Frame system – structural analysis (auditory) [1] , (design) [2]
10. (design) [3]
11. Frame columns (auditory) [1], (design) [2]
12. (design) [3]
13. (design) [3]
14. (design) [3]
15. (design) [3]

Student responsibilities:

- Attendance in lectures and exercises,
- Making an independent exercise assignment,
- Passing both pre-exams (minimum 25 % score).

Grading and evaluation of student work over the course of instruction:

- Exercise assignment grade,
- Students who have achieved minimum 60 % score in a pre-exam are exempt from that part of written exam.

End of semester grading:

- Written exam -minimum 55 % score,
- Oral exam.

Contributions to the final grade:

- Exercise assignment 15 %,
- Written exam (pre-exam results included) 60 %,
- Oral exam 25 %

Required literature:

1. Sorić, Z., Kišiček, T.: *Betonske konstrukcije 1*, *Projektiranje betonskih konstrukcija prema europskim normama EN*, Zagreb 2010, 2011,
2. Sorić, Z.: *Betonske konstrukcije 1*, *Betonske konstrukcije prema Europskoj prednormi(HRN ENV 1992-1-1,* Zagreb 2010,
3. Sorić, Z*.: Betonske i zidane konstrukcije 1 - Zidane konstrukcije* , mimeographed notes by the Faculty of Civil Engineering, Zagreb University, 2008, 2009., 2010df or 2011,
4. Sorić, Z.: *Zidane konstrukcije*, paragraph 11, *- Projektiranje zidanih konstrukcija prema europskim normama EN*, Zagreb 2009, 2010, 2011,
5. Sorić, Z., Pičulin, S., Zamolo, M., Kišiček, T., (Jure Radić i suradnici.): *Osnove proračuna*, paragraph 5, book *Betonske konstrukcije*,university textbook, Zagreb, 2006,. ISBN 953-169-pp. 126-6. Pp. 399-663,Editor: Čandrlić, V.,
6. Sorić, Z., Kišiček, T., Galić J., (Jure Radić and associates): paragraph from the book *Betonske konstrukcije, riješeni primjeri, iii. Konstrukcijski elementi*, pp. 139-390, university textbook, Zagreb, 2006, Hrvatska sveučilišna naklada, Sveučilište u Zagrebu - Građevinski fakultet, SECON HDGK, ANDRIS. Editor: Čandrlić, V.,
7. Tomičić, I.: *Betonske konstrukcije*, Društvo Hrvatskih građevinskih konstruktora, Zagreb, 1996,
8. Tomičić, I.: *Priručnik za proračun armiranobetonskih konstrukcija*, Društvo Hrvatskih građevinskih konstruktora, Zagreb, 1996,
9. Sorić, Z.: *Zidane konstrukcije I*, (second, expanded edition), Zagreb, 2004
10. Lectures and exercises

ROCK MECHANICS

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures:45
- Exercises (auditory):30

Course objectives:

- Gaining theoretical knowledge about the behavior of rock and the stress state in the rock mass caused by the forces acting from its immediate physical environment,
- Application of the obtained theoretical knowledge in solving simple problems in the domain of rock mechanics.

Entry competences (foreknowledge, descriptive):

- Understanding and ability to apply the conditions of equilibrium in the plane,
- Understanding the concepts of stress, strain, stress-strain curve, stiffness and strength,
- Knowledge about Mohr stress circle theory.

Enrolment requirements (correlated courses):

- Teachers signatures: Strength of materials 1

Requirements for examination taking (correlated courses):

- Teachers signatures: Strength of materials 1

Learning outcomes:

- Understanding the primary and secondary stress state, as well as the methods of their determination,
- Gained knowledge in laboratory and field testing of rocks, and the methods of determining parameters of the intact rock (laboratory tests) and the rock mass (field tests),
- Gained knowledge about the classification of rock masses,
- Understanding the concepts of strength and stiffness of the rock mass, as well as the strength of discontinuities,
- Ability to solve simple problems in the domain of rock mechanics: foundations on rock, rock slope stability, the stability of rock falls, the interaction between the rock mass and tunnel support.

Course content:

- Lectures:
  1. Introduction to rock mechanics and rock engineering [3]
  2. State of stress and strain in the rock [3]
  3. Laboratory testing methods ([3]
  4. Field testing methods [3]
  5. Classification of the rock mass [3]
  6. The strength of the rock mass [3]
  7. The strength of the discontinuities [3]
  8. The stiffness of the rock mass [3]
  9. Foundations on the rock [3]
  10. The stability of rock slopes [3]
  11. The stability of rock falls [3],
  12. Reinforcing of rock mass with rock bolts [3]
  13. Tunnelling [3]
  14. Rheology of rock material [3]
  15. Make up pre-exam [3]
- Exercises (auditory):
  1. Introduction to rock mechanics and rock engineering [3]

2. State of stress and strain in the rock [3]
3. State of stress and strain in the rock [3]
4. Laboratory testing methods (carbonate content, ultrasound, PLT) [3]
5. Laboratory testing methods (uniaxial compressive strength, correlation between uniaxial compressive strength and PLT) [3]
6. Classification of the rock mass [3]
7. The stiffness and the strength of the rock mass [3]
8. Foundations on the rock [3]
9. The stability of rock slopes (planar failure) [3]
10. The stability of rock slopes (wedge failure) [3]
11. Pre-exam(Midterm examination) [3]
12. The stability of rock slopes (rotational failure)[3]
13. The stability of rock falls [3]
14. Underground structures [3]
15. Underground structures [3].

Student responsibilities:

- 75% attendance in lectures,
- 100% attendance in exercises,
- 25% score in a pre exam.

Grading and evaluation of student work over the course of instruction:

- None.

End of semester grading:

- Written (theory - 70%, assignments, solving of problem - 30%),
- Oral exam.

Contributions to the final grade:

- Minimum 60% score in the written exam,
- Oral exam.
- Grading:
    - 60-70% = sufficient [2],
    - 70-80% = good [3],
    - 80-90% = very good [4],
    - 90 -100% = excellent [5]).

Required literature:

1. Meho Sasa Kovacevic and Danijela Marcic lecture notes and tables for exercise – power point presentation - available on the web)

Optional literature:

1. Goodman, R.E., *Introduction to Rock Mechanics*, Second Edition, 1989,
2. Hudson, J.A., Harrison, J.P., *Engineering Rock Mechanics, An Introduction to the Principles*, 1997

ROADS

Credit value (ECTS): 6

Number of hours (in semester):

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

Course objectives:

- Acquisition of basic theoretical and practical knowledge in design and geometry of roads.

Entry competences (foreknowledge, descriptive):

- Knowledge of computer programs for technical drawing.

Enrolment requirements (correlated courses):

- Teachers signatures: Soil mechanics.

Requirements for examination taking (correlated courses):

- Examinations passed: Geodesy.

Learning outcomes:

- Understanding the basic principles of traffic, safety, levels of service and capacity,
- Understanding the basic transportation dynamic rules for determining horizontal, vertical and cross-section elements of roads,
- Ability to use the design documents in road construction,
- Ability to search through scientific papers and collect information and data to solve practical problems in everyday engineering practice,
- Basic knowledge needed for the construction of road beds, slope protection and drainage system,
- Basic knowledge needed for the construction of pavement structure.

Course content:

- Lectures:
  1. Introduction. Road vehicles [3]
  2. Motion of vehicles [3]
  3. Horizontal alignment [6]
  4. Vertical alignment [3]
  5. Space alignment. Traffic [3]
  6. Road cross-section [3]
     (1st pre-exam)
  7. Geometry tread [3]
  8. Drainage. Materials. Lower structure [3]
  9. Road junctions [3]
     (2nd pre-exam)
  10. Traffic areas. Road equipment [3]
  11. Pavement structures [6]
- Exercises (auditory, design, laboratory):
  1. Situation [12]
  2. Longitudinal profile [6]
  3. Normal cross-section profile [4]
  4. Characteristic cross-section profiles [4]
  5. Technical description [4]

Student responsibilities:

- Lecture and exercise attendance,
- Program design.

Grading and evaluation of student work over the course of instruction:

- Assessment of the program,
- Pre-exams: students with a 40% score are exempt from the written exam.

End of semester grading:

- Written exam: 40% score for a pass,
- Oral exam.

Contributions to the final grade:

- Programs 20%,
- Pre-exams or written exam 40%,
- Oral exam 40%.

Required literature:

1. Korlaet, Ž.: *Uvod u projektiranje i građenje cesta*, Udžbenik Sveučilišta u Zagrebu, 1995, p. 208
2. Dragčević, V.; Korlaet, Ž.: *Osnove projektiranja cesta*, Udžbenik Sveučilišta u Zagrebu, 2003, p. 93
3. Drugi sadržaji: http://www.grad.unizg.hr/predmet/ceste (web page for Roads - Ceste)

RAILWAYS

Credit value (ECTS): 3

Number of hours (in semester):

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

Course objectives:

- Acquisition of basic theoretical knowledge on the principles of railway transportation, permanent way elements and various influences on track and practical knowledge on requirements for a track arrangement, inspection works and track maintenance.

Entry competences (foreknowledge, descriptive):

- Knowledge of materials mechanical properties.

Enrolment requirements (correlated courses):

- Teachers signatures: Soil mechanics

Requirements for examination taking (correlated courses):

- Examinations passed: Strength of material 1

Learning outcomes:

- Understanding the basic principles of railway traffic,
- Analyzing the basic thesis related to load influence on track,
- Basic knowledge on track design geometry,
- Basic knowledge on track superstructure and permanent way elements,
- Basic knowledge on rail welding procedures and continuous welded rail (CWR),
- Basic knowledge on railway maintenance procedures.

Course content:

- Lectures:
  1. Introduction to railways. Historical development and classification [1]
  2. Clearances. Wheel sets [2]
  3. Rail vehicles. Railway lines categorization [2]
  4. Selection of route and design elements [2]
  5. Railway stations [2]
  6. Horizontal and vertical alignment elements [2]
  7. Track load. Basic calculations [3]
  8. Track superstructure elements. Rails. Sleepers [3]
  9. Track superstructure elements. Fastening systems. Ballast [2] (1st pre-exam)
  10. Permanent way elements. Turnouts. Turntables. Travelling platforms [4]
  11. Basic requirements for a track arrangement. Straight track. Track in curve [2]
  12. Rail welding [2]

13. Track quality control. Track maintenance [2]
    (2nd pre-exam)
14. Special railways [1]

- Exercises (auditory, design):
  1. Calculation of rail stresses depending on superstructure elements and load [5]
  2. Calculation and reconstruction of existing horizontal curve [5]
  3. Calculation of continuously welded track stability [5]

Student responsibilities:
- Lecture and exercise attendance,
- Program design,
- 2 pre-exams (minimum 25% score in each pre-exam, 1 additional make up pre-exam.)

Grading and evaluation of student work over the course of instruction:
- Assessment of the program,
- Pre-exams: students with minimum 60% score in each pre-exam are exempt from the written exam.

End of semester grading:
- Written exam: 50% score for a pass,
- Oral exam.

Contributions to the final grade:
- Program 10%,
- Pre-exams or written exam 50-60%,
- Oral exam 30-40%.

Required literature:
1. Prister, G.; Pollak, B.: *Gornji ustroj i specijalne željeznice*, Građevinski institut, Zagreb, 1988,
2. Lakušić, S.: *Željeznice*, lectures for the 3rd year students at the Faculty of Civil Engineering.

Optional literature:
1. Esveld, C.: *Modern Railway Track*, Second Edition, MRT Productions, Zaltbommel, 2001.

Elective courses

BUILDING TECHNOLOGY

Credit value (ECTS): 3

Number of hours (in semester):
- Lectures: 30

Course objectives:
- Acquisition of knowledge on construction preparatory works; securing a foundation pit,
- Performance of building processes,
- Production, transportation and pouring of concrete,
- Types and work principles of construction machinery,
- Types of formworks and scaffolds; demolition and removal of buildings.

Entry competences (foreknowledge, descriptive):
- Knowledge and skills in previous modules, particularly in construction materials and concrete technology.

Enrolment requirements (correlated courses):
- Examinations passed: Construction materials, Concrete technology.

Requirements for examination taking (correlated courses):

- Examinations passed: Construction materials, Concrete technology.

Learning outcomes:

- Recognising the technology and producing the workflow for specific construction process,
- Selecting the scaffold for specific construction and understanding the erection process,
- Selecting the ormwork for specific construction and understanding the phases of work with it,
- Selecting the type and capacity of machinery for earthworks,
- Selecting the type and capacity of concrete plant,
- Defining the capacity of transportation system and estimating the duration of concrete. Pouring.

Course content:

- Lectures:
  1. Introductory lecture [2]
  2. Workflow charts [2]
  3. Building machinery [4]
  4. Foundation pit securing [2]
  5. Concrete plant [2]
  6. Transport and pouring of concrete [2]
  7. Concrete steel production plant and rebar works [2]
  8. Scaffolds in building [4]
  9. Formworks in building [6]
  10. Boring, cutting and demolition of buildings [2]

Student responsibilities:

- Attendance in lectures and exercises,
- 2 pre-exams: 25% score in each pre-exam, make up pre-exam.

Grading and evaluation of student work over the course of instruction:

- Students who have achieved minimum 60% score in each pre-exam are exempt from the written part of exam.

End of semester grading:

- Written and oral exam.

Contributions to the final grade:

- Pre-exam 60%,
- Exam 40%

Required literature:

1. Mimeographed lecture notes on the faculty website,
2. Zdravko Linarić: *Leksikon osnovne građevinske mehanizacije (Lexicon of elementary construction machinery)*, faculty website

Optional literature:

1. Zdravko Linarić: *Učinak građevinskih strojeva (Performance of construction machines*), faculty website,
2. Gorazd Bučar: *Tesarski,armiračkii betonskiradovi na gradilištu* (*Carpenter, rebar and concrete works on construction site*), Civil Engineering Faculty Osijek, Osijek, 1997

TECHNOLOGY OF HEAVY CONSTRUCTION

Credit value (ECTS): 3

Number of hours (in semester): 30

- Lectures:30
- E-learning: 100% of lectures and examination is supported by e-learning but it is not normalized.

Course objectives:

- Acquiring basic information on technology of heavy construction, which may help in real situations with the industrial and construction production.

Entry competences (foreknowledge, descriptive):

- Knowledge of specific literature, prior knowledge, skills or participation in preparatory modules of undergraduate program (area of: Materials).

Learning outcomes:

- Theoretical or factual knowledge about construction or building technique and technology, specially the technology for heavy construction,
- Cognitive and practical skills which make use of the knowledge about planning of heavy construction technology,
- Productivity of earthworks equipment and transportation,
- Scaffoldings and formworks in heavy construction,
- Competences: integration of knowledge, skills and social and methodological liabilities in work ands study situations in heavy construction or building.

Course content:

- Lectures:
  1. Introduction lecture [2]
  2. Technology of heavy construction– Construction and building works. Construction technique and technology [2]
  3. Construction equipment. Features of modern construction equipment [2]
  4. Technique and technology of surface (crust) earthworks [2]
  5. Earthworks. Surface excavation in soil and rock. Dozers, scrapers, excavators. Work tools and arrangement for excavators. Trenchers. Rock scraping [2]
  6. Transportation of earth material. Loaders and rubber tyred haulage. Embankment works. Graders and rollers [2]
  7. Planning the methods and technology for earthworks [2]
  8. Productivity of equipment and transportation for earthworks [2]
  9. Methods and technology of concrete works (transported concrete) [2]
  10. Concrete works (concrete building). Transportation of concrete. Preparation (mixing) of concrete, concrete- mixing plant [2]
  11. Scaffoldings and formworks in heavy construction. Modern systems of formworks. Scaffoldings system [2]
  12. Transportation of concrete. Tower cranes, concrete building, horizontal concrete building structures [2]
  13. Scaffoldings and formworks systems for bridge construction [2]
  14. Prefabricated building practices for bridges. Auto-and heavy (track, crawler) cranes [2]
  15. Asphalt structures and construction works. Roller compacted asphalt concrete works. Mastic asphalt works. Asphalt macadam works [2]

Student responsibilities:

- Attendance in minimum 75% lectures,
- Achieving a 255 score in pre-exam.

Grading and evaluation of student work over the course of instruction:

- Two pre-exams.

End of semester grading:

- Written exam,
- Or minimum 60% score in pre-exams and oral exam.

Contributions to the final grade:

- Written exam: 100%,
- Required scores in pre-exams and oral exam: 60% and 40%.

Required literature:

1. Course materials available on e-learning system
2. Linarić, Z, *Leksikon osnovne građevinske mehanizacije*,
3. Linarić, Z ,Učinak građevinskih strojeva,
4. Linarić, Z ,*Postrojenja za proizvodnju gradiva, I.dio, Drobilane,Tvornice betona (betonare), Asfaltne baze (asfaltna postrojenja*),
5. Linarić, Z, *Izbor strojeva i planiranje strojnog rada u građenju*.

Optional literature:

6. Linarić, Z, *Tehnologija građenja I, Zemljani radovi*,
7. Linarić, Z ,*Sustavi građevinskih strojeva*,
8. Lončarić Rudolf: *Organizacija graditeljskih projekata*, Sveučilište u Zagrebu, 1995,
9. Eduard Slunjski: *Strojevi u građevinarstvu*

STRUCTURAL ANALYSIS 2

Credit value (ECTS): 4.5

Number of hours (in semester):

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

Course objectives:

- Enhancing theoretical knowledge about the behaviour of structures under various loads and other influences,
- Gaining practical knowledge about the analytic and numerical methods of linear analysis of rod structures.

Entry competences (foreknowledge, descriptive):

- Understanding and ability to apply equilibrium equations,
- Knowledge about the basic theoretical methods of linear static analysis for determination of reactions, internal forces and displacements on statically determinate and indeterminate structures,
- Understanding the principle of virtual work and basics of variational calculus.

Enrolment requirements (correlated courses):

- Teachers signatures: Structural Analysis 1, Strength of Materials 2
- Examinations passed: Mathematics 2, Strength of Materials 1

Requirements for examination taking (correlated courses):

- Teachers signatures: Mechanics 2
- Examinations passed: Structural Analysis 1

Learning outcomes:

- Application analytical and relaxation methods in calculating statically indeterminate structures,
- Interpretation of theoretical foundations of numerical procedures in calculations,
- Application of computer programmes in calculating structures and assessment of possibilities of application of various programmes,
- Explanation and implementation of the procedures of defining influence functions and drawing influence lines.

Course content:

- Lectures:
  1. Displacement method:
     a. Slope–deflection method [6]
     b. Static and kinematic condensation [3]
     c. Application of symmetry and anti-symmetry in force and displacement methods [3]

2. Relaxation methods:
    a. Cross method [4]
    b. Werner and Csonka's method [4]
3. Influential functions and lines:
    a. Statically determinate systems [4]
    b. Statically indeterminate systems [4]
4. Spatial systems [2]

- Auditory exercises:
    1. Displacement method [8]
    2. Relaxation procedures [8]
    3. Influential functions [6]
- Computer room exercises:
    1. Application of computer software [6]

Student responsibilities:

- Attendance in lectures and exercises,
- Making 3 programs and discussing them,
- 1 pre-exam: minimum25% score, one make up pre-exam.

Grading and evaluation of student work over the course of instruction:

- Grading programs,
- Pre-exam: students with 60% score in pre-exam are exempt from the written exam and can take (optional) theoretical pre-exam which entitles them to be exempt from the part of the oral exam.

End of semester grading:

- 50% score in written exam required for a pass,
- Oral exam.

Contributions to the final grade:

- Program 10%
- Pre-exam or written exam 50-60%
- Oral exam 30-40%.

Required literature:

1. V. Simović: *Građevna statika* , Građevinski institut, Zagreb, 1988,
2. M. Anđelić: *Građevna statika 2*, Građevinski fakultet, Zagreb, 2005,
3. K. Fresl: *GS – Bilješke i skice s predavanja*, `http://master.grad.hr/nastava/gs`

Optional literature:

1. M. Sekulić: *Teorija linijskih nosača*, Građevinska knjiga, Beograd, 2005,
2. L. P. Felton, R. B. Nelson: *Matrix Structural Analysis*, Wiley, New York, 1997,
3. W. Wunderlich, W. D. Pilkey: *Mechanics of Structures. Variational and Computational Methods*, CRC Press, Boca Raton, 2003.

NUMERICAL MODELING OF STRUCTURES

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures: 30
- Exercises: 30 (auditory – 8, laboratory – 22)

Course objectives:

- Theoretical knowledge about the behavior of construction under loadings,
- Practical knowledge about the analytical and numerical methods of linear structural analysis,

- Knowledge about the discretization of the calculation model,
- Practical knowledge about the interpretation of software-calculated results.

Entry competences (foreknowledge, descriptive):

- Understanding and ability to apply equilibrium equations in 2D and 3D,
- Knowledge about the basic theoretical methods of linear static analysis for determination of reactions, internal forces and displacements on statically determinate and indeterminate structures,
- Understanding the principle of virtual work and basics of variational calculus,
- Basic mathematical knowledge of differential equations.

Enrolment requirements (correlated courses):

- Teachers signatures: Strength of materials 2
- Examinations passed: Structural analysis 1, Strength of materials 1

Requirements for examination taking (correlated courses):

- Examinations passed: Strength of materials 2

Learning outcomes:

- Application of analytical and relaxation methods for statically indeterminate structures,
- Explanation of theoretical background for numerical methods of analysis,
- Explanation and calculation of influence lines,
- Explanation of numerical structural models for software analysis,
- Application of software package to structural analysis and evaluation of its applicability,
- Interpretation of the results calculated by software packages.

Course content:

- Lectures:
  1. Diplacement Method [2]
  2. Iterative methods [4]
  3. Influence lines [2]
  4. Discretization, Mathematical model of structure [4]
  5. Strong and weak formulation of problem [2]
  6. Ritz Method [2]
  7. Finite difference method [4]
  8. Introduction to FEM [4]
  9. Structures in 3D [2]
  10. Introduction to wall and plate structures [4]
- Exercises (auditory, design, laboratory):
  1. Displacement method [2]
  2. Iterative methods [4]
  3. Influence lines [2]
  4. Introduction to software package (SAP) [4]
  5. Modeling of beam structures (8)
  6. Modeling of gird structures (10)
  7. Introduction to modeling of wall and plate structures [4]
  8. Presentations of students' work [4]

Student responsibilities:

- Attendance in lectures and exercises,
- Solving 4 problems,
- 2 written pre-exams during semester.

Grading and evaluation of student work over the course of instruction:

- Evaluation of the solutions to given tasks,
- Evaluation of pre- exams.

End of semester grading:

- Final seminar paper,
- Oral exam.

Contributions to the final grade:

- Solutions of given tasks 10%,
- Pre- exams 30%,
- Final seminar paper 20%,
- Oral exam 40%.

Required literature:

1. M. Anđelić: *Građevna statika 2*, Građevinski fakultet, Zagreb, 2005.
2. M. Meštrović: *NMK – mimeographed notes*, http://www.grad.hr/predmeti/nmk

3rd year, 6th semester

Compulsory courses

CONSTRUCTION MANAGEMENT I

Credit value (ECTS): 7

Number of hours (in semester):

- Lectures: 45
- Exercises: 42 (auditory – 25, design – 17)
- Seminars: 3
- E-learning: 120

Course objectives:

- Students should be able to understand and organize construction processes and to work from the concept to the implementation phase,
- They should be able to apply key organizational and management tools and skills to different types of construction. Thus, they can work on site or in the office on different assignments such as: estimation, planning, scheduling, site organization and management, construction management, etc.

Entry competences (foreknowledge, descriptive):

- Basic principles of building technology,
- Basic principles of the technology of heavy construction.

Enrolment requirements (correlated courses):

- Examinations passed: Building technology or Technology of heavy construction.

Requirements for examination taking (correlated courses):

- Examinations passed: Building technology or Technology of heavy construction

Learning outcomes:

- Theoretical and practical knowledge about the construction management processes in civil engineering, e.g.: cost management, time/schedule management, site management, safety at work, bill of quantities, basics in project management, performance measurement, etc…

Course content:

- Lectures:
  1. Introduction [1]
  2. System vs Project [4]
  3. Construction project management plan [4]
  4. Organization of construction processes [4]
  5. Site management [4]
  6. Scheduling, monitoring and control in construction projects [6]
  7. Cost and expense calculation in construction projects [6]
  8. Business and stakeholder management [4]
  9. Basics in project management [4]
  10. Construction legislative [4]
  11. Safety at Work [4]
- Exercises (auditory, design, laboratory):
  1. Bill of quantities [4]
  2. Technology alternatives [4]
  3. Technology flowcharts [6]
  4. Organization of the work processes [6]
  5. Scheduling [6]
  6. Construction site planning [4]
  7. Cost estimate [6]
  8. Project management concept [6]
- Seminars:
  1. Current trends in project management

Student responsibilities:

- 80 % attendance in lectures and exercises,
- Completed work assignment,
- Presentation of the seminar paper.

Grading and evaluation of student work over the course of instruction:

- Active participation in work during semester,
- Meeting deadlines with the work assignment,
- A good presentation of the seminar paper.

End of semester grading:

- Three pre- exams,
- A work assignment and 1 presented seminar paper,
- Or the final exam at the end of the semester (writing assignment + oral examination).

Contributions to the final grade:

- Program 30%,
- Pre-exam 60%,
- Seminar paper 10%,
- Final exam 100%.

Required literature:

1. Radujković, M.: *Construction management I*, lectures – hard copy of PPT slides, University of Zagreb, 2008,
2. Marušić , J.: *Construction management*, University of Zagreb, 1994,
3. Lončarić, R.: *Organization of execution construction projects*, HDGI, Zagreb, 1995,
4. Radujković M., Burcar I., Vukomanović M.: *Solved assignment examples from Construction mangement I and Scheduling methods*, University of Zagreb, FCE, 2008,
5. Radujković M., Izetbegović J., Nahod M..M., *Construction law regulation*, University of Zagreb, 2008.

Optional literature:

1. Radujković, M et. al: *Planning and control of project*, University of Zagreb, 2012,
2. Vukomanović, M. and Radujković, M: *Business excellence in construction industry*, University of Zagreb, 2011.

METAL STRUCTURES

Credit value (ECTS): 4

Number of hours (in semester):

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

Course objectives:

- Gaining theoretical knowledge on the behavior of steel and aluminium as building materials and their impact on the resistance of structural elements and connections,
- Gaining knowledge related to spatial stabilisation of structures built of steel or aluminium elements,
- Gaining theoretical and practical knowledge on the design of simple steel structural elements.

Entry competences (foreknowledge, descriptive):

- Knowledge about the statics of rigid body and connected systems,
- Understanding and ability to apply equilibrium conditions to plane and space,
- Knowledge of and ability to determine reactions and internal forces as well as deflections on statically determinate structures.

Enrolment requirements (correlated courses):

- Teachers signatures: Concrete structures 1

Requirements for examination taking (correlated courses):

- Teachers signatures: Concrete structures 1

Learning outcomes:

- Ability to link knowledge about the behavior of steel as a material and the impact of that behaviour on the resistance of steel structural elements,
- Ability to make the layout solutions of simpler structures such as, for example, one story industrial buildings without crane rails,
- Identifying the key factors for determination of the basic actions on structures,
- Ability to determine the action effects at structural elements level for statically determinate systems,
- Ability to determine design resistances of simpler steel structural elements and connections for ultimate limit state and serviceability limit state.

Course content:

- Lectures:
    1. Introduction. Terminology and defining the contents of the course [3]
    2. Types of constructional steel, production and properties [3]
    3. Properties of steel as an engineering material [2]
    4. Reliability concept of steel structures [2]
    5. Action on structures [2]
    6. Classification of cross-sections [2]
    7. Resistance of cross-sections [2]
    8. Buckling resistance of members without lateral-torsional buckling phenomena [2]
    9. Constructional details [2]
    10. Connecting devices [2]
    11. Corrosion and fire protection [2]
    12. Design assisted by testing [2]

13. Fabrication and execution [2]
14. Aluminium structures [2]

- Exercises (auditory, design, laboratory): Design of very simple steel structure.

Student responsibilities:

- Attendance in lectures and exercises,
- Completed, submitted and positively graded individual project task and discussed with the assistant lecture to demonstrate understanding,
- 2 pre-exams to verify the level of acquired theoretical knowledge: earning minimum 25% score in each; make up pre-exam for students who did not achieve minimum 25% score in one or both pre-exams or for students who want to improve the score achieved in regular pre-exam.

Grading and evaluation of student work over the course of instruction:

- Pre-exam – students with minimum 60% score in every pre-exam are not obliged to attend the theoretical part of the exam.

End of semester grading:

- Written exam in two parts: a theoretical part (students may be exempt from taking this part of the exam) and a practical part – design of structural elements (mandatory for all students),
- For a passing grade students must achieve minimum 60% score in each part of the exam.

Contributions to the final grade:

- Achievement in pre-exam throughout the semester.

Required literature:

1. Androić, B.; Dujmović, D.; Džeba, I.: *Metal Structures 1*, IGH, Zagreb, 1994 (In Croatian)
2. Androić, B.; Dujmović, D.; Džeba, I.: *Steel Structures 2*, I. A.Projektiranje, Zagreb, 2007 (In Croatian)
3. Džeba, I.: *Resistance of cross-sections and resistance of members in steel structures* - Design, Sveučilište u Zagrebu, Građevinski fakultet, 2007, (In Croatian)
4. Džeba, I: *Design of Aluminium Structures*, Sveučilište u Zagrebu, Građevinskifakultet, 2007, (In Croatian)
5. Džeba, I.; Skeić, D.: *Print- lectures for exercises*, Sveučilište u Zagrebu, Građevinskifakultet, 2007 (In Croatian)

Optional literature:

1. HRN EN 1993-1-1:2004 Eurocode 3: *Design of Steel Structures – Part 1-1*:General rules and rules for building

BRIDGES

Credit value (ECTS): 4

Number of hours (in semester):

- Lectures: 30
- Exercises: 15 (auditory – 7, design – 8)

Course objectives:

- Gaining basic knowledge about all bearing systems of bridges; bridge design, construction and maintenance procedures and methods,
- Gaining basic knowledge in bridge conceptual design, numerical analysis of bridges and the dimensioning the bearing system.

Entry competences (foreknowledge, descriptive):

- Theoretical knowledge on the behavior of structures under loads and modes of transmission of forces,

- Practical knowledge about the linear calculation methods of statically determinate and indeterminate bar structure models,
- Basic knowledge about the composition, types and classification of soils and rocks, and the specifics of the mechanical behaviour of soils.

Enrolment requirements (correlated courses):

- Examinations passed: Structural analysis 1; Soil and rock mechanics

Requirements for examination taking (correlated courses):

- Examinations passed: Structural analysis 1; Soil and rock mechanics

Learning outcomes:

- Acquiring basic knowledge and skills needed to design the bearing system of a bridge and the application of the basic principles of conceptual design,
- Acquiring knowledge and skills necessary to analyse the behaviour of the bearing system and the bridge design according to the ultimate limit state and the serviceability limit state using modern methods and European codes,
- Knowledge about and ability to select the appropriate bearing system of a bridge, depending on the geometry and boundary conditions in accordance with modern methods and criteria of European codes,
- Basic knowledge about all bearing systems and ability to design a reinforced concrete bridge up to span of 20 m in accordance with the modern methods and the criteria of European norms.

Course content:

- Lectures:
  1. Introduction and basic terms [2]
  2. Types of bridges, basic requirements for bridges and traffic conditions [4]
  3. Loadings on bridge [2]
  4. Factors of bridge reliability; elements of bridge disposition [2]
  5. Bearing systems of bridges – 1st part [2]
  6. Bearing systems of bridges – 2nd part [4]
  7. Substructure and bridge equipment [4]
  8. Aesthetics of bridges [2]
  9. Construction of bridges [2]
  10. Maintaining of bridges and bridges in extraordinary circumstances [2]
  11. Overview of history of bridge building [2]
  12. Contemporary achievements in bridge engineering [2]
- Exercises (auditory, design, laboratory):
  1. Introduction to the program , dispositions and cross-sections of bridges – auditory [1]
  2. Substructure – auditory [1]
  3. Bridge equipment and details – auditory [1]
  4. Disposition - drawing and review – design [1]
  5. Disposition - drawing and review – design [1]
  6. Submission of disposition – design [1]
  7. Loads on bridges, transverse distribution, prepares for structural - auditory [1]
  8. Computer modeling, basics of Sofistik, Structural analysis of bridge using SOFISTIK – auditory [1]
  9. Structural analysis of bridge using SOFISTIK – design [1]
  10. Structural analysis of the computer - SOFISTIK – design [1]
  11. Dimensioning and reinforcement drafting – auditory [1]
  12. Dimensioning and reinforcement drafting, structural analysis review – design [1]
  13. Technical description, amount of reinforcement, program accessories, reinforcement drafting review - auditory + design [1]
  14. Completing and review of the entire program – design [1]
  15. Overview and delivery of the entire program –design [1]

Student responsibilities:

- Attendance in lectures and exercises,
- Exercise program execution,
- Passing two pre-exams (minimum 25% score in each pre-exam).

Grading and evaluation of student work over the course of instruction:

- Evaluation of the exercise program,
- 2 pre-exams: students with 60% score or more in each pre-exam are exempt from the written exam

End of semester grading:

- Written exam: 60% score,
- Oral exam.

Contributions to the final grade:

2. Exercise program 40%,
3. Written exam or pre-exams 40%,
4. Oral exam 20%

Required literature:

1. Radić, J.: *Introduction to bridge engineering (Uvod u mostarstvo),*Hrvatska sveučilišna naklada, Jadring, Sveučilište u Zagrebu-Građevinskifakultet, Zagreb 2009 (in Croatian)
2. Radić, J, Mandić, A., Puž, G.: *Design of bridges (Konstruiranje mostova),* Jadring, Zagreb 2005 (in Croatian)
3. Notes from exercises.

Optional literature:

1. Radić J. et al: *Concrete structures – Handbook*, Andris, Zagreb 2006 (in Croatian)
2. Radić J. et al: *Concrete structures – Practical Examples*, Andris, Zagreb 2006 (in Croatian)

HYDRAULIC ENGINEERING STRUCTURES

Credit value (ECTS): 3.5

Number of hours (in semester):

- Lectures: 45

Course objectives:

- Acquisition of practical and theoretical knowledge in functional and structural elements of hydraulic structures, and characteristic actions on hydraulic structures.

Entry competences (foreknowledge, descriptive):

- Knowledge and understanding of basic hydrological processes,
- Knowledge and understanding of basic fluid mechanics principles,
- Knowledge and understanding of soil and rock characteristics with basic foundation principles,
- Knowledge of concrete structures design.

Enrolment requirements (correlated courses):

- Examinations passed: Hydrology, Mechanics of fluids, Soil and rock mechanics

Requirements for examination taking (correlated courses):

- Examinations passed: Hydrology, Mechanics of fluids, Soil and rock mechanics

Learning outcomes:

- Identifying problems related to the hydraulic structures,
- Participating in design and construction of the hydraulic structures,
- Participating in water management projects.

Course content:

- Lectures:
  1. Introduction: the significance and the role of water in human society development; hydraulic engineering and hydraulic structures in water management;hydraulicstructures–purpose,definition,division.Fundamentalsofhydraulicstructuresdesign [3]
  2. Calculation types and hydraulic structures load and budget types, functionality [3]
  3. Mechanical resistance; stability [3]
  4. Water and surroundings load determination; load schemes for concrete and foundation work [3]
  5. River flood protection structures. Structures for river course training [3]
  6. Canals and canal structures [3]
  7. Road culvert sand structures for road drainage. Aqueducts, syphons, plugs, culverts [3]
  8. Pipelines and accompanying devices [3]
  9. Pipelines under pressure and with free surface [3]
  10. Hydro-engineering tunnels and accompanying devices; pressure tunnels and free-flow tunnels [3]
  11. Dams and weirs [3]
  12. Reservoirs and accompanying devices. Hydro power-plants [3]
  13. Maritime structures [3]
  14. Sea motion, sea waves, sea levels, port structures [3]
  15. Drainages, locks [3]

Student responsibilities:

- Attendance in lectures, three pre-exams.

Grading and evaluation of student work over the course of instruction:

- Three pre-exams.

End of semester grading:

- According to results achieved in two pre-exams over the course of instruction.
- Students with 60% score in partial exams are exempt from written exam.

Contributions to the final grade:

- Attendance in lectures and success achieved in pre-exams.

Required literature:

1. Mimeographed notes of lectures (pdf), Weekly notes of classes (ppt, pdf).

Optional literature:

1. Stojić, P: *Hidrotehničke građe ine I, II, III*, GF Split, 1997, 1998 and 1999,
2. Stojić, P.: *Hidroenergetika*, Građevinski fakultet, Split, 1995,
3. Nonveiller, E.: *Nasute brane*, Školska knjiga, Zagreb, 1983,
4. *Design of Small Dams*, US Department of the Interior, Bureau of Reclamation, 1977,
5. Pršić, M., Tadejević, Z.: *Unutarnji plovni putevi*, mimeographed notes, 1988

EDUCATION ON CONSTRUCTION SITE

Credit value (ECTS): 3

Number of hours (in semester):

- Exercises (on site): 45

Course objectives:

- Introduction to the technology, techniques, organisation and work processes at a construction sites.

Learning outcomes:

- Recognition of technology, techniques, organisation and work processes at construction sites

Course content:

- Exercises (on site):
  1. Construction pits excavation [3]
  2. Excavation in query – aggregate crushers [3]
  3. Excavations in water, aggregate separators [3]
  4. Production and transport of concrete [3]
  5. Foundation pit support [6]
  6. Reinforced concrete works below ground surface [3]
  7. Reinforced concrete works on the ground surface [3]
  8. Reinforced concrete – scaffolds and formworks (9)
  9. Assembling of precast structures [3]
  10. Performance of asphalt works [3]
  11. Water supply and drainage works [3]
  12. Building of bridges [3]

Student responsibilities:

- Tuition attendance,
- Writing a paper.

Elective courses

TIMBER STRUCTURES

Credit value (ECTS): 4

Number of hours (in semester):

- Lectures: 30
- Exercises: 15 (auditory – 9, design – 6)

Course objectives:

- Acquisition of theoretical and applied knowledge about timber as a building material,
- Acquisition of practical knowledge about the timber structures design process and the stabilization of timber structures.

Entry competences (foreknowledge, descriptive):

- Theoretical knowledge about the behavior of structures under load and other actions on structures and force transfer in structures. Understanding stress and strain concepts and terms related to internal forces. Practical knowledge about the calculation methods for statically determinate and statically indeterminate structures.

Enrolment requirements (correlated courses):

- Teachers signatures: Introduction to civil engineering, Mechanics 2, Strength of materials 2, Structural Analysis 1

Requirements for examination taking (correlated courses):

- Teachers signatures: Introduction to civil engineering, Mechanics 2, Strength of materials 2, Structural analysis 1

Learning outcomes:

- Theoretical and applied knowledge of timber as a building material, basic design of timber structures, design of the basic details in timber structures and the structural stabilization of timber structures.

Course content:

- Lectures:
    1. General overview of timber structures: a historical development, systems, methodological approach [2]
    2. Wood as a material: properties of wood, laminated timber and wood based products. Classification of timber in structural engineering [4]
    3. Protection methods and durability of timber structures. Fire safety design [2]
    4. Procedures in design of timber structures: Eurocode 5. The basis of structural analysis (ultimate limit states and serviceability states) [6]
    5. Metal fasteners: nails, bolts, dowels, screws, timber screws, patented fasteners and toothed plate connectors. Design of fasteners according to Eurocode 5 [6]
    6. Traditional timber carpentry joints. Principles of the design of elements and details [2]
    7. Secondary timber structures: design and detailing [2]
    8. Truss structures: design of elements and joints in timber trusses [2]
    9. Frame systems: design and detailing. Spatial stability and bracing systems [4]
- Exercises (auditory):
    1. Introduction to timber engineering. Problem description [1]
    2. Design plan (drawing) of timber truss system [1]
    3. Actions on structures [1]
    4. Structural analysis and design of secondary timber structures according to EC5 [1]
    5. Structural analysis of timber truss. Introduction to structural analysis and design software [1]
    6. Design of main timber truss elements according to EC5 [1]
    7. Structural stabilization of timber structures [1]
    8. Details in timber structures [1]
    9. Executive and detailed design plan. Specifications of project structure [1]
- Exercises (design):
    1. Design plan (drawing) of structure determinate by task [1]
    2. Structural analysis and design of secondary timber structure according to EC [1]
    3. Structural analysis of primary timber structure (timber truss) [1]
    4. Design of main timber truss elements according to Eurocodes [1]
    5. Design of structural stabilization. Design of details in timber structures according to Eurocodes [1]
    6. Executive and detailed design plan. Specifications of project structure [1]

Student responsibilities:

- Attendance in lectures and exercises. Making project task. Two pre-exams with minimum 25% score in each.

Grading and evaluation of student work over the course of instruction:

- Evaluation of students’ project task during semester. Evaluation of two pre-exams - with a 60% score students are exempt from the practical part of the exam.

End of semester grading:

- Practical and theoretical exam.

Contributions to the final grade:

- practical part of exam (or pre-exams) 50%,
- theoretical part of exam 50%

Required literature:

1. Bjelanović, A., Rajčić, V.: *Drvene konstrukcije prema europskim normama*, Hrvatska sveučilišna naklada, Zagreb, 2005, (Second edition, 2007.)
2. Rajčić, V., Čizmar, D., Stepinac, M.: *Riješeni primjeri iz drvenih konstrukcija*, Građevinski fakultet Sveučilišta u Zagrebu, Zagreb, 2014
3. E-learning materials available on the *Merlin* e-learning system

Optional literature:

1. Žagar, Z.: *Drvene konstrukcije 1 & 2*, Pretei, Zagreb, 2003,
2. Magerle, M.: *Svojstva drva*, IGH, Zagreb, 1996,
3. EUROCODE 5: *Design of timber structures – Part 1-1: General – Common rules and rules forbuildings*, CEN, 2004

LIGHTWEIGHT STRUCTURES

Credit value (ECTS): 4

Number of hours (in semester): 45

- Lectures: 30
- Exercises: 15 (auditory – 9,design – 6)

Course objectives:

- Students will get theoretical and practical knowledge about three different materials (timber, aluminium and glass) and will be able to design structural elements (beams, columns, trusses, etc.) and simple structural systems using timber, aluminium and glass. Practical knowledge about the stabilization of timber and aluminium structures is also the objective of the course.

Entry competences (foreknowledge, descriptive):

- Theoretical knowledge about the behavior of structures under load and other actions on structures,
- Uunderstanding the concepts of stress and strain and internal forces, Practical knowledge about the calculation methods for statically determinate and statically indeterminate structures.

Enrolment requirements (correlated courses):

- Teachers signatures: Mechanics 2, Resistance of materials 2, Statics 1, Introduction to civil engineering.

Requirements for examination taking (correlated courses):

- Teachers signatures: Mechanics 2, Resistance of materials 2, Statics 1, Introduction to civil engineering.

Learning outcomes:

- Theoretical and applied knowledge about timber, aluminium and glass as building materials.
- Basic design of timber, aluminium and glass structures. Details on timber, aluminium and glass structures. Structural stabilization of simple structures.

Course content:

- Lectures:
  1. General overview of timber structures: a historical development, systems, methodological approach [2]
  2. Wood as a material: properties of wood, laminated timber and wood based products [2] Classification of timber in structural engineering. Fire design of timber structures
  3. The current design standards and Eurocode 5. Basis of structural analysis (ultimate limit state and serviceability state) [5]
  4. Metal fasteners: nails, bolts, dowels, screws, timber screws, patented fasteners and toothed plate connectors. Design of fasteners [4]
  5. Traditional timber carpentry joints [2]
  6. Truss structures. Design of elements and joints in timber trusses [3]
  7. Aluminium as a building material. Basics of Eurocode 9 [5]
  8. Structural glass. Design of glass panels. Design of glass columns [5]
  9. Design of aluminium-glass facades [2]

- Exercises (auditory):
  1. Problem description. Introduction to timber engineering [1]

2. Design plan (drawing) for timber truss system [1]
3. Actions on structures [1]
4. Design according to Eurocode 5 standards. Structural analysis and design of secondary timber structures [1]
5. Timber truss – structural analyses [1]
6. Design of main timber truss elements. Structural stabilization [1]
7. Details in timber structures [1]
8. Design of glass panes and columns [1]
9. Design of aluminium columns. Technical description of the project [1]

- Exercises (design):
  1. Design plan (drawing) [1]
  2. Structural analysis and design of secondary timber structures [1]
  3. Timber truss – structural analyses [1]
  4. Design of main timber truss elements. Structural stabilization [1]
  5. Details in timber structures [1]
  6. Design of glass panes and columns. Design of aluminium columns [1]

Student responsibilities:

- Attendance in lectures and exercises,
- Preparation of the project,
- Minimum 25% score in each pre-exam.

Grading and evaluation of student work over the course of instruction:

- Evaluation of students' project during the semester,
- Evaluation of pre-exams – with minimum 60% score, students are exempt from the practical part of the exam.

End of semester grading:

- Practical and theoretical exam.

Contributions to the final grade:

- theoretical part of exam 50%,
- practical part of exam (or pre-exams) 50%.

Required literature:

1. Rajčić, V., Bjelanović, A.: *Drvene konstrukcije prema europskim normama*, 2007, ZAGREB
2. Rajčić, V., Čizmar, D.: *Priručnik iz predmeta Lagane konstrukcije*, Zagreb, 2008
3. Rajčić, V., Čizmar, D., Stepinac, M.: *Riješeni primjeri iz drvenih konstrukcija*, Zagreb, 2014
4. E-learning materials available at the Merlin e-learning system

Optional literature:

1. Žagar, Zvonimir: *Drvene konstrukcije II*, Pretei, 1999, Zagreb.
2. Loughran, P.: *Falling Glass – Problems and Solutions in Contemporary Architecture*, New York, 2003,
3. EN 1999: *Design of aluminium structures*, CEN, Brisel, 2007

ORGANISATION OF STUDY

Organisation of instruction and student workload

Curriculum for full time students is based on workload of 40 hours a week, which includes instruction, field work, practical exercises, other types of instruction and time needed for student preparation.

Instruction is organized in semesters according to the curriculum.

An academic year regularly has 44 working weeks, of which 30 cover teaching, and 14 are planned for consultation, exam preparation and exam taking and are instruction-free.

Maximum weekly student workload is 26 hours.

The share of practical and/or field training is determined in ECTS credits.

Full time students in one semester enrol in courses that earn from 25 to 35 ECTS credits.

Particularly successful students can be allowed to take more than 35 ECTS credits for early graduation or extended education.

Physical and health education classes and extracurricular activities are conducted out of the weekly student workload. They are compulsory in the first and second years of undergraduate study, and are elective in senior years. They do not earn ECTS credits.

Courses and/or modules for students to select from other studies

Students can (in accordance with the study program), enrol in courses of other university studies (study programs) of the University that are not offered by the Faculty.

Courses and/or modules that are conducted in a foreign language

The following programs can be conducted in English language:

- Geotechnical engineering
- Construction materials
- Soil and rock mechanics
- Construction management
- Basics of concrete technology
- Materials science
- Applied geology
- Sociology of work and professional ethics

Enrolment into the higher year of study

Students may only enrol in courses for which they have met the requirements according to the curriculum.

The requirements for exam taking and attending lectures in undergraduate study are regulated by a special decision brought by the Faculty Council.

Undergraduate students are allowed to enrol in the higher year of study upon meeting all study requirements (expressed in ECTS credits) which they accepted when enrolling in the previous year of study.

Students who have not met the above requirements can continue studying if they re-enrol in the courses they have not completed and if they enrol in new courses, with the maximum workload of 25 to 35 ECTS credits in a semester. These students can enrol in courses which are not related to the courses they have not completed.

Lectures and exercises

Students are obliged to attend the types of instruction set by the study program and curriculum, which is the requirement, besides meeting other conditions and achieveing relevant results in examinations, for the teacher signature. .

Exams and other types of assessment

Student knowledge can be assessed and evaluated during instruction (pre-exams, practical tasks etc.), and the final grade is determined in the exam. The exam in one course can be taken maximum four times in academic year. The fourth time the exam is taken before an examination board. A student who has failed the exam for the fourth time in the same course is obliged to re-enrol in that course and has the right to take the exam four times, the fourth time before an examination board. If a student fails eight times he/she loses the right to study.

Curriculum may determine that some types of instruction are conducted without grading, or the grades are descriptive, or the final grade can be determined by assessment and evaluation during instruction, or that students' grades in different types of instruction are calculated into the final grade for students' knowledge achieved in the exam and/or other types of assessment.

The lecturer conducting instruction has the right to assess and evaluate students' knowledge in any type of instruction.

Examination periods and administering exams

The examination periods are as follows: winter, summer and autumn. Examination periods last minimum 3 weeks. In each examination period there are three examination terms with minimum 7 day interval.

For a good reason , the Dean can set extraordinary examination periods.

Exams can be taken by students who have met all the requirements set by the curriculum. Students who have enrolled in the course and have attended lectures (confirmed by teacher signature) are entitled to exam taking.

Completion of studies

Undergraduate study is completed by taking the final exam in civil engineering courses of the study program.

Graduation exam

When enrolling in the final semester students select the course and the mentor for the graduation exam.

The theme of the graduation exam is selected by the mentor, and the student has to be informed about it minimum 6 weeks after the final semester started.

The writing and defence of the graduation paper earns 6 ECTS credits, and in difficulty and volume must not extend 180 hours of effective work.

Graduation exam is taken before a three member examination board.

Graduate university study

GENERAL

Duration of study

Two years, 120 ECTS credits.

Enrolment requirements

Completed undergraduate university study in civil engineering, and with additional conditions completed undergraduate university study in related technical sciences or a completed professional study in civil engineering.

Study system

It is organized and conducted in semesters as a full-time study.

Criteria and transfer requirements of ECTS credits

ECTS credits are recognized according to the study program regulations set by the Faculty regardless of their value at students' home study program.

Requirements that have to be met by students who interrupted their studies or lost the right to study if they want to continue

Students who have interrupted their studies, can continue if they comply with the program they are enrolling in.

Students who have lost the right to study at some other study program are allowed to continue if they conform the ECTS credits they have earned to the Faculty's study program.

Academic title awarded upon graduation

Master's degree in civil engineering (abbrev.mag. ing. aedif.).

Document on completed study

Upon the completion of graduate university study students are issued with the degree certifying the graduation and the academic title.

Students are aslo issued with a diploma supplement certifying the exams passed, grades achieved and ECTS credits earned.

PROGRAMME'S LEARNING OUTCOMES

Accomplished learning outcomes upon the completition of undergraduate studies:

(ACQUIRING KONWLEDGE AND UNDERSTANDING)

- comprehensively understand general phenomena and problems in civil engineering, particularly in their area of specialisation
- demonstrate a high level of professional knowledge and conduct in civil engineering

(APPLYING KNOWLEDGE AND UNDERSTANDING)

- apply the obtained knowledge and skills to planning, design, construction, supervision and maintenance of complex building structures, interventions and systems in their specialised area with regard to the issues of stability, safety, occupancy, environment protection and costs
- apply the obtained skills and necessary knowledge in recognizing, formulating and analysing problems and in finding one or more acceptable solutions in their specialised area
- have an analytic approach to work, based on a wider knowledge of science
- plan, supervise and perform professional, developmental and scientific projects

(MAKING INFORMED JUDGEMENTS AND CHOICES)

- interpret the social aspect as well as the social context of construction projects they are working on
- manage companies and research institutions and contribute to innovations
- develop the civil engineering area of his/hr specialisation, respecting the development of other scientific disciplines

(COMMUNICATING KNOWLEDGE AND UNDERSTANDING, WORKING AS PART OF A TEAM)

- explain their ideas and projects to associates
- find solutions to technical and personal problems in working environment
- creatively apply obtained knowledge to decision making at high levels
- work on an international level, taking into account cultural, linguistic, social and economic influences

(CAPACITIES TO CONTINURE LEARNING, ETHICS)

- constantly follow innovations and improve in their profession
- accept responsibility for their decisions
- accept requirements of other professions and be ready to participate in interdisciplinary activities

COURSE TIMETABLE BY SEMESTER

GEOTECHNICAL ENGINEERING PROGRAMME

1st year, 1st semester

Course			Hours per week		ECTS
			Lectures	Practice	
1	Elective subjects	Mathematics 3 Stohastic Processes	3	2	7,5
2	Research Methods		1	0	1,5
3	Geotechnical Engineering		2	2	6
4	Flow Processes in Soil and Rock		2	2	6
5	Applied Soil Mechanics		3	2	7,5
		Total	**11**	**8**	**28,5**

1st year, 2nd semester

Course			Hours per week		ECTS
			Lectures	Practice	
1	Structures		2	2	6
3	Foundation Engineering		3	2	7,5
4	Numerical Modelling in Geotechnics		2	3	7,5
5	Elective subjects	Applied Geology Environmental Protection	2	0	3
6	Elective subjects (1 or 2)				
		Total			**31,5**

Elective subjects (2. semester)		Hours per week		ECTS
		Lectures	Practice	
1	Dynamics of Structures and Earthquake Engineering	3	2	7,5
2	Theory of Elasticity and Plasticity	3	2	7,5
3	Numerical Mathematics	2	2	6
4	Perspective	2	2	6
5	Basic of Differential Geometry	2	2	6
6	Waves and Oscillations	2	2	6
7	Courses of other programmes or electives of other studies	2	2	6

2nd year 3rd semester

	Course	Hours per week		
		Lectures	Practice	ECTS
1	Improvement of Soil and Rock	2	2	6
2	Earthfill and Retaining Structures	2	2	6
3	Hydrogeology and Engineering Geology	2	0	3
4	Geotechnical Laboratory	2	3	7,5
5	Elective subjects (1 or 2)			
	Total			**30**

	Elective subjects (3. semester)	Hours per week		
		Lectures	Practice	ECTS
1	Underground Structures	2	2	6
2	Geotechnics and Environmental Protection	2	1	4,5
3	Soil Dynamics	2	2	6
34	English in Civil Engineering 2	0	3	4,5
5	German in Civil Engineering 2	0	3	4,5
6	Courses of other programmes or electives of other studies			

2nd year 4th semester

	Course	Hours per week		
		Lectures	Practice	ECTS
1	Geotechnical Design	2	2	6
2	Field investigation and Monitoring	2	2	6
3	Final Assignment	0	12	18
	Total			**30**

HYDRAULIC ENGINEERING

1st year, 1st semester

Course			Hours per week: Lectures	Hours per week: Practice	ECTS
1	Elective subjects	Mathematics 3 / Stohastic Processes	3	2	7,5
2	Researche Methods		1	0	1,5
3	Hydraulics 1		3	2	7,5
4	Hydrology 2		2	2	6
5	River Training		3	2	7,5
		Total	**12**	**8**	**30**

1st year, 2nd semester

Course			Hours per week: Lectures	Hours per week: Practice	ECTS
1	Elective subjects	Water Supply and Sewerage 1 / Water Protection	2	1	4
2	Ports and Waterways		3	3	9
3	Drainage and Irrigation 1		3	2	8
4	Sturctures		2	2	6
5	Elective subjects	Applied Geology / Environmental Protection	2	0	3
		Total	**12**	**8**	**30**

2nd year, 3rd semester

Course		Hours per week: Lectures	Hours per week: Practice	ECTS
1	Water Power Use	2	2	6
2	Water Supply and Drainage 2	2	2	6
3	Elective subjects (3)			
	Total			**30**

Elective subjects (3. semester)		Hours per week: Lectures	Hours per week: Practice	ECTS
1	Urban Hydrology	2	2	6
2	Potable and Waste Water Treatment	2	2	6
3	Modeling in Hydraulic Engineering	2	2	6
4	Drainage and Irrigation 2	2	2	6
5	Flood Protection	2	2	6
6	Hydraulics 2	2	2	6
7	Earthfill and Retaining Structures	2	2	6
8	Hydrogeology and Engineering Geology	2	0	3
9	Hydrotechnical Concrete	2	2	6
10	Courses of other programmes or electives of other studies			

2nd year, 4th semester

Course		Hours per week: Lectures	Hours per week: Practice	ECTS
1	Water Resources Engineering	3	1	6
2	Elective subject			
3	Final Assignment	0	12	18
	Total			**30**

Elective subjects (3. semester)		Hours per week: Lectures	Hours per week: Practice	ECTS
1	Design in Hydraulic Engineering	0	4	6
2	Vegetative Water Facilities	2	2	6
3	Special Water Power Projects	2	2	6
4	Maritime Structures	2	2	6
5	Courses of other programmes or electives of other studies			

STRUCTURAL ENGINEERING PROGRAMME

1st year, 1st semester

Course			Hours per week		ECTS
			Lectures	Practice	
1	Elective subjects	Mathematics 3 Stohastic Processes	3	2	7,5
2	Researche Methods		1	0	1,5
3	Prestressed Concrete		2	2	6
4	Bridges 2		2	2	6
5	Metal Structures 2		2	2	6
6	Reliability of Structures		2	0	3
		Total	**12**	**8**	**30**

1st year, 2nd semester

Course		Hours per week		ECTS
		Lectures	Practice	
1	Concrete and Masonry Structures 2	2	2	6
2	Metal Structures 3	2	2	6
3	Timber Structures 2	2	2	6
4	Durability of Structures 1	2	2	6
5	Precast Reinforced Concrete Structures	2	2	6
	Total	**10**	**10**	**30**

2nd year, 3rd semester

Course		Hours per week		ECTS
		Lectures	Practice	
1	Concrete Structures 3	2	2	6
2	Bridges 3	2	2	6
3	Dynamics of Structures	2	1	4,5
4	Elective subject (3)			
	Total			30

Elective subjects (3. semester)		Hours per week: Lectures	Hours per week: Practice	ECTS
1	Stability of Structures	2	1	4,5
2	Durability of Structures 2	2	1	4,5
3	Tall Buildings	2	1	4,5
4	Structural Testing	2	1	4,5
5	English in Civil Engineering 2	0	3	4,5
6	German in Civil Engineering 2	0	4	4,5

2nd year, 4th semester

Course		Hours per week: Lectures	Hours per week: Practice	ECTS
1	Special Engineering Structures	2	1	4,5
2	Composite Structures	2	1	4,5
3	Elective subject			
4	Final Assignment	0	12	18,0
	Total			**30**

Elective subjects (4. semester)		Hours per week: Lectures	Hours per week: Practice	ECTS
1	Earthquake Engineering	2	0	3
2	Numerical Mathematics	2	2	6
3	Perspective	2	2	6
4	Basic of Differential Geometry	2	2	6
5	Waves and Oscillations	2	2	6
6	Courses of other programmes or electives of other studies	2	0	3

CONSTRUCTION MATERIALS PROGRAMME

1st year, 1st semester

Course			Hours per week: Lectures	Hours per week: Practice	ECTS
1	Elective subjects	Mathematics 3 Stohastic Processes	3	2	7,5
2	Researche Methods		1	0	1,5
3	Theory and Technology of Concrete		2	2	6
4	Building Physics		2	2	6
5	Polymers		2	1	4,5
6	Mechanics of Material		2	1	4,5
		Total	**12**	**8**	**30**

1st year, 2nd semester

Course			Hours per week: Lectures	Hours per week: Practice	ECTS
1	Elective subjects	Applied Geology Environmental Protection	2	0	3,0
2	Elective subjects	Quality Management Theory of Elasticity and Plasticity	3	2	7,5
3	Durability of Structural Materials		2	2	6
4	Special Concrete and Technologies		3	2	7,5
5	Concrete and Masonry Structures 2		2	2	6
		Total	**12**	**8**	**30**

2nd year, 3rd semester

Course		Hours per week: Lectures	Hours per week: Practice	ECTS
1	Precast Systems	2	2	6,0
2	Non-destructive Testing	2	2	6,0
3	Fire Protection	2	2	6,0
4	Elective subjects (2)			
	Total			**30**

Elective subjects (3. semester)		Hours per week		ECTS
		Lectures	Practice	
1	Technology of Repair and Strengthening	2	2	6
2	Concretes for Roads	2	2	6
3	Hydrotechnical Concrete	2	2	6
4	Metal Structures 2	2	2	6

2nd year, 4th semester

Course			Hours per week		ECTS
			Lectures	Practice	
1	Elective subjects	Numerical Modeling in Engineering Materials	2	2	6
		High Performance Concrete			
2	Elective subject				
3	Final Assignment		0	12	18
		Total			**30**

Elective subjects (4. semester)		Hours per week		ECTS
		Lectures	Practice	
1	Design of Experiments	2	2	6
2	Applied Metalurgy	2	2	6
3	Numerical Mathematics	2	2	6
4	Perspective	2	2	6
5	Basic of Differential Geometry	2	2	6
6	Waves and Oscillations	2	2	6
7	English in Civil Engineering 2	0	3	4,5
8	German in Civil Engineering 2	0	3	4,5

CONSTRUCTION MANAGEMENT PROGRAMME

1st year, 1st semester

	Course		Hours per week: Lectures	Hours per week: Practice	ECTS
1	Elective subjects	Mathematics 3	3	2	7,5
		Stohastic Processes			
2	Research Methods		1	0	1,5
3	Construction Management 2		2	2	6
4	Building Maintenance Management		2	1	4,5
5	Optimization Methods in Construction		2	2	6
6	Study of Work		2	1	4,5
		Total	**12**	**8**	**30**

1st year, 2nd semester

	Course		Hours per week: Lectures	Hours per week: Practice	ECTS
1	Construction Equipment		2	2	6
2	Management for Construction Industry		2	1	4,5
3	Construction Project Management		4	2	9
4	Elective subjects	Environmental Protection	2	0	3
		English in Civil Engineering 2	0	3	4,5
		German in Civil Engineering 2	0	3	4,5
5	Elective subjects				
		Total			**30**

	Elective subjects (2. semester)	Hours per week: Lectures	Hours per week: Practice	ECTS
1	Construction Technology 1	3	2	6
2	Supervising and Monitoring Construction Projects	2	0	3
3	Numerical Mathematics	2	2	6
4	Perspective	2	2	6
5	Basic of Differential Geometry	2	2	6
6	Waves and Oscillations	2	2	6
7	Courses of other programmes or electives of other studies			

2nd year, 3rd semester

Course		Hours per week: Lectures	Hours per week: Practice	ECTS
1	Construction Business Systems	2	2	6
2	Planning and Scheduling Methods	2	2	6
3	Construction Site Practice	0	4	6
4	Elective subjects (2)			
	Total			**30**

Elective subjects (4. semester)		Hours per week: Lectures	Hours per week: Practice	ECTS
1	Human Resource Management	2	2	6
2	Construction Technology 2	2	2	6
3	Investment Appraisals in Construction	2	2	6
4	Courses of other programmes or electives of other studies	2	2	6

2nd year, 4th semester

Course		Hours per week: Lectures	Hours per week: Practice	ECTS
1	Business Strategies in Construction	3	0	4,5
2	Sociology of Organization	2	1	4,5
3	Elective subjects (2-7 in 2nd semester)			
4	Final assignment	0	12	18
	Total			**30**

TRANSPORTATION ENGINEERING PROGRAMME

1st year, 1st semester

Course			Hours per week		ECTS
			Lectures	Practice	
1	Elective subjects	Mathematics 3 / Stohastic Processes	3	2	7,5
2	Traffic Noise		2	1	4,5
3	Transportation Engineering		2	2	6
4	Highway Design		2	2	6
5	Railway Design and Construction		2	2	6
		Total	**11**	**9**	**30**

1st year, 2nd semester

Course			Hours per week		ECTS
			Lectures	Practice	
1	Management in Civil Engineering		2	0	3
2	Elective subjects	Applied Geology / Environmental Protection	2	0	3
3	Pavements Structures		2	2	6
4	Permanent Way		3	1	6
5	Earthworks		2	2	6
6	Road Intersections		2	2	6
		Total	**13**	**7**	**30**

2nd year, 3rd semester

Course		Hours per week		ECTS
		Lectures	Practice	
1	Research Methods	1	0	1,5
2	Traffic Tunnels	2	2	6
3	Airports	2	1	4,5
4	Road Equipment	3	0	4,5
5	Transport Systems	3	0	4,5
6	Elective subjects (2)			
	Total			**30**

Elective subjects (3. semester)		Hours per week: Lectures	Hours per week: Practice	ECTS
1	Drainage of Transportation Facilities	2	1	4,5
2	Traffic Buildings	2	1	4,5
3	Soil - improvement Methods	2	1	4,5
4	English in Civil Engineering 2	0	3	4,5
5	German in Civil Engineering 2	0	3	4,5
7	Courses of other programmes or electives of other studies			

2nd year, 4th semester

Course		Hours per week: Lectures	Hours per week: Practice	ECTS
1	Pavement Management	2	0	3
2	Elective subjects (2)			
4	Final Assignment	0	12	18
	Total			**30**

Elective subjects (4. semester)		Hours per week: Lectures	Hours per week: Practice	ECTS
1	Parking Facilities	2	1	4,5
2	Track Maintenance	3	0	4,5
3	Urban Railways	2	1	4,5
4	Numerical Mathematics	2	2	6
5	Perspective	2	2	6
6	Basic of Differential Geometry	2	2	6
7	Waves and vibrations	2	2	6
8	Courses of other programmes or electives of other studies			

THEORY AND MODELLING OF STRUCTURES PROGRAMME

1st year, 1st semester

Course		Hours per week		ECTS
		Lectures	Practice	
1	Mathematics 3	3	2	7,5
2	Research Methods	1	0	1,5
3	Mechanics of Materials	2	1	4,5
4	Nonlinear Analysis of Rod Structures	2	1	4,5
5	Experimental Methods 1	2	2	6
6	Metal Structures 2	2	2	6
	Total	**12**	**8**	**30**

1st year, 2nd semester

Course		Hours per week		ECTS
		Lectures	Practice	
1	Theory of Elasticity and Plasticity	3	2	7,5
2	Dynamics of Structures and Earthquake Engineering	3	2	7,5
3	Finite Element Method	2	2	6
4	Theory of Composites	2	1	4,5
5	Concrete and Masonry Structures 2	2	1	4,5
	Total	**12**	**8**	**30**

2nd year, 3rd semester

Course		Hours per week		ECTS
		Lectures	Practice	
1	Space Structures	2	2	6
2	Structural Testings	2	2	6
3	Elective subjects (3 or 4, courses programmes min 13,5 ECTS)			
	Total			**30**

	Elective subjects (3. semester)	Hours per week		ECTS
		Lectures	Practice	
1	Methods of Theory of Elasticity and Plasticity	2	1	4,5
2	Polymers	2	1	4,5
3	Basic of Fracture Mechanics	2	1	4,5
4	Programming Structural Analysis Procedures	2	1	4,5
5	Courses of other programmes or electives of other studies	0	3	4,5

2nd year, 4th semester

	Course	Hours per week		ECTS
		Lectures	Practice	
1	Stability Theory	2	2	6
2	Elective subjects (1 or 2)			
4	Final Assignment	0	12	18
	Total			**30**

	Elective subjects (4. semester)	Hours per week		ECTS
		Lectures	Practice	
1	Numerical Methods in Structural Analysis	2	1	4,5
2	Selected Topics on Strength of Materials	2	1	4,5
3	Stochastic Analysis of Structures	2	1	4,5
4	Numerical Mathematics	2	2	6,0
5	Perspective	2	2	6
6	Basic of Differential Geometry	2	2	6
7	Waves and vibrations	2	2	6
8	Courses of other programmes or electives of other studies			

COURSE CONTENT WITH LEARNING OUTCOMES

GEOTECHNICAL ENGINEERING

1st year, 1st semester

Compulsory courses

RESEARCH METHODS

Look in **Shared courses**

GEOTECHNICAL ENGINEERING

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures:30
- Exercises: 30

Course objectives:

- Introduction to the basic principles of Eurocode 7 and their application in geotechnical engineering,
- Gaining theoretical knowledge about the types and roles of basic geotechnical structures (shallow and deep foundations, retaining structures, foundation pit protection, cut-offs, embankments) and understanding the design situations which apply to geotechnical structures,
- Gaining knowledge about the simple analysis and calculations of geotechnical structures (shallow foundations on soil and rock, piles, retaining structures, stabilization of cuts-offs and excavations in the rock) in terms of Ultimate (ULS) and serviceability (SLS) limit state.

Entry competences (foreknowledge, descriptive):

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

Learning outcomes:

- Ability to identify design situation related to basic geotechnical structures (shallow and deep foundations, retaining structures, slopes, embankments),
- Ability to conduct bearing capacity analysis for shallow and deep foundations in different types of soil and rock,
- Ability to conduct stability analysis of natural and man-made slopes,
- Ability to estimate earth pressures on the various types of retaining structures,
- Ability to conduct stability analysis of various retaining structures,
- Ability to conduct simple seismic analysis of geotechnical structures.

Course content:

- Lectures:
  1. Introduction to Geotechnical Engineering [2]
  2. Principles of Eurocode 7 [2]

3. Types and bearing capacity of shallow foundations in different types of soil and rock [2]
4. Settlement of shallow foundations [2]
5. Calculation methods for stability of natural and man-made slopes [2]
6. Actions on slopes and stabilization procedures [2]
7. Types of retaining structures and the determination of earth pressure [2]
8. Actions on retaining structures and calculation of the stability of retaining structures[2]
9. Application and bearing capacity of deep foundations[2]
10. Performance and transfer of forces in group of pilots[2]
11. Types of embankments and the basics of soil compaction[2]
12. Construction of embankments and stability analysis[2]
13. Introduction to the soil dynamics and the basics of the cyclic behavior of soil[2]
14. Typical problems of seismic geotechnical engineering[2]
15. Simplified seismic geotechnical calculations[2]

- Exercises:
  1. Introduction - review, exercise plan, 'rules of the game' (auditory)[2]
  2. EC7 - review (design situations, design values, partial coefficients) examples for various structures (auditory)[2]
  3. Foundation pad (capacity + settlement) –an example of the bearing capacity calculation for eccentric loaded foundation pad and settlement calculation (Kany, Steinbrenner, M & P), 1st program - task (auditory and construction)[2]
  4. 1st program - solving task (construction)[2]
  5. Slopes - stability analysis in the program GEO - SLOPE, 2nd program - task (auditory and construction)[2]
  6. 2nd program – solving task (construction)[2]
  7. Retaining wall –an example of calculation for gravity and L-typewall (pressures according to Rankine), 3rd program - task (auditory and construction)[2]
  8. 3rd program - solving task (construction)[2]
  9. Retaining structures - an example of calculation of anchored structure, 4th program - task (auditory and construction)[2]
  10. 4th program - solving a task (construction)[2]
  11. Deep pile foundations - an example of calculation of the pile bearing capacity (API and DIN) and pile settlement (DIN), 5th program - task (auditory and construction)[2]
  12. 5th program - solving task (construction)[2]
  13. Seismic analysis - simple examples of seismic calculations for geotechnical structures from previous programs, 6th program - task (auditory and construction)[2]
  14. 6th program - solving a task (construction)[2]
  15. Review of all programs (construction)[2]

Student responsibilities:

- Minimum 10 points in all programs by the end of semester.

Grading and evaluation of student work over the course of instruction:

- 6 programs with maximum 30 points (max 5 points each program).

End of semester grading:

- Written part with maximum 70 points.

Contributions to the final grade:

- 30 points can be earned during semester through programs and 70 points in written exam.

Required literature:

2. Teaching material: Tomislav Ivšić (*lectures, powerpoint presentation - available on the web*)
3. Mimeographed lecture notes: Antun Szavits-Nossan

Optional literature:

1. Any domestic or international book on geotechnical engineering and foundations.

FLOW PROCESSES IN SOIL AND ROCK

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises: 30

Course objectives:

- Students should be able to model the behavior of saturated and unsaturated soils and rock, particularly related to flow, with the full understanding of correct initial and limit conditions, and, most importantly, of the results they should expect.

Learning outcomes:

- Learning about flow processes and associated deformations in saturated and unsaturated soils and rocks (theoretical and factual). Learning about the general behavior of saturated soils (theoretical and factual). Learning to use numerical modeling of flow processes in saturated and unsaturated soils and rocks,
- Ability to solve related problems in geotechnical practice, also by-numerical modeling,
- Ability to integrate the acquired knowledge to the behavior of unsaturated soils with the previously covered behavior of saturated soils with the particular emphasis on flow processes. Ability to incorporate the acquired knowledge in solving practical geotechnical problems.

Course content:

- Lectures:
  1. Introduction [2]
  2. Water in soil: calm water and water flow through homogeneous isotropic soil [4]
  3. Water flow through anisotropic and non homogeneous soil [2]
  4. Soil consolidation [4]
  5. Embankment construction on un-drained and drained foundation soil [4]
  6. Pre-exam [2]
  7. Unsaturated soil: introduction [2]
  8. Unsaturated soil: basic definitions [2]
  9. Changes in soil depending on capillary suction [2]
  10. Characteristic curve of soil-water [2]
  11. Shear strength of unsaturated soil [2]
  12. Water flow through unsaturated soil [2]

- Auditory exercises in the computer room:
  1. Learning about SEEP/W software [2]
  2. Solving simple examples with SEEP/W software for homogeneous, isotropic soil [2]
  3. Solving more complex examples with SEEP/W and SIGMA/W for homogeneous, isotropic soil [2]

4. Water flow through anisotropic and non homogeneous soil [2]
5. Soil consolidation [4]
6. Pre-exam[2]
7. An example of embankment construction on foundation soil in un-drained conditions; an example of embankment construction on coarse grained soil [4]
8. An example of gradual construction of an embankment with the consolidation of foundation soil [4]
9. Functions of permeability coefficient for unsaturated soil; Characteristic curve of soil-water[2]
10. Shear strength of unsaturated soil: application to the slope stability [2]
11. Water flow through unsaturated soil [2]
12. Application of the water flow through unsaturated soil to the slope stability [2].

Student responsibilities:

- Attendance in lectures (7 points),
- Attendance in exercises (7 points),
- Doing 2 homework assignments (14 points),
- Pre-exams (22 points),
- Final exam (50 points).

Grading and evaluation of student work over the course of instruction:

- According to the above stated points, students should acquire 25 points(excluding the final exam) for the teacher's signature.

End of semester grading:

- According to the above stated points, students should acquire a minimum of 50 points (including the final exam) for a passing grade.

Contributions to the final grade:

- As stated above.

Required literature:

1. Fredlund, D.G., Rahardjo, H. (1993): *Soil Mechanics for UnsaturatedSoils*, John Wiley & Sons, New York.

Optional literature:

1. Cedergren, H.R. (1989): *Seepage, Drainage and Flow Nets*. JohnWiley & Sons, New York.

APPLIED SOIL MECHANICS

Credit value (ECTS): 7.5

Number of hours (in semester):

- Lectures: 45
- Exercises (design): 28
- Seminars: 2

Course objectives:

- Understanding the main aspects of real soil stress-strain behaviour as opposed to the behavior of other common building materials, ability to select relevant model parameters from soil laboratory and field tests, and performing basic geotechnical analysis with commercial software.

Entry competences (foreknowledge, descriptive):

- Basic soil mechanics and geotechnical engineering.

Learning outcomes:

- Understanding the complex soil behaviour: influence of drained and un-drained conditions, similarities and differences between fine and coarse grained soils, influence of initial density and confining pressure on stiffness, strength and influence of drainage conditions on soil behaviour; soil permeability as the primary reason for differences between sand and clay behaviour,
- Ability to apply knowledge in soil behaviour to solving typical simple geotechnical problems by numerical modeling with commercially available software,
- Ability to estimate soil model properties from field and laboratory tests.

Course content:

- Lectures:
  1. Laboratory equipment for soil stress-strain testing (oedometer, triaxial apparatus)[6]]
  2. Behaviour of dry sand (influence of density and confining pressure)[3]
  3. Strength, stiffness, dilatancy, critical state of sands[3]
  4. Behaviour of water saturated sands under undrained conditions[3]
  5. Behaviour of clays in oedometer tests, influence of pre-consolidation[3]
  6. Behaviour of normally and over consolidated clays in undrained triaxial tests[3]
  7. Similarities and differences between sand and clay behaviour; drained and undrained conditions; undrained shear strength[3]
  8. Soil models in geotechnical practice: linear elastic model[3]
  9. Soil models in geotechnical practice: linear elastic ideally plastic model, drained and undrained analysis[3]
  10. Soil model parameter determination from laboratory and in situ tests[3]
  11. Pre-exam[3]
  12. Developments of normally consolidated and over, consolidated soil profiles and initial state of stresses[3]
  13. Principles of stress and strain analyses in soils, drained and undrained conditions[3]
  14. fi = 0 analysis[3]

- Exercises (design – work on a PC with commercial software):
  1. Introduction to numerical modelling in geotechnical engineering; GEOSTUDIO program suite[4]
  2. Finite element mesh generation, limit and initial conditions)[2]
  3. Program SIGMA/W (stress-strain analysis: solving various examples)[2]
  4. Program SIGMA/W (stress-strain analysis: solving various examples)[2]
  5. Program SIGMA/W (stress-strain analysis: solving various examples - drained and undrained analysis)[2]
  6. Program SEEP/W (seepage analysis: solving various examples)[2]
  7. Program SEEP/W (seepage analysis: solving various examples) [2]
  8. Program SEEP/W (seepage analysis: solving various examples) [2]
  9. Program SLOPE/W (slope stability and limit equilibrium) [2]
  10. Program SLOPE/W (slope stability and limit equilibrium: various examples) [2],
  11. Program SLOPE/W (slope stability and limit equilibrium: various examples) [2]
  12. Program SLOPE/W (slope stability and limit equilibrium: various examples)[2]
  13. Solving several practical geotechnical problems employing numerical modelling[2]

Student responsibilities:

- Attendance in lectures and exercises, two homework assingments and a pre-exam (see grading bellow)

Grading and evaluation of student work over the course of instruction:

- Students earn points for successful completion of different module requirements:
  - Attendance in lectures 0-7.5 points,
  - Attendance in exercises 0-7.5 points,
  - Completed 2 homework assignments 0-10 points,
  - Written pre-exam 0-25 points
  - Total: 50 points.

End of semester grading:

- Students with 25 points are entitled to taking the final exam.

Contributions to the final grade:

- For the final grade students have to takethe written exam with maximum 50 points.
- For the final grade points earned during the course (maximum 50) are added to the points earned in the written exam (maximum 50). Based on total points, student's results are graded as follows:
  - Sufficient or satisfactory: 55 - 64 points
  - Good: 65 - 74 points
  - Very good: 75 - 84 points
  - Excellent: 85 -100 points

Required literature:

1. Course material available on the course web site

Optional literature:

1. Wood, D. M. (1990): *Soil Behaviour and Critical states Soil Mechanics*, CUP, Cambridge;
2. Wood, D. M. (2004): *Geotechnical Modelling*, Spon Press, London;
3. Mayne, P. W., Christopher, B. R., DeJong, J. (2001). *Manual on Subsurface Investigation*. National Highway Institute., Publication No. FHWA NHI-01-031, Federal Highway Administration, Washington, DC.

Elective courses

MATHEMATICS 3

Look in **Shared courses**

STOCHASTIC PROCESSES

Look in **Shared courses**

1st year, 2nd semester

Compulsory courses

STRUCTURES

Credit value (ECTS): 6

Number of hours (in semester):

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

Course objectives:

- Expanding theoretical knowledge about constructing buildings, hydro technical and geotechnical structures, practical knowledge about the design and analysis of structures, practical knowledge about sizing of structural elements.

Entry competences (foreknowledge, descriptive):

- Knowledge and understanding materials and resistance of materials, understanding basic geotechnical, hydro technical, concrete, steel, masonry and timber structures, base knowledge of various static system analysis.

Learning outcomes:

- Students gain an understanding of the basic principles and problems in constructing structures, students gain the basic knowledge and skills in observation and analysis of the effects on the structures, students gain the basic knowledge and skills for calculations of structural elements, students are familiar with design principles and have the skills to apply them to certain structural elements.

Course content:

- Lectures:
  1. Introduction – the main principles of bearing structures [4]
  2. Structure elements, models and structure modeling [2]
  3. Basics of design and calculation [2]
  4. Actions on structures and structure calculus [2]
  5. Concrete structures [2]
  6. Pre-stressed concrete structures [2]
  7. Steel structures [2]
  8. Foundations [2]
  9. Sustaining walls [2]
  10. Building structures [2]
  11. Bridge structures [2]
  12. Water towers [2]
  13. Floating structures [2]
  14. Field examples [2]
- Auditory exercises:

  Calculation and sizing of 6 different structures:
  1. Ship lock [2]
  2. Inspection chamber [2]

3. Retaining wall [2]
4. Quay [2]
5. Diaphragm [2]
6. Pile [2]

- Construction exercises:
    1. Ship lock [2]
    2. Inspection chamber [2]
    3. Retaining wall [2]
    4. Quay [2]
    5. Diaphragm [2]
    6. Pile [2]

Student responsibilities:

- Attendance in lectures and exercises,
- Executing all individual exercise calculation tasks,
- Minimum 25% score in each pre-exam.

Grading and evaluation of student work over the course of instruction:

- Evaluating the progress of exercise calculation tasks, evaluating students' ability to do independent work correctly and in time.

End of semester grading:

- attendance and timely completion of exercise tasks.

Contributions to the final grade:

- Pre-exam score or written exam60-70%,
- Oral exam 30-40%

Required literature:

1. Tomičić, I.: *Concrete structures*, DHGK Zagreb, Zagreb 1996,
2. Radić, J.: *Concrete structures–examples with a key*, Zagreb, 2006
3. Mimeographed lecture and exercises notes.

Optional literature:

1. Norms EN 199i ; i = 0,1,2,3,4,7,8.

FOUNDATION ENGINEERING

Credit value (ECTS): 7.5

Number of hours (in semester):

- Lectures: 45
- Exercises (design): 30

Course objectives:

- The module provides an advanced course in practical foundation engineering. Main topics cover design of footing, slabs, rafts, axially and laterally loaded piles of various kinds (driven, bored, CFA) including soil-foundation-structure interaction, all according to requirements of Eurocode 7 and current engineering practice.

Entry competences (foreknowledge, descriptive):

- Basic soil mechanics and geotechnical engineering.

Enrolment requirements (correlated courses): none

- Teachers signatures: Geotechnical Engineering, Applied Soil Mechanics

Learning outcomes:

- Knowledge about types, methods of analysis, codes, construction, acceptance criteria of typical structural foundations,
- Ability to design typical structural foundations employing currently acceptable methods and procedures (footings, slabs, bored, CFA and driven piles
- Knowledge and skills required to understand, design and monitor typical foundations on various soils under circumstances common in current geotechnical practice.

Course content:

- Lectures:
  1. Introduction to Foundation Engineering [3]
  2. Foundation design environment (codes and local law) [3]
  3. Design according to Eurocode 7 [3]
  4. Shallow foundations: types, design situations, ultimate and serviceability limit states, design criteria [3]
  5. Various methods of settlement and bearing capacity calculation (immediate – drained and undrained conditions, long term, creep) [3]
  6. Effects of soil structure-interaction (differential settlements, load redistribution) [3]
  7. Soil-structure interaction – axially and laterally loaded piles (t-z and p-y curves) [3]
  8. Influence of pile type and pile installation (bored, CFA, driven, vibrated), negative skin friction [3]
  9. Pile testing (load tests, integrity tests, dynamic bearing capacity tests, monitoring of piles) [3]
  10. Pile foundation construction, pile drivability [3]
  11. Design of pile foundations according to Eurocode 7 [3]
  12. Structural design of foundations (Eurocode 2 and Eurocode 3 [3]
  13. Other deep foundations (pile rafts, caissons) [3]
  14. Foundation design and ground investigation [3]
  15. Dynamically loaded foundations [3]
- Exercises (design – work on a PC with commercial software):
  1. Introduction: Design of simple footings, Eurocode 7 [2]
  2. Design of simple footings [2]
  3. Design(settlement) of a single footing by computer program SETTLE [2]
  4. Design(settlement) of a single footing by computer program SETTLE [2]
  5. Soil-structure interaction (total and differential settlements): footings of a frame Structure [2]
  6. (program SETTLE) [2]
  7. Soil-structure interaction: footings of a frame structure (program SETTLE) [2]
  8. Soil-structure interaction (contact pressure redistribution): slab foundation (program SLAB) [2]
  9. Soil-structure interaction: slab foundation (program SLAB) [2]
  10. Axially loaded piles (program AXPILE) [2]
  11. Axially loaded piles (program AXPILE) [2]
  12. Soil-structure interaction: computation of internal forces of a complex structure Foundedon shallow foundations (programs SETTLE and SAP) [2]

13. Soil-structure interaction: computation of internal forces of a complex structure founded on shallow foundations (programs SETTLE and SAP)[4].

Student responsibilities:

- Attendance in lectures and exercises, two homework reports and a pre-exam.

Grading and evaluation of student work over the course of instruction:

- Students earn points for successful completion of seven design exercises (maximum 70 points).

End of semester grading:

- At the end of semester students are required to complete seven exercises to apply for the exam.

Contributions to the final grade:

- For the final grade students have to complete a written examinations for which they can earn a maximum of 30 points. For the final grade points earned during the course (maximum 70) are added to the points earned in the written exam (maximum 30). Based on these total points, students' results are graded as:
    - Sufficient or satisfactory: 60 - 70 points
    - Good: 71 - 80 points
    - Very good: 81 - 90 points
    - Excellent: 91 -100 points

Required literature:

1. Course material available from the course web site

Optional literature:

1. Bond, A., Harris, A. (2008). *Decoding Eurocode 7*, Taylor & Francis, London.;
2. Rees, L. C., Isenhower, W. M., Wang, S.-T. (2006). *Analysis and Design of Shallow and Deep Foundations,* John Wiley & Sons, New Jersey.
2. Tomlinson, M. J. (2000),*Foundation design and construction,* Prentice Hall;
3. Bowles, J. E. (1997). *Foundation analysis and design*, McGraw-Hill;
4. Canadian Geotechnical Society (2006). *Foundation Engineering Manual*, Canadian Geotechnical Society.

NUMERICAL MODELING IN GEOTECHNICS

Credit value (ECTS): 7.5

Number of hours (in semester):

- Lectures: 30
- Exercises (design):45

Course objectives:

- Students should be able to model complex geotechnical problems related to stress-strain behavior, seepage and soil stability, with the full understanding of all issues related to numerical modeling.

Enrolment requirements (correlated courses):

- Teachers signatures: Applied Soil Mechanics, Flow Processes in Soil and Rock

Learning outcomes:

- Learning about the Finite element method(theoretical), the importance of engineering judgement in numerical modeling, issues related to numerical modeling in geotechnical engineering (factual), meshing (theoretical and factual), drained and und rained analyses (theoretical and factual), different constitutive equations for soils (theoretical). By solving examples of complex geotechnical problems, learning how to use numerical modeling in practice,

- Ability to solve complex geotechnical problems in practice by correct numerical modeling
- Ability to integrate the acquired knowledge on numerical modeling with all the facts previously learned about geotechnical engineering covered behavior of saturated

  soils with the particular emphasis on flow processes. Ability to incorporate the acquired

  knowledge in solving complex practical geotechnical problems.

Course content:

- Lectures:
  1. Introduction [2]
  2. Revision of modelling from 1st semester [2]
  3. The importance of final elements network [2]
  4. The importance of limit conditions [2]
  5. The importance of soil parameters [2]
  6. Modeling in geotechnics: engineering judgment, parameter analyses, feedback analyses [2]
  7. Excavation of the foundation pit reinforced by diaphragm and geotechnical anchors [2]
  8. Stability of slopes [2]
  9. Reinforcement of slopes[2]
  10. Sudden lowering of water in artificial lakes [2]
  11. Stability of soil under shallow foundations [2]
  12. Stability of backfill behind retaining structures [2].
- Auditory exercises in the computer room:
  1. Simple examples of modelling from 1st semester [2]
  2. The importance of finite elements network [2]
  3. The importance of limit conditions [2]
  4. Parameter analyses; feedback analyses [2]
  5. Tunnel excavation [2]
  6. Excavation of foundation pit reinforced with diaphragm and braces [2]
  7. Excavation of foundation pit reinforced with diaphragm and geotechnical anchors [3]
  8. Stability of slopes [3]
  9. Stability of infinite slopes [3]
  10. Reinforcement of slopes with anchors and spikes [3]
  11. Reinforcement of slopes with geotextile [3]
  12. Soil stability under shallow foundations and backfills behind supporting structures [3].

Design exercises:

- During exercises students use numerical modeling tosimulate complex geotechnical problems.

Student responsibilities:

- Attendance in lectures (7 points),
- Attendance in exercises (10.5points),
- 2 homework assignments (6points),
- Pre-exams (20.5points),
- Final exam (50 points).

Grading and evaluation of student work over the course of instruction:

- According to the above stated points students should earn 25 points(excluding the final examin) for theteacher's signature.

End of semester grading:

- According to the above stated points, students should earn a minimum of 50 points (including the final examin) for a passing grade.

Contributions to the final grade:

- As stated above.

Required literature:

1. Potts, D.M., Zdravkovic, L. (1999): *Finite Element Analysis in Geotechnical Engineering: Application*. Thomas Telford, London, Great Britain.

Optional literature:

1. Potts, D.M., Zdravkovic, L. (1999): *Finite Element Analysis in Geotechnical Engineering: Theory*. Thomas Telford, London, Great Britain, 1999

Elective courses

APPLIED GEOLOGY

Credit value (ECTS): 3

Number of hours (in semester):

- Lectures: 30

Course objectives:

- Acquiring basic knowledge in general geology, mineralogy and petrology,
- Acquiring basic knowledge in hydrogeology and engineering geology for application in civil engineering.

Entry competences (foreknowledge, descriptive):

- Basic knowledge about chemical elements and chemical compounds.

Learning outcomes:

- Ability to tell the difference between igneous, metamorphic and sedimentary rocks,
- Ability to recognise layers, faults and covers,
- Understanding the process of karst formation and various karst forms and learning about the problems that civil engineers meet when building tunnels in karst,
- Ability to use geological maps – recognising geological symbols, reading the geological age of rocks, their composition and other important geological features of a particular terrain,
- Knowledge about basic engineering geological classifications of rock mass.

Course content:

- Lectures:
  1. Introduction [2]
  2. General information about geology. Stratigraphic geology. Constitution of the Earth. Mineralogy, mineral, crystal [2]
  3. Isotropic and anisotropic mineral. Pyrogenic, pneumatogenic, hydrothermal, hidatogen minerals. Axis, plane, center of symmetry. Crystal systems. Properties of crystals, crystal bonds. Tetrahedron coordination. Coordination number. Polymorphism, isomorphism [2]
  4. Mineral properties, mineral groups, oxides and hydroxides. Carbonates, sulphates, silicates [2]
  5. Introduction to petrology. Rocks, phenocrysts, monomineral rocks. Igneous rocks. Creation of igneous rocks. Structure and texture of igneous rocks. Acidity of magmas. Bowen's series of crystallisation. Table of igneous rocks [2]
  6. Sedimentary rocks. Sediment transport. Mineral composition of sedimentary rocks. Structure and texture of sedimentary rocks. General outline od sedimentary rocks. Metamorphic rocks. Zones of metamorphism. Division os metamorphic rocks. [2]

7. Tectonics. Outgrowths, layer thickness. Layers, wrinkles, anticlines, synclines. Faults. Covers. Types of cracks,
8. Egzodynamics of the Earth, insolation, hydrogeology, water, hydrological cycle. Porosity, permeability. Laminar and turbulent flow. Types of aquifers. Ghyben Herzberg's law. Ice and snow. Wind, organisms [2]
9. Karst, external karst forms, internal karst forms [2]
10. Types of caves, speleothems. Groundwater[2]
11. Landslides, endodynamics, orogenesis, epirogenesis [2]
12. Volcanoes, earthquakes, seismic scales, seismicity [2]
13. Geological maps. RMR and Q classification of rocks in civil engineering. Determining the age of rocks) [2].

Student responsibilities:

- Attendance in 75% of lectures,
- Minimum 25% score in pre-exams, a make up pre-exam.

Grading and evaluation of student work over the course of instruction:

- None.

End of semester grading:

- Written and oral exam.

Contributions to the final grade:

- Minimum 60% score in written exam required for taking the oral exam.

Required literature:

1. Herak, M., *Geologija*, 1990,
2. Šestanovic, S., *Osnove geologije i petrologije*, 2001

Optional literature:

1. West, T., *Geology applied to Engineering*, 1994,
2. Monroe, J., Wicaander, R., *Physical geology*, 2006,
3. Plummer, D., McGeary, D., *Physical Geology*, 2010.

ENVIRONMENTAL PROTECTION

Look in **Hidraulic Engineering**

DYNAMICS OF STRUCTURES AND EARTHQUAKE ENGINEERING

Look in **Theory And Modeling Of Stuctures**

THEORY OF ELASTICITY AND PLASTICITY

Look in **Theory And Modeling Of Stuctures**

NUMERICAL MATHEMATICS

Look in **Shared Courses**

PERSPECTIVE

Look in **Shared Courses**

BASICS OF DIFFERENTIAL GEOMETRY

Look in **Shared Courses**

WAVES AND OSCILLATIONS

Look in **Shared Courses**

2^{nd} year, 3^{rd} semester

Compulsory courses

IMPROVEMENT OF SOIL AND ROCK

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures:30
- Exercises (auditory):24
- Exercises (field and laboratory):6

Course objectives:

- Gaining theoretical knowledge on methods of soil and rock improvement,
- Gaining theoretical knowledge on selecting appropriate methods of soil and rock improvement, depending on the problem under consideration (settlement limitation, accelerated consolidation, etc.).

Entry competences (foreknowledge, descriptive):

- Understanding the terms of stiffness and strength of soils and rocks,
- Understanding the principles of soil consolidation and pore pressure,
- Knowledge of the methods of determining the settlement of structure, as well as the capacity of the foundation soil/rock.

Enrolment requirements (correlated courses):

- Teachers signatures: Geotechnical engineering, Foundations, Applied soil mechanics

Requirements for examination taking (correlated courses):

- Teachers signatures: Geotechnical engineering, Foundations, Applied soil mechanics

Learning outcomes:

- Ability to identify problems and to select an optimal method for soil improvement, depending on the problem considered,
- Ability to determine the degree of soil improvement and calculation of improved soil stiffness if limitation of settlements is considered, as well as the calculation of improved soil strength parameters if improvement of bearing capacity is considered,
- Ability to determine the velocity of consolidation and the time required for the overall consolidation if the reduction of pore pressure and acceleration of consolidation are considered,
- Ability to perform simple laboratory and field experiments in order to control the quality of the soil improvement works (device for uniaxial pressure, SASW)

Course content:

- Lectures:
  1. Principles of soil and rock improvement: an increase in bearing capacity, control of total and differential settlements, reducing the time required to achieve deformations of soil, reducing liquefaction potential, reducing the permeability of the soil, removing water from the soil, increasing the shear strength and slope stability, increased erosion stability, execution of internal drainage system [2]
  2. Replacement of the soil, displacement of the soil, reducing load[2]
  3. Vertical drains [2]
  4. Deep vibration techniques [2]
  5. Vibro stone columns [2]
  6. Consolidation and jet grouting [2]
  7. Adding load [2]
  8. Inundation [2]
  9. Pressure berms [2]
  10. Anchored structures [2]
  11. Soil reinforcement [2]
  12. Chemical methods of soil improvement [2]
  13. Freezing, heating, vegetation [2]
  14. Quality control of soil and rock improvement: laboratory investigations, field investigations [2]
  15. Methods of measurements and observations of improved soil and rock [2].
- Exercises
  16. Vertical drains[auditory] [2]
  17. Deep vibration techniques [auditory] [2]
  18. Vibro stone columns[auditory] [2]
  19. Vibro stone columns[auditory] [2]
  20. Consolidation grouting[auditory] [2]
  21. Jet grouting [auditory] [2]
  22. Jet grouting[auditory] [2]
  23. Adding of load [auditory] [2]
  24. Anchored structures[auditory] [2]
  25. Pre-exam[2]
  26. Soil reinforcement [auditory] [2]
  27. Soil reinforcement [auditory] [2]
  28. Quality control of soil and rock improvement [laboratory][2]
  29. Quality control of soil and rock improvement [field][2]
  30. Methods of measurements and observations of improved soil and rock [field][2].

Student responsibilities:

- Attendance in 75% of lectures, in 100% of exercises,
- Minimum 25% score in the pre-exam.

End of semester grading:

- Written and oral exam.

Contributions to the final grade:

- Minimum 60% score in written exam is required for taking the oral exam,
- Grades:
  - 60-70% = sufficient (2)
  - 70-80% = good (3)
  - 80-90% = very good (4)
  - 90 -100% = excellent (5)

Required literature:

1. Meho Saša Kovačević - lecture notes - powerpoint presentation.

Optional literature:

1. Mitchell, J. M., Jardine, F.M. *A Guide to Ground Treatment,* CIRIA publication C573, London, UK, 2002,
2. Bell, F.G. *Engineering Treatment of Soils*, Spon Press, London, UK, 1993,
3. Moseley, M.P. *Ground Improvement*., CRC Pres, Boca Raton, Florida, USA, 1993.

EARTHFILL AND RETAINING STRUCTURES

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures:30
- Exercises: 30

Course objectives:

- Gaining theoretical knowledge about the types of earth structures, selection of materials and method of construction,
- Gaining theoretical and practical knowledge on calculation of earth structures,
- Gaining theoretical knowledge about the types of retaining structures,
- Gaining theoretical and practical knowledge on calculation of retaining structures.

Entry competences (foreknowledge, descriptive):

- Knowledge of basic physical and mechanical properties of the soil (strength, stiffness),
- Understanding of groundwater seepage in the soil, knowledge of the concepts of flow, critical hydraulic gradient, the permeability coefficient,
- Knowledge of soil classification and selection of parameters depending on the type of soil,
- Knowledge of the basic principles of numerical modeling.

Enrolment requirements (correlated courses):

- Teacher's signature: Numerical modeling in geotechnics,
- Examinations passed: Applied soil mechanics, Geotechnical engineering.

Requirements for examination taking (correlated courses):

- Teacher's signature: Numerical modeling in geotechnics,
- Examinations passed: Applied soil mechanics, Geotechnical engineering.

Learning outcomes:

- Selection of design situations related to different types of earth dams (embankments),
- Conduction of seepage and stability analysis for different types of earth dams(embankments),
- Understanding the basic problems related to the stability of earth dams and understanding of remedial works for earth structures,
- Understanding earth pressures on retaining structures and understanding of procedures for their determination,
- Determination of all the actions on the retainingstructure including earth pressures, its own weight, earthquake and other actions,
- Ability to calculate stability of earth and retaining structures.

Course content:

- Lectures:
  1. Types of earth structures (dams and flood protection embankments, road embankments, landfills)[2]
  2. Selection of earth materials, field and laboratory investigation works, methods of construction[2]
  3. Theory of soil compaction, properties of compacted material[2]
  4. Geotechnical calculations of earth structures 1 (seepage, limit equilibrium methods, FEM analyzes using simple soil models)[2]
  5. Geotechnical calculations of earth structures 2 (seismic stability, selection of parameters)[2]
  6. Selection of embankments, zoned embankments, solution variations, presentation of major dams[2]
  7. Monitoring of earth structures, instabilities, damage and destruction of the dam, the impact of construction on stability and deformation[2]
  8. The application and types of retaining structures[2]
  9. Basis of earth pressure calculation 1 (concepts of earth pressure, strength parameters)[2]
  10. Basis of earth pressure calculation 2 (Rankine states, Coulomb method and accuracy)[2]
  11. Basis of earth pressure calculation 3 (additional load on the surface, seismic load)[2]
  12. Retaining walls, reinforced earth structures[2]
  13. Embedded retaining walls, anchored retaining structures, geotechnical anchors calculation[2]
  14. Analysis of embedded retaining walls (design and theoretical requirements)[2]
  15. Analysis of embedded retaining walls (calculatio00n procedures)[2].
- Exercises:
  1. Examples of geotechnical calculation of embankment - seepage (auditory)[2]
  2. Examples of geotechnical calculation of embankment - slope stability (auditory)[2]
  3. Geotechnical calculations of flood protection embankment (computer work)[6]
  4. Geotechnical calculations and preparation of report (computer work)[2]
  5. Geotechnical calculations and preparation of report, submission of report (computer work)[2]
  6. Examples of geotechnical calculations of retaining structures - soil pressures (auditory)[2]
  7. Examples of geotechnical calculations of retaining structures - a retaining wall (auditory)[2]
  8. Examples of geotechnical calculations of retaining structures - Embedded retaining walls (auditory)[2]
  9. Working on task - solving retaining structure example (construction)[8]
  10. Submission of the program[2].

Student responsibilities:

- 75% attendance in lectures,
- Submission of the program.

End of semester grading:

- Written and oral exam.

Contributions to the final grade:

- 60% score in written exam is the requirement for taking the oral exam.

Required literature:

1. Tomislav Ivšić , Lectures, powerpoint presentation - available on the web,
2. Nonveiller, E. (1981): *Mehanika tla i temeljenje građevina*, 2nd edition, Školska knjiga, Zagreb
3. Nonveiller, E.: *Nasute brane - projektiranje i građenje*, Školska knjiga, Zagreb, 1983, 359 pp.

Optional literature:

1. Nonveiller, E.: *Kliženje i stabilizacija kosina*, Školska knjiga, Zagreb, 1987, 204 pp.

2. *Embankment Dam Engineering* - Casagrande Volume, Eds. R.C. Hirschfeld and S.J. Poulos, John Wiley & Sons, New York, 1973, 454 pp.
3. US Dept. of Interior, Bureau of Reclamation: *Design of small dams,* 3rd ed, 1987
4. Dembicki,E.: *Tlak, otpor i nosivost tla*, Sveučilišna naklada Liber, Zagreb, 1982
5. Gaba, A.R., Simpson, B.,Powrie, W., Beadman, D.R: *Embedded retaining walls-guidance for economic design*, Report CIRIA C580, London, 2003

HYDROGEOLOGY AND ENGINEERING GEOLOGY

Credit value (ECTS): 3

Number of hours (in semester):

- Lectures:30

Course objectives:

- Gaining knowledge of hydrogeology and engineering geology for use in civil engineering,
- Understanding the groundwater regime in the karst,
- Gaining theoretical knowledge on research methods for determination of rock properties needed for rock mass classification.

Entry competences (foreknowledge, descriptive):

- Knowledge of basic geological terms.

Enrolment requirements (correlated courses):

- Examination passed: Applied geology.

Requirements for examination taking (correlated courses):

- Examination passed: Applied geology.

Learning outcomes:

- Understanding the impact of groundwater regime on construction works in the karst,
- Introduction to methods of determining water-protected areas,
- Understandingthe impact of geological structures on bearing capacity under foundations and on the stability of slopes in rock mass,
- Understandingthe impact of geological structures on the stability of underground openings in rock mass,
- Ability to determine the geological parameters necessary for rock mass classifications.

Course content:

- Lectures:
    1. Introduction, hydrogeology [2]
    2. The role of hydrogeology in civil engineering [2]
    3. Classification of groundwater [2]
    4. Groundwater regime[2]
    5. Research methods [2]
    6. Water in Karst [2]
    7. Karst [2]
    8. Pre-exam [2]
    9. Determination of protection zones, interpretation of hydrogeological investigations [2]
    10. Pre-exam (make up) [2]
    11. Engineering geology and its role in civil engineering [2]

12. Engineering geology and its role in civil engineering [2]
13. Engineering geology and its role in civil engineering, landslides [2]
14. EG classification of rocks [2]
15. Investigation methods for determination of rock properties needed for the civil engineering [2].

Student responsibilities:

- Attendance in 75% of lectures,
- Minimum 25% score in the pre-exam.

End of semester grading:

- Written and oral exam.

Contributions to the final grade:

- Minimum 60% score in the written exam required for taking the oral exam.

Required literature:

1. Herak, M., *Geologija*, 1990
2. Šestanović, S., *Osnove geologije i petrologije*, 2001
3. West, T., *Geology Applied to Engineering*, 1994
4. Monroe, J. & Wicander, R. , *Physical geology*, 2006
5. Plummer,C., McGeary,D. & Carlson, C., *Physical Geology*, 2006

Optional literature:

1. Weight, W. & Sonderregger,J. , *Manual of Applied Field Hydrogeology*, 2004
2. Weight, W. , *Hydrogeology Field Manual*, 2008
3. Waltham, T., *Foundations of Engineering Geology*, 2002
4. Poehls, D. J. & Smith, G. J., *Encyclopedic Dictionary of Hydrogeology*, 2009
5. Fetter, C. W., *Applied Hydrogeology*, 2000
6. Rahn, P., *Engineering geology: An Environmental Approach*, 1996

GEOTECHNICAL LABORATORY

Credit value (ECTS): 7.5

Number of hours (in semester):

- Lectures:30
- Exercises (laboratory):45

Course objectives:

- Gaining theoretical knowledge about the physical and mechanical characteristics of the soil and rocks that can be determined by laboratory tests,
- Gaining theoretical and practical knowledge about the procedures and methodologies of testing in the laboratory,
- Gaining knowledge about the manner of displaying and interpreting the results of laboratory tests.

Entry competences (foreknowledge, descriptive):

- Knowledge of basic physical and mechanical properties of soil and rock needed for designing,
- Skills in Microsoft Office-in (Word, Excel).

Enrolment requirements (correlated courses):

- Teachers signatures: Applied soil mechanics, Geotechnical engineering, Foundations

Requirements for examination taking (correlated courses):

- Teachers signatures: Applied soil mechanics, Geotechnical engineering, Foundations

Learning outcomes:

- Acquired knowledge and understanding of the essential role of laboratory experimental methods in geotechnical engineering,
- Ability to conduct laboratory experiments on coherent and non-coherent soil samples, and the intact rock samples,
- Ability to analyze and interpret the results of laboratory tests,
- Drawing borehole logs and engineering-geological soil profile,
- Ability to write final reports on laboratory tests.

Course content:

- Lectures:
  1. The role of the laboratory in geotechnical engineering[2]
  2. The program of laboratory investigation activities [2]
  3. Basic concepts in measuring : accuracy, precision, resolution, sensitivity, linearity, hysteresis, noise, measurement error[2]
  4. Determination of natural moisture and particle density[2]
  5. Classification tests: sieving, aerometry, liquid limit, plastic limit[2]
  6. Determining the coefficient of permeability: the test with constant fall and the test with changing fall[2]
  7. Determination of soil compaction: standard and modified Proctor test[2]
  8. Determination of stiffness and strength of soils and rocks: oedometer tests[2]
  9. Determination of stiffness and strength of soils and rocks: direct shear tests[2]
  10. Determination of stiffness and strength of soils and rocks: uniaxial and triaxial tests[2]
  11. Determination of the point strength of rock monoliths: PLT test[2]
  12. Determination of parameters of weathered rock mass: slake durability test[2]
  13. Determination of calcium carbonate content in the rock samples[2]
  14. Geophysical methods: measuring the velocity of propagation of longitudinal and shear waves in soil and rock samples[2]
  15. A report on the results of laboratory tests[2]
- Exercises (laboratory):
  1. Determination of natural moisture and particle density[2]
  2. Classification tests: sieving, aerometry[2]
  3. Classification tests: liquid limit, plastic limit[2]
  4. Determination of coefficient of permeability: test with constant fall and test with changing fall[2],
  5. Determination of soil compaction: standard and modified Proctor test[2]
  6. Determination of stiffness and strength of soils and rocks: oedometer tests[2]
  7. Determination of stiffness and strength of soils and rocks: direct shear tests[2]
  8. Determination of stiffness and strength of soils and rocks: uniaxial and triaxial tests[2]
  9. Determination of the point strength of rock monoliths: PLT test[2]
  10. Determination of parameters of weathered rock mass: slake durability test[2]
  11. Determination of calcium carbonate content in the rock samples[2]
  12. Geophysical methods: measuring the velocity of propagation of longitudinal and shear waves in soil and rock samples[2]
  13. A report on the results of laboratory tests[6]

Student responsibilities:

- 75% attendance in lectures,
- 100% attendance in exercises.

Grading and evaluation of student work over the course of instruction:

- Assessment of knowledge in thepre-exam.

End of semester grading:

- Written and oral exam.

Required literature:

1. Danijela Marčić, lectures –powerpointpresentation.

Optional literature:

3. Head, K.H., *Manual of Soil Laboratory Testing, Volume 1, 2 i 3*, John Wiley & Sons, West, Sussex, UK, 1998,
4. Bardet, J.P., *Experimental Soil Mechanics,* Prentice Hall, New Jersey, USA, 1997.

Elective courses

UNDERGROUND STRUCTURES

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures:30
- Exercises (auditory):10
- Exercises (design):20

Course objectives:

- Gaining theoretical knowledge about the state of stress around the openings in the rock mass due to the construction of underground structures,
- Gaining knowledge about the interaction of the support system and the rock mass,
- Gaining theoretical knowledge on design and construction technologies of underground structures,
- Dealing with complex problems in the field of underground construction.

Entry competences (foreknowledge, descriptive):

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

Enrolment requirements (correlated courses):

- Teachers signatures: Geotechnical engineering.

Requirements for examination taking (correlated courses):

- Teachers signatures: Geotechnical engineering.

Learning outcomes:

- Ability to calculate the relevant parameters of the soil/rock required for numerical modeling based on the results of laboratory and field tests and on the basis of the classification of rock masses,
- Ability to choose the system to ensure stability of underground structures, depending on the environment in which it is located,
- Ability to conduct a complex two-dimensional and three-dimensional stress-strain analysis in order to assess the stability of an underground structure,

- Knowledge of the principles of interactive design in underground construction using observations and measurements during construction.

Course content:

- Lectures:
  1. Basic concepts and development of underground structures [2]
  2. Investigation works for design and construction of underground structures [2]
  3. Design process of underground structures [2]
  4. Elements of the primary support system [2]
  5. Elements of secondary support system [2]
  6. Loading on support system: Theories of self-supporting arch, Elastically supported ring, 2D and 3D models [2]
  7. Stress-strain analysis of underground structures [2]
  8. Division of tunnel profile (cross section), Time for installing support system [2]
  9. Characteristic curves of rock mass and support system [2]
  10. Designing of support system based on RMR classification [2]
  11. Designing of support system based on Q classification [2]
  12. Improving the rock mass for the excavation of underground structures and methods of excavation [2]
  13. New Austrian Tunneling Method: main and specific principles [2]
  14. Observations and measurements of underground structures [2]
  15. Long-term deformations of underground structures [2].
- Exercises
  1. Elements of the primary support system[4]
  2. Elements of secondary support system[4]
  3. Loading on support system: Theories of self-supporting arch [2]
  4. Loading on support system: Elastically supported ring[2]
  5. Designing of support system based on RMR classification[2]
  6. Designing of support system based on Q classification[2]
  7. Characteristic curves of rock mass and support system[4]
  8. Stress-strain analysis of underground structures[6]
  9. Long-term deformations of underground structures[4]

Student responsibilities:

- Attendance in 75% lectures, in 100% exercises,
- Minimum 25% score in the pre-exam.

End of semester grading:

- Written and oral exam.

Contributions to the final grade:

- Minimum 60% score in written exam required for taking the oral exam,
- Grades:

  - 60-70% = sufficient (2),
  - 70-80% = good (3),
  - 80-90% = very good (4),
  - 90-100% = excellent (5).

Required literature:

1. Meho Sasa Kovačević, lectures – powerpoint presentation.

Optional literature:

4. Hoek, E., Brown, E. T. , *Underground excavations in rock*,The Institution of Mining and Metallurgy, London, England, 1980,
5. ITA, *Guidelines for the design of tunnels*, ITA Working Group on General Approaches to the Design of Tunnels, Tunnelling and Underground Space Technology, Vol. 3, No. 3, 1988.

GEOTECHNICS AND ENVIRONMENTAL PROTECTION

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures:30
- Exercises: 15

Course objectives:

- Learning about appropriate actions and measures in geotechnical practice aimed at preventing environmental pollution,
- Learning about types of pollution and ways of dealing with them,
- Acquiring theoretical and practical knowledge on the protection of landfills as the most important geotechnical structures in the field of environmental protection.

Entry competences (foreknowledge, descriptive):

- Knowledge of flow process in soil (terms of flow, hydraulic gradients, etc.),
- Knowledge of slope stability analysis of earth materials.

Enrolment requirements (correlated courses):

- Teacher signature: Numerical modeling in geotechnics.

Requirements for examination taking (correlated courses):

- Teacher signature: Numerical modeling in geotechnics.

Learning outcomes:

- Knowledge on calculation of seepage of contamination through soil,
- Knowledge on calculation of stability of slopes in landfills in static and seismic conditions,
- Understanding the role of geosynthetics to protect the ground from contamination (geomembrane) and to ensure the stability of the slope (geotextiles, geogrids, etc.),
- Exploring the possibilities of using waste materials as building materials,
- Theoretical knowledge about long-term monitoring of behavior of landfill parameters which are essential from geotechnical standpoint.

Course content:

- Lectures:
    1. Basic principles of environmental protection 1 (environmental science, the environment of the earth, the concept and the origin of soil, water and air contamination)[2]
    2. Basic principles of environmental protection 2 (current trends in solving environmental problems, the concept of sustainable development, regulations)[2]
    3. Waste and waste management - the concept of a closed landfill[2]
    4. Waste and waste disposal - integral parts of the landfill, harmful products[2]
    5. Geotechnical aspects of landfill[2]
    6. Properties of waste as construction material[2]

7. Stability of landfill slope 1 (static and seismic conditions), geosynthetics, the impact of eluates[2]
8. Stability of landfill slope 2, geosynthetics interfaces, the impact of eluates[2]
9. Properties of natural and synthetic materials as sealing and drainage layers[2]
10. Landfill construction types, the use of geosynthetics[2]
11. Monitoring of the landfill and the environment, examples of instability of landfills[2]
12. Transfer of contamination through soil and water[2],
13. Preventing pollution and remedial works on contaminated soil[2]
14. Presentation of seminar papers and discussions[2]
15. Presentation of seminar papers and discussions[2].

- Exercises:
  1. Examples of landfill stability calculations (auditory)[2]
  2. Examples of calculation of pollution transfer through soil and the impact of remedial measures (auditory)[2]
  3. Analysis of stability of landfill - the landfill body and cover (computer work)[4]
  4. Presentation of seminar papers and discussions[7]

Student responsibilities:

- A seminar paper.

End of semester grading:

- Oral exam

Contributions to the final grade:

- A seminar paper is required for taking the oral exam.

Required literature:

1. Teaching material: Tomislav Ivšić - lectures, powerpoint presentation - available on the web
2. Znidarčić, D., Kovačić, D., Kvasnička, P., Mulabdić, M.,*Geotehnologija pri odlaganju komunalnog otpada, Hrvatsko društvo građevinskih inženjera*, Građevni godišnjak, 1996
3. Z. Milanović, *Deponij – trajno odlaganje otpada*, ZGO-Zagreb, 1992
4. Z. Milanović, S.Radović, V.Vučić, *Otpad nije smeće*, Gospodarstvo i okoliš, V.Gorica, 2002

Optional literature:

1. M.L.McKinney, R.M.Schoch,*Environmental Science (Systems and Solutions)*, 3rd ed., Jones and Bartlett Publishers, Boston, 2003
2. ISSMFE Technical Committee TC 5,*Environmental Geotechnics*, Report, Bochum, 1997
3. R.M.Koerner,D.E.Daniel,F*inal Covers for Solid Waste Landfills and Abandoned Dumps*, ASCE Press & Thomas Telford, 1997
4. R.M.Koerner,*Designing with Geosynthetics*, 4th edition, Prentice Hall, 1998
5. R.K.Rowe,R.M.Quigley,J.R.Booker, *Clayey Barrier Systems for Waste Disposal Facilities*, E&FN

SOIL DYNAMICS

Credit value (ECTS): 6

Number of hours (in semester):

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

Course objectives:

- Acquiring theoretical knowledge about phenomena in soil and geotechnical structures in response to dynamic and seismic stimuli,
- Acquiring theoretical and practical knowledge about geotechnical and seismic calculi.

Entry competences (foreknowledge, descriptive):

- Knowledge about basics of free and forced oscillations, structure diynamics,
- Knowledge about the basics of soil mechanics and physical-mechanical properties of soil (strength, stiffness).

Enrolment requirements (correlated courses):

- Teachers signatures: Applied soil mechanics, Foundations, Dynamics of Structures and Earthquake engineering,

Requirements for examination taking (correlated courses):

- Teachers signatures: Applied soil mechanics, Foundations, Dynamics of Structures and Earthquake engineering,

Learning outcomes:

- Understanding the expansion of seismic waves in a half-space,
- Understanding complex relationships between strain and deformations in cyclic load on soil materials,
- Calculating dynamic loads on foundations,
- Determining the potential liquefaction of water saturated soil,
- Analyses and verification of the stability of slopes, earth and retaining structures subjected to earthquake action.

Course content:

- Lectures:
  1. Introduction: basics of oscillations (free and forced oscillations of an undamped and damped simple oscillator), oscillation measuring instruments [4]
  2. Waves in elastic media: longitudinal and transverse waves in rods, reflection, waves in infinite media (longitudinal, transverse, reflection and refraction), waves at boundaries (Raylegh and Lowe’s waves, attenuation, dispersion [2]
  3. Properties of cyclic loads on soils: hysteresis, stiffness, attenuation, strength, cyclic volume deformations and pore pressures, laboratory experiments, field experiments [4]
  4. Foundation oscillations: vertical, lateral, torsion, rocking and related oscillations of shallow foundations, theory and measuring, oscillations of foundations on piles, vibration defence [4]
  5. Bearing capacity of soil in dynamic conditions[2]
  6. Geotechnical earthquake engineering: impact of earthquakes on soil and structure, examples from practice [2]
  7. Earthquake load: definition of terms, characteristics of ground motion during earthquakes, propagation of seismic waves: vertical propagation in a stratified medium, non-linear behaviour of soil, amplification [2]
  8. Behavior of walls and slopes in earthquakes: Mononobe-Okabe theory for walls, sliding block method, dimensioning walls to limited lateral displacements, permanent displacements in slopes and embankments
  9. Liquefaction: liquefaction in laboratory and in the field, laboratory and field experiments, improving liquefaction prone soil [4]
- Auditory exercises:
  1. Calculus of dynamic loads on foundations[4]
  2. Determining the liquefaction potential of soil [4]

3. Calculus of seismic stability of slopes and earth structures [4]
4. Seismic calculus of supporting structures [4].

- Design exercises:
    1. Calculus of dynamic loads on foundations [4]
    2. Determining the liquefaction potential of soil [4]
    3. Calculus of seismic stability of slopes and earth structures [4]
    4. Seismic calculus of supporting structures [4].

Student responsibilities:

- Attendance in lectures and exercises,
- Program submission.

End of semester grading:

- Written and oral exam.

Contributions to the final grade:

- Minimum 60% score in written exam is the requirement for taking the oral exam.

Required literature:

1. Das, B. M.: *Principles of Soil Dynamics*. Brooks/Cole, Pacific Growe, CA, 1993,
2. Lecture notes – power point presentation.

Optional literature:

1. Kramer, S. L.: *Geotechnical Earthquake Engineering*. Prentice Hall, NJ, 1996,
2. Prakash, S.: *Soil Dynamics*. McGraw-Hill, NY, 1981

ENGLISH IN CIVIL ENGINEERING 2

Credit value (ECTS): 4.5

Number of hours (in semester):

- Exercises: 45

Course objectives:

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

Entry competences (foreknowledge, descriptive):

- Intermediate level, B 1.

Learning outcomes:

- Developing language competences which include professional terminology in the field of transport facilities and geotechnical engineering,
- Independent user – ability to read technical literature independently,
- Revision of basic grammar categories in professional language – passive, past tenses, modal verbs,
- Confident use of sentences in professional language, developing presentation skills and skills in writing professional papers.

Course content:

- Exercises:
    1. A Career in Transportation Engineering [2]

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

Student responsibilities:

- 75% attendance in lectures,
- Making a presentation,
- 3 pre-exams.

Grading and evaluation of student work over the course of instruction:

- Through regular attendance and continuous work students can be exempt from a part of exam or the entire exam,
- Checking acquired knowledge in written or oral form is conducted regularly,
- The skills required include comprehension of engineering texts, summary writing, giving presentation on technical topics, mastering grammar categories most applied in technical reports.

Contribution to the final grade:

- The credits earned through all the testing and pre-exams make up the final grade. The grades are based as follows: pre-exam results, points earned during semester - active participation in class, grammar checks, translations into a foreign language, translations from a foreign language, professional vocabulary checks. Maximum number of points that can be earned in the pre-exam is 20 – the grade is multiplied by four. Students who have not earned enough points are required to take the final exam.
- Grading is as follows
  - 50-62% score = sufficient (2),
  - 63-75% score = good (3),
  - 76-88% score = very good (4),
  - 89-100% score = excellent (5).

End of semester grading:

- As stated above.

Required literature:

1. A. Kralj Štih: *English in Transportation and Geotechnical Engineering*, course materials.

Optional literature:

1. D. Bonamy*: Technical English 4*, Pearson Longman, 2011
2. The Internet pages, program Building Big, Brantacan, ASCE.
3. Z. Vulelija: *Ilustrirani rječnik arhitekture i građe inar t a – hrvatsko engleski i englesko hrvatski*, Masmedia, Zagreb, 2010
4. A. Prager: *Trojezični građevinski rječnik*, Masmedia, Zagreb, 2002

GERMAN IN CIVIL ENGINEERING 2

Credit value (ECTS): 4.5

Number of hours (in semester): 45

- Exercises (auditory):45

Course objectives:

- Systemic overview of basic civil engineering topics and grammatical structures,
- Acquisition of general civil engineering vocabulary in the fields of construction materials, transportation, geotechnical, hydro-engineering, structural engineering,
- Acquiring key terms through the survey of the history of civil engineering,
- Mastering translation techniques in professional vocabulary,
- Giving short presentations, focusing on sentence structure, style and most common mistakes.

Entry competences (foreknowledge, descriptive):

- German language competence at B1, B2 level.

Learning outcomes:

- Understanding and interpreting technical texts,
- Independent oral skills in technical field, ability to explain professional terms,
- Writing a CV and job applications.

Course content:

- Auditory exercises:
    1. Die Geschichte des Kuppelbaus [3]
    2. Wie schreibt man einen Lebenslauf? [3]
    3. Bewerbungsschreiben [3]
    4. Wie man sich auf ein Interview vorbereitet [3]
    5. Die größte Drehbrücke der Welt [3]
    6. Bewerbungsschreiben [3]
    7. Die Geschichte der Tunnelkonstruktion [3]
    8. Kräfte und Gegenkräfte [3]
    9. Einige Festigkeitsarten [3]
    10. Elastizität und Verformung [3]
    11. Der Straßenbau [3]
    12. Gebäude im Erdbeben [3]
    13. Der Flughafen [3]

Student responsibilities:

- 75% attendance in exercised,
- Preparing one presentation,
- 3 pre-exams.

Grading and evaluation of student work over the course of instruction:

- Through regular attendance and continuous work students can be exempt from a part of exam or the entire exam,
- Checking acquired knowledge in written or oral form is conducted regularly,
- The skills required include comprehension of engineering texts, summary writing, giving presentation on technical topics, mastering grammar categories most applied in technical reports.

End of semester grading:

- The credits earned through all the testing and pre-exams make up the final grade. The grades are based as follows: pre-exam results, points earned during semester - active participation in class, grammar checks, translations into a foreign language, translations from a foreign language, professional vocabulary checks. Maximum number of points that can be earned in the pre-exam is 20 – the grade is multiplied by four. Students who have not earned enough points are required to take the final exam.
- Grading is as follows
  - 50-62% score = sufficient (2),
  - 63-75% score = good (3),
  - 76-88% score = very good (4),
  - 89-100% score = excellent (5).

Required literature:

1. A. Kralj Štih: *Deutsch für Konstruktionen, Geotechnik, Verkehr un Theorie un M ellierung der Konstruktionen*, Kursunterlagen, 2011

Optional literature:

1. A. Prager: *Trojezični građevinski rječnik*, Masmedia, Zagreb, 2002

2nd year, 4th semester

Compulsory courses

GEOTECHNICAL DESIGN

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures:30
- Exercises: 30

Course objectives:

- Introduction to all aspects of geotechnical design,
- Acquiring experience in designing of complex geotechnical procedures.

Entry competences (foreknowledge, descriptive):

- Knowledge about programs for numerical modeling in geotechnical engineering,
- Knowledge about basic physical and mechanical properties of soil and rock needed for designing,
- Knowledge about laboratory and field investigation works,
- Determining design situations for geotechnical structures.

Enrolment requirements (correlated courses):

- Teacher's signature: Geotechnical laboratory, Earthfill and retaining Structures,
- Examinations passed: Geotechnical engineering, Flow processes in soil and rock, Foundations.

Requirements for examination taking (correlated courses):

- Teacher's signature: Geotechnical laboratory, Earthfill and retaining Structures
- Examinations passed: Geotechnical engineering, Flow processes in soil and rock, Foundations.

Learning outcomes:

- Planning geotechnical investigations (laboratory and field),
- Analysis and interpretation of geotechnical investigation results,

- The characteristic engineering-geological soil profile based on geotechnical investigation results,
- Selection of relevant parameters for the calculation,
- Selection of appropriate design solution for a particular type of geotechnical problem,
- Preparation of the analysis models relevant to a given geotechnical problem,
- Analysis and interpretation of the results obtained by numerical modelling,
- Selection of construction technology for the specific design solution,
- Preparation of bills of quantities of the works based on selected design solution,
- Development of the overall design with the accompanying drawings, bill of quantities, technical description, calculations and technical requirements for the execution of the selected design solution.

Course content:

- Lectures:
    1. General principles and specificity of geotechnical and civil engineering design [2]
    2. Overview of the relevant regulations and general principles of Eurocode 7: Geotechnical Engineering (procedures for design and procedures for mechanical resistance and stability proof) [2]
    3. Eurocode 7: Geotechnical Engineering (limit states, geotechnical data) [2]
    4. Eurocode 7: Geotechnical Engineering (typical geotechnical structures) [2]
    5. Eurocode 7: Geotechnical Engineering (seismic geotechnical engineering) [2]
    6. Quality management and quality assurance in geotechnical design and construction[2]
    7. Planning of field and laboratory investigation works for typical cases (selection of method, depth, sampling density) [2]
    8. Presentation of investigation works results, geotechnical models of foundation soil, selection of relevant geotechnical parameters [4]
    9. Variations of technical solutions, selection of materials and characteristics of construction technology [4]
    10. Presentation of complex geotechnical structures from practice [6]
    11. Discussion about projects[2].
- Exercises:
    1. Geotechnical design of typical geotechnical structures (construction) [2]
    2. Work on geotechnical design - preparation of geotechnical data, geotechnical model of the ground (construction) [4],
    3. Work on geotechnical design - preparation of geotechnical data, selection of relevant parameters (construction) [2]
    4. Work on geotechnical design – selection of technical solutions (construction) [4]
    5. Work on geotechnical design – geotechnical calculations (construction, work on computer) [8]
    6. Work on geotechnical design – graphical part, technical terms of execution and costs (construction, work on computer)[8]
    7. Submission of geotechnical design (construction)[2]

Student responsibilities: working on geotechnical design

Grading and evaluation of student work over the course of instruction: working on geotechnical design

End of semester grading:

- A design presentation is the requirement for taking the oral exam.

Required literature:

1. Tomislav Ivšić - lectures, powerpoint presentation - available on the web

Optional literature:

1. Eurocode 7 – *Geotehnika: Geotehničko projektiranje*, HRN EN 1997-1: 2004

2. Nonveiller, E. (1981): *Mehanika tla i temeljenje građevina*, 2nd ed. ,Školska knjiga, Zagreb
3. Tomlinson, M. J. (1995): *Foundation Design and Construction*, Longman Scientific and Technical, Harlow
4. Bowles, J. E. (1982): *Foundation Analysis and Design*, McGraw Hill, NY
5. Coduto, D. P. (1994): *Foundation Design, Principles and Practices*, Prentice Hall, NJ
6. Winterkorn, H.F., Fang, H.-Y. (1982): *Foundation Engineering Handbook*, Van Nostrand Reinhold Company, New York, 752 str.
7. *Geotechnical Engineering Handbook Vol 1-3*, Ed. U.Smoltzyck, Ernst&Sohn Verlag, Berlin, 2002
8. *Technical engineering and design guides*,adapted from the US Army Corps of Engineers, ASCE
9. CIRIA – design reports, London

FIELD INVESTIGATION AND MONITORING

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures:30
- Exercises (auditory):14
- Exercises (field):16

Course objectives:

- Gaining theoreticalknowledge ofin-situpropertiesof the soiland rocksduringfield testing,
- Understandingthe conceptsof measurement purposes, measured values, measurement equipmentandmeasurement results,
- Gaining theoreticalknowledgeaboutthe measuring equipmentduringfield testing,
- Gaining practical knowledgeabout the procedureandmethodologyof the field tests,
- Gaining knowledgeon the interpretationandpresentation of the resultsof fieldtests.

Entry competences (foreknowledge, descriptive):

- Knowledge about basic physical and mechanical properties of soil needed for design,
- Knowledge of basic physical and mechanical properties of rock needed for design,
- Knowledge of concepts of strain, displacement, stress, force, stiffness, necessary for understanding the principles of geotechnical structures monitoring.

Enrolment requirements (correlated courses):

- Teachers signatures: Improvement of soil and rock, Geotechnical engineering, Geotechnical laboratory.

Requirements for examination taking (correlated courses):

- Teachers signatures: Improvement of soil and rock, Geotechnical engineering, Geotechnical laboratory.

Learning outcomes:

- Knowledge about and understanding the essential role of investigation and experimental methods in geotechnical engineering – in design (field investigations) and in verification of executed structures (field measurements and observations),
- Ability to conduct simple field tests as part of investigation work,
- Ability to use measuring equipment for observation and monitoring,
- Ability to analyse and interpret the results of field tests,
- Ability to make the final report on field investigations.

Course content:

- Lectures:
  1. Trial pits and borehole drilling[2]
  2. Determining the level of groundwater[2]
  3. Penetration tests: standard penetration test, static penetration test, light penetration probe[2]
  4. Pressuremeter tests: Menard pressuremeter, self-drilled pressuremeter, dilatometer[2]
  5. Geophysical investigation: refraction, reflection, cross-hole, down-hole[2]
  6. Geophysical investigation: Spectral analysis of surface waves, Multi-channel analysis of surface waves[2],
  7. The program of geotechnical structures monitoring[2]
  8. Measurement and monitoring of soil and rock deformation: the geodetic measurements[2]
  9. Vertical and horizontal inclinometer[2]
  10. Sliding deformeter and micrometer, inclinometer[2]
  11. Measuring of the cracks[2]
  12. Measurement and monitoring of stress in rock and soil by using pressure cells[2]
  13. Methods for testing the integrity and capacity of the piles[2]
  14. Interpretation of the results of measurements and observations[2]
  15. Numerical back-analysis based on the measurement results[2].
- Exercises
  1. Determining the level of groundwater [field][2]
  2. Penetration test: static penetration test [auditory][2]
  3. Penetration test: static penetration test [field][2]
  4. Pressuremeter test: dilatometer[auditory][2]
  5. Pressuremeter test: dilatometer[field][2]
  6. Refraction and Spectral analysis of surface waves [auditory][2]
  7. Refraction and Spectral analysis of surface waves [field][2]
  8. Vertical and horizontal inclinometer [auditory][2]
  9. Vertical and horizontal inclinometer [field][2]
  10. Sliding deformeter and micrometer, inclinometer [auditory][2]
  11. Sliding deformeter and micrometer, inclinometer [field][2]
  12. Measurement and monitoring of stress in rock and soil by using pressure cells [auditory][2]
  13. Measurement and monitoring of stress in rock and soil by using pressure cells [field][2]
  14. Methods for testing the integrity and capacity of the piles [auditory][2]
  15. Methods for testing the integrity and capacity of the piles [field][2].

Student responsibilities:

- Attendance in 75% lectures, in 100% exercises
- Minimum 25% score in pre-exam.

Grading and evaluation of student work over the course of instruction:

- None.

End of semester grading:

- Writtenand oral exam.

Contributions to the final grade:

- Minimum 60% score in written exam is the requirement for taking the oral exam,

- Grades:
    - 60-70% = sufficient (2),
    - 70-80% = good (3),
    - 80-90% = very good (4),
    - 90 -100% = excellent (5).

Required literature:

1. Meho Saša Kovačević:lectures – powerpoint presentation.

Optional literature:

1. Simons, N., Menzies, B.,Matthews, M. *A short course in geotechnical site investigation,* Thomas Telford, London, UK, 2002,
2. Dunnicliff, J. *Geotecnical Instrumentation for Monitoring Field Performance*, John Wiley & Sons, New York, USA, 1993,
3. Nicholson, D., Tse, C.-M., Penny, C. *The Observational Method in Ground Engineering,* CIRIA. Report 185, London, UK, 1999

HYDRAULIC ENGINEERING

1st year, 1st semester

RESEARCH METHODS

Look in **Shared Courses**

HYDRAULICS 1

Credit value (ECTS): 7.5

Number of hours (in semester):

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

Course objectives:

- Introducing the elements of unsteady and multidimensional fluid flow.

Entry competences (foreknowledge, descriptive):

- Understanding the elements of fluid mechanics.

Learning outcomes:

- Ability to understand the basics of unsteady fluid flows and understanding the influence of fluid flow on civil engineering constructions and vice versa.

Course content:

- Lectures:
  1. The energy principle of fluid flow, models in hydraulic engineering, non - uniform flow in open channels [3]
  2. Unsteady flow in open channels [3]
  3. Propagation of a discontinuous surge front[3]
  4. Dam failure, short objects (spillway, orifices, stilling basins)[3]
  5. Steady flow in pipe networks[3]
  6. Non-steady flow with gradual changes – oscillatory motion[3]
  7. Non-steady flow with sudden changes – water hammer[3]
  8. Pumps and turbines[3]
  9. Hydraulics of groundwater[3]
  10. Continuum approach[3]
  11. Wells (steady and un-steady flow[3]
  12. Parameter identification in pumping tests[3]
  13. Regional models, groundwater flow in the karstic aquifers[3]
  14. Regional pollutant transport models in aquifers[3]
  15. Transport in sea, wind impact on structures[3].
- Exercises (auditory, design, laboratory):
  1. Non uniform flow in open channel[2]
  2. Unsteady flow in open channel[2]
  3. Overflow over a weir (laboratory)[2]

4. Discharge thru the orifice (laboratory)[2]
5. Hydraulic jump (laboratory)[2]
6. Hydraulic losses (laboratory)[2]
7. Water distribution system[2],
8. Surge tank[2]
9. Water hammer[2],
10. Groundwater flow [2]
11. Groundwater flow under the dam[2]
12. Wells (laboratory)[2]
13. Flow and transport processes in the subsurface[2]
14. Erosion processes (laboratory)[2]
15. Drag force (laboratory)[2].

Student responsibilities:

- Attendance in lectures and laboratory exercises,
- Making programs.

Grading and evaluation of student work over the course of instruction:

- Regular, after each exercise.

End of semester grading:

- Oral and written exam.

Contributions to the final grade:

- Numerical exercises – execution of non-stationary calculus,
- Measuring on physical models and result data processin.

Required literature:

1. Gjetvaj: *Hydraulics* - mimeographed lecture notes,
2. Gjetvaj etal.*Praktikum*- mimeographed lecture notes.

Optional literature:

1. W. Kinzelbach; *Groundwater modeling*, Elsevir; Ven te Chow; OpenChannel Hydraulics, McGraw-Hill Book Company 1986,

HYDROLOGY 2

Credit value (ECTS): 6

Number of hours (in semester):

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

Course objectives:

- Acquiring theoretical and practical knowledge in the field of hydrology, which includes an analysis of data on rainfall, hydrological processes on the land: interception and evapotranspiration, seepage into ground and surface water flow, groundwater, soil moisture, saturated and unsaturated zones, parametric methods for determining process runoff in the basin - the method for determining the direct runoff, and mathematical modeling in hydrology.

Entry competences (foreknowledge, descriptive):

- Basic knowledge in hydrology, which include water and water motion in the nature, atmospheric processes, hydrometry, processing of hydrometric data, the application of probability and statistics in hydrology,

- Knowledge and understanding of the physical properties of substances (phases of matter, density, specific volume and quantity of the substance).

Learning outcomes:

- Understanding the concepts of: hydrological processes on land and enumerate them, analysis of precipitation data, runoff processes in the catchment area - the methods for determining the direct runoff, and mathematical modeling in hydrology,
- Applying the acquired theoretical knowledge of hydrology in civil engineering, in the design of structure ability with the objective to solve simple problems and hydrological tasks,
- Explaining concepts and applying the basic analysis of meteorological data, hydrological analysis and elaboration of hydrological data,
- Students will have knowledge about the meaning and role of water in development of society, the role of the hydraulic structures in the management of water resources, about the division, the purpose and definition of hydrological background and analysis when designing water management structures.

Course content:

- Lectures:
  1. Analysis of data on rainfall, spatial and temporal variability in rainfall intensity. Determination of representative precipitation data. Preparation of IDF curve (intensity, duration, frequency). [2]
  2. Hydrological processes on land, interception and evapotranspiration, seepage into the ground and surface water flow. [2]
  3. Groundwater, soil moisture, saturated and non-saturated zone, field capacity soil, moisture wilting. [2]
  4. Groundwater level measurement. Identification and types of aquifer. Permeability and transmissivity of the aquifer. Darcy's law of filtration. [2]
  5. Groundwater and surface water connection. Base and direct runoff, separation and display of base and direct runoff hydrograph. [2]
  6. Methods of determining the direct runoff, unit hydrograph method, synthetic unit hydrograph, instantaneous unit hydrograph. Isochrones, isochrones method. [2]
  7. Concentration time of direct runoff from catchment and lead time of hydrograph depending on the rainfall duration. S - hydrograph. The formation of T-hour unit hydrograph. [2]
     (Pre-exam 1)
  8. Srebrenović and Gavrilović method of direct runoff. [2]
  9. The formation of the forecast hydrograph with different probabilities of occurrence by using the unit hydrograph. [2]
  10. SCS method, SCS unit hydrograph, reduction of the hydrograph of storm rainfalls with shorter duration of concentration time. [2]
  11. The retention and retardation characteristics of the basin. The method of linear reservoirs. [2]
  12. Hydrological modelling, theoretical, conceptual and systematic models. [2]
  13. Application of GIS technology in hydrology. [2]
      (Pre-exam 2)
- Exercises (auditory and design):Exercises accompany lectures
  1. Revision of basic concepts: runoff components, the physical characteristics of a basin (auditory) [2]
  2. Hydrological and cartographic basis (auditory and design) [2]
  3. Modeling in hydrology (auditory and design) [2]
  4. Modeling in HEC-HMS (auditory and design) [2]
  5. The elements of the model basin in the HEC-HMS (auditory and design) [2]
  6. Model of precipitation losses and base flow model (auditory and design) [2]

7. Determination of topographic characteristics, time of concentration and lead time. Division into sub-basins (auditory and design) [2]
8. Model of direct runoff from the catchment area (auditory) [2]
9. Model of direct runoff from the surface (design) [2]
10. Model of transformation of water wave in the stream (auditory and design) [2]
11. IDF curves, design rainfall (auditory) [2]
12. Modeling of rain in HEC-HMS, design rainfall (design) [2]
13. Simulation of runoff in the HEC-HMS (auditory) [2]
14. Simulation of runoff in the HEC-HMS (design) [2]
15. Analysis of the HEC-HMS outputs(auditory and design) [2]

Student responsibilities:

- Regular attendance in lectures and exercises,
- 2 pre-exams: in each pre-exam minimum 10 points should be earned,
- Developing 1 design assignment,
- At the end of semester: one makeup pre-exam for meeting the requirements for the teacher's signature.

Grading and evaluation of student work over the course of instruction:

- Grading design assignments.

End of semester grading:

- Written exam: minimum 20 points score.
- Oral exam.

Contributions to the final grade:

- Design assignment 40%
- Witten exam 30-40%,
- Oral exam 20-30%.

Required literature:

1. Husno Hrelja: *Inženjerska hidrologija*, Univerzitet u Sarajevu – Građevinski fakultet, Sarajevo, 2007,
2. Ranko Žugaj: *Hidrologija*, Sveučilište u Zagrebu – Rudarsko-geološko-naftni fakultet, Zagreb, 2000,
3. Stevan Prohaska.: *Hidrologija I & II deo*, Rudarsko geološki fakultet, Beograd, 2003,
4. Dionis Srebrenović: *Primijenjena hidrologija*, Tehnička knjiga, Zagreb, 1986,
5. Eugen Čavlek: *Osnove hidrologije*, Geodetski fakultet, Zagreb, 1992,
6. Ognjen Bonacci: *Oborine, glavna ulazna veličina u hidrološki ciklus*, Split, 1994

Optional literature:

1. Ven Te Chow: *Handbook of Applied Hydrology*, McGrow-Hill book Company, New York,1964,
2. Wilson E.M.: *Engineering Hydrology*, Fourth Edition, Macmillan Press, London, 1990,
3. ViessmanW.Jr. & Lewis. L.G.: *Introduction to Hydrology*, Harper-Collins-College-Publishers, New York, 1996

RIVER TRAINING

Credit value (ECTS): 7.5

Number of hours (in semester):

- Lectures: 45
- Exercises (auditory): 30

Course objectives:

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

Entry competences (foreknowledge, descriptive):

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

Learning outcomes:

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

Course content:

- Lectures:
    1. Purpose, problems and training tasks, training role in water management [3]
    2. Morphology of a riverbed [3]
    3. Hydrologic properties of natural watercourses; water, sediment and ice regime [3]
    4. Hydraulic calculation methods for natural and artificial watercourses[2]
    5. Basic equations for open channel watercourses[3]
    6. Sediment transport equations[3]
    7. Riverbed stabilityanalyses [3]
    8. Training structures at watercourse bed [3]
    9. River training structures on overbanks [3]
    10. Revetments[3]
    11. Other river training structures [3]
    12. Water regime training [3]
    13. Training works in the catchment area and water regime altering structures [3]
    14. Flood protection, technical defense of an levee[3]
    15. Hydraulic structures[3].
- Exercises (auditory):
    1. Placing horizontal alignment and regulation lines [4]
    2. Hydraulic calculations of mean water flow – manually[4]

3. Hydraulic calculations of high water flow – manually[4]
4. Hydraulic calculations - HEC-RAS [4]
5. Selection and placement of river training works [4]
6. Selection and elaboration of river training structures[4]
7. Stability design of river training structures[4]
8. Graphical design of river training structures [2].

Student responsibilities:

- Attendance in lectures and exercises,
- Developing an individual project assignment,
- Minimum 25% score in each pre-exam.

Grading and evaluation of student work over the course of instruction:

- Project grading,
- Pre-exams: students with minimum 60% score are not required to take the written exami.

End of semester grading:

- Written exam: minimum of 50% score,
- Oral exam.

Contributions to the final grade:

- Project 10%,
- Pre-exam or written exam 50-60%,
- Oral exam 30-40%.

Required literature:

4. M. Gjurović: *Regulacijerijeka,*

Optional literature:

6. Ž. Vuković: *Osnovehidrotehnike*,
7. E. Svetličić: *Otvorenivodotoci– regulacije*.

Elective courses

MATHEMATICS 3

Look in **Shared courses**

STOHASTIC PROCESSES

Look in **Shared courses**

1st year, 2nd semester

Compulsory courses

PORTS AND WATERWAYS

Credit value (ECTS): 9

Number of hours (in semester):

- Lectures:45
- Exercises (auditory, design):20
- Seminars:25

Course objectives:

- Creating the preconditions for students' training in their future tasks in design and construction of ports and waterways.

Entry competences (foreknowledge, descriptive):

- Prior knowledge in hydraulics, river training, design of concrete structures and foundations.

Enrolment requirements (correlated courses):

- Teachers signatures: Hydraulics 1, River training, Hydrology 2,

Requirements for examination taking (correlated courses):

- Examinations passed: Hydraulics 1, River training.

Learning outcomes:

- Ability to apply the knowledge in structural and geotechnical science to ports and waterways design,
- Knowledge in basics of wave mechanics and statistics,
- Ability to predict long-term surface gravity waves,
- Ability to assess wave forces on coastal structures,
- Understanding the basic aspects in design of ports, defence structures, seawalls, rubble mound structures,
- Understanding the basic aspects in construction technology of maritime structures.

Course content:

- Lectures:
    1. Introduction [3]
    2. Basics of wave mechanics[3]
    3. Sea waves[3]
    4. Wave theories[3]
    5. Wave transformations[3]
    6. Long-term wave predictions: spectral description, statistical description[3]
    7. Wave generation, short-term predictions[3]
    8. Wave forces: Morison equation, diffraction theory, forces on seawalls[3]
    9. Construction technology: concrete in sea, subsea works[3]
    10. Technology of rubble mound breakwaters[3]
    11. Technology of vertical concrete breakwaters[3]
    12. Ports:ships andmanoeuvres in ports, the terms of port and landing stage[3]

13. Transportation functions of port, goods traffic, port types, port layouts, port facilities[3]
14. Inland navigable ways: types and classification[3]
15. Locks and activities on inland water ways[3].

- Exercises (auditory, design):
  1. PR 1 – small amplitude wave parameters in deep water, PR2 –small amplitude wave parameters in transitional area, PR3 – wave energy[3]
  2. PR4 –diffraction,[2]
  3. PR 5 – wave refraction plan [2]
  4. PR6 – single diffraction, PE7 – double diffraction [2]
  5. PR 8 – height elevations of quay, PR 9 – pressure on a vertical wall, PR 10 – reflection on an inclined slope [3]
  6. PR 11 – wave forecasts. [2]
  7. PR 12 – general cargo, PR 13 – bulk cargo [2]
  8. PR 14 – passengers, PR 15 – containers [2]
  9. Internal and external port construction [2].
- Seminars:
  1. Presentation of waves by Airy theory[5]
  2. Transformations of waves by numerical model (MIKE 21-BW)[5]
  3. Long-term wave predictions[5]
  4. Wave forces on piles and seawalls[5]
  5. Stability of seawalls[5].

Student responsibilities:

- 5 pre-exams,
- 5 seminar papers,
- Written and/or oral examination depending on credits obtained in pre-exams.

Grading and evaluation of student work over the course of instruction:

- Studentsearn scores over the entire semester through five pre-exams and seminars.

End of semester grading:

- The final grade is based on the seminar pre-exam scores.

Required literature:

1. Pršić, M.,*Plovni putevi i luke*, web-mimeographed lecture notes, University of Zagreb Faculty of Civil Engineering, 2014

Optional literature:

1. CEM - *Coastal Engineering Manual*, US Army, Waterways Experimental Station, 2003,
2. EAU - *Empfehlungen des Arbeit aus schusses Ufereinfassungen*, Ernst und Sohn, 1996,
3. *Technical standards and Commentaries for Port and Harbour Facilities in Japan*, The Overseas Coastal Area Development Institute of Japan, 2002

DRAINAGE AND IRRIGATION 1

Credit value (ECTS): 8

Number of hours (in semester):

- Lectures: 45
- Exercises: 30 (auditory - 15, design - 15)

Course objectives:

- Acquiring basic knowledge about surface and ground drainage and irrigation, the significance and purpose of hydro engineering ameliorations, environmental sustainability and environmental characteristics of amelioration, measures and design of hydraulic elements.

Entry competences (foreknowledge, descriptive):

- Basics of Hydrology and Hydraulic,
- Knowledge of specialised computer software.

Enrolment requirements (correlated courses):

- Teachers signatures: Hydraulics , Hydrology 2 and River Training,

Requirements for examination taking (correlated courses):

- As entry competences.

Learning outcomes:

- Practical knowledge about surface and ground drainage and irrigation, the significance and purpose of hydro engineering ameliorations, environmental sustainability and environmental characteristics of amelioration, measures and design of hydraulic elements,
- Skills for conducting operational tasks,
- Ability to implement integrated knowledge and skills with methodological competencies to carry out research and design of facilities and systems for drainage (surface and ground drainage) and irrigation.

Course content:

- Lectures:
    1. Introduction [1]
    2. The significance and purpose of hydro engineering ameliorations[2]
    3. Preconditions and basic indicators of the construction level of hydro amelioration facilities and systems in Croatia[2]
    4. Basic documents for elaboration of plans and project documentation for hydro amelioration facilities and systems[2]
    5. Hydro amelioration facilities and systems for surface drainage[2]
    6. Influence of environmental characteristics of amelioration domain on the interspaces and other specifications of amelioration canals of IVth and IIIrd order[2]
    7. Determination of the appropriate hydro modulus of surface drainage[2]
    8. Dimensioning of amelioration canals - hydraulic and geometric elements[2]
    9. General map of the canal network and road network with relevant facilities[2]
    10. Facilities on amelioration canals:- tube culverts and plate culverts, - stone and concrete cascades,- plugs and automatic plugs, -inverted siphons and dams, - protection of canal bottoms and slopes against erosion, - pumping stations[2]
    11. Basic technical and financial indicators for the construction and maintenance of amelioration canals - systems of surface drainage[2]
    12. Hydro amelioration systems for ground drainage - purpose and preconditions for their construction and functioning[2]
    13. Basics of amelioration petrology - basic documents for ground drainage systems[1]
    14. Determination of the distance of drainage pipes and their basic elements[1]
    15. Determination of the hydromodulus of ground drainage[1]
    16. General map of the ground drainage system[1]
    17. The influence of precipitation and other characteristics of the amelioration area on relevant elements of the ground drainage system[1]

18. The facilities and the filtering material in ground drainage systems[1]
19. Hydro amelioration facilities and irrigation systems - purpose and preconditions for their construction[1]
20. Facilities for water intake and sedimentation tanks used in irrigation of agricultural areas[1]
21. Determination of standards and the irrigation hydro modulus[1]
22. Facilities of irrigation systems; selection of the method and type of irrigation[1]
23. Fish-ponds - preconditions and facilities for construction[1]
24. Hydro engineering ameliorations in the Law on water resources and the Law on water management financing[2]
25. Field practice - two days[2]
26. Practice: Route design for a drainage canal and location determination for facilities[1]
27. Hydrological calculation of runoff; Hydraulic calculation of flow[2]
28. Selection and elaboration of the canal construction and construction of facilities[2]
29. Deesign and calculation of facilities; Elaboration of textual and graphical sections[2].

- Exercises:
  1. Route design for a drainage canal and location determination for facilities[6]
  2. Hydrological calculation of runoff[6]
  3. Hydraulic calculation of flow[6]
  4. Selection and elaboration of the canal construction and construction of facilities [6]
  5. Design and calculation of facilities; Elaboration of textual and graphical sections [6].
- (Seminars:)
  1. 2 program designs.

Student responsibilities:

- Getting familiar with professional literature, off-prints (authorized lecture), participation in field practice,
- 75% attendance in lectures, 100% attendance in practical tasks,
- 2 pre-exams, minimum 25% score in each,
- 100% score in program design.

Grading and evaluation of student work over the course of instruction:

- Discussion,
- 2 pre-exams,
- Written and oral exam (depending on credits obtained in pre-exams and practical work – program design).

End of semester grading:

- Written exam (if student did not achieve a minimum 25% score in each pre-exam),
- Oral exam(minimum 25% score in each pre-exam).

Contributions to the final grade:

- Discussion,
- 2 pre-exams,
- Written and oral exam (depending on credits obtained in pre-exams and practical work – program design).

Required literature:

1. Kos, Z.: *Hidrotehničke melioracije tla – odvodnjavanje,* Školska knjiga, Zagreb, 1989
2. *Hidrotehničke melioracije tla – navodnjavanje,* Školska knjiga, Zagreb, 1987
3. Group of authors,*Priručnik za hidrotehničke melioracije*, I. Kolo, selected paragraphs

4. Volume 2, *Podloge za hidrotehničke melioracije*, 1984 (Tomić, F.)
5. Volume 2, *Osnovna mreža površinskog odvodnjavanja*, 1985, projektiranje (Kos, Z.)
6. Volume 4, *Detaljna mreža podzemnog odvodnjavanja*, 1987, – Projektiranje (Kos, Z.)
7. Volume 5, *Građenje sustava površinske i podzemne odvodnje*, 1989, (Marušić, J.)
8. Volume 6, *Održavanje sustava površinske i podzemne odvodnje*, 1991, (Marušić, J.); Društvo za odvodnjavanje i navodnjavanje Hrvatske, Zagreb.
9. Group of authors,*Priručnik za hidrotehničke melioracije – navodnjavanje*, II. Kolo, selected paragraphs
10. Volume 3, *Metode natapanja*, 1994, (Kos, Z.); b) Knjiga 4, *Sustavi, građevine i oprema za natapanje*, 1995, (Kos, Z.)
11. Volume 5, *Planiranje, projektiranje i organizacija natapnih sustava*, 1996, (Kos, Z.); Građevinski fakultet Rijeka i Hrvatsko društvo za odvodnju i navodnjavanje (HDON), Zagreb
12. Group of authors,*Priručnik za hidrotehničke melioracije*, III. kolo
13. Volume 1, *Suvremeni pristup i metode planiranja i upravljanja hidromelioracijskim sustavima,* Rijeka, 2003, (Ožanić, N.)
14. Knjiga 2, Elementi planiranja sustava za navodnjavanje, Rijeka, 2005 (Ožanić, N.); Građevinski fakultet Sveučilišta u Rijeci, HHD i HDON. Vidaček, Ž.: Gospodarenje melioracijskim sustavima odvodnje i natapanja; Agronomski fakultet Sveučilišta u Zagrebu i HDON, Zagreb, 1998.

STRUCTURES

Credit value (ECTS): 6

Number of hours (in semester):

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

Course objectives:

- Expanding theoretical knowledge about constructing buildings, hydro technical and geotechnical structures, practical knowledge about the design and analysis of structures, practical knowledge about sizing of structural elements.

Entry competences (foreknowledge, descriptive):

- Knowledge and understanding of materials and resistance of materials, understanding of basic geotechnical, hydro technical, concrete, steel, masonry and timber structures, base knowledge of various static system analysis.

Learning outcomes:

- Understanding the basic principles and problems of constructing structures,
- Gaining the basic knowledge and skills in observation and analysis of the effects on the structures,
- Gaining the basic knowledge and skills in calculating structural elements,
- Understanding the design principles and skills to apply them to certain structural elements.

Course content:

- Lectures:
    1. Introduction – the main principles of bearing structures [4]
    2. Structure elements, models and structure modeling [2]
    3. Basics of design and calculation [2]
    4. Actions on structures and structure calculus [2]
    5. Concrete structures [2]
    6. Pre-stressed concrete structures [2]
    7. Steel structures [2]

8. Foundations [2]
9. Sustaining walls [2]
10. Building structures [2]
11. Bridge structures [2]
12. Water towers [2]
13. Floating structures [2]
14. Field examples [2]

- Auditory exercises:

  Calculation and sizing of 6 different structures:

  1. Ship lock [2]
  2. Inspection chamber [2]
  3. Retaining wall [2]
  4. Quay [2]
  5. Diaphragm [2]
  6. Pile [2]

- Construction exercises:

  1. Ship lock [2]
  2. Inspection chamber [2]
  3. Retaining wall [2]
  4. Quay [2]
  5. Diaphragm [2]
  6. Pile [2]

Student responsibilities:

- Attendance in lectures and exercises,
- Finishing all individual exercise calculation tasks,
- 2 pre-exams (minimum 25% score in each).

Grading and evaluation of student work over the course of instruction:

- Evaluation of the progress of exercise calculation tasks,
- Evaluation of students' ability to do independent work accurately and in time.

End of semester grading:

- Attendance in lectures and exercise,
- Timely completion of exercise tasks.

Contributions to the final grade:

- Pre-exam 60-70% ,
- Oral exam 30-40%.

Required literature:

1. Tomičić, I.: *Concrete structures*, DHGK Zagreb, Zagreb, 1996,
2. Radić, J.: *Concrete structures–solved examples*, Zagreb, 2006,
3. Mimeographed lecture and exercise notes.

Optional literature:

1. Norms EN 199i : i = 0,1,2,3,4,7,8.

Elective courses

WATER SUPPLY AND SEWERAGE 1

Credit value (ECTS): 4

Number of hours (in semester):

- Lectures:30
- Exercises (auditory):15

Course objectives:

- Acquisition of theoretical and practical knowledge about the basic aspects of the management (planning, design, construction and operation) of water supply and sewerage systems; acquisition of basic knowledge about hydraulic analysis of water supply and sewerage systems.

Learning outcomes:

- Planning, design, construction and operation of water supply and sewerage systems facilities: water intakes, pumping station, water conditioning plants, water tanks, water supply networks, sewerage networks, sewerage facilities, waste water treatment plants, outlets, house water supply and sewerage networks.

Course content:

- Lectures:
  1. Water supply – introduction [2]
  2. Water supply systems [2]
  3. Water consumption [2]
  4. Springs[2]
  5. Water intakes [2]
  6. Pumping stations [2]
  7. Water conditioning [2]
  8. Water tanks [2]
  9. Water supply networks [2]
  10. Home water supply networks
  11. Sewerage systems [2]
  12. Design waste water quantities [2]
  13. Sewerage networks [2]
  14. Sewerage facilities [2]
  15. Waste water treatment, outlets, house sewerage [2].
- Exercises (auditory):
  1. Numerical examples of water consumption [2]
  2. Water intakes [2]
  3. Pumping stations [2]
  4. Water conditioning [1]
  5. Water tanks [1]
  6. Water supply networks [2]
  7. Design waste water quantities [1]
  8. Sewerage networks [2]
  9. Waste water treatment [2].

Student responsibilities:

- Attendance in lectures and exercises,
- Two pre-exams.

Grading and evaluation of student work over the course of instruction:

- Students with a minimum 60 % score in every pre-exam are exempt from the final exam.

End of semester grading:

- Written and oral exam.

Contributions to the final grade:

- Written exam 50 %,
- Oral exam 50 %.

Required literature:

1. Vuković, Ž.: *Water Supply and Sewerage 1*, Manuscript, 2014, Zagreb (in Croatian).

Optional literature:

1. Ratnayaka, D. D., Brandt, M. J., Johnson, K. M.: *Twort□s Water Supply*, 6th Edition, Elsevier, 2009,
2. Trifunović, N.: *Introduction to Urban Water Distribution*, Taylor & Francis Group, London, 2008,
3. Margeta, J.: *Vodoopskrba naselja: planiranje, projektiranje, upravljanje, obrada vode*, AG fakultet, Split, 2010

WATER PROTECTION

Credit value (ECTS): 4

Number of hours (in semester):

- Lectures: 30
- Exercises (auditory): 15

Course objectives:

- Acquiring knowledge about the basic properties and processes in natural water bodies, technologies of wastewater treatment, water quality modeling and legal water protection.

Entry competences (foreknowledge, descriptive):

- General secondary school knowledge,
- Basics of mathematical modeling.

Learning outcomes:

- Acquiring basic knowledge about natural and wastewater properties, anthropogenic impacts on water quality, legal measures on water protection, water quality modeling and wastewater treatment.

Course content:

- Lectures:
    1. Basic ecological principles: biotic and abiotic factors, biotopes, biocenosis, ecosystems. Water properties: structure, physical, chemical, biological [2]
    2. Water quality: physical, chemical and biological indicators. Changes in water quality: pollution sources, wastewater types, water autopurification [2]
    3. Water quality models: empirical models, numerical models, QUALL, WASP [2]
    4. Aquatic systems degradation: eutrophication, chronic and acute pollution [2]

5. Water quality management: political and sociological issues, legal measures, physical planning, financial and economic measures, scientific and technological measures, institutional measures, water protection plans and programs [2]
6. Wastewater treatment: general principles, mechanical treatment, physico-chemical treatment [2]
7. Wastewater treatment: biological - conventional treatment with active sludge [2]
8. Wastewater treatment: biological – extended aeration, SBR [2]
9. Wastewater treatment: biological – nitrogen and phosphorus removal [2]
10. Wastewater treatment: sludge treatment[2]
11. Wastewater treatment: sludge treatment [2]
12. Wastewater treatment: alternative wastewater treatment [2]
13. Mixing models in lakes and seas: (VISUAL PLUMES, CORMIX) [2]
14. Best Management Practices in runoff treatment [2]
15. Non point pollution control: phenomenon, sources, control technics [2].

- Exercises (auditory, design, laboratory):
    1. Waste water analyses: physical, chemical, biological [2]
    2. Streeter-Phelps oxygen sag curve calculation [2]
    3. River water quality modeling (QUAL, WASP) [2]
    4. River water quality modeling (QUAL, WASP) [2]
    5. River water quality modeling (QUAL, WASP) [2]
    6. Dynamics of wastewater generation and inflow [2]
    7. Mechanical treatment dimensioning [2]
    8. Kinetics equations of biological treatment [2]
    9. Conventional biological treatment dimensioning [2]
    10. Attached microorganisms systems dimensioning [2]
    11. Primary and secondary settling dimensioning [2]
    12. Facilities for sludge treatment dimensioning [2]
    13. Alternative WWTP dimensioning [2]
    14. Long sea outfalls dimensioning [2]
    15. Mathematical modelling of pollution transport and dilution (VISUAL PLUMES, CORMIX) [2].

Student responsibilities:

- Regular attendance in lectures and exercises,
- 100% exercise attendance ,
- 75% lecture attendance.

Grading and evaluation of student work over the course of instruction:

- 2 pre-exams, each maximum 100 points,
- 1 make up pre-exam the students who earned less than 25% score in one or both pre-exams.

End of semester grading:

- o 120 – 140 points = satisfactory (2)
- o 140 – 160 points = good (3)
- o 160 – 180 points = very good (4)
- o ≥ 180 points =excellent (5)

Contributions to the final grade:

- A bonus for regular attendance - maximum 20 points.

Required literature:

1. Power point presentations of lectures,
2. Tedeschi, S.: *Zaštitavoda*, a textbook printed by the Zagreb University, 1997,

Optional literature:

1. Metcalf & Eddy: *Wastewater Engineering, Treatment, Disposal and Reuse*, McGraw-Hill International Editions, 2003

APPLIED GEOLOGY

Look in **Geotechnical Engineering**

ENVIRONMENTAL PROTECTION

Credit value (ECTS): 3

Number of hours (in semester):

- Lectures: 30

Course objectives:

- Acquisition of basic knowledge about ecological concepts, rational use of natural resources, environmental sustainability, and measures and environmental protection procedures.

Learning outcomes:

- Ability to understand and solve some practical problems in field of environmental protection.

Course content:

- Lectures:
    1. Introduction [2]
    2. Basic ecological concepts (ecology, biotop, biocenose, ecosystem, biodiversity) [2]
    3. Global changes in biosphere (changes in atmosphere) [2]
    4. Pedosphere and hydrosphere [2]
    5. Changes through energy discharge [2]
    6. Reduction of biodiversity [2]
    7. Impact of civil engineering on environment (city impact, impact of landfill, transportation facilities impact,) [2]
    8. Impact of civil engineering on environment (impact of hydraulic structures) [2]
    9. Environmental sustainability and sustainable development [2]
    10. Measures and environmental protection procedure (political and sociological approach [2]
    11. Legal measures [2]
    12. Environment planning [2]
    13. Economic and financial measures [2]
    14. Scientific approach and technological measures [2]
    15. Institutional measures [2].

Student responsibilities:

- Attendance in lectures and exercises,
- Two pre-exams.

Grading and evaluation of student work over the course of instruction:

- **S**tudents with a minimum of 60 % score in each pre-exam are exempt from the final exam.

End of semester grading:

- Oral exam.

Contributions to the final grade:

- Oral exam 100 %.

Required literature:

1. Vuković, Ž.: *Environment Protection*, Manuscript, 2014, Zagreb (in Croatian).

Optional literature:

1. Raven, P. H., Berg, L. R., Hassenzahl, D. M.: *Environment*, 7th Edition, Wiley, 2010,
2. Miller, G. T.: *Living in the Environment: Principles, Connections, and Solutions*, 15th Edition, Thomson Books, 2007

2nd year, 3rd semester

Compulsory courses

WATER POWER USE

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures:30
- Exercises: 30 (auditory: 4, design : 26)

Course objectives:

- Acquiring practical and theoretical knowledge in water power use and design of hydro power plants.

Entry competences (foreknowledge, descriptive):

- Knowledge and understanding of basic hydrological processes,
- Knowledge and understanding of basic fluid mechanics and hydraulics principles,
- Knowledge and understanding of soil and rock characteristics with basic foundation principles,
- Knowledge of concrete structures design.

Enrolment requirements (correlated courses):

- Teachers signatures: Hydraulics 1, Hydrology 2, River training,

Requirements for examination taking (correlated courses):

- Teachers signatures: Hydraulics 1, Hydrology 2, River training,

Learning outcomes:

- Identifying problems related to design of hydro power plants,
- Understanding principles of water power use and different types of hydropower plants,
- Solving problems related to hydro energetic calculations,
- Participation design and construction of hydro power plants.

Course content:

- Lectures:
  1. Energy and water power in the nature. Basic principles of water power use. Basic hydropower plants types. Investigation works related to water power usage. Hydro energetic calculations in variable heads and flows. Size and choice of installed capacity [10]
  2. Environmental impact of hydropower plants [2]
  3. Low pressure hydropower plants. Medium and heigh-pressure hydropower plants. Major structure groups accompanying hydropower plants [14]
  4. Mechanical and electrical equipment [4].
- Exercises:
  1. Auditory – hydro energetic calculations [4]
  2. Design – hydropower plant design (26)

Student responsibilities:

- Attendance in lectures and exercises,
- Making programs.

Grading and evaluation of student work over the course of instruction:

- Two pre-exams.

End of semester grading:

- Students with a minimum 60% score in the pre-exams are exempt from the written exam,
- Oral exam.

Contributions to the final grade:

- Attendance in lectures and success 0achieved in pre-exams.

Required literature:

1. Weekly lecture notes - ppt, pdf.

Optional literature:

1. Stojić, P.: *Hidroenergetika*, Građevinski fakultet, Split, 1995,
2. Mosony, E.: *Water Power Development*, Vol I-II, Budapest, Akademial Kiado, 1987

WATER SUPPLY AND SEWERAGE 2

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises (auditory, design, laboratory): 30
- Seminars: 2

Course objectives:

- Acquisition of theoretical knowledge about water supply and sewerage systems,
- Acquisition of theoretical knowledge about the methods and technologies of water intake, transport and consumption of potable water, collection transport and disposal of wastewater,
- Acquisition of practical knowledge about the functionality, design, construction, operation and maintenance of water supply and sewerage facilities.

Entry competences (foreknowledge, descriptive):

- Fundamental knowledge about the functionality, design, construction, operation and maintenance of water supply and sewer systems.

Enrolment requirements (correlated courses):

- Teachers signatures: Hydraulics, Hydrology 2
- Examinations passed: Water Supply and Sewerage 1, Hydrology 1

Requirements for examination taking (correlated courses):

- Examinations passed: Hydraulics, Hydrology 2

Learning outcomes:

- Knowledge about the exact content of project documentation (design projects) for water supply and sewer systems,
- Knowledge about defining the relevant input parameters in the design of water supply and sewer systems,
- Ability to conduct hydraulic analysis (calculations) in the design of water supply systems by applying modern software tools,
- Ability to shape and size the objects in water supply systems (water intake, valve chambers, regulation chamber, measurement chambers, pumping stations, water tanks, etc.),
- Ability to conduct hydraulic analysis (calculations)in the design of gravity sewer systems by applying modern software tools,
- Ability to shape and size objects in the gravity sewer system (canals, manholes, combined sewer overflows, retention basins, pumping stations, etc.),
- Ability to apply the methodology for reduction of water losses in water supply systems,
- Knowledge about the functionality, design, construction, operation and maintenance of alternative wastewater collection systems,
- Knowledge about the functionality, design, construction, operation and maintenance of road runoff collection and disposal systems,
- Knowledge about planning, construction, operation and maintenance of water supply and sewer system.

Course content:

- Lectures:
  1. Introduction, preliminary exam, project documentation of water supply systems [2]
  2. Water demand and consumption – international trends, Croatian practice, the definition of relevant water demands and patterns [2]
  3. Facilities and equipment of water supply systems – pipes, water tanks, pumping stations, valve chambers, valves, fittings, control units, measurement units, etc.[6]
  4. Hydrant network for fire fighting – internal and external [2]
  5. Water losses – basics, water audit, IWA methodology, zoning the system –DMA zones, the methodology of water losses analysis [2]
  6. Project documentation of sewer systems – defining the relevant quantity of wastewater (sanitary and industrial wastewater, rainwater runoff, combined wastewater) [2]
  7. Wastewater quantity analysis – international trends, Croatian practice, the definition of relevant waste water flow and patterns [2]
  8. Facilities and equipment of sewer systems – canals (pipes), manholes, combined sewer overflows, retention basins, pumping stations, etc.[4]
  9. Alternative wastewater collection systems – pressure sewer system, vacuum sewer system, small diameter gravity system [2]
  10. Road runoff collection, transport and disposal systems [2]
  11. Planning, construction, operation and maintenance of water supply and sewer systems [2]
  12. Trenchless technologies in construction and renovation of pipe network in water supply and sewer systems [2]

- Exercises (auditory, design, laboratory):
    1. Water demand and consumption analysis with the definition of relevant flow regarding the dimensioning of water supply systems [1-auditory, 1– design],
    2. Hydraulic analysis of water supply systems – manual calculations and the application of EPANET software tool [2 - auditory, 4 – design],
    3. Shaping and dimensioning of water supply facilities – water tanks, pumping stations, valve chambers, etc. [2 - auditory, 1- design],
    4. Dimensioning of hydrant network for fire fighting – internal and external [2– design],
    5. Water loss analysis – creating the DMA zones, application of IWA methodology, economic analysis [1-auditory, 1-design],
    6. Wastewater quantity analysis with the definition of relevant flow regarding the dimensioning sewer systems [1 - auditory, 1–design],
    7. Hydraulic analysis of gravity sewer systems – manual calculations and the application of EPASWMM software tool [2 - auditory, 4–design],
    8. Shaping and dimensioning of facilities and equipment of gravity sewer systems –manholes, combined sewer overflows, retention basins, pumping stations, etc.[2 - auditory, 1–design],
    9. Hydraulic analysis of alternative wastewater collection systems [2–auditory],
    10. Hydraulic analysis, shaping, and dimensioning of road runoff collection, transport and disposal systems [2–auditory].

Seminars:

- 1 seminar paper for each student – theoretical considerations related to the certain objects/facilities or planning, design, operation and maintenance of the water supply and sewer systems,
- 2 practical assignments for each student – 1 preliminary design project of water supply system, 1 preliminary design project of gravity sewer system.

Student responsibilities:

- Attendance in lectures (80 %) and exercises (100 %),
- Each student is required to do a 1 seminar paper – theoretical considerations related to the certain objects/facilities or planning, design, operation and maintenance of the water supply and sewer systems,
- Each student is required to finish 2 practical assignments – 1 preliminary design project of water supply system, 1 preliminary design project of gravity sewer system,
- Each student is required to fulfill the minimum requirements in 2 regular written pre-exams – 1 regular written pre-exam is related to water supply systems (theory and design), 1 regular written pre-exam is related to sewer systems (theory and design). The minimum requirement 25% score,
- Students who didn't meetl the minimum requirements in 2 regular written pre-exams are required to fulfill the minimum requirements in a make up pre-exam that is related to the whole course content – water supply and sewer systems (theory and design). The minimum requirement 25% score.

Grading and evaluation of student work over the course of instruction:

- Activities in the exercises (valuing the seminar work, and valuing the practical work),
- Results from 2 regular written pre-exams (minimum 60% score),

End of semester grading:

- Results in the final written exam(minimum 60% score),
- Oral exam.

Contributions to the final grade:

- Activities on the exercises 20 %,

- Results in2 regular written pre-exams or 1 final exam 80%.

Required literature:

1. Lecture notes published on the web page of the course Water Supply and Sewerage 1,
2. Lecture notes published on the web page of the course Water Supply and Sewerage2,
3. Margeta, Jure,*Vodoopskrba naselja: planiranje, projektiranje, upravljanje, obrada vode,*Sveuciliste u Splitu, Gradjevinsko-arhitektonski fakultet, Split, 2010,
4. Margeta, Jure,*Kanalizacija naselja: odvodnja i zbrinjavanje otpadnih i oborinskih voda,*Sveuciliste u Splitu, Gradjevinsko-arhitektonski fakultet, Split, 2009

Optional literature:

1. Steel, E. W., McGhee, T. J.: *Water Supply and Sewerage*, Mc Graw Hill Book Company, London, 1991

Elective courses

URBAN HYDROLOGY

Credit value (ECTS): 6

Number of hours (in semester):

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

Course objectives:

- Acquiring theoretical and practical knowledge on the impact of urbanization on the hydrological processes, on the processing of precipitation data, and on the methods for runoff determination by empirical approach and by mathematical modelling.

Entry competences (foreknowledge, descriptive):

- Basic knowledge of the subjects Hydrology and Hydrology 2, which include water and water motion in the nature and in the atmosphere, hydrometry, processing hydrometric data, the application of probability and statistics in hydrology and parametric methods for determining the process,
- Basic knowledge about the subject Hydrology 2, which include knowledge and understanding of: hydrological processes, analysis of precipitation data, runoff processes in the catchment area - the methods for determining the direct runoff, and mathematical modelling in hydrology.

Learning outcomes:

- Defining and explaining: hydrological processes in urban catchments, methods of processing data on precipitation and methods for runoff in urban catchments,
- Developing IDF-curve and design rainfall on the basis of data on precipitation and associated project hydrograph,
- Identifying and selecting the appropriate method for design rainfall and runoff hydrograph,
- Applying the acquired theoretical knowledge of urban hydrology in the construction industry, in the design of buildings, ability to solve simple problems and tasks of urban hydrology.

Course content:

- Lectures:
    1. The impact of urbanization on the hydrological processes, differences in urban and natural catchments. Hydrological processes in urban basins [2]
    2. Precipitation, interception, infiltration, water retention in depressions, surface flow and retention in the collection gutters, chutes and channels [2]

3. Hydrologic and hydraulic characteristics of the urban system, the characteristics of the elements of rain and mixed sewage, open storm water drainage systems [2]
4. Flat and pitched roofs, paved areas, parks and unpaved surfaces, gutters and gutters, drains and manholes, culverts under roads and other facilities, sewage network, overflow, retention and expansion pools, retractable bottom and outlet structures [2]
5. Calculation of runoff from heavy rains, the empirical formula and rational method, runoff concentration time and the time lag of maximum runoff of rain shorter than that the concentration time [2]
6. Effective rainfall and runoff coefficient, correlation rainfall - runoff, runoff from melting snow [2]
7. Making and meaning of IDF-curve rain in urban areas, formation of rainfall data sets relevant data to create ITP-curve [2]
8. Methods of determining the runoff hydrograph, unit hydrograph urban catchment [2]
9. Los Angeles hydrograph, Chicago hydrograph, SCS method (Soil Conservation Service Method), other methods [2]
10. Determination of relevant rainfall for urban drainage system, flooding in urban areas, the economic aspects of determining project rain [2]
11. Determination of the project based on the modelling of runoff hydrograph and the implementation of the economic analysis of the cost of drainage systems and urban flood damage caused by rains of high intensity [2]
12. Specifics of the hydrology of roads, highways and airports [2]
13. Modern principles of urban drainage and water quality in urban catchments [2]
14. Collection and use of rainwater, engaging in underground [2]
15. Management of urban drainage system based on the application of mathematical modelling of runoff [2].

- Exercises (auditory and design):
    1. The formation of relevant rainfall data sets to calculate the IDF-curve (auditory) [2]
    2. The formation of relevant rainfall data sets to calculate the IDF-curve (design) [2]
    3. Calculation of the IDF-curve (auditory) [2]
    4. Calculation of the IDF-curve (design) [2]
    5. Application of unit and in stantaneousunith ydrograph for urban areas (auditory) [2]
    6. Application of unit and instant aneousunit hydrograph for urban areas (design) [2]
    7. Application of Los Angeles hydrograph (auditory) [2]
    8. Application of Los Angeles hydrograph (design) [2]
    9. Application of Chicago hydrograph (auditory) [2]
    10. Application of Chicago hydrograph (design) [2]
    11. Application of HEC-HMS modelling for runoff calculation in urban areas (auditory) [2]
    12. Application of HEC-HMS modelling for runoff calculation in urban areas (design) [2]
    13. Determination of the relevant rainfall and design hydrograph based on the run off modeling and the implementation of the economic analysis of the cost of drainage systems and urban flood damage caused by rains of high intensity (auditory) [2]
    14. Determination of the relevant rainfall and design hydrograph based on the run off modeling and the implementation of the economic analysis of the cost of drainage systems and urban flood damage caused by rains of high intensity (design) [2]
    15. Presentation of student program [2].

Student responsibilities:

- Regular attendance in lectures and exercises,

- 2 pre-exams: in each pre-exam minimum 10 point score,
- 1 design assignment,
- at the end of semester one make up pre-exam for meeting the requirements for the signature.

Grading and evaluation of student work over the course of instruction:

- Grading the design assignments.

End of semester grading:

- Minimum 20 point score in written exam,
- Oral exam.

Contributions to the final grade:

- Design assignment 0-15%,
- Written exam 20-70%,
- Oral exam 0-15%

Required literature:

1. Akan A. O., Houghtalen R. J.: *Urban Hydrology, Hydraulics, and Stormwater Quality – Engineering Application and Computer Modeling*, John Wiley & Sons Ltd. 2003,
2. Maksimović Č., Tejada-Guibert J. A.: *Frontiers in Urban Water Management*, IWA Publishing, London, 2001,
3. Ven Te Chow: *Handbook of Applied Hydrology*, McGrow-Hill book Company, New York,1964,
4. *Urbana hidrologija - Okrugli stol*, Split 25-26 travnja 2002, zbornik radova, Hrvatsko hidrološko društvo i Hrvatske vode,
5. Ognjen Bonacci: *Oborine, glavna ulazna veličina u hidrološki ciklus*, Split, 1994

POTABLE AND WASTE WATER TREATMENT

Credit value (ECTS): 6

Number of hours (in semester):

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

Course objectives:

- Acquiring knowledge on technologies and techniques in wastewater treatment and potable water purification and skills in water treatment facilities dimensioning.

Entry competences (foreknowledge, descriptive):

- Basic knowledge about processes in the water bodies, wastewater generation and composition, physical and biological treatment.

Requirements for examination taking (correlated courses):

- Examinations passed: Water protection.

Learning outcomes:

- Knowledge about technical and technological aspects of water purification and waste water treatment and procedures in the treatment facilities dimensioning.

Course content:

- Lectures:
    1. Hydraulic and pollution load calculation, determination of data for plant design [2]
    2. Purpose and legal aspects of water treatment [2]

3. Mechanical treatment [2]
4. Biological treatment, suspended microbial cultures [6]
5. Biological treatment, attached microbial cultures [2]
6. Biological nutrient removal [2]
7. MBR treatment [2]
8. Lagoons and constructed wetlands [2]
9. Fundamentals of water purification [2]
10. Coagulation, flocculation [2]
11. Clarification and filtration [2]
12. Colors, metals and chemicals removal [2]
13. SCADA, pilot plants, operation and maintenance [2].

- Auditory exercises:
  1. Input data analyses by ATV rules [2]
  2. Mechanical treatment design [2]
  3. Biological reactors' design [2]
  4. Oxygen requirements calculation, and aeration equipment selection [2]
  5. Dimensioning and selection of pumping facilities for water and sludge transportation [2]
  6. Technological calculation of CAS systems [2]
  7. Technological calculations of activate sludge systems [2]
  8. Technological calculations of attached microbial cultures systems [2]
  9. Biological phosphorus and nitrogen removal calculation and dimensioning [2]
  10. Sludge treatment techniques calculation and dimensioning [2]
  11. Sludge dewatering, drying, thermal treatment, and disposal [2]
  12. WWTP water and sludge line, layout and vertical arrangement [2]
  13. Dimensioning potable water purification processing units [2]
  14. Dimensioning potable water purification processing units [2]
  15. Pilot plant design [2].

Student responsibilities:

- 100% exercise attendance,
- 75% lecture attendance.

Grading and evaluation of student work over the course of instruction:

- 2 pre-exams, maximum 100 points,
- 1 make up pre-exam the students who earned less than 25% points in one or both pre-exams.

End of semester grading:

- Grading:
  - 120 – 140 points= satisfactory (2)
  - 140 – 160 points = good (3)
  - 160 – 180 points = mark very good (4)
  - ≥ 180 points = excellent (5)

Contributions to the final grade:

- Bonus for regular attendance, maximum20 points.

Required literature:

1. Lecture notes power point presentations,
2. Gulić, I.: *Water purification*, Text book printed by Zagreb University,2003,
3. Metcalf & Eddy: *Wastewater Engineering, Treatment, Disposal*, Reuse, McGraw-Hill International Editions, 2003

MODELING IN HYDRAULIC ENGINEERING

Credit value (ECTS): 6

Number of hours (in semester):

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

Course objectives:

- Obtaining practical knowledge related to numerical modeling of open channel flow/transport, ground water flow/transport, eco-system dynamics and wave generation-deformations. Getting the insight into the possibilities of modern numerical models.

Entry competences (foreknowledge, descriptive):

- Knowledge about differential and integral calculus (including ordinary differential equations) and linear algebra,
- Knowledge about and understanding the particle mechanics(speed, acceleration, Newton's laws, the change of momentum, energy, force, work, power),
- Understanding the concepts of initial and boundary conditions,
- Knowledge about basic rheology principles, knowledge about the laws of thermodynamics.

Learning outcomes:

- Understanding the concept of “model”,
- Recognizing the advantages and disadvantages of numerical modeling approach,
- Recognizing the consequences of adopted assumptions and imperfections,
- Identifying an appropriate description of boundary and initial conditions,
- Identifying the appropriate dimensionality of the problem and possible simplification,
- Understanding the principles of numerical discretization of partial differential equations,
- Ability to apply the results of numerical models to the calculations of pressure and forcesactingon the structure,
- Recognising the abilities of modern “free of charge” and “commercial” models.

Course content:

- Lectures:
    1. Description of flow and transport in continuous liquid environment [2]
    2. Basic equations of flow and heat transfer (3D mass conservation equation, 3D momentum equations, 3D energy conservation equation)[2]
    3. Navier-Stokes equation for Newtonian fluids (conservative form)[2]
    4. Differential and integral form of general transport equation[2]
    5. Classification according to physical characteristic[2]
    6. Turbulence models (Reynolds averaged Navier-Stokes equations for incompressible fluids, turbulent flow calculation, „mixing length“ and „k-ε“ turbulence models)[2]
    7. 2D and 3D open channel flow models with heat exchange component[2]
    8. Description of flow and transport in porous environment (groundwater flow)[2]
    9. Basic process equations (mass conservation equation, transport components, generalisation of Fick’s law, transport equations, initial and boundary equations)[2]
    10. Reactive process (linear decay, mass exchange between liquid-solid phases)[2]
    11. Flow and transport model for environment with inter granular porosity[2]
    12. Modeling the aquatic eco-system (population dynamics, Michaelis-Menten kinetics)[2]
    13. Modeling the aquatic eco-system (eco system with two, three and four state variables, link to convective-dispersion transport)[2]

14. Modeling the wave generation (problem formulation and basic generative process involved)[2]
15. Modeling the non-linear wave interaction (spectral dissipation in deep water region, dissipation due to white capping, non-linear interactions in shallow water region, bottom induced dissipation[2].

- Exercises: (auditory, design, laboratory):
  1. Implementation of 2D numerical model for stationary and non-steady open channel flow (model spatial domain, initial and boundary conditions)[2]
  2. Implementation of 2D numerical model for stationary and non-steady open channel flow (spatial and temporal discretisation, advantages and disadvantages of various methods)[2]
  3. Implementation of 2D numerical model for stationary and non-steady open channel flow (calculation procedure, stability condition, sensitivity analysis)[2]
  4. Implementation of 2D numerical model for stationary and non-steady open channel flow (pre-processing and post-processing, handling the input and output files)[2]
  5. Implementation of 3D numerical model for stationary and non-steady open channel flow (model spatial domain, initial and boundary conditions)[2]
  6. Implementation of 3D numerical model for stationary and non-steady open channel flow (spatial and temporal discretisation, advantages and disadvantages of the various methods)[2]
  7. Implementation of 3D numerical model for stationary and non-steady open channel flow (calculation procedure, stability condition, sensitivity analysis)[2]
  8. Implementation of 3D numerical model for stationary and non-steady open channel flow (pre-processing and post-processing, handling the input and output files)[2]
  9. Implementation of numerical 2D groundwater flow and transport models (model spatial domain, initial and boundary conditions[2]
  10. Implementation of numerical 2D groundwater flow and transport models (spatial and temporal discretisation, advantages and disadvantages of the various methods)[2]
  11. Implementation of numerical 2D groundwater flow and transport models (calculation procedure, stability condition, sensitivity analysis)[2]
  12. Implementation of numerical 2D groundwater flow and transport model (pretprocessing and post-processing, handling the input and output files)[2]
  13. Implementation of Eco-system numerical model (system of governing equations and process variables, initial and boundary condition, stability condition, sensitivity analysis)[2]
  14. Implementation of wave generation and deformation numerical model (model spatial domain, initial and boundary conditions)[2]
  15. Implementation of wave generation and deformation numerical model (pre-processing and post-processing, handling the input and output files) [2].

Student responsibilities:

- Attendance in75%lectures and 100% exercises.

Grading and evaluation of student work over the course of instruction:

- Monitoring the dynamics ofmodels development and implementation.

End of semester grading:

- Oral exam.

Contributions to the final grade:

- Attendance inlectures and exercises.

Required literature:

1. Novak, P.: *Hydraulic modelling - an introduction: principles, methods and applications*, Spoon Press, London, 2010,
2. Wang, H.F., Anderson, N.P.: *Introduction to groundwater modeling*, Academic Press, USA, 1985,
3. Versteeg, H.K., Malalasekera, W.: *An introduction to computational fluid dynamics*, Pearson Educaton Limited, UK, 2007

Optional literature:

1. Abbott, M., Basco, D.: *Computational fluid dynamics*, Wiley & Sons, New York, USA, 1989,
2. Barnsley, M.J.: *Environmental modeling*, CRC Press, New York, USA, 2007

DRAINAGE AND IRRIGATION 2

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises: 30 (auditory - 14, design - 14, presentations - 2)
- Seminars: 1

Course objectives:

- Acquiring advanced knowledge about drainage and irrigation, getting acquainted with hydro engineering and agro engineering literature, including amelioration and ameliorative pedology, off prints and copies of proceedings' publications, participation in field practice.

Entry competences (foreknowledge, descriptive):

- Basic of Hydraulics and Hydrology,
- Knowledge of Drainage and Irrigation 1,
- Knowledge of specialist software programs,
- Knowledge of English language.

Learning outcomes: theoretical and practical

- Practical skills in maintenance and use of amelioration systems,
- Integrated knowledge in hydro engineering ameliorations 1 and 2: ability to participate in the process of designing, constructing, maintaining and using hydro amelioration systems and facilities (surface and subsurface) drainage, and particularly irrigation of agricultural and other soils

Course content:

- Lectures:
    1. Introduction, relation "plant-soil-water" in hydro engineering ameliorations [2]
    2. Basics of ameliorative pedology: soil formation, soil classification, mechanical and physical properties of soil, water in soil, amelioration problems of hydromorphic soils, pedologic investigation[2]
    3. The impact of field characteristics of amelioration areas on design and working elements of hydroamelioration facilities and systems for surface and subsurface drainage and irrigation[2]
    4. Technical requirements and standards in the maintenance of amelioration system of surface drainage [2]
    5. Elements in planning amelioration systems for irrigation [2]
    6. Quality of irrigation water [2]
    7. Hydraulic dimensioning of pipes for irrigation systems [2]
    8. Establishment and maintenance of water regime of agricultural soils: requirements of optimal development of plant cultures[2]
    9. The importance of the maintenance of hydroamelioration facilities and systems for optimal soil water regime and their impact on stable crops of plant cultures[2]
    10. Machines and equipment: surface, subsurface drainage and irrigation[2]
    11. Technology and costs of construction of hydroamelioration systems[2]

12. Hydroamelioration systems and multipurpose water management facilites.
13. Application of multi criterion analysis in planning hydro systems [2]
14. Control of operation of amelioration systems and technical-financial indicators of construction [2]
15. Hydro engineering amelioration in Water law and Law on financing water management [2].

- Exercises (auditory, design):
  1. Analysis of terrain and climatic data for amelioration areas [4]
  2. Planning, study and design solutions for construction of facilities and systems for drainage and irrigation of agricultural soils 4)
  3. Methods for determining the potential evapotranspiration [4]
  4. Calculus of necessary irrigation water for relevant crops by using software CROPWAT [4],
  5. Selecting the manner and type of irrigation [6]
  6. Organization and construction management of facilities and systems for drainage and irrigation of agricultural soils[6]
  7. Organization and maintenance of facilities and systems for drainage of surface and subsurface waters, particularly of the agricultural soils irrigation systems[2].
- Seminars:
  1. Students are required to prepare one seminar papershowing practical skills in maintenance and use of amelioration systems.

Student responsibilities:

- Getting acquainted with hydroengineering and agro engineering literature, including amelioration and ameliorative pedology, off prints and copies of proceedings' publications,
- Participation in field practice.

Grading and evaluation of student work over the course of instruction:

- Attendance in 75% lectures, 100% practice,
- 2 pre-exams, with minimum 25% score in each,
- 100% score in seminar design.

End of semester grading:

- Written exam (if student did not succeed earn minimum 25% score in each pre-exam),
- Oral exam (the requirement for taking the exam is minimum 25% score in each pre-exam).

Contributions to the final grade:

- Discussion, 2 pre-exams,
- Written and oral exam (depending on credits earned in pre-exams and practice),
- Programdesign.

Required literature:

1. Group of authors, *Priručnici za hidrotehničke melioracije*, I. kolo: knjiga 5 i 6, 1989-1991,
2. Group of authors, *Priručnici za hidrotehničke melioracije*, II. kolo, knjiga 5, 1996, knjiga 7, 1999., odabrana poglavlja, Hrvatsko društvo za odvodnju I navodnjavanje Zagreb, Građevinski fakultet, Rijeka.

Optional literature:

1. Vidaček, Ž.: *Gospodarenje melioracijskim sustavima odvodnje i natapanja*, selected paragraphs, Agronomski fakultet Zagreb i Hrvatsko društvo za odvodnju i navodnjavanje, Zagreb, 1998,
2. *Priručnik za hidrotehničke melioracije*, II. kolo, knjiga 4, 1995. i knjiga 6, 1997, Hrvatsko društvo za odvodnju i navodnjavanje, Zagreb i Građevinski fakultet Rijeka.
3. Authorised lecture notes and a CD with papers from lifelong learning courses in the field of ameliorations, hydrology, hydro pedology, environment protection and water management.

FLOOD PROTECTION

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises (auditory): 30
- Seminars: 1

Course objectives:

- Transferring basic know-how about flood protection and flood risk management,
- Introducing students with global and local riverbed instability mechanisms and mathematical tools for its description,
- Transferring know-how about design of hydrotechnical structures as part of flood defense systems.

Entry competences (foreknowledge, descriptive):

- Knowledge of linear algebra, differential and integral calculus (including ordinary differential equations),
- Knowledge of basic fluid dynamics (momentum equation, general equations for description of the fluid in motion (Saint-Venant and Navier-Stokes equations), the law of conservation of energy, Bernoulli equation for viscous fluid, resistance to flow, determination of local and friction energy losses, pressure and energy grade, measurement of flow velocity, pressure and discharge),
- Knowledge of descriptive and differential geometry, drawing in 3D space, finding line intersections with digital elevation model,
- Computer literacy: drawing with CAD based software, advanced operations on vectorized background images,
- Knowledge of HEC-RAS software.

Learning outcomes:

- Defining flood hazard maps on digital elevation model and estimate material damage and size of potentially endangered population,
- Analysis of flood defense system elements,
- Design of flood defense structures and their interaction,
- Estimate of erosional capacity of flow around submerged structures on watercourses,
- Distinguishing the applicability of different approaches in empirical estimates of erosional capacity of flow,
- Estimating the extents of flow change influence for constructions in riverine environment.

Course content:

- Lectures:
    1. Introduction, water management longitudinal watercourse profile, watercourses as elements of water management system [2]
    2. Estimation of flood risk [2]
    3. Development of flood hazard maps [4]
    4. Estimate proportions of flood damage and development of flood risk maps [4]
    5. Analysis of floods protection system elements, flood relief channels and lateral channels, frontal and lateral retentions and retention areas in accumulations system [6]
    6. Water management facilities, dams, overflows, stoppers investigations. Approaches to protection embankment optimal dimensions specification, their construction and maintenance [2]

7. Investigations on small watercourse regulation with immobile wetted perimeter, approach to riverbed dimensioning by means of permitted flow velocity [2]
8. Approach to optimal dimensions specification of riverbed by using permitted tractive force procedure [2]
9. Scientific approach to riverbed protection modes from fluvial erosion and to the calculation of technical and construction elements [2]
10. Riverbed regime concept, stable bed dimensions in alluvium [2]
11. Approach for calculation of local scour extent [2].

- Exercises (auditory, design):
  1. Developing HEC-RAS model geometric data[6]
  2. Development of flood hazard maps [8]
  3. Local scour model - HEC-RAS [4]
  4. Design of detention basin and lateral inlet structure [8]
  5. Calculation of seepage through levee and design of drainage system [4].
- Seminars:
  1. Calculation of local scour around structures and design of countermeasures

Student responsibilities:

- Attendance in lectures and exercises,
- Developing individual project assignment,
- Minimum 25% score in each pre-exam.

Grading and evaluation of student work over the course of instruction:

- Project grading,
- Pre-exams: students with minimum 60 % score in each pre-exam are exempt from the written exam.

End of semester grading:

- Written exam: minimum 50 % score,
- Oral exam.

Contributions to the final grade:

- Project 10%,
- Seminar 10%,
- Pre-exam 40-50%,
- Oral exam 20-30%

Required literature:

1. Chang H. H: *Fluvial processes in River Engineering*, Krieger publishing company,1998,
2. Jansen, P. Ph. et al: *Principles of River Engineering – The non – tidal alluvial river*, Pitman Publishing Limited, London, 1979

Optional literature:

1. *Water Resources Project Planning*, UN Office of Tehnical Cooperation: Water Resources Series No. 41, NY, 1972,
2. Hemphil, R. &Bramley, M. E.: *Protection of river and canal banks*, CIRIA and Butterworths, London, UK, 1989

HYDRAULICS 2

Credit value (ECTS): 6

Number of hours (in semester):

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

Course objectives:

- Highlighting the importance of experiments to consider the fluid flow which is not enough investigated, as well as describing elements of remote monitoring and control of hydrotechnical objects.

Entry competences (foreknowledge, descriptive):

- Knowledge of hydraulics.

Enrolment requirements (correlated courses):

- Examinations passed: Hydraulics 1

Requirements for examination taking (correlated courses):

- Examinations passed: Hydraulics 1

Learning outcomes:

- Learning how to organize an experiment and how to understand the operation of a fluid-containing system,
- Ability to measure some of the parameters of a flowing fluid. This knowledge can be applied to design improved systems and to predict their future operation

Course content:

- Lectures:
  1. Physical models, methods of investigating fluid flow, short history of hydraulic modeling, basics of physical modeling and similarity criterion, examples of physical modeling, advantages and disadvantages of physical models [2]
  2. Hidraulic laboratory - organization and measurement methods[2]
  3. Characteristic dimensionless parameters, models with distortion, measurement effect, laboratory effect [2]
  4. On fulfilling Reynolds's and other conditions of hydrodynamic similarity [2]
  5. Analysis of model concepts [2]
  6. Measuring technique- measuring of water level, measurement of velocity and discharge[2]
  7. pressure and force measuring, measuring of other parameters (temperature, substance concentration,...)[2]
  8. Measuring methods and instrumentations, measurementplanning, optimization of an experiment[2]
  9. Measurements in nature: organization and measure methods, measuring the level and flow, measuring sediments [2]
  10. Collecting and processing measured data- measuring setting, sensors, signals elaboration[2]
  11. Graphic representation and interpretation of results, measurement failure[2]
  12. Multiplexors, AD convertors[2]
  13. Data presentation and processing, remote data transmission [2]
  14. Presentation of conducted modeling [2]
  15. Pre-exam [2].

- Exercises (auditory, design):
    1. Introduction about model execution, selection of the problem to be modeled, measuring technique at disposal [2]
    2. Selecting the model concept, selection of measuring technique, selection of the scale of the model, locating the model in the laboratory, development of hydraulic scheme and experiment outline [2]
    3. Material collection and analysis of measuring equipment and its relevance to the model [2]
    4. Verification of the model concept [2]
    5. Model development, installation of measuring technique and its calibration [4]
    6. Trial operation of the model and identifying defects [2]
    7. Elimination of defects on the model [2]
    8. Carrying out measurements [4]
    9. Measurement data processing [2]
    10. Additional measurements (repetition of failed measurements – developing necessary modifications [2]
    11. Processing and analysis of new measurements – conclusions and guidelines for the next model [2]
    12. Presentation of the developed model and the obtained results [2]
    13. Submission of the final report and conservation of the model [2].

Student responsibilities:

- Attendance in lectures (75%) and exercises (100%),
- Pre-exam,
- Making their own experiment.

Grading and evaluation of student work over the course of instruction:

- Making a model and carrying out measurements on it.

End of semester grading:

- Presentation of the experiment,
- Oral exam.

Contributions to the final grade:

- Developing a model and measuring and data processing.

Required literature:

1. Gjetvaj:Lecture notes,Kobus,H.: *Hydraulic modeling,* Verlag Paul Parey, Hamburg, 1980

Optional literature:

1. Novak P.,Čabelka.J, *Models in Hydraulic Engineering*, Pitman,1981
2. Tavoularis S*., Measurement in Fluid Mechanics*, CambridgeuniversityPress, 2005

EARTHFILL AND RETAINING STRUCTURES

Look in **Geotechnical Engineering**

HYDROGEOLOGY AND ENGINEERING GEOLOGY

Look in **Geotechnical Engineering**

HYDROTECHNICAL CONCRETE

Look in **Construction Materials**

2nd year, 4th semester

Compulsory courses

WATER RESOURCES ENGINEERING

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures:45
- Exercises. 15 (auditory - 3, design - 12)

Course objectives:

- Acquiring practical and theoretical knowledge in water resources engineering.

Entry competences (foreknowledge, descriptive):

- Knowledge and understanding of basic hydrological processes,
- Knowledge and discerning hydraulics structures purposes
- Knowledge and understanding technical characteristics of hydraulics structures.

Learning outcomes:

- Identifying problems related towater management,
- Knowledge about legislation correlated to water resources,
- Understandingthe principles of problem solving technology,
- Comparing different water resource projects based on financial analysis,
- Participation in water management teams.

Course content:

- Lectures:
  1. Water and water resources[3]
  2. Basic terms: system, processes, water management, water research [3]
  3. Place and tasks of water management in the state economy [3]
  4. Legislation [3]
  5. Water development projects: goals and tasks [3]
  6. Multipurpose water development projects management [3]
  7. Environmental changes in connection with water development projects and hydraulic structures [3]
  8. Evaluation goals, criteria and measures [3]
  9. Decision making process, optimisation [3]
  10. Assessment of water development project systems [3]
  11. Water development project benefits and costs [3]
  12. Allocation of benefits and costs in multipurpose systems [3]
  13. Examples of water development projects (explanation and visit) [6]
  14. Water development projects maintenance [3].

Exercises:

1. Water development project analyses [15]

Student responsibilities:

- Attendance in classes and exercises,
- Making programs.

Grading and evaluation of student work over the course of instruction:

- Two pre-exams.

End of semester grading:

- Minimum 60% score in pre-exams is required to be exempt from the written exam,
- Written and oral exam.

Contributions to the final grade:

- Attendance in lectures,
- Pre-exam score..

Required literature:

1. Weekly lecture notes - ppt, pdf.

Optional literature:

1. *Water Resources Systems Planning and Management,* An Introduction to Methods, Models and applications, Daniel P. Loucks and Eelco van Beek, Studies and Reports in Hydrology, UNESCO PUBLISHING, 2005
2. *Vodič za analizu troškova i koristi investicijskih projekata*, FOIP biblioteka, 2007
3. Legislation

Elective courses

DESIGN IN HYDRAULIC ENGINEERING

Credit value (ECTS): 6 ECTS

Number of hours (in semester):

- Exercises (design):60
- Seminars:1

Course objectives:

- Ability to recognize and collect design supporting documents, structure preliminary design in hydraulic engineering and incorporateconstructioninto environment.

Entry competences (foreknowledge, descriptive):

- Prior knowledge in Ports and waterways, River training, Water resources engineering, Drainage and irrigation 1, Water protection, Water supply and Sewerage 1

Learning outcomes:

- Ability to structure civil engineering designs (hydraulic engineering),
- Practical skills in collecting design supporting documents.

Course content:

- Exercises (design):
    1. Developing a preliminary design of waterrelated structure withmentor supervision: elaboration and presentation of design basics: spatial planning, geodetic, geotechnical, hydrological, climatic, maritime, traffic, demographic [10]
    2. Defining the design conditions: relevant design conditions: special planning, ecological, functional and structural [10]
    3. Determining functionality: setting the function of the building concept by estimated capacity, estimated section structure and situational solution. Relevant calculi for confirming or changing the assumed concept: hydraulic, agropedological, energetical, tehnological, ecological or traffic [10]

4. Structure calculus: bearing capacity calculus (2D calculus of stability or strength) of the assumed section for one of the structures of the planned water structure [10]
5. Cost estimate, technological or functional solution, design calculations, technicaldescription, bill of quantities, drawings. A design should suit thestandards of EU legal system. (A course project can beselected and agreed on between student and mentor of anyhydraulic engineering professional subject) [10]
6. Drafts: situation, ground plan with the equipment, staking plan, longitudinal sections, typical cross-section [10].

Student responsibilities:

- Creation of seminar (preliminary design) and its presentation.

Grading and evaluation of student work over the course of instruction:

- Students earn scores over the entire semester according to the consultations with the mentor.

End of semester grading:

- The final grade is based on seminar and presentation scores.

Required literature:

1. CEM - *Coastal Engineering Manual*, US Army, Waterways Experimental Station, 2003,
2. Linsley P.K, Franzini J.B: *Water-resources Engineering*; New York, McGraw Hill Book Com. 1991,
3. Steel, E. W. And Terence, J. McG.,*Water Supply and Sewerage*,
4. Linsley P.K, Franzini J.B,*Water-resources Engineering,* New York, McGraw Hill Book Com. 1991

Optional literature:

1. CEM - *Coastal Engineering Manual*, US Army, Waterways Experimental Station, 2003

VEGETATIVE WATER FACILITIES

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures:30
- Exercises: 30
- Seminars:2

Course objectives:

- Acquisition of specific theoretical and engineering knowledge on soil, water and vegetation with the goal to apply it within the scope of environmental and hydro engineering for solving complex problems of environmental protection, utilisation and protection of water resources, rivers, natural and artificial lakes and their surroundings.

Entry competences (foreknowledge, descriptive):

- Hydrology course basic knowledge including hydrologic characteristics of natural water flows, water regime, sediment regime, ice regime. River training course basic knowledge including basic morphological characteristics of water flow, riverbed instability conditions. The interaction of riverbed geometric elements and hydraulic design of natural and artificial water flows.

Learning outcomes:

- Knowledge about the state of the art in specific parts of ecology, ecohydrology and environmental engineering,
- Professional skills which can be applied in current ecological and ecohydrological knowledge in professional environmental and river engineering.
- Ability to implement integrated ecological, ecohydrological and botanical current knowledge and skills in designing and making environmental and river engineering structures.

Course content:

- Lectures:
    1. Theoretical and practical content of ecology, ecohydrology and biology for solving some environmental and hydro engineering tasks [2]
    2. Role of vegetation in hydro and environmental engineering[2]
    3. Significance of vegetative water facilities construction[2]
    4. Hydraulical effect of ecological regulation of watercourses[2]
    5. Water and vegetation, basic aspects of vegetation[2]
    6. Water regime impact on vegetation and vice versa[2]
    7. Water level duration and vegetation period on open watercourses and lakes[2]
    8. Major coastal and littoral vegetation, growth and preparation, watercourse coastal and shoreline protection[2]
    9. Vegetation as a constitutive part of river training structures, plant selection, site preparation, seeding, turfing, planting[2]
    10. Slope stabilisation, stabilization of soil slopes[2]
    11. Soil erosion and soil conservation[2]
    12. Application of reed and willows, live wicker, shrubby vegetation and soft - wood trees[2]
    13. Parks and landscape architecture and artificial lakes[2]
    14. Use of vegetation in river restoration[2]
    15. Vegetative impact on preservation and protection of water [2].
- Exercises (consultations, discussions):
    1. The impact of river vegetation on water regime: duration curve of water level. Water regime and vegetation period in open water courses and artificial lakes. Coastal vegetation frames[4]
    2. Hydraulic effect of ecological regulation of water courses [4]
    3. The influence of vegetation on the erosion and the stability of waterbeds [4]
    4. Comparison of vegetative water facilities and massive water facility construction [4]
    5. Renaturalization of regulated water courses – solution examples [4]
    6. The influence of vegetative water facilities on preservation and protection of water courses – solution examples [6]
    7. Presentation of students' seminar papers [4].

Student responsibilities:

- Attendance in lectures and participation in practical work by discussion,
- Seminar paper,
- Written and/or oral examin depending on score achieved in pre-exams and seminar work.

Grading and evaluation of student work over the course of instruction:

- Evaluation of 2 seminar papers.

End of semester grading:

- Students must achieve a positive grade in both pre-exams to take the oral exam.

Contributions to the final grade:

- Seminar 60 %,
- Oral exam 40 %

Required literature:

1. Coppin, N. J., Richards, I. G.*: Use of vegetation in Civil Enginerind CIRIA*(Constructions Industry Research and Information Association), London, 1990,
2. *Der biologische Wasserbau – an den Bundeswasserstrassen*, Bundesanstalt fur Gewasserkunde Koblenc, Verlag Eugen Uliner, Stuttgart, 1965,
3. Svetličić, E.,*Otvoreni vodotoci – pokosi i njihova sigurnost*, JVP Hrvatska vodoprivreda Zagreb, 1979,

4. Petraš, J.,*Biološke vodogradnje*– authorised lectures, Građevinski fakultet Zagreb, 2000

Optional literature:

1. *Flusse und Bache erhalten - entwickeln - gestalten*, Wasserwirtschaft in Bayern, Oberste Baubehörde im Bayerischen Staatsministerium des Innern, Heft 21, München, 1989.
2. *Flusse - Bache - Auen. Pflegen und gestalten*, Wasserwirtschaft in Bayern, Oberste Baubehörde im Bayerischen Staatsministerium des Innern, Besonders Publikation, München, 1991.

SPECIAL WATER POWER PROJECTS

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures:30
- Exercises: 30 (design)

Course objectives:

- Acquisition of practical and theoretical knowledge in water power use and design of small hydropower plants, pumped-storage hydropower plants and other modes of water resource uses.

Entry competences (foreknowledge, descriptive):

- Knowledge about and understanding basic hydrological processes,
- Knowledge about and understanding basic fluid mechanics, hydraulics principles and water use principles,
- Knowledge about and understanding soil and rock characteristics with basic foundation principles,
- Knowledge about concrete structures design.

Enrolment requirements (correlated courses):

- Teachers signatures: Hydraulics 1, Water power development

Requirements for examination taking (correlated courses):

- Examinations passed: Water power development

Learning outcomes:

- Identifying problems related to design of small and pumped-storage hydro power plants,
- Understanding principles of water power use and different (new) types of hydropower plants,
- Participation in design and construction of special water power plants.

Course content:

- Lectures:
  1. Small hydropower plants (SHP) [2]
  2. Definitions, construction conditions use of SHP and fitting into the energetic system [2]
  3. Water intakes, power houses, equipment, management and mainteinance, changes in the environment [2]
  4. Background and investigations [2]
  5. Interventions, inlets and outlets [2]
  6. Power houses and equipment for production and management[2]
  7. Management and maintenance [2]
  8. Economic role and its profitability, changes in the environment [2]
  9. Pumped-storage hydropower plants (PSHP): their role in the electric system [2]
  10. Definitions, construction conditions use of PSHP and fitting into the energetic system [2]
  11. Reservoirs – construction, maintenance and usage [2]
  12. Interventions, inlets and outlets, hydraulic calculations [2]
  13. Power houses room and equipment (turbines and pumps) [2]

14. Changes in the environment [2]
15. Other forms of water resourcces usage: the power of the level change (tide), the power of waves, mechanical energy of water (mills) and similar facilities [2].

- Exercises:
    1. Hydraulic calculations [5],
    2. Design – small hydropower plant design (25).

Student responsibilities:

- Attendance in lectures and exercises,
- Making a program.

Grading and evaluation of student work over the course of instruction:None.

End of semester grading:

- According to the results in exercises and discussions about students' project. If it is not enough, written part of exam and oral exam.

Contributions to the final grade:

- Attendance in lectures and successachieved in exercises.

Required literature:

1. Weekly lecture notes - ppt, pdf

Optional literature:

1. *Civil Engineering Guidelines for Planning and Designing Hydroelectric Developments*, New York, American Society of Civil Engineering, 1989, Vol.4 Small-scale Hydro; Vol.5 – *PumpedStorage and Tidal Power*.
2. Stojić P,*Hidroenergetika*, Split, Građevinski fakultet Sveučilišta u Splitu, 1995
3. *Zgradimo majhno hidroelektrarno*; Zveza organizacij za tehnično kulturu Slovenije. 1986, Del 1-5
4. Mosony E,*Water Power Development*, Vol I-II, Budapest, Akademiai Kiado, 1987, Third Ed.

MARITIME STRUCTURES

Credit value (ECTS): 6 ECTS

Number of hours (in semester):

- Lectures:30
- Exercises:10
- Seminars:20

Course objectives:

- Professional knowledge in designing the rubble mound breakwaters, vertical concrete breakwaters, design and construction of submarine pipelines, designing marinas.

Entry competences (foreknowledge, descriptive):

- Prior knowledge in wave mechanics and statistics, designing of ports, subsea construction technology, strength of materials.

Enrolment requirements (correlated courses):

- Examinations passed: Ports and waterways

Learning outcomes:

- Knowledge in designing and construction of rubble mound and vertical breakwaters,
- Knowledge in designing and setting of submarine pipelines,
- Knowledge in designing of marinas (functionality and structures).

Course content:

- Lectures:
    1. Breakwaters: types and detailed design, loads, stability calculations, functionality calculations, construction technology [4]
    2. Calculus of lining (Van den Meer), design of details [4]
    3. Submarine pipelines: pipe types, setting technology, loads on pipes, stability calculations, resistance calculations [4]
    4. Structure calculus (stability on the seabed),design of details [4]
    5. Marinas: types, layouts, defence structures, inner structures, nautical fleet, berthing methods, mooring system [4]
    6. Introduction to seminars [4]
    7. Locks: types, hydraulic calculus [4].
- Exercises :
    1. Organising teams. Task distribution among teams. Execution of content and presentation of current know how on the topic of the seminar paper [4],
    2. Individual work with teams (30),
    3. Presentation of seminar papers [6].
- Seminars:
    1. Designing breakwaters, stability of submarine pipelines, setting of pipelines, breakwater types (details), floating breakwaters, breakwaters hazards (disasters)

Student responsibilities:

- Participation in seminar paper preparation,
- Presentation of seminar papers.

Grading and evaluation of student work over the course of instruction:

- Students earn scores in seminar papers during the entire semester.

End of semester grading:

- The final grade is based on seminar scores.

Contributions to the final grade:none.

Required literature:

1. Pršić, M. *Pomorskegrađevine*, web-lecture notes, University of Zagreb Faculty of Civil Engineering, 2013

Optional literature:

1. CEM - *Coastal Engineering Manual*, US Army, Waterways Experimental Station, 2003,
2. EAU - *Empfehlungen des ArbeitausschussesUfereinfassungen*, Ernst und Sohn, 1996,
3. *Technical standards and Commentaries for Port and Harbour Facilities in Japan*, The Overseas Coastal Area Development Institute of Japan, 2002

STRUCTURAL ENGINEERING

1st year, 1st semester

RESEARCH METHODS

Look in **Shared courses**

PRESTRESSED CONCRETE

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises: 30 (auditory - 12, design – 18)

Course objectives:

- Acquiring theoretical knowledge on: systems and technologies of prestressing, suitable materials, differences in relation to reinforced concrete, approach principles for design, the application of prestressed concrete for different types of structures in their exploitation but also using prestressing for the construction of special types of structures,
- Acquiring theoretical and practical knowledge on: realisation of the prestressing force and its losses, design for bending, shear and torsion, cracks control, deflections, introduction of prestressing force into the structure, tendons layout and designing construction details.

Entry competences (foreknowledge, descriptive):

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

Learning outcomes:

- Knowledge and skills needed for designing prestressed structural elements,
- Knowledge and ability to select prestressing steel and concrete depending on the condition of the use of prestressed structural element and aggressive environmental conditions in accordance with contemporary methods and criteria of European standards,
- Knowledge and skills necessary to analyse the behaviour and to design the prestressed structural elements according to the ultimate limit states using contemporary methods and criteria of European standards,
- Knowledge and skills necessary for verification of serviceability limit states using contemporary methods and criteria of European standards,
- Ability to shape and design the prestressed structural elements.

Course content:

- Lectures:
  1. The basic principles, Historical development, Types and systems of prestressing [2]
  2. Materials, Systems and Technology, and the scope of the prestressing [2]
  3. Prestressing force, immediate and time losses [2]
  4. Axially prestressed elements [1]
  5. Elements subjected to bending [5]
  6. Shear and torsion [2]
  7. Deflections and cracking, tansfer of prestressing [2]
  8. Details and constructive rules for prestressing of concrete construction [3]

9. Cantilever beams [1]
10. Continuous and partially continuous beam [2]
11. Composite beams [1]
12. Prestressed slabs [3]
13. Elements in compression, Circular prestressing [2]
14. External prestressing [2].

- Exercises (auditory):
  8. Layout of the structure [1]
  9. Definition of actions, the construction phases and usage [1]
  10. Immediate and time losses of prestressing force [2]
  11. Structural analysis [2]
  12. Designing of prestressed girder for ultimate limit state [2]
  13. Verification of serviceability limit states [2]
  14. Detailing of structure [1]
  15. Crating the plan for a prestressed reinforcement [1]
- Exercises (design):
  1. Conceptual design of a prestressed structure according to the points explained in the auditory exercises.

Student responsibilities:

- Attendance in lectures and exercises,
- Conceptual design of the assigned structure,
- Two pre-exams (25 % score in each is required for the signature).

Grading and evaluation of the student work over the course of instruction:

- Evaluation of the conceptual designof the assigned structure,
- Preliminary exams: 60% score in each pre-exam exempts students from the written exam),
- Pre-exams: 70% score in each pre-exam exempts students from taking the written and oral final exams.

End of semester grading:

- Written final exam: 50% score required for a pass,
- Oral final exam: optional.

Contributions to the final grade:

- Conceptual design and commitment to exercise 50 %,
- Pre-exams or final exam 50%

Required literature:

1. A.Mandić, A.Kindij,*Prestressed concrete* – lectures published at the web (*in Croatian*), Zagreb, 2010/2011,
2. Radić, J. et al,*Concrete structures* – Handbook *(in Croatian)*, Hrvatska sveučilišna naklada: Andris, Zagreb, 2006,
3. Radić, J. et al,*Concrete structures – Practical examples (in Croatian),* Hrvatska sveučilišna naklada: Andris, Zagreb, 2006
4. Exercise notes published on the web.

Optional literature:

1. Rombach, G.,*Spannbetonbau*, Ernst&Sohn, Berlin, 2010,
2. Zilch, K.,Zehetmaier G.: *Bemessung im konstruktiven Betonbau nach DIN 1045-1 und DIN EN 1992-1-1*, Springer-Verlag Berlin Heidelberg 2006,
3. Sengupta, A.K.,Menon, D.: *Prestressed Concrete Structures*, Indian Institute of Technology Madras, 2006,

4. Nawy, E.: *Prestressed Concrete: A Fundamental Approach*, Pearson Education, New Jersey, 2003,
5. Menn, C.: Bruckenbau 1: *Grundzüge des Brückenbaus in Stahlbeton und Spannbeton*, Zürich, 1979,
6. Libby, J.R.: *Modern Prestressed concrete: Design Principles and Construction Methods*, Litton Educational Publishing, 1977,
7. Mehmel, A.: *Vorgespannter Beton: Grundlagen der Theorie, Berechnung und Konstruktion*, Springer-Verlag, Berlin, Heidelberg, 1973

BRIDGES 2

Credit value (ECTS): 6

Number of hours (in semester):

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

Course objectives:

- Expanding theoretical knowledge about bridge structures (concrete, steel and composite bridges), practical knowledge of calculations and analysis of bridges, practical knowledge of sizing and design of the structural elements of concrete, steel and composite bridges.

Entry competences (foreknowledge, descriptive):

- Comprehension and application of the analysis of concrete and steel structures, knowledge about the basic structural systems of bridges, comprehension and knowledge of structural analysis of various statical systems

Learning outcomes:

- Ability to make a conceptual design of various bridge structures,
- Ability to perceive and analyze different loads on bridges using contemporary European standards,
- Ability to conduct intensive structural analysis of concrete, steel and composite bridges,
- Ability to analyze and size individual structural parts of concrete, steel and composite bridges using modern methods and codes according to European standards.

Course content:

- Lectures:
  1. Introduction - greatest world and Croatian bridge achievements[2]
  2. Conceptual preliminary design of bridge structural system[2]
  3. Slab girder bridges[2]
  4. Ribbed girder bridges[2]
  5. Box girder bridges[2]
  6. Substructure[2]
  7. Steel plate bridges[2]
  8. Orthotropic decks[2]
  9. Composite bridges[2]
  10. Truss bridges[2]
  11. Frame, braced and integral bridges [2]
  12. Cable stayed bridges [2]
  13. Suspension bridges [2]
  14. Small bridges and overpasses[2]
  15. Arch bridges [2].
- Exercises (auditory):
  1. Setting the bridge disposition[2]

2. Cross section forming[2]
3. Substructure forming[2],
4. Load analysis (dead load, permanent load, traffic load, temperature, wind, earthquake, combinations)[3]
5. Transverse influence lines construction[2],
6. Statical analysis by construction stages[2]
7. Sizing and design of cross section elements [2].

- Exercises (design):
    1. Doing the program assignment according to the items listed under auditory exercises.

Student responsibilities:

- Attendance in lectures and exercises,
- Doing an individual bridge design task,
- Two pre-exams - minimum 25% score in each.

Grading and evaluation of student work over the course of instruction:

- Evaluation of the progress of exercise design task program,
- Evaluation of student's ability to do independent work correctly and on time.

End of semester grading:

- Grading the completed exercise design task program,
- Oral exam in design task program comprehension.

Contributions to the final grade:

- Grading the completed exercise design task program 50%,
- Pre-exam or written exam 30%,
- Oral exam 20%.

Required literature:

1. Radić, J., Mandić, A.; Puž, G.: *Design of bridges*, Hrvatska sveučilišna naklada, Jadring, Zagreb, 2005,
2. Radić, J*., Concrete bridges*, Hrvatska sveučilišna naklada, Andris, Zagreb, 2007,
3. Radić, J.,*Introduction to bridge engineering*, Hrvatska sveučilišna naklada, Jadring, Zagreb, 2009,
4. Horvatić, D., Šavor, Z.: *Steel bridges*, Udžbenici Sveučilišta u Zagrebu, HDGK, Zagreb, 1998

Optional literature:

1. Ryall, M. J.; Parke, G. A. R.; Harding, J. E.,*Manual of bridge engineering*, Thomas Telford, London, 2000,
2. Wiedemann: *Brueckenbau, Stahlbeton und Spannbeton Bruecken*, Werner-Verlag, Duesseldorf, 1982,
3. Mathivat, J.,*The cantilever construction of prestressed concrete br*idges, John Wiley and Sons, New York, 1983

METAL STRUCTURES 2

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises (design): 30

Course objectives:

- Learning the principles of conceptual design of steel structures taking into consideration reliability, efficiency, functionality, environmental aspect, aesthetics and sustainability,

- Understanding and prediction of the behaviour of structural elements (beams subjected to biaxial bending and axial force, uniform built-up compression members, fatigue- dimensioning, cold-formed thin-walled members, plates, welded plate girders),
- Applying the extended knowledge to specific projects of steel structures.

Entry competences (foreknowledge, descriptive):

- Basics of metal structures (undergraduate study).

Learning outcomes:

- Practical knowledge and skills required for the design of structural elements of steel structures and for the application of basic principles of conceptual design,
- Analysing the action effects and combination of action for steel structures,
- Identifying the advantages of steel in construction and stressing its potentials in thefuture,
- Analysing and dimensioning structural elements of steel structures by using modern methods and the European standards criteria (EN).

Course content:

- Lectures:
  1. Introduction [2]
  2. Characteristics of steel structures [2]
  3. Architecture and steel [2]
  4. Economic parameters of steel constructions [2]
  5. Basics of design procedure [2]
  6. Actions on structures [2]
  7. Beams subjected to bending and axial force [2]
  8. Uniform built-up compression members [2]
  9. Fatigue – dimensioning [2]
  10. Basic approaches of plasticity theory [2]
  11. Cold-formed thin-walled structures [2]
  12. Design of plate elements and welded plate girders [2]
  13. Spatial structural systems [2]
  14. Structural systems of multi-storey buildings [2]
  15. Details in steel structures [2]
- Design exercises:
  1. Revision of the examples in design of tension members within the course Metal structures [2]
  2. Revision of the examples in design of compression members within the course Metal structures [2]
  3. Design examples of beams subjected to axial force and bending [4]
  4. Design examples with uniform built-up compression members [4]
  5. Fatigue design of steel members[4]
  6. Examples of application of plastic theory [2]
  7. Design examples with thin-walled structures [4]
  8. Design examples with plate elements and girders [4]
  9. Preliminary design of spatial structures[4].

Student responsibilities:

- Attendance in lectures and exercises,
- Preparation of 9 program assignments,
- Written pre-exam.

Grading and evaluation of student work over the course of instruction:

- Grading the program assignments,
- Written pre-exam (minimum 25% score).

End of semester grading:

- Final written exam: numerical and theoretical tasks (minimum 50% score),
- Oral exam.

Contributions to the final grade:

- Attendance in lectures 0-15 points,
- Attendance in exercises 0-15 points,
- Pre-exam 0-20 points,
- Final written and oral examination 0- 50 points.
- Criteria for completing the module: collecting minimum 60 points,
- Grading scale:
    - 60- 69 points = sufficient (2),
    - 70- 79 points = good (3),
    - 80- 89 points = very good (4),
    - 90-100 points = excellent (5).

Required literature:

1. Androić, B., Dujmović, D., Džeba, I.,*Čelične konstrukcije 1*, IA Projektiranje, Zagreb 2009.,
2. Androić, B., Dujmović, D., Džeba, I.,*Čelične konstrukcije 2*, IA Projektiranje, Zagreb 2008.,
3. Androić, B., Dujmović, D., Džeba, I.,*Metalne konstrukcije 4*, IA Projektiranje, Zagreb 2003.,
4. Lecture notes.

Optional literature:

1. Trahair, N.S., Bradford, M.A., Nethercot, D.A., Gardner, L.,*The Behaviour and Design of Structures to EC 3,* Taylor and Francis, London 2008
2. Beg, D., Kuhlmann, U., Davaine, L.; Braun, B.,*Design of Plated Structures*, Ernst und Sohn, Berlin 2011

RELIABILITY OF STRUCTURES

Credit value (ECTS): 3

Number of hours (in semester):

- Lectures: 30

Course objectives:

- Learning fundamental notions of structural reliability,
- Quantifying different types of uncertainties associated with actions, material properties, geometrical data,
- Learning the methods of reliability design from the aspect of mathematical statistics,
- Calculating reliability of simpler structural elements which is based on determining the probability of failure i.e. by using reliability index,
- Probabilistic concept of structural reliability for the assessment of the achieved reliability level which permits the application of new structural systems and new material based on scientifically proven facts.

Entry competences (foreknowledge, descriptive):

- Knowledge about probability theory and statistics.

Learning outcomes:

- Identifying a framework within which design standards are developed with special emphasis on the EN1990,
- Describing quantitatively the loads using probabilistic method for different situations,
- Assessing the probability of failure for structural elements using time independent reliability methods,
- Applying the first-order reliability and second-order methods for the analysis of structural elements,
- Applying the methods of simulation, including a “Crude Monte Carlo” method and "Importance sampling" method for the reliability assessment of structural elements,
- Identifying the optimal values of partial factors of action and resistance in order to achieve a target reliability levels.

Course content:

- Lectures:
    1. The meaning of reliability engineering [2]
    2. Definitions and basic notions [2]
    3. The analysis and assessment of structural damage [2]
    4. Hazards in civil engineering and residual risks [2]
    5. Identifying hazards and planning the countermeasures [2]
    6. Collecting and processing of data on structures [2]
    7. Stochastic modelling of structural responses, actions andresistances [2]
    8. Basic variables and models [2]
    9. The reliability of structural elements [2]
    10. The fundamental problem of the limit state function [2]
    11. The extensions of problem of the limit state function [4]
    12. The reliability of structures in fire [4]
    13. The basic principles of reliability in European standards [2]

Student responsibilities:

- Attendance in lectures,
- 2 written pre-exams.

Grading and evaluation of student work over the course of instruction:

- Written pre-exams – minimum 25% score.

End of semester grading:

- Final written exam: theory (minimum 50% score),
- Oral exami.

Contributions to the final grade:

- Attendance in lectures 0-14 points,
- Pre-exams 0-36 points,
- Final written and oral examination 0- 50 points.
- Minimum 60 points is required for completing the module,
- Grading scale (based on collected points):
    - 60- 69 points = sufficient (2),
    - 70- 79 points = good (3),
    - 80- 89 points = very good (4),
    - 90-100 points = excellent (5).

Required literature:

1. Androić, B., Dujmović, D., Džeba, I.,*Inženjerstvo pouzdanosti*, IA Projektiranje, Zagreb, 2003,
2. Androić, B., Dujmović, D., Džeba, I.,*Metalne konstrukcije 4*, IA Projektiranje, Zagreb, 2004,
3. Androić, B., Dujmović, D., Džeba, I.,*Čelične konstrukcije* , IA Projektiranje, Zagreb, 2009,
4. Lecture notes.

Optional literature:

1. Ditlevsen, O., Madsen, H. O.,*Structural Reliability Methods*, Wiley, New York, 1996,
2. Miličić, V., Peroš, B.,*Uvod u teoriju sigurnosti nosivih konstrukcija*, GF Split, Split, 2003

Elective courses

MATHEMATICS 3

Look in **Shared courses**

STOHASTIC PROCESSES

Look in **Shared courses**

1st year, 2nd semester

Compulsory courses

CONCRETE AND MASONRY STRUCTURES 2

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures:30
- Exercises: 30 (auditory – 18, design - 12)

Course objectives:

- Expanding theoretical knowledge about reinforced concrete and masonry elements and structures design,
- Expanding practical knowledge about reinforced concrete and masonry elements and structures design and doing their advanced calculations.

Entry competences (foreknowledge, descriptive):

- Theoretical and practical knowledge about the basics of reinforced concrete and masonry elements and structures design.

Learning outcomes:

- Acquiring knowledge and skills needed for designing reinforced concrete and masonry structural systems,

- Knowledge about the basic principles of conceptual design,
- Knowledge and skills needed to analyse behaviour of reinforced concrete and masonry structures according to ultimate and serviceability limit states,
- Ability to use modern methods and European norms criteria.

Course content:

- Lectures:
  1. Short revision of masonry structures knowledge in undergraduate course: "Concrete and masonry structures 1". Constructive details (beginning) [2]
  2. Types of walls, thicknesses and connections. Details of reinforcement. Connections of walls. Thermal and long term movements. Masonry below ground. Calculation examples. Masonry executions. Materials and their storage. Preparation of mortar and infill concrete. Protection of newly constructed masonry. Permissible deviations of the design values. Category of masonry execution. Other measures of masonry construction. Fixing accessories on masonry walls [2]
  3. Masonry structures in seismic areas. Materials and masonry bond arrangements. Rules of construction. Special rules for simple buildings [2]
  4. Masonry structures in seismic areas (continued). Design models. Calculation examples. Special rules for simple buildings [2]
  5. Rules for seismic areas. Stability and robustness. Loadings, strengths and limitation of dimensions. Wall thicknesses. Rules for stiffening walls, wall piers and chimneys. Walls subjected mainly to wind loading. Non load bearing intern walls. Wall chases and recesses. Outer walls of one-story houses. Simplified calculation methods and simple rules for masonry buildings. Calculation examples. Strengthening of walls. Buildings damaged by earthquake [2]
  6. Building heritage. Connections of masonry building elements. Research. Strengthening masonry buildings. Calculation examples [2]
  7. Introduction with the new European norms EN 1996 and EN 1998 (related to masonry structures). Masonry structures damaged in fire [2]
  8. Pre-exam no. 1 – (Masonry walls capacity when subjected to seismic forces,. [2]
  9. Short revision of the subject related to concrete structures in undergraduate course "Concrete and masonry structures 1". Shearbetween web andflangesof T-sections.Beamswithinclinedchords (edges). Serviceability limit states. Creepandshrinkageofconcrete [2]
  10. Deflectionsofslabsandbeams. Calculationofdeflectionsaccording to EC2 [2]
  11. Cracks. Minimum reinforcementarea for crackingcontrol. Calculationofcrackwidthaccording toEC2 [2]
  12. Punchingshear. Torsionofreinforcedconcretesections. Deepbeams [2]
  13. Pre-exam no. 2 – Deflectionofreinforcedconcrete slab or beam[2]
  14. Slendercolumns. Foundations. Strengtheningandretrofitting ofreinforcedconcretestructures [2]
  15. New Europeannorms EN 1992 and EN 1998 (for concretestructures) [2].
- Exercises (auditory, design):
  1. Introduction, layout and dimensions of elements,structuralloadanalysis (auditory) [2]
  2. Designofroofstructureand one reinforcedconcreteroofbeam (auditory) [2]
  3. Designofstaircases (auditory) [2]
  4. Design[2]
  5. Design ofreinforcedconcretetwo-way slab. Modeling slab withdesignsoftware. Reinforcementdetails. (auditory) [2]
  6. Design ofreinforcedconcretebeam (auditory) [2]
  7. Design[2]

8. Calculation of wall capacity to vertical loading and to horizontal wind loading perpendicular to wall. (auditory) [2]
9. Seismicanalysisofmasonrystructureandcalculationofseismicforces on differenttypesofmasonrywalls (confined and reinforced) (auditory) [2]
10. Design[2]
11. Resistancecalculationofmasonrywallssubjected to in-plane horizontalseismicload(auditory) [2]
12. Design[2]
13. Design of reinforcedconcretebasementwalls subjected to verticaland horizontalload. Designoffoundations. (auditory) [2]
14. Design[4]

Student responsibilities:

- Attendance in lectures and exercises,
- Doing an independent exercise assignment,
- Pass in both pre-exams (minimum 25% score).

Grading and evaluation of student work over the course of instruction:

- Exercise assignment grading,
- Students with minimum 60% score in pre-exams are exempt from the written exam.

End of semester grading:

- Written exam – minimum 55% score,
- Oral exam.

Contributions to the final grade:

- Exercise assignment 15 %,
- Written exam (midterm exams included) 60 %,
- Ooral exam 25 %.

Required literature:

1. Sorić, Z., Kišiček, T.,*Betonske konstrukcije 2*, *Projektiranje betonskih konstrukcija prema europskim normama EN*, mimeographed lecture notes, Faculty of civil engineering, Zagreb, 2012,
2. Sorić, Z., Kišiček, T., Galić, J., *Betonske i zidane konstrukcije 2 - Betonske konstrukcije prema EC2 - 2* , mimeographed lecture notes, Faculty of civil engineering, Zagreb, 2009, 2010, 2011,
3. Sorić, Z.: *Betonske konstrukcije 1, betonske konstrukcije prema Europskoj prednormi* (HRN ENV 1992-1-1), Zagreb, 2010,
4. Sorić, Z., Kišiček, T.,*Betonske konstrukcije 1, projektiranje betonskih konstrukcija prema europskim normama EN*, Zagreb, 2010, 2011,
5. Sorić, Z.,*Zidane konstrukcije I*, (second, revised ed.), Zagreb, 2004,
6. Sorić, Z.,*Betonske i zidane konstrukcije 2 - Zidane konstrukcije*, mimeographed lecture notes, Faculty of civil engineering, Zagreb, 2008, 2009, 2010 ori 2011,
7. Sorić, Z., *Betonske i zidane konstrukcije 1 - Zidane konstrukcije*, mimeographed lecture notes, Faculty of civil engineering, Zagreb, 2008, 2009, 2010 or 2011,
8. Sorić, Z.,*Zidane konstrukcije*, paragraph 11 - *Projektiranje zidanih konstrukcija prema europskim normama EN*, Zagreb 2009, 2010, 2011,
9. Lectures and exercises

METAL STRUCTURES 3

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Construction exercises: 30

Course objectives:

- Practical application of plastic theory to frame steel structures,
- Modeling frame systems for analysis, basic concepts of analyses,
- Different methods of global analyses of frame systems are considered,
- Expanding theoretical knowledge in field of instability problems and learning to include these effects in the analysis and dimensioning,
- Characterisation of joints as well as their modelling considering the analysis of frame structures,
- Basic design aspects of tensile-integrity structures, multi-storey and lattice steel domes,
- Basic principles of design of steel structures for earthquake conditions.

Entry competences (foreknowledge, descriptive):

- Knowledge about the basic procedures for plastic analyses in structural systems,
- Dimensioning steel structural elements.

Enrolment requirements (correlated courses):

- Teachers signatures: Metal structures 2

Requirements for examination taking (correlated courses):

- Examinations passed: Metal structures 2

Learning outcomes:

- Learning the application of global elastic and plastic analyses and adequate dimensioning of structural steel elements,
- Identifying instability modes of frame structures,
- Explaining how to take into account instability effects for analysis and dimensioning of frame systems,
- Applying the basic principles of design and construction tensile-integrity structures, multi-storey and domes.

Course content:

- Lectures:
  1. Modeling steel frame structures [2]
  2. Classification of frames, imperfections of frames and bracing systems [2]
  3. The elastic critical load of frame for sway mode [2]
  4. The methods of global elastic frame analysis [3]
  5. The methods of global plastic frame analysis [1]
  6. Plasticity theory in steel frame structures [3]
  7. Analysing and dimensioning of frame systems [2]
  8. Numerical examples [2]
  9. The analysis and classification of joints [2]
  10. Floor structures [2]
  11. Special types of steel structures (tensegrity structures) [3]
  12. Structural systems of steel structures (multi-storey buildings, domes) [3]

13. Seismic resistance of steel structures [4]

- Design exercises:
  1. Design of steel structure – structural concept and preliminary dimensioning [4]
  2. Analysis of actions on structure [2]
  3. Determining the effects of actions (bending moments & internal forces) [4]
  4. Dimensioning of structural elements[6]
  5. Dimensioning of joints [4]
  6. Preparation workshop drawings[6]
  7. Quality assurance program[2]
  8. Final submission of programs[2].

Student responsibilities:

- Attendance in lectures and exercises,
- Submitted program - design of single storey steel structure,
- Written pre-exam.

Grading and evaluation of student work over the course of instruction:

- Grading exercise programs,
- Written pre-exam (minimum 25% score).

End of semester grading:

- Final written exam – theory (minimum 50% score),
- Oral exam.

Contributions to the final grade:

- Attendance in lectures 0-15 points,
- Attendance in exercises 0-15 points,
- Pre-exams 0-20 points,
- Final written and oral examins 0- 50 points.
- Criteria for completing the module: earning minimum 60 points,
- Grading scale:
  - 60- 69 points = sufficient (2),
  - 70- 79 points = good (3),
  - 80- 89 points = very good (4),
  - 90-100 points = excellent (5).

Required literature:

1. Dujmović, D., Androić, B., Džeba, I.,*Modeliranje konstrukcija prema EC3*, IA Projektiranje, Zagreb, 2004,
2. Androić, B., Dujmović, D., Džeba, I., *Čelične konstrukcije 1*, IA Projektiranje, Zagreb 2008,
3. Androić, B., Dujmović, D., Džeba, I.,*Metalne konstrukcije 4*, IA Projektiranje, Zagreb, 2003,
4. Džeba, I., Androić, B., Dujmović, D.,*Metalne konstrukcije 3*, IA Projektiranje, Zagreb, 1998,
5. Lecture notes.

Optional literature:

1. Trahair, N.S., Bradford, M.A., Nethercot, D.A., Gardner, L.,*The Behaviour and Design of Structures to EC 3,* Taylor and Francis, London, 2008,
2. Davies, J.M., Brown, B.A.,*Plastic Design*, Blackwell Science, 1996

TIMBER STRUCTURES 2

Credit value (ECTS): 6

Number of hours:

- Lectures: 30
- Exercises: 30 (auditory – 15, construction – 15)
- E-learning: 15

Course objectives:

- Acquisition of theoretical knowledge on timber laminated and space structures, practical knowledge on design of wooden structures (laminated beams, three-hinged systems, wooden bridges, wooden roofs, wooden houses), practical knowledge about the stabilization of wooden structures.

Entry competences (foreknowledge, descriptive):

- Theoretical knowledge about the behavior of structures under load and other actions on structures, understanding the concepts of stress and strain and internal forces, practical knowledge about the calculation methods for statically determinate and statically indeterminate structures, practical and theoretical knowledge about design of timber structures and joints in timber structures, basics of Eurocode 5.

Learning outcomes:

- Theoretical and practical knowledge about wood and wood products. Design of timber structures made of laminated and cross laminated timber. Details in timber structures. Limit state design of planar and spatial timber structures. Structural stabilization of timber structures with complicated geometry. Design of timber houses and timber roofs. Basic knowledge about the design of timber bridges. Basic knowledge about timber composite structures.

Course content:

- Lectures:
  1. Introduction [2]
  2. Industrial production of standard laminated elements [2]
  3. Wood and wood products: quality control, laminated timber and wood based products, cross laminated timber, new materials and composites [3]
  4. Glue laminated elements: the current design standards according to Eurocode 5. Basis of structural analysis (ultimate limit states and serviceability state) [3],
  5. Stresses in curved laminated beams as the result of production. Practical measures for strengthening elements with dominant stress perpendicular to grain [3]
  6. Planar systems made of glue laminated elements: frames and arches. Spatial systems. Details in planar and spatial structures [2]
  7. Traditional and modern timber carpentry roofs. The protection, restoration and rehabilitation of timber structures [2]
  8. Fundamentals of design and construction of timber multi-storey buildings[2]
  9. Fundamentals of design and construction of timber bridges: history and modern systems (types, details and design)[2]
  10. Spatial concepts and spatial systems made of timber: arches, spheres and geodetic domes [2]
  11. Structural modeling and design of details. Design models; plane and spatial [2]
  12. Structural timber composites. Prestressing in wooden structures Howe and Cruciano lattice systems. Transversely prestressed systems [2]
  13. Components and assemblies made of wood. Glued thin-webbed beams. Mechanically jointed and glued columns [3].

- Auditory exercises:
  1. Problem description. Introduction to timber engineering[1]
  2. Design plan (drawing) for timber truss system [2]
  3. Actions on structures [2]
  4. Design according to Eurocode 5 standards. Structural analysis and design of secondary timber structures [2]
  5. Timber truss – structural analyses [1]
  6. Design of main timber truss elements. Structural stabilization [2]
  7. Details in timber structures [2]
  8. Design of glass panes and columns [2]
  9. Design of aluminium columns. Technical description of the project [1].
- Exercises (design):
  1. Design plan (drawing) [3]
  2. Structural analysis and design of secondary timber structures [3]
  3. Timber truss – structural analyses [3]
  4. Design of main timber truss elements. Structural stabilization[3]
  5. Details in timber structures [3].

Student responsibilities:

- Attendance in lectures and exercises,
- Preparation of a project,
- Pre-exams - minimum 25% score.

Grading and evaluation of students work over the course of instruction:

- Evaluation of students' projects during semester,
- Evaluation of pre-exams. Students with minimum 60% score in pre-exams are exempt from the practical part of the exam.

End of semester grading:

- Practical and theoretical exam.

Contributions to the final grade:

- Theoretical part of the exam 35%
- Practical part of the exam (or pre-exams) 35%
- Project 30%.

Required literature:

1. Rajčić, V., Bjelanović, A.,*Drvene konstrukcije prema europskim normama*, Zagreb, 2007,
2. Rajčić, V., Čizmar, D., Stepinac, M., *Riješeni primjeri iz drvenih konstrukcija*, Zagreb, 2014,

Optional literature:

1. Žagar, Zvonimir,*Drvenekonstrukcije I*, Pretei, Zagreb, 2002,
2. Žagar, Zvonimir,*Drvenekonstrukcije II*, Pretei, Zagreb, 2002,
3. Žagar, Zvonimir,*Drvenimostovi*, Pretei,Zagreb, 2003,
4. Halas, R.; Scheer, C*., Holzbau-Tachenbuch*, IES Verlag, Berlin, 2000,
5. Natterer et all.,*Holzbauatlas* ,Birkhauser, München, 2003

DURABILITY OF STRUCTURES 1

Credit value (ECTS): 6

Number of hours (in semester):

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

Course objectives:

- Acquiring theoretical knowledge oncontemporary design for durability, mechanisms of deterioration of structures made of different materials, the impact of the design, construction and maintenance on the durability, methods for achieving durability of structures made of various materials, risk management, the methodology of reconstruction following major destruction, sustainable building.
- Acquiring practical knowledge aboutthe durability design of new structures, the inspection of the structure, categorisation of damages, assessing the condition of the existing structure.

Entry competences (foreknowledge, descriptive):

- Knowledge on structures in terms of properties of materials and design methods

Learning outcomes:

- Knowledge on different effects on durability through the design, construction and maintenance of structures,
- Knowledge on the maintenance of existing structures and structural management,
- Skills in durability verification in designing new structures,
- Knowledge and skills in collecting data on existing structures for their assessment.

Course content:

- Lectures:
    1. Definitions, Basic concepts, Contemporary approach to the durability of construction, Design for durability [2]
    2. Mechanisms of deterioration of concrete, masonry, steel and wooden structures, Examples of structural damages [2]
    3. Impact of the design on durability, Impact of the construction on durability [2]
    4. Impact of the maintenance on durability, Structural management, Other influences on the structural durability [2]
    5. Diagnostics and monitoring of structures [2]
    6. Durability design and limit states [2]
    7. Achieving durability of concrete structures [3
    8. Achieving durability of masonry structures [2]
    9. Achieving durability of wooden structures [2]
    10. Achieving durability of steel structures [2]
    11. Failures, accidents and disasters, Risk Management [3]
    12. Temporary and auxiliary buildings, renovation methodology [2]
    13. Aesthetic, ecological and ethical aspects of durability [2]
    14. Sustainable construction [2].
- Auditory exercises:
    1. Inspection and assessment of structures [2]
    2. Making the basic documentation for the inspection of buildings [2]
    3. Inspection of bridges [3]
    4. Inspection of buildings [2]
    5. Types of damages and their graphical representation [2]

6. Examples of durability verification, grades of exposure [2]
7. The categorisation of damages and the assessment of the structure [2].

Design exercises:

1. Students make the project: *Visual inspection and assessment of the structure* according to the points explained in the auditory exercises for an assigned existing building or a bridge.

Student responsibilities:

- Attendance inf lectures and exercises,
- Project containing a visual inspection and assessment of an existing structure,
- Two pre-exams (minimum 25 % score in each exam required for the signature)

Grading and evaluation of the student work over the course of instruction:

- Evaluation of the assessment project of an assigned structure,
- Pre-exams. Students with minimum 60% score in each are exempt from the written final exam,
- Pre-exams. Students with minimum 70% score in are exempt from the written and oral exams.

End of semester grading:

- Written final exam - minimum 50% score,
- Oral final exam - optional.

Contributions to the final grade:

- Project assignment and commitment to exercise 50 %,
- Pre-exams or final exam 50%

Required literature:

1. J. Radić,*Durability of structures I* (*in Croatian*), Hrvatska sveučilišna naklada, Jadring, Sveučilište u Zagrebu, Građevinski fakultet, Zagreb, 2010,
2. Exercise notes published on the web.

Optional literature:

1. J. Radić et al.,*Concrete structures* – Handbook (*in Croatian*), Hrvatska sveučilišna naklada, Sveučilište u Zagrebu,Građevinski fakultet, Andris, Zagreb, 2006,
2. J. Radić et al.,*Concrete structures – Practical examples* (in Croatian), Hrvatska sveučilišna naklada, Sveučilište u Zagrebu ,Građevinski fakultet, SECON HDGK, Andris, Zagreb, 2006,
3. J. Radić et al.,*Masonry structures – Handbook* (in Croatian), Hrvatska sveučilišna naklada, Sveučilište u Zagrebu,Građevinski fakultet, Andris, Zagreb, 2007,
4. J. Radić et al.,*Concrete structures – Construction* (*in Croatian*), Hrvatska sveučilišna naklada, Sveučilište u Zagrebu, Građevinski fakultet, SECON HDGK, Andris, Zagreb, 2008,
5. J. Radić et al.,*Concrete structures – Repairs* (*in Croatian*), Hrvatska sveučilišna naklada, Sveučilište u Zagrebu,Građevinski fakultet, SECON HDGK, Andris, Zagreb, 2008,
6. *Proceedings of the International Symposium: Durability and Maintenance of Concrete Structures*, Ed.: J. Radić, 2004.

PRECAST REINFORCED CONCRETE STRUCTURES

Credit value (ECTS): 6

Number of hours (in semester):

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

Course objectives:

- Practical and theoretical knowledge on design and construction methods of different structural types of precast concrete,
- Ability to use the knowledge in practice.

Entry competences (foreknowledge, descriptive):

- Prior knowledge on structures from bachelor degree program.

Learning outcomes:

- Ability to make a conceptual design of various systems of precast concrete structures (frames and combined structures),
- Ability to observe and analyse various actions on precast concrete structures by applying contemporary European standards,
- Ability to analyse precast concrete structures,
- Ability to analyse and dimension structural elements, precast concrete structures by using contemporary European methods and criteria.

Course content:

- Lectures:
    1. What it precast concrete?[2]
    2. Materials used in precast structures[2]
    3. Precast frame analysis[2]
    4. Precast concrete floors[2]
    5. Precast concrete beams[2]
    6. Columns and shear walls[2]
    7. Horizontal floor diaphragms[2]
    8. Beam and column connections[2]
    9. Joints and connections[2]
    10. Precast reinforced concrete with other structures [2]
    11. Precast column foundation connections[2]
    12. Earthquake analysis of precast concrete constructions[2]
    13. Design of precast concrete structures [2]
    14. Analysis of ductility of precast concrete structures [2]
    15. Precast concrete elements in bridges[2]
- Auditory exercises:
    1. Layout of the structure[2]
    2. Analysis of vertical loadings[2]
    3. Analysis of horizontal loadings[1]
    4. Actions on precast concrete construction[1]
    5. Modeling for structural analysis on computer[2]
    6. Static analysis on computer[2]
    7. Creating the plan for steal and prestressed reinforcement[2]
- Design exercises :
    1. Conceptual design of a precast structure according to the points explained inauditory exercises.

Student responsibilities:

- Attendance in lectures and exercises

- Conceptual design of the assigned structure
- Two pre-exams (minimum 25% score necessary for the signature).

Grading and evaluation of student work over the course of instruction:

- Design of the assigned structure,
- Pre-exams – students with minimum 60% score are exempt from the written final exam.

End of semester grading:

- Written final exam - minimum 50% score,
- Oral final exam - optional.

Contributions to the final grade:

- Conceptual design and commitment to exercises 40%,
- Preliminary exams and final exam 60%

Required literature:

1. Twelmeier, H.,*Betonfertigteilkonstruktionen*, TU Hannover, 1973,
2. Mokk, L.,*Montagebau in Strahlbeton*, Akademiai Kiado, Budapest, 1968,
3. Elliott, K.S.,*Precast concrete structures*, Butternwoorth-Heineman, 2002,
4. Elliott, K.S.,*Multi-storey precast concrete framed structures*, Blackwell Science, 1996,
5. *Seismic design of precast concrete building structures*. State of art, FIB, October 2003

Optional literature:

1. *Precast concrete in mixed construction*. State of art, FIB, June 2002,
2. *Floor Connections – Precast concrete Connection Details*, Beton – Verlag, Düsseldorf, 1981,
3. *Structural Design Manual – Precast Concrete Connection Details*, Beton – Verlag, Düsseldorf, 1978

2nd year, 3rd semester

Compulsory courses

CONCRETE STRUCTURES 3

Credit value (ECTS): 7

Number of hours (in semester):

- Lectures:30
- Exercises: 30 (auditory – 12, design - 18)

Course objectives:

- Expanding theoretical knowledge about reinforced concrete structures design,
- Ecxpanding practical knowledge about reinforced concrete structures design and making of their advanced calculations.

Entry competences (foreknowledge, descriptive):

- Theoretical and practical knowledge about reinforced concrete elements and structures design.

Enrolment requirements (correlated courses):

- Teachers signatures: Concrete and masonry structures 2, Precast reinforced concrete structures,
- Examinations passed: Concrete and masonry structures 2, Prestressed concrete.

Requirements for examination taking (correlated courses):

- Teachers signatures: Dynamics of structures,
- Examinations passed: Precast Reinforced Concrete Structures.

Learning outcomes:

- Acquiring knowledge and skills needed to design reinforced concrete structural systems and to use conceptual designing principles,
- Knowledge and skills needed to analyse behaviour of advanced reinforced concrete structures according to ultimate and serviceability limit states,
- Ability to use modern methods and European norms criteria to analyse the behaviour of advanced reinforced concrete structures.

Course content:

- Lectures:
    1. Short revision of concrete structures in undergraduate courses.(Concrete and masonry structures 1 and Concrete and masonry structures 2, Engineering structures [2]
    2. Engineering structures. Brief introduction to codes EN 1990 and EN 1991 [2]
    3. Confinement of concrete, ductility, determining of moment – curvature diagram of concrete section. Balanced failure, partially loaded areas of reinforced concrete elements, shear at the interface between concrete cast at different times, modification of partial factors for materials[2]
    4. Strength of concrete at time *t*. Creep and shrinkage of concrete. Plasticity theory. [2]
    5. Slender columns[2]
    6. Biaxial bending and lateral instability of slender beams[2]
    7. Concrete structures in seismic active areas - Concrete structures in seismic areas. Recent earthquakes and damages to reinforced concrete structures. Provisions for reinforced concrete beams, columns and walls according to EN 1998-1 [2]
    8. (continued) Concrete structures in seismic active areas - Response spectrum of structures on seismic excitation. Seismic forces. Ability of energy dissipation and ductility classes. Local ductility conditions. Preparation for midterm exam: Determination of (M-1/r) diagrams, confinement, ductility, balanced failure [2]
    9. (continued) Concrete structures in seismic active areas - Calculation of Medium Ductility Class (MDC) and of High Ductility Class (HDC) for beams, columns and walls in seismic loaded reinforced concrete structures. Confining concrete core of columns. Pushover Analysis Method and seismic calculation. Preparation for pre-exam: Determination of (M-1/r) diagrams, confinement, ductility, balanced failure [2]
    10. Reinforced concrete thin shell structures [2]
    11. FRP reinforcement in new reinforced concrete structures, strengthening of reinforced concrete structures with FRP materials, fiber reinforced concrete, high strength concrete. [2]
    12. Pre-exam. 1 [2]
    13. Case studies [2]
    14. Lightweight aggregate concrete structures, plain and lightly reinforced concrete structures[2]
    15. Overview of nonstandard buildings: Sea and river piers, Ship channels, Ship slipways, Foundations of gas and steam turbines. High reinforced concrete buildings. Anti-vibration and anti-seismic isolations. Reinforcement of dynamic loaded foundations. Recapitulation of the course, guidelines for the exam and for the make up pre-exam. [2]
- Exercises:
    1. Introduction to assignments in exercises assignments. (auditory) [2],
    2. Definingloadbearingstructure for each student assignment. (auditory) [2],
    3. Definingloads on everytypeofstructure. (auditory) [2],

4. Some specificremarks on the calculationofeveryloadbearingstructure. (auditory) [2],
5. (design) [10],
6. Designofloadbearingstructuralelements. (auditory) [2],
7. (design) [2],
8. Reinforcementlayouts (auditory) [2],
9. (design) [6].

Student responsibilities:

- Attendance in lectures and exercises,
- Doing an independent exercise assignment,
- Pre-exam – minimum 25 % score.

Grading and evaluation of student work over the course of instruction:

- Exercise assignment grading,
- Passing pre-exam.

End of semester grading:

- written exam – minimum 55 % score
- Oral exam.

Contributions to the final grade:

- Exercise assignment20 %,
- Pre-exam 20%,
- Written exam 30%,
- Oral exam30%

Required literature:

1. EN 1992,
2. EN 1990,
3. EN 1991,
4. EN 1998,
5. Technical regulations for concrete structures (2009),
6. Sorić, Z., Kišiček, T., *Betonske konstrukcije 3, Projektiranje betonskih konstrukcija prema europskim normama EN*, mimeographed lecture notes by the Faculty of Civil Engineering, Zagreb, 2013,
7. Sorić, Z., Kišiček, T.,*Betonske konstrukcije 1, Projektiranje betonskih konstrukcija prema europskim normama EN*, mimeographed lecure notes, Faculty of Civil Engineering , Zagreb, 2013,
8. Sorić, Z., Kišiček, T.,*Betonske konstrukcije 2, Projektiranje betonskih konstrukcija prema europskim normama EN*, mimeographed lecture notes, Faculty of Civil Engineering, Zagreb, 2013,
9. Scientificpapers,
10. Tomičić, I.,*Betonske konstrukcije - Odabrana poglavlja*, Zagreb, 1996,
11. Lectures and exercises

BRIDGES 3

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises: 30 (auditory - 9, design - 21)

Course objectives:

- Gaining knowledge on the management and maintenance of bridges,

- Gaining basic theoretical knowledge of bridge aesthetics and its application in a variety of bearing systems,
- Gaining additional knowledge about the accidental loads on bridges and application of new materials and structures in bridge engineering.

Entry competences (foreknowledge, descriptive):

- Adopted knowledge about the analysis of bridge loads and dimensioning of structural elements of reinforced concrete, steel and composite bridges,
- Adopted knowledge and skills of prestressed structural elements design,
- Adopted a basic knowledge of degradation processes in structure, maintenance of existing and new buildings and calculation of structure durability according to modern codes.

Enrolment requirements (correlated courses):

- Examinations passed: Prestressed concrete, Bridges II, Durability of structures I

Requirements for examination taking (correlated courses):

- Examinations passed: Prestressed concrete, Bridges II, Durability of structures I

Learning outcomes:

- Knowledge about different methods of bridge maintenance and elements of bridge management system,
- Practical knowledge about various causes of bridge elements damages with elaborate methods of repair and rehabilitation,
- Basic knowledge about the diagnosis, monitoring, evaluation and categorization of bridge condition and different methods of calculation of the remaining service life of structures,
- Knowledge and skills necessary for the aesthetic design of bridges, depending on bearing system and bridge function,
- Knowledge about and ability to select and design appropriate bearing system of bridge, depending on the geometry and boundary conditions in accordance with European codes and aesthetic criteria,
- Additional knowledge about accidental loads on bridges as well as the application of advanced materials and structures to bridge engineering.

Course content:

- Lectures:
    1. Introduction to the course: problems of bridge management, philosophy of durability and economic issues [2]
    2. Development of bridge management system: examples of different management systems, data base: content, creation, updating data[2]
    3. Damage of bridges: examples and causes of damages of structural elements. Diagnostics and monitoring: examinations, investigations, determining the condition [2]
    4. Assessment and classification of conditions; prediction of future condition- strategies for maintenance: maintenance plan, LCC and LCA analysis[2]
    5. Calculation of remaining life, calculation of remaining capacity: assumptions, different methods and approaches[2]
    6. Maintenance, repair, renovation, reconstruction, additional protection. Examples from practice[2]
    7. Design of contemporary bridges: bridge aesthetics, harmony with the environment, aesthetic design of a whole bridge and bridge elements[2]
    8. Aesthetic bridge design according tothe bearing systems: girders, arches, strut frame bridges, suspension bridges, cable-stayed bridges[2]
    9. Aesthetic bridge design according to their function: pedestrian bridges, overpasses, large crossings [2]

10. Culture of bridge building: examples of modern bridge design[2]
11. Suspension bridges[2]
12. Cable-stayed bridges[2]
13. Polygonal arch bridges [2]
14. Timber bridges [2]
15. Integrated multidisciplinary approach to bridge design[2].

- Exercises (auditory, design,):
  1. Introduction to exercises – auditory[2]
  2. Task 1 - investment strategy for rehabilitation of deteriorated bridges - auditory [2]
  3. Solving the task 1 – design[2]
  4. Completion of task 1 – design[2]
  5. Task 2 – predicting bridge condition (degradation) using Markov chain model – auditory[2]
  6. Guidelines for the 1st pre-exam, solving the task 2 - auditory + design
  7. 1st pre-exam; completion of task 2 - design [2]
  8. Topics of written seminars: consideration and selection of topics; Completion of task 2 - auditory + design [2]
  9. Seminar overview – design[4]
  10. Seminar Presentations – design[4]
  11. Seminar presentations; guidelines for the 2nd pre-exam - auditory + design [2]
  12. Seminar Presentations - design [2]
  13. 2nd pre-exam, submission of seminars – design[2].

Student responsibilities:

- Presence in lectures and exercises,
- Solving 2 tasks, presentation and submission of seminar papers during exercises,
- Passing two pre-exams (minimum 25% score in each).

Grading and evaluation of student work over the course of instruction:

- Evaluation of the 2 tasks and seminar,
- 2 pre-exams: students who achieve minimum 60% score are exempt from the exam.

End of semester grading:

- Written exam – minimum 60% dvotr,
- Oral exam.

Contributions to the final grade:

- 2 tasks 20%,
- Seminar paper 10%,
- Written exam or pre-exams 50%,
- Oral exam 20%

Required literature:

1. Radić J. et al.,*Concrete structures – Rehabilitation*, Andris, Zagreb 2008 (in Croatian)
2. Radić J. et al.,*Concrete structures* – Handbook, Andris, Zagreb 2006 (in Croatian)
3. Radić J., Bleiziffer J., Kušter M., Puž G.,*Bridges 3 – lectures published on the web*, Zagreb, 2013/2014,
4. Mimeographed exercise notes.

Optional literature:

1. Radić, J.: *Introduction to bridge engineering* (Uvod u mostarstvo), Hrvatska sveučilišna naklada, Jadring, Sveučilište u Zagrebu-Građevinski fakultet, Zagreb 2009, (in Croatian)

2. Radić, J.: *Masonry bridges (Masivni mostovi*), Hrvatska sveučilišna naklada, Sveučilište u Zagrebu-Građevinski fakultet, Andris, Zagreb 2007, (in Croatian)
3. Radić, J, Mandić, A., Puž, G.: *Design of bridges (Konstruiranje mostova*), Jadring, Zagreb 2005, (in Croatian)
4. Horvatić D., Šavor Z.: *Steel bridges (Metalni mostovi),* HDGK, Zagreb, 1998 (in Croatian)

DYNAMICS OF STRUCTURES

Credit value (ECTS): 6

Number of hours (in semester):

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

Course objectives:

- Theoretical knowledge related to structural response under dynamic excitations,
- Theoretical and practical knowledge related to dynamic analysis procedures,
- Understanding of structural design regulations for seismic loads.

Entry competences (foreknowledge, descriptive):

- Knowledge about differential and integral calculus (including ordinary differential equations) and linear algebra,
- Knowledge of linear static analysis procedures for frame structures,
- Knowledge of kinematics fundamentals for simple structural systems,
- Knowledge of dynamics of a material point.

Learning outcomes:

- Applying the principles of structural dynamics,
- Carrying out the analyses of structures under dynamic excitations,
- Analysing the results of dynamic structural analyses,
- Following scientific and professional literature in the field of structural dynamics.

Course content:

- Lectures:
    1. Introductory examples [2]
    2. Single-degree-of-freedom systems without damping [2]
    3. Single-degree-of-freedom systems with damping [2]
    4. Single-degree-of-freedom systems: harmonic excitation [2]
    5. Single-degree-of-freedom systems: Duhamel's integral [2]
    6. Concept of response spectrum [2]
    7. Response of linear systems to earthquake excitations [2]
    8. Response of elastoplastic systems to earthquake excitations [2]
    9. Generalised single-degree-of-freedom systems: Rayleigh quotient [2]
    10. Multi-degree-of-freedom-systems: problem formulation [2]
    11. Multi-degree-of-freedom-systems: static condensation [2]
    12. Multi-degree-of-freedom-systems without damping and with damping [2]
    13. Multi-degree-of-freedom-systems: harmonic excitation [2]
    14. Damping in structures [2]
    15. Response of linear multi-degree-of-freedom-systems to earthquake excitations and application of response spectrum to response of multi-degree-of-freedom-systems [2].

- Exercises (auditory):
    1. Single-degree-of-freedom systems without damping: formulation of the problem and evaluation of stiffness [3]
    2. Single-degree-of-freedom systems without damping: static condensation [1]
    3. Single-degree-of-freedom systems without damping: forced vibrations - analytical solution [1]
    4. Single-degree-of-freedom systems without damping: forced vibrations - Duhamel's integral [1]
    5. Single-degree-of-freedom systems without damping: concluding remarks [1]
    6. Response of linear systems to earthquake excitations and application of response spectrum [1]
    7. Multi-degree-of-freedom systems without damping: formulation of the problem [1]
    8. Multi-degree-of-freedom systems: modal analysis [1]
    9. Multi-degree-of-freedom systems: numerical examples [5].

Student responsibilities:

- Attendance in lectures and exercises,
- Two written pre-exams: minimum 25% score, one make up exam.

Grading and evaluation of student work over the course of instruction:

- Written tests: students with minimum 50% score in each pre-exam are exempt from the written part of the final exam.

End of semester grading:

- Written part of the final exam - minimum 50% score,
- Oral exam.

Contributions to the final grade:

- Written tests or written part of the final exam 50%,
- Oral exam50%.

Required literature:

1. Lazarević, D., *Dinamika konstrukcija s uvodom u potresno inženjerstvo* , mimeographed lecture notes, GF, Zagreb, 2012

Optional literature:

1. Chopra, A.: *Dynamics of Structures, Theory and Application to Earthquake Engineering*, 3rd Edition, Prentice Hall, New Jersey, 2007,
2. Mihanović, A.: *Dinamika konstrukcija*, Građevinski fakultet Sveučilišta u Splitu, Split, 1995,
3. Čaušević, M.: *Dinamika konstrukcija*, *diskretni sustavi*, Školska knjiga, Zagreb, 2005

Elective courses

STABILITY OF STRUCTURES

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures: 30
- Exercises (design): 15

Course objectives:

- Understanding the concepts of stable elastic equilibrium are presented as well as the criteria for elastic stability,

- Understanding the explanation of energy methods and numerical methods for the assessment of critical load,
- The effects of geometrical and structural imperfections on the assessment of buckling resistance of columns-beams, and buckling of structural plate elements and shells are considered.

Entry competences (foreknowledge, descriptive):

- Knowledge about the methods for determination of action effects in structural systems (bending moments, internal forces).

Learning outcomes:

- Ability to calculate critical load of structural elements and simple framing systemsexactly or approximately by energy methods,
- Ability to explain the effects of material plasticity and geometrical and structural imperfections on the bucklingresistance of structural elements,
- Ability to analyze geometrically perfect and imperfect systems for structural stability,
- Ability to identify the difference between linear and nonlinear buckling analysis,
- Ability to explain the occurrence of post buckling behaviour,
- Ability to applymethods in analysing the basic structural elements and systems which are susceptible to instability.

Course content:

- Lectures:
  1. General criteria for elastic stability [2]
  2. Methods of critical load assessment [2]
  3. Global and local instability of structural elements [2]
  4. Iterative methods for solving the stability problems [4]
  5. The impact of imperfections on the stability of structural elements and systems [2]
  6. Stability of real structural elements [2]
  7. Stability of structural elements subjected to axial force and bending [2]
  8. Stability of real framing systems [2]
  9. Stability of real plates [2]
  10. Analysis of shell stability [2]
  11. The stabilityproblems of framed systems with plastic hinges [2]
  12. Stability in the European standard [2]
  13. Special problems of structural stability [2]
  14. Practical examples [2].
- Design exercises:
  1. Numerical example: Computation of critical load and the adequate buckling mode [6]

     a) Exact

     b) The Raleigh method

     c) The Rayleigh-Ritz method

     d) The Galerkin method

     e) The Vianello-Newmark method
  2. Numerical example: Computation of critical load of regular frames [7]

     a) Exact computation of critical load

     a1) Sway is prevented / a2) Sway is not prevented

     b) Approximate computation of critical load by finite el.

     b1) Sway is prevented/ b2 Sway is not prevented

3. Numerical example: Computation of critical stress of rectangular plate under compression by Rayleigh-Ritz method [2].

Student responsibilities:

- Attendance in lectures and exercises,
- Preparing 3 program assignments,
- 1 pre-exam, one make up exam.

Grading and evaluation of student work over the course of instruction:

- Grading 3 program assignments,
- Pre-exam (minimum 25% score).

End of semester grading:

- Final written exam - theory (minimum 50% score).
- Oral examination.

Contributions to the final grade:

- Student collects points for successful completion of different module requirements, partly during the duration of the module and partly from a written examination,
- Attendance in lectures 0-15 points,
- Attendance in exercises 0-15 points,
- Pre-exam 0-20 points,
- Final written and oral examination 0- 50 points.
- The requirement for completing the module - minimum 60 points,
- Grading scale (based on collected points):
  - 60- 69 points = satisfactory (2),
  - 70- 79 points = good (3),
  - 80- 89 points = very good (4),
  - 90-100 points = excellent (5).

Required literature:

1. Čaušević, M.,*Statika i stabilnost konstrukcija*, Građevinski fakultet Rijeka, Rijeka 2004,
2. Androić, B.; Dujmović, D.; Džeba, I.,*Čelične konstrukcije 1*, IA Projektiranje, Zagreb 2009,
3. Androić, B.; Dujmović, D.; Džeba, I.,*Čelične konstrukcije 2*, IA Projektiranje, Zagreb 2008,
4. Dujmović, D.; Androić, B.; Džeba, I,: *Modeliranje konstrukcija prema EC3*, IA Projektiranje, Zagreb 2003,
5. Lecture notes for the course in structure stability, Faculty of Civil Engineering, Zagreb

Optional literature:

1. Galambos, T.V., Surovek, A.E. *Structural Stability of Steel*, John Wiley and Sons, 2008,
2. Galambos, T.V. (ed.) *Guide to Stability Design Criteria for Metal Structures*, John Wiley and Sons, 1998,
3. Beg, D., Kuhlmann, U., Davaine, L., Braun, B.,*Design of Plated Structures*, Ernst und Sohn, Berlin, 2011

DURABILITY OF STRUCTURES 2

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures: 30
- Exercises: 15 (auditory - 5, design - 10)

Course objectives:

- Acquiring theoretical knowledge on contemporary implicit and explicit design for durability, achieving robust structures, assessment of existing structures, numerical modeling reinforced structures for effects of corrosion, effects and modeling accidental actions on structures such are earthquakes, fire, impacts, different methods and technologies for repair and strengthening of structures with emphasis on using fibre reinforced polymers and external pre-stressing.
- Acquiring practical knowledge about the durability design of new structures and assessment of existing structure, methods for repair and strengthening of structures using fibre reinforced polymers and external pre-stressing.

Entry competences (foreknowledge, descriptive):

- Knowledge on the basic concepts and principles in achieving durable structures,
- Knowledge on implicit durability design of structures for the life time of 50 years,
- Knowledge on the design of reinforced and prestressed concrete structures.

Enrolment requirements (correlated courses):

- Examinations passed: Durability of structures I.

Requirements for examination taking (correlated courses):

- Examinations passed: Durability of structures I.

Learning outcomes:

- Knowledge on maintenance of existing structures and structural management,
- Knowledge on numerical modeling of corrosion effect on concrete structures,
- Ability to verify the durability in designing a new structure using contemporary methods and the European standards,
- Knowledge and skills in collecting the data on existing structures for their assessment,
- Ability to assess the existing structures according to contemporary understanding of structural reliability,
- Ability to verify ultimate and serviceability limit states for existing structures.

Course content:

- Lectures:
    1. Contemporary approach to structural durability through design, construction and maintenance [2]
    2. Implicit and explicit design for durability: theory and examples [2]
    3. Robustness of structures [2]
    4. Assessing existing structures – introduction, collection of data on structure, numerical modeling of the existing structures and procedures for reliability verification [2]
    5. Assessment of existing structures – methods of assessing existing structures, classes and levels of assessment [2]
    6. Assessment of existing structures – Further knowledge on structural inspection [2]
    7. Assessment of existing structures – Examples [4]
    8. Numerical modeling of concrete structures – linear and nonlinear analysis, basics on fracture mechanics, Microplane model [2]
    9. Numerical modeling of corrosion effect in concrete structures [2]
    10. Earthquakes: general information, regulations and standards, seismic assessment of structures [2]
    11. Protective barriers on roads and bridges, the impact of vehicle collision with overpass piers[2]
    12. Fire: General knowledge, Design of the building for the fire situation [2]
    13. Repairs and strengthening [2]
    14. Strengthening of structures using fibre reinforced polymers and external pre-stressing[2].

- Auditory exercises:
  1. Examples of durability verification in designing a new structure [2]
  2. Design examples of assessing existing structure [3].
- Design exercises:

  Students present topics that are processed in seminars (research work) and other students ask questions and express their views and opinions,
- Seminars:

  Students individually or in pair (sometimes in larger groups depending on the complexity of the issue) prepare a research paper on a given topic. Topics are mainly practical and are related to real existing structures.

Student responsibilities:

- Attendance in lectures and exercises,
- Preparing a research paper on a given topic and presenting it in front of other students,
- Taking two preliminary exams during semester (minimum 25 score in each exam required for the signature).

Grading and evaluation of the student work over the course of instruction:

- Evaluation of the research paper and the presentation of the assigned topic,
- Pre-exams – students with minimum 60% scorein each preliminary exam are exempt from the written exam,
- Pre-exams – students with minimum 70% score in each pre-examare exempt from the complete written and oral final exam.

End of semester grading:

- Written final exam - minimum 50% score,
- Oral final exam – optional.

Contributions to the final grade:

- Research paper and its presentation and commitment to exercise 50 %,
- Pre- exams or final exam 50%

Required literature:

1. J. Radić & A. Mandić,*Durability of structures II*, lecture notes published on the web, 2010/2011,
2. J. Radić,*Durability of structures* I (*in Croatian*), Hrvatska sveučilišna naklada, Jadring, Sveučilište u Zagrebu, Građevinski fakultet, Zagreb, 2010,
3. J. Radić et al.,*Concrete structures – Repairs* (in Croatian), Hrvatska sveučilišna naklada, Sveučilište u Zagrebu ,rađevinski fakultet, SECON HDGK, Andris, Zagreb, 2008

Optional literature:

1. Rombach, G.,*Spannbetonbau,* Ernst&Sohn, Berlin, 2010
2. J. Radić et al.,*Concrete structures* – Handbook (*in Croatian*), Hrvatska sveučilišna naklada, Sveučilište u Zagrebu – Građevinski fakultet, Andris, Zagreb, 2006,
3. J. Radić et al,: *Concrete structures – Practical examples* (in Croatian), Hrvatska sveučilišna naklada, Sveučilište u Zagrebu , Građevinski fakultet, SECON HDGK, Andris, Zagreb, 2006,
4. J. Radić et al.,*Masonry structures – Handbook* (in Croatian), Hrvatska sveučilišna naklada, Sveučilište u Zagrebu, Građevinski fakultet, Andris, Zagreb, 2007,
5. J. Radić et al.,*Concrete structures – Construction* (*in Croatian*), Hrvatska sveučilišna naklada, Sveučilište u Zagrebu, Građevinski fakultet, SECON HDGK, Andris, Zagreb, 2008,
6. Vollrath, F., Tathoff, H.,*Handbuch der Brücken – instandhaltung*, Verlag Bau+Technick GmbH, Düsseldorf 2002,
7. Demetrios E. Tonias, Jim J. Zhao,*Bridge Engineering: Design, Rehabilitation and Maintenance of Modern Highway Bridges*, McGraw-Hill Companies, 2007,

8. *Management of bridges/Gestion des ponts*, Highway agency-Service d'Etudes Techniques des Routes et Autoroutes-Transport Research Laboratory-Laboratoire Central des Ponts et Chaussées, Thomas Telford, 2005,
9. *Protection of structures against hazards*, Proceedings of the 3rd International Conference organized by CI-Premier Conference Organisation, Venice, Italy, 28-29 September 2006, Ed.: C. Majorana, V. Salamoni, T.S. Lok
10. Rücker, W., Hille, F., Rohrmann, R. : F08a - *Guideline for the Assessment of Existing Structures*, SAMCO Final Report 2006, Federal Institute of Materials Research and Testing (BAM), Division VII.2 Buildings and Structures, Berlin, Germany
11. *Durability and Maintenance of Concrete Structures*, Proceedings of the International Symposium organized by CSSE and ASCCT, Dubrovnik, Croatia, Oct 21-23, 2004, Ed.: J. Radić, SECON HDGK, 2004

TALL BUILDINGS

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures: 30
- Exercises: 15 (auditory)

Course objectives:

- Acquiring theoretical knowledge about the structural systems of tall buildings, the acquisition of theoretical and practical knowledge about governing loads for tall buildings, general knowledge about the architecture of tall buildings and their equipment, practical knowledge about the design of the tall building structure made of steel and/or concrete elements.

Entry competences (foreknowledge, descriptive):

- Knowledge about engineering mechanics, statics and dynamics of structures, knowledge about the base design of concrete and steel structures and Eurocode norms EN1990 and EN1991.

Enrolment requirements (correlated courses):

- Teachers signatures:Precast reinforced concrete structures , Steel structures 3,
- Examinations passed: Prestressed concrete , Steel structures 2.

Requirements for examination taking (correlated courses):

- Teachers signatures:Precast reinforced concrete structures , Steel structures 3,
- Examinations passed: Prestressed concrete , Steel structures 2.

Learning outcomes:

- Identifying structural systems of tall buildings and the performance of concrete and/or steel parts, identifying the requirements of the space, purpose, location, safety, special architectural features and other conditions that affect the structural design of tall buildings, comprehension of the flow of horizontal and vertical loads in the main load bearing structural parts of tall buildings (with the focus on the effects of the horizontal actions),
- Applying acquired knowledge about concrete and steel structures to practical examples of complex structures of tall buildings,
- Ability to draw and make an approximate calculation of a tall building according to architectural demands.

Course content:

- Lectures:
    1. Historical overview of tall residential or commercial buildings, examples of important tall buildings and their structural systems [2]

2. Special demands in the design of tall buildings[2]
3. Use of structural systems in tall buildings[2]
4. Vertical loads[2]
5. Fire loads[2]
6. Wind loads[2]
7. Earthquake loads[2]
8. Frame structures[2]
9. Braced structures [2]
10. Tube structures[2],
11. Shear wall structures[2]
12. Outrigger structures[2]
13. Hybrid structures[2]
14. Floor constructions[2]
15. Numerical modeling of tall buildings, equipment of tall buildings [2].

- Auditory exercises:
  1. Tall building design concept[2]
  2. Program design task explanation[2]
  3. Load analysis[2]
  4. Calculus for the stability and horizontal loads distribution[2]
  5. Strain control [2]
  6. Ultimate limit state design[2]
  7. Serviceability limit state design[2].

Student responsibilities:

- Attendance in lectures and exercises,
- Completion of an individual bridge design task,
- 2 pre-exams (minimum 25% score in each).

Grading and evaluation of student work over the course of instruction:

- Evaluating the progress of exercise design task program,
- Evaluation of student’s ability to do independent work accurately and on time.

End of semester grading:

- Grading the finished design assignment,
- Grading the oral exam.

Contributions to the final grade:

- Pre-exam or written exam 60-70%,
- Oral exam 30-40%.

Required literature:

1. Lecture notes: http://www.grad.unizg.hr/predmet/visgra_a
2. Puž, G., Perić, K., Brozović, T., Čačić, B.,*Tall buildings*, mimeographed lecture notes,
3. Stafford Smith, B., Coull, A.,*Tall Building Structures, Analysis and Design*, John Wiley & Sons, 1991

Optional literature:

1. Dupré, J.,*Skyscrapers*, Revised Edition, Black Dog & Leventhal Publishers, Inc., 2008,
2. Chew Yit Lin, M.,*Construction Technology for Tall Buildings*, (2nd Edition), Singapore University Press & World Scientific Publishing Co., 2007,
3. Wells, M.: *Skyscrapers Structure and Design*, Yale University Press, 2005,
4. Terranova, A. (Ed.),*New Urban Giants - the Ultimate Skyscrapers*, Edizioni White Star, 2008

STRUCTURAL TESTING

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures: 30
- Exercises (laboratory): 15

Course objectives:

- Expanding theoretical and practical knowledge about the behaviour of structures under real action loads,
- Learning about modern measuring equipment and methods in the field of structure testing in construction.

Entry competences (foreknowledge, descriptive):

- Knowledge about the procedures for determining forces in structures,
- Knowledge about the calculus of stress and deformations caused by axial and shear forces, torque moment (moment of force) and banding moment,
- Knowledge about the basic procedures in analysing and dimensioning structures (concrete, metal and timber).

Learning outcomes:

- Analysing the behaviour of structure elements and bearing systems based on investigations,
- Understanding the behaviour of structures at static and dynamic loads action, impact of the surroundings and rheological changes in the material,
- Selection and application of equipment, procedures and methods in structural testing,
- Planning the procedures to verify the structural safety,
- Assessment of the state of structures and structural elements based on investigations,
- Proving the structure's and its elements' ability to withstand the anticipated loads.

Course content:

- Lectures:
    1. Introduction: the object of structural testing, classification of testings (research , control, laboratory, static and dynamic, short-term and long-term [3]
    2. Mechanical and geometrical measures which are measured in structural testing. Absolute displacement of structural point. Changing the spacing of structural points (deformation). Angle of twist. Curvature. Relative deformations [3]
    3. Measuring mechanical and geometric measures: equipment elements, hysteresis, measuring area etc. [2]
    4. Measuring mechanical and geometric measures. Measuring equipment for: displacement, change of length, angle changes etc. Calibrating the equipment [2]
    5. Tensometer, types of tensometers: mechanical, optical-mechanical, optical, acoustic, electric [2]
    6. Electro-resistant tensometers (ERT). Types. Installation, making an additional device for measuring displacement, acceleration, pressure force etc. [2]
    7. Analysis of plane state of stress by deformation measurements. Types of states of stress. [2]
    8. Methods of analysing the state of deformation and strain of structures and their elements. Moire method. Procedure with brittle materials [2]
    9. Methods of analysing the state of deformation and strain of structures and their elements. Holographic methods, surveying, modelling [2]

10. Procedures for material testing and characteristics of tested structure. Extracting cores, ultra sound, sclerometer, radiography [2]
11. Static structural testing, project, implementation of the project [2]
12. Static structural testing. Loading mode. Result evaluation. Standards and conditions for the validity of a structure [2]
13. Dynamic testing. Project, implementation of the project. Loading mode and measurements taken [2]
14. Dynamic testing. Dynamic parameters of structures. Measurement result evaluation [2].

- Laboratory exercises:
  1. Demonstration and description of the instruments for static and dynamic measuring [2]
  2. Measuring the same measure by a portable comparator (determining the accuracy of the instrument). Calibrating the dose for measuring force (determining the constant of the instrument). Calibrating the inductive sensor (LVDT) for measuring displacement [3]
  3. Measuring the deformations and deflection on the model of grids and walls with openings (models of plexiglass) [2]
  4. Photoelastic method [2]
  5. Measuring vibrations on the models [2]
  6. Presentation of some examples of model testing and structure elements in laboratory [4].

Student responsibilities:

- Attendance in lectures and exercises,
- Doing seminar work.

Grading and evaluation of student work over the course of instruction:

- Grading seminar work.

End of semester grading:

- Written exam – minimum 50% score,
- Oral exam.

Contributions to the final grade:

- Seminar work 30%,
- Written exam 40%,
- Oral exam 30%.

Required literature:

1. Lj. Herceg: *Ispitivanje konstrukcija – skripta*, http://www.grad.unizg.hr/predmet/ispkon
2. D. Damjanović: *Ispitivanje konstrukcija – Bilješke preda anja*, http://www.grad.unizg.hr/predmet/ispkon
3. A. Kiričenko i sur.: *Mjerenje deformacija i analiza naprezanja konstrukcija*, DIT-Zagreb, Zagreb, 1982,
4. D. Aničić: *Ispitivanje konstrukcija*, Osijek, 2002

Optional literature:

1. J. Krolo, D. Šimić, *Mehanika materijala*, Sveučilište u Zagrebu, Građevinski fakultet, Zagreb, 2011,
3. I. Alfirević, S. Jecić, *Fotoelasticimetrija*, Liber, Zagreb, 1983,
4. V. Brčić, R. Čukić, *Eksperimentalne metode u projektiranju konstrukcija*, Građ. knjiga, Beograd, 1988,
5. Thomas G. Beckwith, Roy D. Marangoni, John H. Lienhard, *Mechanical measurements*, Addison-Wesley Publishing company, New York, 1995

ENGLISH IN CIVIL ENGINEERING 2

Credit value (ECTS): 4.5

Number of hours (in semester):

- Exercises: 45

Course objectives:

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

Entry competences (foreknowledge, descriptive):

- Intermediate level, B 1.

Learning outcomes:

- Developing language competences which include professional terminology in the field of transport facilities and geotechnical engineering,
- Independent user – ability to read technical literature independently,
- Revision of basic grammar categories in professional language – passive, past tenses, modal verbs,
- Confident use of sentences in professional language, developing presentation skills and skills in writing professional papers.

Course content:

- Exercises:
  1. A Career in Structural Engineering – Varieties in the field of structural engineering [3]
  2. Bridge Building – Damages in Arch Building [3]
  3. Europe's Longest Viaduct[3]
  4. Wembley Stadium[3]
  5. Weak Points of the House[3]
  6. At the Heart of Dome's Design Process [3]
  7. Joint students' presentations [3]
  8. Single students' presentations [3]
  9. The Story of the Dome[3]
  10. Hyatt Hotel Collapse[3]
  11. Terminology practice in TIMBER STRUCTURES I [3]
  12. Career Job Hunting – avoiding potential job (interview) disasters – Tips and Advice [3]
  13. Creating a CV - How to write a CV? How to write a letter of application / Job Interview Questions [3]
  14. Professional Development. Preparing for the Interview Skills – Techniques, Tips and Advice. Recruitment of graduates [3]
  15. Preliminary exam [3]

Student responsibilities:

- 75% attendance in lectures,
- Making a presentation,
- 3 pre-exams.

Grading and evaluation of student work over the course of instruction:

- Through regular attendance and continuous work students can be exempt from a part of exam or the entire exam,

- Checking acquired knowledge in written or oral form is conducted regularly,
- The skills required include comprehension of engineering texts, summary writing, giving presentation on technical topics, mastering grammar categories most applied in technical reports.

Contribution to the final grade:

- The credits earned through all the testing and pre-exams make up the final grade. The grades are based as follows: pre-exam results, points earned during semester - active participation in class, grammar checks, translations into a foreign language, translations from a foreign language, professional vocabulary checks. Maximum number of points that can be earned in the pre-exam is 20 – the grade is multiplied by four. Students who have not earned enough points are required to take the final exam.
- Grading is as follows
  - 50-62% score = sufficient (2),
  - 63-75% score = good (3),
  - 76-88% score = very good (4),
  - 89-100% score = excellent (5).

End of semester grading:

- As stated above.

Required literature:

1. A. Kralj Štih: *English in Structural Engineering*, course materials.

Optional literature:

5. D. Bonamy*: Technical English 4*, Pearson Longman, 2011
6. The Internet pages, program Building Big, Brantacan, ASCE.
7. Z. Vulelija: *Ilustrirani rječnik arhitekture i građe inar t a – hrvatsko engleski i englesko hrvatski*, Masmedia, Zagreb, 2010
8. A. Prager: *Trojezični građevinski rječnik*, Masmedia, Zagreb, 2002

GERMAN IN CIVIL ENGINEERING 2

Look in **Geotechnical Engineering**

2nd year, 4th semester

Compulsory courses

SPECIAL ENGINEERING STRUCTURES

Credit value (ECTS): 4.5

Number of hours (in semester):

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

Course objectives:

- Acquiring theoretical knowledge on specifics of engineering structures in terms of use of appropriate materials, loading analysis, design and construction of details, design of the main structure and foundations,

- Acquiring theoretical and the practical knowledge about conceptual design, loading analysis, design for ultimate and serviceability states, detailing, preparation of reinforcement and workshop drawings for structures such are telecom tower, masts and water towers.

Entry competences (foreknowledge, descriptive):

- Knowledge on structures in terms of properties of materials and design of basic elements,
- Knowledge on action effects on structures.

Learning outcomes:

- Theoretical knowledge about the specifics of engineering structures such as shells, tensile structures, high buildings, towers, chimneys, masts, wind and water towers, telecommunication structures, movable and floating bridges and submerged tunnels,
- Ability to design a special engineering structure,
- Knowledge and skills required to analyse the effects of wind and earthquakes on special engineering structures,
- Knowledge and ability to design a special engineering structure in accordance with contemporary methods and criteria of European standards.

Course content:

- Lectures:
    1. Shells – theory, types, design, examples [3]
    2. Tensile structures – form finding, materials [2]
    3. Tensile structures – actions, examples of real structures [2]
    4. Tall buildings – structural systems, horizontal actions, rigid systems [3]
    5. Towers, chimneys, masts, wind towers – general, types, function, examples [2]
    6. Concrete towers – foundation, design [4]
    7. Water towers – function, shapes, construction, seismic design of liquid containers [2]
    8. Steel towers, masts, chimneys – design [2]
    9. Telecommunication structures – design of masts with stay cables, demolition of masts and towers, foundations [4]
    10. Movable bridges – types, examples of design, construction and maintenance [2]
    11. Floating bridges – types, examples of design, construction and maintenance [2]
    12. Submerged tunnels [2].
- Auditory exercises:
    1. Layout of the structure [1]
    2. Definition of actions [1]
    3. Structural analysis [1]
    4. Designing for ultimate limit state [1]
    5. Verification of serviceability limit states [1]
    6. Detailing structure, creating the plan for a reinforcement or workshop drawing [1].
- Design exercises:
    1. Conceptual design of a special engineering structure according to the points explained in the auditory exercises.

Student responsibilities:

- Attendance in lectures and exercises,
- Conceptual design of a special engineering structure,
- Taking two pre-exams during semester (25 % score in each exam necessary for the signature).

Grading and evaluation of the student work over the course of instruction:

- Evaluation of the conceptual project of the assigned structure,

- Pre-exams – students with minimum 60% score in each pre-exam are exempt from the written final exam,
- Pre-exams – students with minimum 75% score in each pre-exam are exempt from the entire written and oral final exam.

End of semester grading:

- Written final exam - minimum 50% score,
- Oral final exam – optional.

Contributions to the final grade:

- Project assignment and commitment to exercise 33 %,
- Pre-exams or final exam 67%

Required literature:

1. Z. Šavor, A.Mandić: *Special Engineering Structures* – lectures published on the web (*in Croatian*), Zagreb, 2011/2012,
2. Exercise notes published on the web.

Optional literature:

1. Smith, B.V., *Communication Structures*,Thomas Telford, 2007,
2. Turmbauwerke, *BetonKalender 2006 Teil 1*, Ernst & Sohn, 3-517,
3. Lewis, W.J., *Tension Structures Form and Behaviour*, Thomas Telford, 2003,
4. Huntigton, C.G., *TheTensioned Fabric Roof*, ASCE Press, 2004,
5. Schlaich, J., Bergermann, R., *leicht weit Light Structures*, Prestel,
6. *Widespan Roof Structures*, compiled by M. Barnes & M. Dickson, Thomas Telford, 2000,
7. Petersen, Ch., *Abgespannte Maste und Schornsteine Statik und Dynamik*, Bauingenieur-Praxis, Heft 76, W. Ernst & Sohn 1970,
8. Irvine, M., *Cable Structures,* MIT Press, Cambridge, Mass., 1981,
9. *Frei Otto Complete Works, Lightweight Construction Natural Design*, Birkhäuser. Architekturmuseum TU München, 2005.
10. Koglin, T.L., *Movable Bridge Engineering*, John Wiley & Sons, 2003.
11. *Analysis of the submerged floating tunnel concept*, Forum of European National Highway Research Laboratories (FEHRL), Report No. 1996/2a.
12. Watanabe, E., Floating Bridges: Past and Present, *Structural Engineering International (SEI), 2/2003.*

COMPOSITE STRUCTURES

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures: 30
- Design exercises: 15

Course objectives:

- Gaining theoretical knowledge on the behavior of composite steel concrete structures,
- Gaining knowledge about the action effects on composite structures,
- Gaining theoretical and practical knowledge on design of composite structural elements: beams, slabs and columns.

Entry competences (foreknowledge, descriptive):

- Knowledge about statics of rigid body and connected systems,
- Knowledge about the behavior of steel and reinforced concrete structures,

- Knowledge about theoretical and practical procedures related to the design of steel and concrete structural elements and connections.

Enrolment requirements (correlated courses):

- Examinations passed: Metal structures 2

Requirements for examination taking (correlated courses):

- Examinations passed: Metal structures 2

Learning outcomes:

- Ability to apply knowledge about the behaviour of steel and concrete as materials and the impact of that behavior on the resistance of composite structural elements,
- Identifying key factors for determination of basic actions on composite structures,
- Ability to determine the action effects at structural elements level for statically determined and statically undetermined systems,
- Ability to determine design resistances of composite structural elements of beams, slabs and columns relating to ultimate limit state and serviceability limit state.

Course content:

- Lectures:
    1. Introduction[2]
    2. Terminology and defining the contents of the course[4]
    3. General information on composite action, materials, types of connectors[4]
    4. Structural analysis of composite structures [4]
    5. Composite beams [2]
    6. Composite slabs [2]
    7. Composite columns and composite compression members [2]
    8. Serviceability limit state[2]
    9. Composite joints[2]
    10. Resistance of cross-sections and member[2]
    11. Shear connection[2]
    12. Constructional details [2].
- Design exercises:
    1. Composite and non-composite state of steel elements[1]
    2. Determination of creep of concrete[1]
    3. Resistance of shear connectors[2]
    4. Plastic bending resistance of composite beams[2]
    5. Elastic bending resistance of composite beams[2]
    6. Bending resistance of beams with partial shear connection[1]
    7. Resistance of composite slabs[1]
    8. Resistance of composite slabs – without end anchorage[1]
    9. Resistance of composite slabs – with end anchorage[1]
    10. Resistance of composite columns in compression[1]
    11. Resistance of composite columns in combined compression and uniaxial bending[1]
    12. Resistance of composite columns in combined compression and biaxial bending[1].

Student responsibilities:

- Attendance in lectures and exercises,
- 2 pre-exams - minimum 25%score in each,
- Makeup pre-exam for students who did not achieve minimum 25% score in pre-exams, or for students who want to improve their score in regular pre-exam.

Grading and evaluation of student work over the course of instruction:

- Pre-exam – students with minimum 60% score are exempt from the practical part of the exam.

End of semester grading:

- A two-part written exam and oral exam. The written part of the exam contains a practical part – design (students may be exempt from taking this part of the exam) and a theoretical part (mandatory for all students),
- Minimum 60% score in each part of the exam.

Contributions to the final grade:

- Achievement in pre-exams and the oral part of the exam.

Required literature:

1. Androić, Dujmović, Džeba: *Steel Structures* , IA Projektiranje, Zagreb, 2009,
2. Džeba: *Composite Structures* - Lectures, www.grad.hr/metali
3. Horvatić: *Composite Strucures Steel - Concrete*, Masmedia, Zagreb, 2003

Optional literature:

1. HRN EN 1994-1-1:2012 – *Design of composite steel and concrete structures,* Part 1-1: *General rules and rules for buildings,*
2. Johnson: *Composite Structures of Steel and Concrete*, Blackwell Publishing, Oxford, 3rd Edition, 2004

Elective courses

EARTHQUAKE ENGINEERING

Credit value (ECTS): 3

Number of hours (in semester):

- Lectures: 30

Course objectives:

- Understanding earthquake engineering,
- Knowledge about the basic terms of earthquake civil engineering,
- Acquiring practical knowledge about earthquake design of concrete, steel, masonry and composite structures.

Entry competences (foreknowledge, descriptive):

- Prior knowledge on structures from Bachelor degree program,
- Understanding and ability to apply calculus for concrete and steel structures,
- Understanding basic structure systems,
- Understanding and knowledge about static calculus for various static systems.

Learning outcomes:

- Ability to do conceptual design of various structure systems (concrete, steel, masonry and composite structures),
- Ability to identify and analyse earthquake action on buildings and bridges by the use of modern European standards,
- Ability to do conceptual design of structures with passive energy dissipation systems,
- Ability to analyse and design seismically isolated structures.

Course content:

- Lectures:
    1. Introduction to earthquakes [2]

2. Characteristics of the movement of the earth's surface [2]
3. Structural dynamic analysis [2]
4. Introduction to the range of responses [2]
5. The energy concept of earthquake engineering [2]
6. Earthquake design by Eurocode8 [2]
7. Fundamentals of seismic design of buildings and bridges [2]
8. Earthquake design of concrete structures [2]
9. Earthquake design of steel structures [2]
10. Earthquake design of masonry structures [2]
11. Earthquake design of composite structures [2]
12. Basic concept and design of structures with passive energy dissipation systems [2]
13. Dampers [2]
14. Basic analysis and design of structures for earthquake isolated structures [2]
15. Seismically isolated systems [2].

Student responsibilities:

- Attendance in lectures,
- Two pre- exams.

Grading and evaluation of student work over the course of instruction:

- Preliminary exams - students with less than 50%, score will have their grade reduced.

End of semester grading:

- Written final exam - minimum 50% score,

Contributions to the final grade:

- Written exam 100%.

Required literature:

1. Čaušević, M.,*Potresno inženjerstvo*, Sveučilišni udžbenik, Školska knjiga, Zagreb, 2001,
2. Čaušević, M.,*Dinamika konstrukcija*, Sveučilišni udžbenik, Školska knjiga, Zagreb, 2005

Optional literature:

1. Chopra, A.K,*Dynamics Of Structures – Theory and Applications to Earthquake Engineering*, Second edition, Prentice Hall, New Jersey, 2001,
2. Clough, R.; Penzien, J.,*Dynamics Of Structures*, McGraw-Hill, New York, 1975,
3. Eurocode 8 – *Design of structures for earthquake resistance – Part 1: General rules, seismic actions and rules for buildings,* EN 1998-1, Doc CEN/TC250/SC8/N335, Brussels, January 2003

NUMERICAL MATHEMATICS

Look in **Shared courses**

PERSPECTIVE

Look in **Shared courses**

BASICS OF DIFFERENTIAL GEOMETRY

Look in **Shared courses**

WAVES AND OSCILLATIONS

Look in **Shared courses**

CONSTRUCTION MATERIALS

1st year, 1st semester

Compulsory courses

RESEARCH METHODS

Look in **Shared courses**

THEORY AND TECHNOLOGY OF CONCRETE

Credit value (ECTS): 6.0

Number of hours (in semester):

- Lectures: 30
- Exercises: 14 (auditory -8, laboratory – 6)
- Seminars: 16

Course objectives:

- To understand the process of hydration and hardening of concrete,
- To understand concrete microstructure and transport of moisture within concrete structure,
- To acquire knowledge needed for proper selection of material, adequate production, placement and compaction in order to provide properties of fresh and hardened concrete for specific purpose (performance based design),
- To acquire knowledge on thermo-hygrometric, mechanical and deformational characteristics of concrete as a basis for knowledge on structure behaviour,
- To learn basic properties of special concrete types,
- To acquire knowledge on future trends in the field of concrete technology.

Entry competences (foreknowledge, descriptive):

- Basic knowledge on components for concrete production,
- Knowledge about concrete mix design.

Learning outcomes:

- Making concrete mix design for required properties in use (validated by testing on the structure),
- Making designed concrete in concrete plant,
- Creating quality assurance plan for execution of concrete structures,
- Testing concrete properties in fresh state and certain properties in hardened state,
- Estimating influence of components and technology of production on the properties of concrete in fresh and hardened state,
- Evaluating the results of testing concrete properties,
- Ability to differentiate special concrete types and their basic properties,
- Knowledge about future trends in the field of concrete technology.

Course content:

- Lectures:
  1. Introduction [2]
  2. Components of concrete composition – Cement – classification according to types and production technology, production, hydration, setting, hardening, quality assurance [2]
  3. Components of concrete composition – Aggregate – significance, classification, types, mineralogy, texture, grain size distribution; Water [2]
  4. Components of concrete composition – Additives, classification, significance, types, influence on concrete properties [2]
  5. Fresh concrete – properties and its significance; concrete mix design [2]
  6. Structure of hardened concrete [2]
  7. Strength and conditions of stress in concrete [2]
  8. Dimensional stability [4]
  9. Durability / Influences – special durability loads, causes of concrete degradation and consequences of durability loads [2]
  10. Concrete production; Transport, placing, compaction and curing [2]
  11. Modeling concrete properties, the most significant software programs, explanation, application [2]
  12. Special concretes – new types and technologies [4]
  13. The future of concrete – scope and perspectives in properties and application [2].
- Exercises (auditory, design, laboratory):

  Auditory exercises:
  1. Quality assurance of materials for concrete structures – selection of constituents for concrete, production, quality control, conformity assessment [2]
  2. Quality assurance of materials for concrete structures – requirements for execution of concrete works, maintenance plan for concrete structure [2]
  3. Concrete mix design by using software programs [2]
  4. Control of concrete production and placement [2].

  Laboratory exercises:
  1. Testing concrete properties in fresh state [3]
  2. Testing concrete properties in hardened state [3].
- Seminar:
  1. Selection of concrete constituents for specific concrete structure, concrete mix design, quality control of execution of concrete structure including transport, placement, compaction, curing and sampling of concrete

Student responsibilities:

- Attendance in lectures – minimum 75 %,
- Attendance in all exercises,
- Seminar paper,
- pre-exams – minimum 25% score in each.

Grading and evaluation of student work over the course of instruction:

- Minimum 60 % score in each pre-exam,
- Positively graded seminar paper,
- Participation in lectures and exercises.

End of semester grading:

- Written exam - minimum 60 % score,
- Oral exam.

Contributions to the final grade:

- Written exam50 %
- Oral exam50 % or
- Pre-exams 60 %,
- Seminar paper 30 %
- Participation in lectures and exercises 10 %

Required literature:

1. D. Bjegović, N.Štirmer,*Theory and technology of concrete*, course repository `http://www.grad.unizg.hr/predmet/titb`,
2. Ukrainczyk, V.,*Concrete – structure, properties and technology*, Alcor, Zagreb, 1994,
3. P. Krstulović, *Properties and technology of concrete*, Faculty of civil engineering, University of Split, ISBN 953-6116-20-0
4. P. K. Mehta, P. J. M.Monteiro,*Concrete – microstructure, Properties and Materials*, McGraw-Hill, 2006,
5. A. M. Neville, *Properties of Concrete*, Prentice Hall, 1995,
6. D. Bjegović, G.Balabanić, D. Mikulić,*Construction materials - collection of solved problems*, Faculty of civil engineering, University of Zagreb, 2007,
7. A. Đureković, *Cement, cement composite and additives for concrete*, Školska knjiga, Zagreb, 1996

Optional literature:

1. M. F. Ashby, D. R. Jones, *Engineering materials 1*, Butterworth Heinemann, 1996,
2. J. M. Illston, P. L. J. Domone, (ed.), *Construction materials – their nature and behaviour*, E & FN SPON Chapman & Hall, 1994,
3. K. Maekawa, Chaube, R. P., Kishi, T.,*Modelling of Concrete Performance, Hydration, Microstructure and Mass Transport*, Spon Press, 2000,
4. Dewar, J.,*Computer modeling of Concrete Mixtures*, Spon Press, 2000,
5. Muravljov, M.,*Basics of theory and technology of concrete*, 3rd edition, Građevinska knjiga, Beograd, 2005,
6. Grdić, Z.,*Technology of concrete*, GAF, Niš, 2011

BUILDING PHYSICS

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises: 30 (auditory - 16, design - 8, laboratory - 6)

Course objectives:

- Acquiring theoretical knowledge about combined heat, moisture and air transfer through construction material and structure elements,
- Acquiring practical knowledge about testing thermal and acoustic properties of materials in laboratory,
- Acquiring knowledge about calculating thermal and acoustic properties of structures.

Entry competences (foreknowledge, descriptive):

- Knowledge about physical, mechanical and thermal properties of materials,
- Knowledge about the basics of statistics.

Learning outcomes:

- Describing the production technology of various construction materials,

- Ability to explain testing manners of thermal-hygrometric and acoustic properties of insulation building materials,
- Ability to define the mechanisms of action of the environment on insulating materials,
- Designing thermal-hygrometric and acoustic protection of buildings,
- Ability to compare the properties of different insulation materials,
- Ability to apply the testing results of insulating building materials.

Course content:

- Lectures:
  1. Introduction to Building physics. Definition, importance, history [2]
  2. Heat: basic scientific terms on heat. Heat transfer – conduction, convection, radiation, solar radiation [2]
  3. Thermal properties of building materials [2]
  4. Thermal insulation of construction elements. Temperature curve. Heat accumulation [2]
  5. Moisture transport. Moisture, humid air. Condensation on the inner surface of the outer building elements [2]
  6. Diffusion of water vapour through construction elements [2]
  7. Combined transport – heat, air, moisture [2]
  8. Thermal bridges [2]
  9. Thermal stability of outer construction elements [2]
  10. Acoustics: physical properties of sound. Sound waves in enclosed space [2]
  11. Building materials for noise protection. Contemporary materials [2]
  12. Transmission of airborne sound from room to room [2]
  13. Transmission of impact sound from room to room [2]
  14. Noise. Sound insulation and calculation methods of sound insulation [2]
  15. Noise protection [2].
- Exercises (auditory):
  1. Thermal problems – tasks [2]
  2. Mass transport problems [2]
  3. Mass transport problems – tasks [2]
  4. Introduction to the calculation standards [2]
  5. Design project phases [2]
  6. Moisture [2]
  7. Noise [2]
  8. Noise protection – details of construction [2].
- Exercises (design):
  1. Computer software for building physics – program task solutions [8]
- Exercises (laboratory):
  1. Thermal conductivity: task perfosmance, interpretation of results [2]
  2. Thermography [2]
  3. A visit to the Laboratory for building physics at the Croatian Civil Engineering Institute [2].

Student responsibilities:

- Attendance in lectures – minimum 75%,
- Attendance in exercises 100%,
- Program execution,
- Seminar paper,
- Two pre-exams – minimum 50% score in each,

- One make up exam.

Grading and evaluation of student work over the course of instruction:

- Pre-exam 50%,
- Seminar paper and programs 40%,
- Attendance in lectures 10%.

End of semester grading:

- Oral exam.

Contributions to the final grade:

- Grade achieved during semester 60%,
- Oral exam 40%.

Required literature:

1. Šimetin, Vladimir, *Građevinska fizika*, GI, Fakultet građevinskih znanosti Sveučilišta u Zagrebu, Zagreb, 1983,
2. Hens, Hugo, *Building Physics - Heat, Air and Moisture: Fundamentals and Engineering Methods with Examples and Exercises*, Wiley-VCH, 2008,
3. Hagentoft, Carl-Eric, *Introduction to Building Physics*, Studentlitteratur AB, 2001,
4. Galović, Antun, *Termodinamika I*, Fakultet strojarstva i brodogradnje, Zagreb, 2004,
5. Galović, Antun, *Termodinamika II*, Fakultet strojarstva i brodogradnje, Zagreb, 2003,
6. Kulišić, Petar, *Mehanika i toplina*, Školska knjiga, Zagreb, 2005

Optional literature:

1. Staufenbiel, Georg, Wessig, Josef, *Bauphysik und Baustofflehre – eine Einfuhrung in Experimenten*, Bauverlag BV GmbH, 1989,
2. Porges, George, *Applied Acoustics*, Peninsula Publishing, 1987,
3. Burns, William, *Noise and Man*, John Murray Publishers Ltd, 1973,
5. Brandt, Jörg, Moritz, Helmut, *Bauphsysik nach Maß*, Vbt Verlag Bau U. Technik, 2003,
6. Cammerer, Walter F.,*Wärme- un Kälteschutz im Bauwesen un in der Industrie*, Springer, Berlin, 2002,
7. Monograph,*Građevinska fizika i materijali* – Jugoslovensko društvo za ispitivanje i istraživanje materijala i konstrukcija, Beograd, 2003.
8. Gaskell, David,*Introduction to the Thermodynamics of Materials*, Taylor & Francis, London, 1995,
9. Isachenko, V.,Osipova, Sukomel, Alexander,*Heat Transfer*, University Press of the Pacific, 2000

POLYMERS

Look in **Theory and modeling of structures**

MECHANICS OF MATERIALS

Look in **Theory and modelling of structures**

Elective courses

MATHEMATICS 3

Look in **Shared courses**

STOHASTIC PROCESSES

Look in **Shared courses**

1st year, 2nd semester

Compulsory courses

DURABILITY OF STRUCTURAL MATERIALS

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises: 20 (auditory - 12, design - 8)
- Seminars: 10

Course objectives:

- Gathering wider theoretical and practical knowledge on the behaviour of structural materials and structures under environmental loading during service life,
- Ability to differentiate between different mechanisms of deterioration of structural materials and correlation between causes and consequences of certain environmental loading.

Entry competences (foreknowledge, descriptive):

- Knowledge about the main properties and composition of structural materials,
- Understanding the main transport mechanisms and exchange of mass inside materials,
- Knowledge about the basic chemical reactions between materials and the environment.

Enrolment requirements (correlated courses):

- Teachers signatures: Theory and technology of concrete

Requirements for examination taking (correlated courses):

- Teachers signatures: Theory and technology of concrete

Learning outcomes:

- Extensive knowledge on degradation processes (chemical, physical, mechanical and biological) of structural materials and special environmental loading,
- Independent preparation of structural assessment and plan of maintenance depending on the type of structural material and service life,
- Consulting targeted groups on new methods of prevention of structural material degradation depending on the environment and material type,
- Ability for interdisciplinary research (civil engineering, electrochemistry, timber industry, mechanical engineering etc.).

Course content:

- Lectures:
  1. Introduction: general facts on durability; corrosion; destructions; special durability loads [2]
  2. Mechanisms of metal corrosion; types of metal corrosion; methods and measuring instruments applied in determining the condition of metals [2]
  3. Methods of metal protection [2]
  4. Mechanisms of concrete destruction; types of concrete destruction; methods and measuring instruments applied in determining the condition of concrete [2]
  5. Methods of concrete protection [2]
  6. Pre-exam [2]

7. Mechanisms of wood destruction; types of wood destruction; methods and measuring instruments applied in determining the condition of wood, methods of wood protection [2]
8. Destruction mechanisms of stone, glass, types of stone, glass destruction; methods and measuring instruments applied in determining the condition of stone, glass; methods of protecting stone, glass [2]
9. Destruction mechanisms of masonry and polymer destruction; types of destruction; methods and measuring instruments applied in determining the condition of masonry and polymers; protection methods of masonry and polymers [2]
10. Degradation of materials in soil [2]
11. Sustainable structural materials [2]
12. Durability design strategy of concrete structures: design with set service life; various models of designing durability; probabilistic method of service life design; the expense of total service life [2]
13. Durability design strategy of metal structures: design with set service life; various models of designing durability; probabilistic method of service life design; the expense of total service life [2]
14. Pre-exam [2]
15. Presentation of student projects [2].

- Auditory exercises:
  1. Fundamentals of electrochemical corrosion of metals, methods for detecting corrosion [2]
  2. Corrosion of steel in concrete – calculation of material loss and crack formation [2]
  3. Examples of protection of metals and reinforced concrete (inhibitors, cathodic and anodic protection, stainless steel) [2],
  4. Application of software for calculation of service life of structures in different environments[2]
  5. Methods for investigating corrosion of steel in concrete (electrochemical methods, corrosion monitoring)[2]
  6. Methods and instruments for assessing the degradation of concrete in structures [2].
- Design exercises:
  1. Specific types of corrosion in civil engineering and other engineering fields [2]
  2. Protection of metals – example of galvanising [2]
  3. Examples of degradation of timber in civil engineering and other engineering fields [2]
  4. Examples of methods for detecting corrosion in soil [2].
- Seminars:
  1. Application of Faraday's law, determining corrosion behaviour of different materials[1]
  2. Recognition of different degradation mechanisms based on the chemical and microscopic analysis [1]
  3. Critical overview of state of the art in the field of durability of structural materials [1]
  4. Calculation of expected service life using software [1],
  5. Student project on assessment of structure (choice of structure, categorisation of degradation, analysis of causes and consequences of environmental loading depending on the structural material) [1].

Student responsibilities:

- 75% attendance in lectures,
- 100% attendance in exercises,
- 60% score in each of 2 pre-exams,
- Independent preparation and presentation of homework assignment,
- Team preparation and presentation of student project.

Grading and evaluation of student work over the course of instruction:

- Two pre-exams,
- Seminar – four homework assignments, one student project.

End of semester grading:

- Grading according to the performance during semester.

Contributions to the final grade:

- Two pre-exams 60% ,
- Homework assignment 20%
- Project work 20%.

Required literature:

1. Bjegović, D., Serdar, M., Baričević. A., *Mimeographed lecture notes*, http://www.grad.unizg.hr/predmet/tkm
2. Bijen, J.,*DurabilityofEngineeringStructures*, CRC Press, WoodheadPublishingLimited, Cambridge, England, 2003

Optional literature:

1. Mays, G. *DurabilityofConcreteStructures*, E & FN Soon, London, 1992,
2. Bentur, A., Diamond, S., Berke, N. S.,*Steel CorrosioninConcrete*, E & FN Soon, London, 1997,
3. Maekawa, K., Rajesh, P., ChaubeandKishi, T.,*CoupledMass Transport, HydrationandStructureFormationTheory for DurabilityDesignofConcreteStructures*, http://concrete.t.utokyo.ac.jp/en/demos /ducom/brieftheory/ consec1.html.
4. E. Gjorv, Koji Sakai,*ConcreteTechnology for a SustainableDevelopment in the 21st Century*, E&FN SPON, London, 2000,
5. Ch. F. Hendriks, H.S. Pieterson,*SustainableRawmaterials, ConstructionandDemolitionwaste*, RILEM, Report 22, 2000,
6. Jamal M. Khatib,*Sustainabilityofconstructionmaterials*, WoodheadPublishingLimited, 2009

SPECIAL CONCRETES AND TECHNOLOGIES

Credit value (ECTS): 7.5

Number of hours (in semester): 75

- Lectures: 45
- Exercises: 30 (auditory - 16, laboratory - 14)
- E-learning: optional

Course objectives:

- Learning about special concrete types and technologies used in different areas of civil engineering,
- Theoretical and practical informations about special concrete components, mix design, structure, fresh and hardened state properties, production, technology, quality control and application,

Entry competences (foreknowledge, descriptive):

- Basic knowledge on concrete components, composition, properties and technologies.

Enrolment requirements (correlated courses):

- Teachers signatures:Theory and technology of concrete

Learning outcomes:

- Basic knowledge of the propertiesin fresh and hardened state for different special concretes and technologies,

- Practical skills in mix design for various special concretes,
- Practical knowledge about different requirements for special concrete types and technologies depending on structural and environmental issues,
- Theoretical knowledge about advantages and disadvantages of particular concrete type for a given practical application,
- Understanding the process of quality control for different special concrete types,
- Integration of knowledge in future study and work.

Course content:

- Lectures:
  1. Development of concrete technology [3]
  2. Self compacting concrete [3]
  3. Architectural concrete types [3]
  4. Fibre reinforced concrete [3]
  5. Lightweight and heavyweight concrete [3]
  6. Sprayed concrete [3]
  7. High performance/high strength concrete [3]
  8. Mass concrete, roller compacted concrete [3]
  9. Concrete in roads, concrete in tunnels [3]
  10. Polymer modified concrete and mortar, repair concrete and mortar [3]
  11. Concrete with recycled aggregate [3]
  12. Mortars, injection grouts [3]
  13. Concrete technology for extreme clime conditions [3]
  14. Special technology of concrete production [3]
  15. Advanced processes and concrete technologies [3].
- Exercises (auditory):
  1. Special concretes achievement [2]
  2. Self compacting concrete [2]
  3. Fibre reinforced concrete [2]
  4. Thermal analysis of mass concrete [2]
  5. High performance concrete [2]
  6. High performance fibre reinforced concrete [2]
  7. Quality control of concrete and components [2]
  8. Case studies [2].
- Exercise (laboratory):
  1. Self compacting concrete [2]
  2. Fibre reinforced concrete [2]
  3. Properties of concrete components [2]
  4. Testing methods for fresh concrete [2]
  5. Durability testing of high performance concrete [2]
  6. Mechanical properties tests for high performance concrete [2]
  7. Analysis and interpretation of experimental results [2].
- Student projects:
  1. Self compacting concrete seminar,
  2. Fibre reinforced concrete seminar.

Student responsibilities:

- Attendance in lectures - minimum 75 %,

- Attendance in auditoryexercises - 100 %,
- Attendance in laboratory exercises - 100 %,
- Self compacting concrete seminar,
- Fibre reinforced concrete seminar,
- Two pre-exams.

Grading and evaluation of student work over the course of instruction:

- Minimum 60 % score in each pre-exam,
- Positive grade of seminar papers.

End of semester grade:

- Oral exam.

Contributions to the final grade:

- Oral exam70 %,
- Laboratory exercises and seminar 20 %,
- Attendance in lectures and exercises 10 %.

Required literature:

6. Beslać. J., Skazlić, M.,*Special concrete types, in Concrete structures 3*, Andris, Zagreb, 2007, (in Croatian)
7. Ukrainczyk, V.,*Concrete: structure, properties and technology*, Alcor, Zagreb, 2001, (in Croatian)
8. Newman J., Seng Choo B.,*Advanced Concrete Technology-Process*, Elsevier Ltd., 2003
9. Kosmatka S.H., Kerkhoff B., Panarese W.C., MacLeod N.F., McGrath R.J.,*Design and Control of Concrete Mixtures, Cement Association of Canada*, Seventh Edition, 2002

Optional literature:

1. Mehta P.K.,*Concrete, Structure, Properties and Materials*, New Yersey, Prentice Hall, Inc., Englewood Cliffs,1986
8. Neville, A.M.,*Properties of concrete*, Essex, Longman Group Limited,1995
9. Nawy, E.,*Fundamentals of high-performance concrete*, Second edition, John Wiley&Sons, Inc., New York, 2001
10. Aitcin, P. C.,*High-Performance Concrete*, E&FN SPON, London, 1998

CONCRETE AND MASONRY STRUCTURES 2

Look in **Structural Engineering**

Elective courses

APPLIED GEOLOGY

Look in **Geotechnical Engineering**

ENVIRONMENTAL PROTECTION

Look in **Hydraulic Engineering**

QUALITY MANAGEMENT

Credit value (ECTS): 7.5

Number of hours (in semester):

- Lectures: 45
- Exercises: 30 (auditory – 10, design – 20)

Course objectives:

- Acquiring knowledge on quality management principles,
- Acquiring knowledge on application of statistical methods for assessment of construction materials quality,
- Acquiring knowledge on conformity assessment of construction materials.

Entry competences (foreknowledge, descriptive):

- Knowledge on basic probability distributions,
- Kknowledge on conformity assessment of construction materials.

Enrolment requirements (correlated courses):

- Teachers signatures: Theory and technology of concrete

Learning outcomes:

- Preparation of quality manual,
- Organizing interlaboratory comparison testing,
- Ability to apply statistical methods for construction materials quality assessment,
- Creating a sampling plan,
- Making a control chart and operative curve,
- Describing management systems.

Course content:

- Lectures:
  1. Introduction to quality and quality management [3]
  2. Laboratory accreditation and certification of construction products [3]
  3. Basic principles of quality control, quality assurance and total quality management [3]
  4. Statistical tools for analysing data [3]
  5. Quality information systems [3]
  6. Quality management methods and techniques [3]
  7. Factory production control [3]
  8. Quality management in concrete production [3]
  9. Harmonisation of Croatian legislation with EU legislation [3]
  10. European and international quality standards [3]
  11. Quality in construction projects [3]
  12. Environmental management – life cycle assessment (LCA) [3]
  13. Uncertainty measurement [3]
  14. Quality assurance of testing results [3]
  15. Trends in quality management [3].
- Auditory exercises:
  1. Creation of laboratory quality manual [2]
  2. Materials sampling plans for testing quality control [2]

3. Preparation of quality control plan for construction materials [2]
4. Application of statistical methods for assessment of materials quality [2]
5. Conformity assessment of construction materials [2].

- Design exercises:
  1. Preparing procedures for laboratory quality manual, sampling plans, operative curves, assessment of measurement uncertainty [20].

Student responsibilities:

- Attendance lectures minimum 75 %,
- Attendance in exercises 100%,
- programs,
- pre-exams - minimum 25 % score in each.

Grading and evaluation of student work over the course of instruction:

- Minimum 60 % score in each preliminary exam,
- Positive grade of programs,
- Participation in lectures and exercises

End of semester grading:

- Written exam– minimum 60 % score,
- Oral examination

Contributions to the final grade:

- Written exam50 %
- Oral exam50 % or
- Pre-exams 80 % and oral exam 20 %.

Required literature:

1. Štirmer, N., Gabrijel, I.,*Quality management*, course repository, `http://www.grad.unizg.hr/predmet/uprkva`
2. Juran, J. M., Gryna, F. M., *Quality Planning and Analysis*, 3rd edition, Mate d.o.o., Zagreb, 1999
3. Skoko, H.,*Quality management*, Sinergija, Zagreb, 2000

Optional literature:

1. De Feo, J.,Barnard, W.*, Juran Institute's Six Sigma Breakthrough and Beyond*, Juran Institute, 2003
2. Feigenbaum, A. V., *Total quality control*, McGraw-Hill, 1991
3. Juran, J. M., De Feo, J.,*Juran's Quality Handbook: The Complete Guide to Performance Excellence*, 6th Edition, McGraw Hill, 2010
4. Deming, W. E.,*Some Theory of Sampling*, Dover Publications, 2010
5. Kelly, J. M.,*Total Quality Management*, Protecon, Zagreb, 1997
6. Shewhart, W. A.,*Statistical Method from the Viewpoint of Quality Control*, Dover Publications, 2011

THEORY OF ELASTICITY AND PLASTICITY

Look in **Theory and modeling of structures**

2nd year, 3rd semester

Compulsory courses

PRECAST SYSTEMS

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises: 30 (auditory – 24, design – 6)

Course objectives:

- Acquiring knowledge about various possibilities of application of precast concrete systems,
- Acquiring theoretical and practical knowledge on material properties, design, detailing, production, transportation and installation of different precast elements for succesful application of precast concrete systems.

Entry competences (foreknowledge, descriptive):

- Basic knowledge about the concrete structures: material, properties, design and detailing.

Enrolment requirements (correlated courses):

- Teachers signatures: Special concrete and technologies,

Requirements for examination taking (correlated courses):

- Teachers signatures: Special concrete and technologies,

Learning outcomes:

- Basicknowledge of precast elements properties for application in different areas of civil and environmental engineering,
- Practical skill on designing and detailing connections between precast concrete systems and elements,
- Practical knowledge of requirements for production, storage, transport, erection and quality control of different precast concrete elements,
- Theoretical knowledge of advantages and disadvantages of particular precast concrete type for a given practical application,
- Understanding process of interaction between precast element design, material properties, technology of production and construction and type of concrete structure,
- Integration of knowledge in future study and work.

Course content:

- Lectures:
  1. Basic principles of production and building with precastelements [2]
  2. Materials for precast systems [2]
  3. Structuralsystems [2]
  4. Properties of precast elements [2]
  5. Precast elements in building construction [2]
  6. Non-reinforced precast elements [2]
  7. Precast clay elements [2]
  8. Application of precast elements in road construction [2]
  9. Precast systems in other fields of civil engineering [2]
  10. Composite structures with precast elements [2]

11. Precast concrete plants[2]
12. Storage, transport and erection of precast elements [2]
13. Special technologies and materials in precastelements [2]
14. Robotics, economics and coordination between designers and manufacturers [2]
15. Ecological aspects of precast construction [2].

- Auditory exercises:
  1. Design procedures and connections between precast concrete elements [2]
  2. Types of joints and connections in precast concrete systems[2]
  3. Precast concrete skeletal elements connections[2]
  4. Connections in precast panel systems[2]
  5. Precast floor structures joints[2]
  6. Connections of composite structures [2]
  7. Special connections between precast concrete [2]
  8. Case study on precast element design[2]
  9. Case study on precast element production[2]
  10. Case study on transport and erection of precast concrete elements [2].
- Design exercises:
  1. Precast concrete elements production plants[2]
  2. Precast systems in bridge construction[2]
  3. Advanced concrete types in precast concrete systems[2].
- Student projects: Seminar on practical application of certain precast concrete elements

Student responsibilities:

- Attendance in lectures – minimum 75%,
- Attendance in auditory exercises – 100%,
- Attendance in design exercises – 100%,
- Two pre-exams – minimum 25% score in each,one make up exam,
- Seminar on application of precast concrete elements.

Grading and evaluation of student work over the course of instruction:

- Students with minimum 60% score in each pre-exam are exempt from a part of the written exam.

End of semester grading:

- Written exam – minimum 60% score,
- Oral exam.

Contributions to the final grade:

- Written exam 30%,
- Oral exam 70%.

Required literature:

1. FIB Commission 6, *Planning and Design Handbook on Precast Building Structures*, 2004
2. Kim S. Elliot, *Precast Concrete Structures*, Butterworth Heinmann, 2002
3. Kim S. Elliot, *Multi-storey precast concrete framed structures*, Blackwell Science, 1996
4. National Precast Concrete Association Australia, Concrete Institute of Australia: *Precast Concrete Handbook*, 2002
5. FIB Task Group 6.4: Precast concrete bridges, 2004.
6. FIB Task Group 3.1: Environmental issues in prefabrication, 2003.
7. FIB Task Group 6.3: Precast concrete in mixed construction, 2002.

Optional literature:

1. Precast Concrete Institute: *Design Handbook Precast and Prestressed Concrete*, Fifth Edition,1999

NON-DESTRUCTIVE TESTING

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises: 30 (auditory - 10, laboratory - 20)

Course objectives:

- Learning about different methods of non-destructive testing of construction materials and structural elements
- Acquiring of knowledge of basic methods of non-destructive tests and interpretation of getting results for determining desired properties and/or defects in different materials and elements used in civil engineering

Entry competences (foreknowledge, descriptive):

- Basic knowledge on material properties, quality control, structural elements used in civil engineering, durability of structures

Enrolment requirements (correlated courses):

- Teacher signatures: Special concretes and technologies, Durability of construction materials,
- Examinations passed: Building physics.

Requirements for examination taking (correlated courses):

- Teachers signatures: Special concretes and technologies, Durability of construction materials,
- Examinations passed:Building physics.

Learning outcomes:

- Basicknowledge of the non-destructive testing methods used in civil engineering,
- Practical skill on application ofcertain testing method, analysis and interpretation of getting results for testing material property or structural integrity,
- Theoretical and factual knowledge of advantages and disadvantages of non-destructive testing methods for a practical application,
- Understanding process of quality control of new and existing structural elements and materials used in civil engineering,
- Understanding correlation between results of non-destructive testing and material or structural state and property,
- Integration of knowledge in future study and work.

Course content:

- Lectures:
    1. Definitionsand classificationof non-destructivetesting [2]
    2. Planning and selection of non-destructive testing, equipment fornon-destructive testing, reliability of test results, penetrantmethods [2]
    3. Basicprinciplesof visual inspection, tools and methodologyof implementation [2]
    4. Non-destructivedetermination ofmaterial strength in construction, correlation with the resultsof destructivetesting [2]
    5. Early age concrete strength and properties [2]
    6. Concrete durability tests, electromagnetic testing methods [2]
    7. Ultrasonictesting method [2]
    8. Impact echo, dynamic response testing methods [2]
    9. Acoustic emission [2]
    10. Thermography: development, theoretical basis, the application [2]

11. Radar [2]
12. Radiography and radiometry [2]
13. Standards and regulations and standardsfor the implementation ofnon-destructive testing, statistical analysisand interpretationof test results [2]
14. Application ofnon-destructivetesting methodsduring construction [2]
15. Applicationof non-destructivetesting methodsfor evaluationof existing structures properties [2]

- Auditory exercises:
  1. Planning and interpretation of in-situ testing [2]
  2. Non-destructive testing of concrete strength [2]
  3. Testsof concrete propertiesrelevantfordurability [2]
  4. Non-destructive methods based on wave propagation through material [2]
  5. Case study and examplesof non-destructivetesting on existingbuildings, bridges, tunnelsandother facilities [2]
- Laboratory exercises:
  1. Schmidt hammer, pull-out and pull-off tests [2]
  2. Maturity testing methods [2]
  3. Eletromagnetic concrete cover measurement, corrosion rate tests, concrete absorption and permeability tests [2]
  4. Non-destructive testingof durability properties [2]
  5. Ultrasound pulse velocity method for fresh concrete [2]
  6. Applicationof ultrasound tests inhardenedconcrete [2]
  7. Impact echo and impulse response [2]
  8. Acoustic emission [2]
  9. Thermography [2]
  10. Analysis and interpretation of thenon-destructive testingresults [2]

Student responsibilities:

- Attendance in lectures – minimum 75%,
- Attendance in auditory exercises – 100%,
- Attendance in laboratory exercises – 100%,
- Two pre-exams – minimum 25% score in each, one make up exam.

Grading and evaluation of student work over the course of instruction:

- Two pre-exams: min. 60 % on each preliminary exam.

End of semester grading:

- Oral exam.

Contributions to the final grade:

- Laboratory exercises and seminar: 30%,
- Oral exam: 70%.

Required literature:

1. Malhotra, V. M., Carino, N. J., *Handbook on Nondestructive Testing of Concrete*, Second Edition, CRC Press, 2004
2. *Proceedings from International Symposium Non-Destructive Testing in Civil Engineering*, Berlin, 2003.
3. Bungey, J. H.; Millard, S. G.: *Testing of concrete in structures*, Blackie Academy & Professional, 1996.

Optional literature:

1. Innovations in Non-Destructive Testing of Concrete, ACI International SP-168, ed. Pessiki S. And Olson L., 1997.
2. FIB bulletin no. 22, *Monitoring and Safety Evaluation of Existing Concrete Structures*, State-of-art report, 2003

FIRE PROTECTION

Credit value (ECTS): 6

Number of hours (in semester):

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

Course objectives:

- Defining parameters of fire development in enclosed spaces,
- Principles of testing and classification building materials in accordance to properties related to contribution to fire development,
- Analysis of structural elements made of different building materials in accordance with prescriptive and performance-based design,
- Principles of active fire protection,
- Principles of Croatian regulatory framework related to fire protection measures,
- Defining parameters for assessment of fire damaged structures in accordance with material they are made of.

Entry competences (foreknowledge, descriptive):

- Elementary knowledge aboutf materials science, mathematics, thermodynamics and chemistry.

Enrolment requirements (correlated courses):

- Examinations passed: Building physics.

Learning outcomes:

- Quantitative assessment of various parameters offires in enclosed spaces (fire load, heat release rate, the maximum temperature achieved in enclosed space, maximum temperature thatstructural element is exposed to, etc.),
- Evaluating and classifyingmaterialsandbuilding productsaccording tothe results ofreaction to fire testing,
- Analysing the main effects of fire temperatures on the properties (thermal and mechanical) of the construction materials (concrete, steel, wood, etc.),
- Analysing the structural elements in case of fire, using the prescriptive and the performance-based design,
- Developing the Study of fire protection according to the current regulations in the Republic of Croatia,
- Assessing the structures after fire considering the material of structure (concrete, steel, wood, brick, etc.).

Course content:

- Lectures:
  1. Introduction into course[2]
  2. Basics of occurrence and spread of fires in buildings [2]
  3. Modeling the occurrence and spread of fire[2]
  4. Effects of fires on materials and structures – generally[2]
  5. Architectural and urban measures of fire protection – part 1 [2]
  6. Architectural and urban measures of fire protection – part 2 [2]
  7. Architectural and urban measures of fire protection – part 3 [2]
  8. Architectural and urban measures of fire protection – part 4 [2]
  9. Fire fightening systems and active fire measures –part 1 [2]
  10. Active fire measures– part 2 [2]

11. The effect offireon the reinforced concretestructural elementsandtheir protection [2]
12. The effect offireon steel structural elementsandtheir protection [2],
13. The effect offireon the wood structural elementsandtheir protection [2]
14. Assessment of fire damaged structuresandstrengthening of structures [2]
15. Legislationin the fieldof fire protection [2].

- Exercises
  1. Pre-exams [2].
- Auditory exercises:
  1. The basics of occurrence and spread of fire in the enclosed spaces [4]
  2. Effect offireonstructural elements, depending on materials they are made of (concrete,steel, wood, brick)[2]
  3. The realfires andanalysis of fire consequences [2]
  4. Examples of assessment of fire damaged structures [2].
- Laboratory exercises:
  1. Reaction to fire testsof building materialsandproducts[2]
  2. Fire resistance testsof structural elements [2].
- Design exercises:
  1. Development and presentation of student projects: Study of fire protection measures in buildings [14].

Student responsibilities:

- Attendance in lectures – 75% ,
- Attendance in exercises–100%,
- Two pre-exams – minimum 60% score in each,
- Independent preparation and presentation of projects (Study of fire protection measures in buildings).

Grading and evaluation of student work over the course of instruction:

- Two pre-exams,
- Project: Study of fire protection measures in building: 1.

End of semester grading:

- Grade formed according to the performance during semester.

Contributions to the final grade:

- Pre-exams 60%,
- Project 30%,
- Attendance in classes 10%.

Required literature:

1. Bjegović, D. et al. *Subject repository*,http://www.grad.unizg.hr/predmet/zop (inCroatian)
2. BuchananA.H.*, StructuralDesign for FireSafety*, JohnWiley&SonsLtd, England, 2002
3. Purkiss, J.A.,*Firesafetyengineering – Designofstructures*, Secondedition. Oxford: Elsevier Ltd., 2007
4. *Designofbuildings for thefiresituation*, Leonardo da Vinci pilot project CZ/02/B/F/PP-134007 (http://eurocodes.jrc.ec.europa.eu/showpublication.php?id=66)
5. Vidaković M.,*Fireandarchitecturaldesign*, Fahrenheit, Beograd, 1995 (inSerbian).

Optional literature:

1. D. Drysdale, *AnIntroduction to Fire Dynamics*, Wiley&Sons, 2003. (selected paragraphs)
2. Dougal Drysdale, *AnIntroduction to Fire Dynamics*, 2nd Ed., Wiley 1998,http://www.civ.ed.ac.uk/research/fire/technicalreports.htmlhttp://www.civ.ed.ac.uk/research/fire/thesis.html
3. B. Karlssonand, J.G. Quintiere, *EnclosureFire Dynamics*, CRC Press, 2000 (selected paragraphs)

4. HRNEN 1991-1-2:2008,Eurocode 1: *Actions on structures* -- Part 1-2: General actions -- Actions on structuresexposed to fire (EN 1991-1-2:2002)
5. HRNEN 1992-1-2:2008,Eurocode 2: *Designof concrete structures* -- Part 1-2: General rules – Structuralfiredesign (EN 1992-1-2:2004+AC:2008)
6. HRNEN 1993-1-2:2008,Eurocode 3: *Designofsteelstructures* -- Part 1-2: General rules – Structuralfiredesign (EN 1993-1-2:2005+AC:2005)
7. HRNEN 1994-1-2:2008, Eurocode 4: *Designofcompositesteeland concrete structures* -- Part 1-2: General rules – Structuralfiredesign (EN 1994-1-2:2005+AC:2008)
8. HRNEN 1995-1-2:2008, Eurocode 5: *Designoftimberstructures* -- Part 1-2: General – Structuralfiredesign (EN 1995-1-2:2004+AC:2006)

Elective courses

TECHNOLOGY OF REPAIR AND STRENGTHENING

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises: 22 (auditory - 14, design - 8)
- Seminars: 8

Course objectives:

- Integrating knowledge from different undergraduate and graduate courses with the additional knowledge for the purpose of autonomous performance of the analysis of existing structures and designing their repair (repair, retrofit or strengthening).

Entry competences (foreknowledge, descriptive):

- Understanding specific properties of different structural materials and their corresponding degradation mechanisms,
- Theoretic and practical knowledge about the behaviour of structures under loading,
- Differentiating degradation mechanisms of materials based on the assessed damage.

Enrolment requirements (correlated courses):

- Teacher signatures: Special concrete and technology, Durability of structural materials,
- Examinations passed: Building physics.

Requirements for examination taking (correlated courses):

- Teachers signatures: Theory and technology of concrete, Durability of structural materials,
- Examinations passed: Building physics.

Learning outcomes:

- Correlating specific degradation mechanism of concrete to principles and methods of repair of reinforced concrete structure,
- Differentiating and comparing different materials and systems for repair and strengthening of reinforced concrete structures,
- Defining required properties of materials and systems for repair and strengthening reinforced concrete structures,

- Analysing and comparing different methods for repair of structures based on their functional, durability, ecological and economic benefits through the entire service life,
- Recommending and prescribing optimal principle and method of repair depending on the mechanism of degradation and based on the multi-criteria analysis of alternatives,
- Independent preparation of repair project, which includes: assessment of structure, recommended principle and method of repair, required properties of materials and systems, quality control plan during and after repair works.

Course content:

- Lectures:
  1. Processes of material destruction: causes of damage; essential properties of material durability[2]
  2. Assessment of structures[2]
  3. Principles and methods of repair of reinforced concrete structures[2]
  4. Materials and systems for repair of reinforced concrete structures[2]
  5. Methods of strengthening structures[2]
  6. Pre-exam [2]
  7. Repair of historic structures[2]
  8. Special repair technologies[2]
  9. Methodology for multi-criteria analysis of alternative repair solutions[2]
  10. Control and assurance of repair work quality[2]
  11. Main principles of monitoring repaired structures[2]
  12. Standards and recommendations in the field of repair[2]
  13. Pre-exam [2],
  14. Final presentation of student projects with discussion[4].
- Auditory exercises:
  1. Typical damage of structures and corresponding principles and methods of repair[2]
  2. Examples of repair materials[2]
  3. Examples of structure strengthening[2]
  4. Examples of repair of historic structures[2]
  5. Examples of special repair technologies[2]
  6. Methods of comparing different repair options[2]
  7. Examplesof comprehensive repair projects[2].
- Design exercises:
  1. Choice and assessment of real structure[2]
  2. Choice of principle and method of repair[2]
  3. Specifying required material and system properties, defining quality control and assurance plan during and after repair works[2]
  4. Plan of activities and approximate budget for repair of the structuren[2].
- Seminars:
  1. Analysis of example from the literature of repair project (anamnesis - assessment of structure, diagnosis - causes of degradation and therapy - chosen repair solution),
  2. Prescribing requirements for materials and systems,
  3. Analysis and critical overview of state of the art in the field of repair of structures,
  4. Multi-criteria analysis of different repair strategies.

Student responsibilities:

- 75% attendance in lectures,
- 100% attendance in exercises,
- Two pre-exams, minimum 60% score in each,

- Independent preparation and presentation of homework assignment,
- Team preparation and presentation of student projects.

Grading and evaluation of student work over the course of instruction:

- Two pre-exams,
- Seminar – four homework assignments, one student project.

End of semester grading:

- Grading based on the performance during semester.

Contributions to the final grade:

- Two pre-exams 60%,
- Homework assignment 20%,
- Projecs 20%.

Required literature:

1. Bjegović, D.; Serdar, M.,*Mimeographed lecture notes*, subject repository, http://www.grad.unizg.hr/predmet/tsio
2. HRN EN 1504 *Proizvodiisustavizazaštituipopravakbetonskihkonstrukcija*
3. StipanovićOslaković, I., ŠkarićPalić, S., Mavar, K.*, Općeplaniranjepopravka // Betonskekonstrukcije - Sanacije* / Zagreb :Hrvatskasveučilišnanaklada, Sveučilište u Zagrebu – GrađevinskiFakultet, Secon HDGK, Andris, 2008
4. Barišić, E.,*Materijalizazaštituipopravak, Betonskekonstrukcije – Sanacij,* Zagreb,:Hrvatskasveučilišnanaklada, Sveučilište u Zagrebu – GrađevinskiFakultet, Secon HDGK, Andris, 2008
5. Mavar, K., Balagija, A.,*Metodepopravkabetona, Betonskekonstrukcije – Sanacije,* Zagreb :Hrvatskasveučilišnanaklada, Sveučilište u Zagrebu – GrađevinskiFakultet, Secon HDGK, Andris, 2008
6. Bjegović, D., Hranilović, M., Serdar, M.,*Elektrokemijskemetodezaštite armature// Betonskekonstrukcije - Sanacije* / Zagreb :Hrvatskasveučilišnanaklada, Sveučilište u Zagrebu – GrađevinskiFakultet, Secon HDGK, Andris, 2008

Optional literature:

1. Allen, R. T. L., Edwards, S. C.,*Repair of Concrete Structures*, Blackie & Son Limited, 1987
2. Emmons, P. H.,*Concrete Repair and Maintenance Illustrated*, Construction Publishers & Consultants, 1993
3. *Concrete Repair Manual*, ICRI & ACI International, 1999
4. Perkins, P.H.,*Repair, Protection and Waterproofing of Concrete Structures*, E&FN Spon, London, 1997
5. *Repair of Concrete Structures to EN 1504*, Danish Standards Association, 2004
6. fib Report: *Management, maintenance and strengthening o concrete structures*, Lausanne, 2002
7. fib Report: *Monitoring and safety evaluation of existing concrete structures*, Lausanne, 2003
8. BRITE-EURAM project BE4062 *The service life of reinforced concrete structures,*
9. CONTECVET IN30902I. 2001, *A validated users manual for assessing the residual life of concrete structures*, DG Enterprise, CEC,
10. *DuraCrete (2000) DuraCrete Final Technical Report*, Document no. BE95-1347/R17, Gouda, CUR.
11. REHABCON IPS-2000-00063*, Strategy for Maintenance and Rehabilitation in Concrete Structures,* DG Enterprise of the European Commission, 2000-2004

CONCRETES FOR ROADS

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises: 30 (auditory – 14,design - 6, laboratory - 10)

Course objectives:

- Acquiring theoretical knowledge about the technology of production, properties and use of concrete on roads,
- Acquiring practical knowledge about laboratory testings on the properties relevant for the concrete for roads,
- Acquiring knowledge about designing concrete composition,
- Acquiring knowledge about construction materials quality control.

Entry competences (foreknowledge, descriptive):

- Knowledge on physical, mechanical and thermal properties of materials,
- Basic statistics.

Enrolment requirements (correlated courses):

- Teacher signatures: Special concretes and technologies,

Requirements for examination taking (correlated courses):

- Teachers signatures: Special concretes and technologies,

Learning outcomes:

- Ability to describe the technology of materials for particular concrete elements on roads,
- Ability to explain relevant properties of concrete for elements,
- Ability to design concrete composition,
- Compare the properties of different concretes for roads,
- Ability to apply the concrete testing results on individual elements.

Course content:

- Lectures:
    1. Concrete elements on roads and aeroports [2]
    2. Calculation of temperature flow in concrete and assessing the risk of cracks [2]
    3. Pavements: concrete pavements, asphalt pavements [2]
    4. Pavement joints [2]
    5. Surface treatment – roughness [2]
    6. Fiber reinforced concretes [2]
    7. Porous concrete [2]
    8. Polymer modified concretes [2]
    9. Jet concretes [2]
    10. Concrete in tunnels [2]
    11. Injection [2]
    12. Repair concretes and mortars [2]
    13. Production technology of concretes for roads [2]
    14. Vacuum concrete [2]
    15. Quality control of concrete [2].

- Auditory exercises:
  1. Technical requirement for concrete used for road elements [4]
  2. Outline of regulations for concrete pavements [2]
  3. Durability of concrete properties with examples [2]
  4. Testing of concrete pavements [2]
  5. Quality control of concrete pavements [2]
  6. Program of quality and control of concrete works on roads [2].
- Design exercises:
  1. Defining the elements for quality program – program [2]
  2. Description of relevant materials – program solving [2]
  3. Description of relevant properties with control – program solving [2].
- Laboratory exercises:
  1. The effect of chemical additives on the properties of fresh concrete [2]
  2. The effect of chemical additives on the properties of hardened concrete [2]
  3. Porous concrete [2]
  4. Polymer modified and fibre reinforced concrete [2]
  5. Durability properties of concretes for roads [2].

Student responsibilities:

- Attendance in lectures – 75%,
- Attendance in auditory and laboratory exercises – 100%,
- Development of one program,
- Pre-exam – minimum 50% score, one make up exam.

Grading and evaluation of student work over the course of instruction:

- Students with a minimum 60% score in the pre-exam who have met other requirements are exempt from the written exam,
- Grading during semester: pre-exam 50%, laboratory exercises and programs 40%, attendance 10%.

End of semester grading:

- Written exam – minimum 50% score,
- Oral exam.

Contributions to the final grade:

- Written exam 50%,
- Oral exam 50%,
- Students who are exempt from the written exam: grades during semester 60%, oral exam 40%.

Required literature:

1. Ukrainczyk, V., *Beton: struktura, svojstva, tehnologija*, Građevinski fakultet Sveučilišta u Zagrebu, 1994
2. Ukrainczyk, V., *Poznavanje gradiva*, Alcor, Zagreb, 2001
3. Beslać, J., *Materijali u arhitekturi i građevinarstvu*, Školska knjiga, Zagreb, 1989
4. Korlaet, Ž., *Uvod u projektiranje i građenje cesta*, udžbenik, Sveučilište u Zagrebu, 1995

Optional literature:

1. *ACI Manual of Concrete Practice*, ACI Publication, USA
2. Derucher, K. N., Korfiatis, G. P., *Materials for Civil & Highway Engineers*, second edition, Prentice Hall, 1988

HYDROTECHNICAL CONCRETE

Credit value (ECTS): 6

Number of hours (in semester):

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

Course objectives:

- To acquire knowledge on characteristic properties of mass concrete,
- To acquire knowledge on different methods for preventing thermal cracks,
- To acquire knowledge on protection of concrete elements in hydrotechnical structures,
  Tto acquire knowledge on possibilities of using special concrete types and technologies for hydrotechnical structures.

Entry competences (foreknowledge, descriptive):

- Knowledge on concrete composition and properties.

Learning outcomes:

- Ability to estimatethe risk of thermal cracks in mass concrete,
- Ability to select appropriate components for mass concrete composition,
- Ability to analyse influence of components and environment on the temperature changes in concrete,
- Ability to recommend technology of execution for concrete in hydrotechnical structures,
- Ability to evaluate results of testing concrete in hydrotechnical structures,
- Ability to analyze and evaluate materials for repair of hydrotechnical structures.

Course content:

- Lectures:
  1. Introduction: characteristics and application of concrete for hydrotechnical structures [2]
  2. Mass concrete. Heat of hydration: thermal stresses and cracking; volume changes [2]
  3. Selection of components for mass concrete and concrete mix design [2]
  4. Control of cracks in mass concrete [2]
  5. Transport, placement and curing of concrete: dynamics of concreting [2]
  6. Concreting at extreme weather conditions [2]
  7. Strength and deformations: risk of cracking [2]
  8. Cooling systems for mass concrete [2]
  9. Special concrete types and technologies for execution of hydrotechnical structures: roller-compacted concrete, preplaced -aggregate concrete, underwater concreting [2]
  10. Concrete with improved water impermeability [2]
  11. Erosion of concrete in hydraulic structures. Examples of repair [2]
  12. Materials for repair of hydrotechnical structures [2]
  13. Repair of concrete structures under water [2]
  14. Assessment of concrete condition in existing hydrotechnical structures [2]
  15. Regulations and standards for application of concrete in hydrotechnical structures [2]
- Auditory exercises:
  1. Thermal stress and cracking: cracking risk calculations [2]
  2. Control of concrete temperature and temperature gradient [2]
  3. Recommendations for selection of aggregate type, cement and concrete additives: influence of components on concrete temperature development [2]
  4. Concrete placement and curing methods [2]

5. Calculation of temperature changes in concrete - Schmidt's numerical method [2]
6. Modelling of temperature development in concrete [2]
7. Calculation of temperature flow in mass concrete and cracking risk estimation - examples [2]
8. Protection of concrete elements in hydrotechnical structures [2]
9. Testing methods for relevant concrete properties for hydrotechnical structures [2]

- Design exercises:
  1. Schmidt's numerical method, risk of thermal cracks in mass concrete [12]

Student responsibilities:

- Participation in lectures min. 75 %,
- Participation in all exercises,
- One program,
- Two preliminary exams (min. 25 % on each).

Grading and evaluation of student work over the course of instruction:

- Min. 60 % on each preliminary exam,
- Positively graded program,
- Participation in lectures and exercises.

End of semester grading:

- written examination (min. 60 %),
- Oral examination.

Contributions to the final grade:

- Written examination 50 % and oral examination 50 % or
- Preliminary exams 80 % and oral examination 20 %.

Required literature:

1. Štirmer, N.; Gabrijel, I.: *Concrete for hydrotechnical structures*, course repository, http://www.grad.unizg.hr/predmet/hidbet
2. *Advanced Concrete Technology, Processes*, ed. Newman, J.; Seng Choo, B., Elsevier, 2003
3. ACI 207.1R-05 *Guide to Mass Concrete*
4. ACI 207.2R-07 *Report on Thermal and Volume Change Effects on Cracking of Mass Concrete*
5. ACI 207.3R-94 *Practises for Evaluation of Concrete in Existing Massive Structures for Service Conditions*
6. ACI 207.4R-05 *Cooling and Insulating Systems for Mass Concrete* (Reapproved 2012)
7. ACI 207.5R-11 *Report on Roller-Compacted Mass Concrete*
8. ACI 210R-93 *Erosion of Concrete in Hydraulic Structures*

Optional literature:

1. *Prevention of Thermal Cracking in Concrete in Early Ages*, RILEM Report, Ed. R. Springenschmid, E & FN Spon, 1998.
2. Monteiro, P. J. M.: *Concrete – microstructure*, Properties and Materials, McGraw-Hill, 2006

METAL STRUCTURES 2

Look in **Structural Engineering**

2nd year, 4th semester

Elective courses

NUMERICAL MODELING IN ENGINEERING MATERIALS

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises: 16
- Seminars: 14

Course objectives:

- Basic understanding ofthe application of computer simulation in materials engineering through the application of different numerical methods (finite differences, finite elements, stochastic modelling).

Entry competences (foreknowledge, descriptive):

- Understanding physical properties of construction materials,
- Understanding the basic principles of mass and energy transport,
- Basic calculus knowledge.

Learning outcomes:

- Ability to identify heat and mass transport mechanism required for numerical analysis of transport through concrete,
- Ability to simulate temperature distribution in early age concrete,
- Ability to analyze rate of chloride ingress into concrete exposed to maritime environment,
- Ability to perform numerical investigation of thermal bridging in building physics,
- Ability to simulate hydration process in Portland cement.

Course content:

- Lectures:
    1. Introduction into transport processes [2]
    2. Molecular transport mechanisms [2]
    3. Principle of equilibrium [2]
    4. Initial and boundary conditions [2]
    5. Finite difference method (truncation error and Taylor series, elliptical equation, parabolic equation) [6]
    6. Finite element method [4]
    7. Application of FEA on 1-dimensional time dependent problems [2]
    8. Invers methods [2]
    9. Stohastic methods [2]
    10. Artificial intelligence and expert systems [2]
    11. Neural networks and fuzzy logic [2].
- Exercises (auditory, design):
    1. Solving heat and mass transfer problems using FDM [4]
    2. Modeling temperature distribution in early age concrete [4]
    3. Application of FEA on heat transfer problems [4]

4. Simulation of stresses caused by temperature distribution [1]
5. Simulation of cement hydration [3].

- Seminars:
  1. Solving assignments [14].

Student responsibilities:

- Attendance in lectures – 75 %,
- Attendindance in exercises – 100 %.

Grading and evaluation of student work over the course of instruction:

- Program development – computer aided numerical modeling of materials.

End of semester grading:

- Assignment grade,
- Exam.

Contributions to the final grade:

- Assignment 50%,
- Exam 50%.

Required literature:

1. Balabanić, G., *Numeričkomodeliranje u inženjerstvumaterijala*, (selected chapters), mimeographed lecture notes, 2010

Optional literature:

1. Chapra S.C. ,Canale. R.P.,*Numerical Methods for Engineers*, McGraw-Hill, Sixth Edition, 2009
2. Brodkey R.S., Hershey H.C.,*Transport Phenomena – A Unified Approach*, McGraw-Hill, 1988
3. Rappaz, M.; Bellet, M.; Deville, M.,*Numerical modeling in materials science and engineering*, Springer, 2002
4. Raabe, D.,*Computational materials: The simulation of materials Microstructure and properties*, John Wiley & Sons Inc, 1998
5. DalbeloBašić, B.,*Umjetneneuronskemreže*–mimeographed lecture notes for the course Artificial Intelligence, Faculty of electrical engineering and Computing, Zagreb, May, 2008

HIGH PERFORMANCE CONCRETE

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises: 30 (auditory - 20, laboratory - 10)
- E-learning: optional

Course objectives:

- Learning about high performance concretes used in civil engineering, and about the technology of their production. Special attention is paid to interaction between mechanial and durability properties and concrete technology,
- Acquiring knowledge about basic methods of concrete testing according to domestic and international regulations and standards of their production and quality control.

Entry competences (foreknowledge, descriptive):

- Basic knowledge on concrete components, concrete mix design and propertiesin fresh and hardened state.

Enrolment requirements (correlated courses):

- Examinations passed: Special concrete types, Durability of structural materials, Non-destructive testing.

Learning outcomes:

- Basicknowledge about high performance concrete propertiesin freshandhardenedstate and high performance concrete mix design,
- Practical skill in applying certainhigh performance concrete technologydependingon the type ofstructure,
- Theoretical and practical knowledge about advantages and disadvantages of high performance concrete in practice,
- Understanding the process of high performance concrete quality control in concrete production plant and on-siteby usinglaboratory and fieldtest methods,
- Knowledge about specialtypesof high performance concrete,
- Integration of knowledge in future study and work.

Course content:

- Lectures:
  1. Historical development, definitions and classification [2]
  2. High performance concrete principles [2]
  3. Materials selection [2]
  4. Compatibility of components [2]
  5. Mix design methods [2]
  6. Technology of concrete production, transport and construction [2]
  7. Optimization of curing process [2]
  8. Correlation between concrete structure and properties [2]
  9. Properties in fresh state [2]
  10. Testing methods [2]
  11. Mechanical properties [2]
  12. Durability properties [2]
  13. Technology selection based on the structure type [2]
  14. Special types of high performance concretes [2]
  15. Potential for structural application [2].
- Auditory exercises:
  1. Introductiontoselecting concrete componentsandmix design [2]
  2. Selection ofconcrete components based onthe requiredproperties [2]
  3. Mix design methods for different concrete types [2]
  4. Specific problemsof concrete technology ina variety of applications [2]
  5. Quality control [2]
  6. High performance fiber reinforced concrete [2]
  7. High performance concrete in aggressiveenvironment [2]
  8. High performance concrete laboratory and on-sitepropertytests [2]
  9. Case studies in building construction [2]
  10. Case studies in infrastructure objects [2].
- Laboratory exercise:
  1. Determining the properties of high performance concrete components [2]

2. Mix design[2]
3. Testing fresh concrete properties[2]
4. Testingdurability properties[2]
5. Testing mechanical properties in hardened state[2].

- Student project:
  1. Seminar paper on high performance concrete mix design.

Student responsibilities:

- Attendance in lectures – minimum 75 %,
- Attendance in auditoryexercises– 100 %,
- Attendance in laboratory exercises–100 %,
- High performance concrete mix design seminar,
- Two pre-exams.

Grading and evaluation of student work over the course of instruction:

- Minimum 60 % score in each pre-exam,
- Positive grade of seminar paper.

End of semester grade:

- Oral exam.

Contributions to the final grade:

- Oral examination 70 %,
- Laboratory exercises and seminar 20 %,
- Attendance in lectures and exercises 10 %.

Required literature:

1. Nawy, E.,*Fundamentals of high-performance concrete*, Second edition, John Wiley&Sons, Inc., New York, 2001
2. Aitcin, P. C.,*High-Performance Concrete*, E&FN SPON, London, 1998
3. Caldarone, M.,*High-strength concrete*, Taylor and Francis, 2009
4. ACI SP-189,*High Performance Concrete: Research to Practice*, 1989
5. *Proceedings from the International Symposium on Ultra High Performance Concrete*

Optional literature:

1. Mehta P.K.,*Concrete, Structure, Properties and Materials*, New Yersey: Prentice Hall, Inc., Englewood Cliffs,1986
2. Neville, A.M.,*Properties of concrete*, fourth edition. Essex: Longman Group Limited,1995
3. Ukrainczyk, V.,*Concrete: structure, properties and technology*, Alcor, Zagreb, 2001, (in Croatian)
4. *Proccedings from the International Symposiums on Utilization of High Strengtth/High Performance Concretes*
5. *Proceedings from the International Symposium on High Performance Fiber Reinforced Cement Composites (HPFRCC)*

DESIGN OF EXPERIMENTS

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises: 30 (auditory - 12, design - 14, laboratory - 4)

Course objectives:

- Acquiring theoretical knowledge about the combined effect on structures (performances, environment, load),
- Acquiring practical knowledge about laboratory and field testings and their combination that simulate real life conditions,
- Acquiring knowledge about the procedures in planning investigations for professional and scientific purposes.

Entry competences (foreknowledge, descriptive):

- Knowledge about physical, chemical, mechanical and thermal properties of materials,
- Basic statistics.

Enrolment requirements (correlated courses):

- Teacher signatures: Non-destructive testing,

Requirements for examination taking (correlated courses):

- Teachers signatures: Non-destructive testing,

Learning outcomes:

- Ability to describe the effects (of loading) on materials and buildings,
- Ability to describe the mechanisms of environmental effects on materials,
- Ability to describe the testing methods for the properties of building materials with regard to various effects,
- Ability to design testing methods for assigned effects,
- Ability to compare the results of materials measurements,
- Ability to apply the testing results on builging materials.

Course content:

- Lectures:
    1. Introducton, goals, types and importance of testing [2]
    2. Modeling physical phenomena [4]
    3. Numerical solution and programming of physical models [2]
    4. Planning and developing experiments [4]
    5. Selection of experiment instruments [2]
    6. Statistical design of experiments [2]
    7. Design of measuring instruments [2]
    8. Electrical measuring of non-electrical measures [2]
    9. Computer aided automation of measuring [2]
    10. Virtual laboratory [2]
    11. An experiment example for professionaldly oriented investigations [2]
    12. An experiment example for scientifically oriented investigation [2]
    13. Research literature [2].
- Auditory exercises:
    1. Defining experiments [2]
    2. Selection of instruments [2]
    3. Instrument design for non-standardized testing [2]
    4. Examples for non-standardized measurements [2]
    5. Virtual laboratory [2],

- Design exercises:
  1. Task assignment – defining the problem (program) [2]
  2. Modeling physical-chemical processes [4]
  3. Selection of instruments [2]
  4. Computer aided automation of measuring [2]
  5. Data processing [2]
  6. Result analysis [2]
- Laboratory exercises:
  1. Laboratory standardized testings [2]
  2. Laboratory non-standardized testings [2].

Student responsibilities:

- Attendance in lectures – minimum 75%,
- Attendance in auditory, design and laboratory exercises – 100%,
- Program development,
- Pre-exam – minimum 50% score,
- One make up exam.

Grading and evaluation of student work over the course of instruction:

- Pre-exam 50%,
- Program 40%,
- Attendance in lectures and exercises 10%.

End of semester grading:

- Oral exam.

Contributions to the final grade:

- Grading during instruction 60%,
- Oral exam 40%.

Required literature:

1. Montgomery, D. C., *Design and Analysis of Experiments*, International Student Version, 7th Edition, Wiley, 2009

Optional literature:

1. Hicks, C. R., *Fundamental Concepts in the Design of Experiments*, Holt, Reinhart and Winston, Inc., 1973,
2. Ashby, M. F., Joneas, D. R. H., *Engineering Materials 1*, Butterworth-Heinemann, Oxford - Boston - Johannesburg - Melbourne - NewDelhi - Singapore, 1996

APPLIED METALLURGY

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises: 30 (auditory - 10, design - 20)

Course objectives:

- Expanding basic engineering knowledge about structural steels with the purpose of acquiring new knowledge in the field of proof of the reliability of steel structures, their manufacture and installation,
- Acquiring theoretical knowledge on manufacture of structural steels, their properties related to the selection of materials for relevant structures exposed to the specific conditions of use,

- Acquiring practical knowledge about the selection of relevant type and group of steels with respect to brittle fracture and resistance to lamellar splitting, i.e. to the application of European norm EN 1993-1-10,
- Acquiring theoretical basis for the estimate of durability of existing structures and quality assurance in construction of new structures.

Entry competences (foreknowledge, descriptive):

- Knowledge about basic manufacture methods and properties of steels,
- Basic knowledge about dimensioning of steel structures.

Learning outcomes:

- Ability to explain contemporary production methods and design of alloyed carbon seel products,
- Ability to explain advanced engineering properties of steel with the emphasis on toughess and material fatigue properties,
- Ability to apply knowledge and skills required for the selection of steel quality when designing structural elements of steel structures in various conditions of use according to contemporary methods and European norm criteria,
- Ability to explain and apply knowledge about the weldability of structural steels,
- Ability to apply specific skills and knowledge in steel structure design to avoid brittle fracture,
- Ability to explain the basics of advance fracture mechanics and asses the durability of structures.

Course content:

- Lectures:
  1. Indroduction [2]
  2. Properties of carbon steel alloys [2]
  3. Design and production methods [2]
  4. Introduction to engineering properties of steel [2]
  5. Advanced engineering properties of steel – toughness [2]
  6. Advanced engineering properties of steel – material fatigue properties [2]
  7. General information on types and qualities of steel [2]
  8. Selection of high-quality groups of steel [2]
  9. Selection of high-quality groups of steel to avoid brittle fracture – toughness requirements [2]
  10. High-quality groups of steel according to Eurocode 3 [3]
  11. Weldability of structural steels [3]
  12. Additional regulations on design with regard to avoiding brittle fracture [2]
  13. Assessment of fatigue (durability of structures) based on fracture mechanics [4].
- Auditory exercises:
  1. Determining engineering properties of steel [2]
  2. Determining mechanical properties of welds by testing hardness [2]
  3. Toughness at fracture [2]
  4. Selection of high-quality subgroup of steel with regard to maximum permitted thickness[1]
  5. Selection of high-quality subgroup of steel with regard to maximum permitted thickness based on the examples of structural elements on bridges [1]
  6. Additional design regulations with the purpose of avoiding brittle fracture [1]
  7. Selection of high-quality subgroup of steel with regard to the properties related to element thickness based on the examples of structural connections (joints) on bridges [1].
- Design exercises:
  1. Selection of high-quality subgroup of steel with regard to the maximum allowed thickness [1]

2. Selection of high-quality subgroup of steel with regard to maximum permitted thickness based on the examples of structural elements on bridges [3]
3. Additional design regulations with the purpose of avoiding brittle fracture based on the examples of structural connections [3]
4. Selection of high-quality subgroup of steel with regard to element thickness based on the examples of structural connections (joints) on bridges [7]
5. Assessment of fatigue (remaining service life) in existing steel structures based on the example of Ličanka bridge [4].

Student responsibilities:

- Attendance in lectures and exercises,
- Development of four programs,
- Pre-exam – minimum 25% score,
- One make up exam.

Grading and evaluation of student work over the course of instruction:

- Program grade,
- Attendance in lectures and exercises,
- Pre-exam.

End of semester grading:

- Written exam – task - minimum 50% score,
- Written exam – theory – minimum 50% score.

Contributions to the final grade:

- Programs 15%,
- Lectures 15%,
- Pre-exam 20%,
- Written exam, task, 20%,
- Written exam, theory, 30%.

Required literature:

1. G. Sedlacek et al., *Commentary and worked examples to EN 1993-1- Material toughness and through thickness properties and other toughness oriented rules in EN 993*, First Edition, September 2008,
2. Androić, B. (a group of authors), *Assessment of Existing Steel Structures: Recommendations for Estimation of Remaining Fatigue Life*, JRC Scientific and Technical Reports, Joint Report, JRC European Commission, February 2008,
3. Skejić, D., Androić, B., Dujmović, D., *Izvor čelika s obzirom na žilavost*, Građevinar 64 (2012) 10, pp. 805-815,
4. mimeographed lecture and exercise notes.

Optional literature:

1. McGannon, H. E., *The Making, Shaping and Treating of Steel*, 1985,
2. Brockenbrough, R. L., *Metallurgy Chapter 1.1, Constructional Steel Design, an International Guide*, 1992,
3. Leslie, W. L., *The Physical Metallurgy of Steels*, Washington, New York, London : Hemisphere Publishing Corporation, 1981,
4. Dahl, W., *Steel-Handbook of Materials Research and Engineering Vol. 1*, Duesseldorf : Springer-Verlag, 1990

NUMERICAL MATHEMATICS

Look in **Shared courses**

PERSPECTIVE

Look in **Shared courses**

BASICS OF DIFFERENTIAL GEOMETRY

Look in **Shared courses**

WAVES AND VIBRATIONS

Look in **Shared courses**

ENGLISH IN CIVIL ENGINEERING 2

Credit value (ECTS): 4.5

Number of hours (in semester):

- Exercises (auditory): 45

Course objectives:

- Developing skills in writing expert reports, CVs, summaries and information from technical fields,
- Independent presentations in foreign language.

Entry competences (foreknowledge, descriptive):

- English language competence on intermediate and upper intermediate level.

Learning outcomes:

- Understanding technical texts,
- Independent report writing on technical procedures and heir performance,
- Coherent and structured speking competence and clear presentation of ideas with accurate pronunciation,
- Using technical terms in efficient communication.

Course content:

- Auditory exercises:
  1. Environmental Engineering – Development & Scope [3]
  2. Wellspring of the High Plains – Ogallala Aquifer [3]
  3. Writing a Letter of Application / Job [5]
  4. Interview Questions and How to Master Them [5]
  5. The Secrets of Roman Concrete [3]
  6. Who Builds Big? – Interviews [5]
  7. Irrigation & Drainage Systems [3]
  8. Environmental Matters [3]
  9. Canals – Factfile about canal [3]
  10. Engineering – Falkirk Lock [3]
  11. Dams – Aswan High Dam – a Success or a Failure? [3]

12. Principal Construction Materials [3]
13. Stormwater and Floods [3].

Student responsibilities:

- Attendance in lectures – 75%,
- Developing a presentation,
- 3 pre-exams.

Grading and evaluation of student work over the course of instruction:

- By continous work during semester students can be made exempt from the whole exam or the part of it,
- Knowledge of each unit is checked in every class in oral and writeen form,
- Regular check of the adoption of professional vocabulary and competence in professional texts,
- Understanding texts, developing summaries, adopting grammar structures in professional language.

End of semester grading:

- Pre-exam results,
- Participation in lectures,
- Grammar checks,
- Translations into foreign language,
- Translations to Croatian language,
- Checks of professional vocabulary,
- Pre-exam – maximum 20 points (it is multiplied by 4),
- Grading:
  - 50 – 62 points = satisfactory (2),
  - 63 – 75 points = good (3),
  - 76 – 88 points = very good (4),
  - 89 – 100 points = excellent (5).

Required literature:

1. A. Kralj Štih, *English in Hydro Engineering and Constructio*n Materials, course materials, Zagreb, 2010

Optional literature:

1. M. Ibbotson, *Professional English in Use*, Cambridge University Press, 2011,
2. I. Williams, *English for Science and Engineering*, Thomson ELT, USA, 2007

GERMAN IN CIVIL ENGINEERING 2

Credit value (ECTS): 4.5

Number of hours (in semester):

- Exercises (auditory): 45

Course objectives:

- Developing reading and writing skills for independent use of professional literature,
- Developing communication skills for discussions, oral presentations etc. In technical fields.

Entry competences (foreknowledge, descriptive):

- Intermediate and upper intermediate level of German language (B 1, B 2).

Learning outcomes:

- Understanding and interpretation of technical texts,
- Independent oral communication in technical areas,
- Ability to define expert terms,
- Writing CV and job application.

Course content:

- Auditory exercises:
  1. Bauplanung und Bauablauf
     - 1.1. Projektmanagement im Ingenieurbau [2]
     - 1.2. Bauhandwerk und Bauindustrie [2]
     - 1.3. Die Geschichte einer Renovierung [2]
  2. Beton – Stahlbeton – Spannbeton
     - 2.1. Holz [3]
  3. Eine Brücke wandert
     - 3.1. Konstruktion nach einem Modell [2]
     - 3.2. Bauen und Heben im Takt [2]
  4. Das Beispiel eines Damms [3]
  5. Jobsuche und Berufswelt
     - 5.1. Wie schreibt man korrekt eine E-Mail [1]
     - 5.2. Bewerbungsschreiben- ein Musterbrief [2]
     - 5.3. Ein Lebenslauf [2]
     - 5.4. Intervju – Training [2]
  6. Porträts der Bauingenieure
     - 6.1. Das Portrait einer Bauingenieurin – Nadia [2]
     - 6.2. Das Portrait einer Bauingenieurin – Monika [2]
     - 6.3. Bernard Schirm [2]
     - 6.4. Berufswelt Bau – Kämpfernaturen gesucht [3]
     - 6.5. Ein Tag im Leben eines Bauingenieurs [3]
  7. Stellenanzeigen
     - 7.1. Vertriebsleiter [1]
     - 7.2. Bauleiter [1]
     - 7.3. Versorgungsingenieur [1]
     - 7.4. Bauleiter (Rohbau) [1]
     - 7.5. Konstruktiver Ingenieurbau [1]
     - 7.6. Verkehrsrichtung [1]
     - 7.7. Bauleiter [1],
  8. Filme
     - 8.1. Was machen Ingenieure? [1]
     - 8.2. Bauingenieure gesucht [1]
     - 8.3. Beruf Dachdeckerin [1]
     - 8.4. Wie sind Ingenieure? [1]

Student responsibilities:

- Attendance in exercises - 75%,
- Developing a presentation,
- Three pre-exams.

Grading and evaluation of student work over the course of instruction:

- By continous work during semester students can be made exempt from the whole exam or the part of it,
- Knowledge of each unit is checked in every class in oral and writeen form,
- Regular check of the adoption of professional vocabulary and competence in professional texts,
- Understanding texts, developing summaries, adopting grammar structures in professional language.

End of semester grading:

- Pre-exam results,
- Participation in lectures,
- Grammar checks,
- Translations into foreign language,
- Translations to Croatian language,
- Checks of professional vocabulary,
- Pre-exam – maximum 20 points (it is multiplied by 4),
- Grading:
  - 50 – 62 points = satisfactory (2),
  - 63 – 75 points = good (3),
  - 76 – 88 points = very good (4),
  - 89 – 100 points = excellent (5).

Required literature:

1. A. Kralj Štih, *Deutch für Bauwirtschaft un Bauleitung, Hydrotechnik un Baustoffe*, Kursunterlagen, 2011

Optional literature:

1. A. Prager, *Trojezični građevinski rječnik*, Masmedia, Zagreb, 2002

CONSTRUCTION MANAGEMENT

1st year, 1st semester

Compulsory courses

RESEARCH METHODS

Look in **Shared courses**

CONSTRUCTION MANAGEMENT 2

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises: 28 (auditory - 10, design - 18)
- Seminars: 5
- E-learning: 120

Course objectives:

- Ability to apply advanced construction management tools and skills to construction processes and projects,
- Ability to formulate a concept and select the most appropriate alternative for construction processes,
- Developing a special competence in calculation and estimation of construction cost, use of IT applications in construction management, organization of the procurement process and development of organizational models.

Entry competences (foreknowledge, descriptive):

- Bachelor degree in civil engineering.

Learning outcomes:

- Theoretical and practical knowledge about the advanced methods in construction management processes, e.g.: theory of relevant cost items in construction projects, various cost calculation methods in construction project, cost estimation in construction projects, different procurement routes, value management etc…

Course content:

- Lectures:
  1. Introduction [2]
  2. Drafting alternative solutions in construction management [2]
  3. The theory of significant cost items [2]
  4. Methods of direct calculation of construction processes [2]
  5. Cost calculation by software applications – trends [2]
  6. Time/schedule versuscost in construction projects [2]
  7. Value management in construction projects [2]
  8. Developing work and organization breakdown structures [3]

9. Procurement in construction processes [2]
10. Organization structures and contract management in construction [3]
11. The concept of buildability [2]
12. Multicultural and global environment affects on construction [2]
13. Building Information Management [2]
14. New trends in construction management [2].

- Exercises:
  1. Alternative solutions of construction
  2. Technology alternatives
  3. Technology flowcharts
  4. Significant cost item calculation
  5. Direct cost calculation
  6. Organization breakdown Structure
  7. Work breakdown structure
  8. Construction organizational concept
  9. Modeling Building Information
- (Seminars:)
  1. Current trends in construction management

Student responsibilities:

- 80 % attendance in lectures and exercises,
- Seminar assignment completed and successfully presented.
- Two pre-exams.

Grading and evaluation of student work over the course of instruction:

- Participation in lectures and exercises during semester,
- Doing and presenting the seminar assignment.
- Students with minimum 60% score in pre-exams are exempt from the exam.

End of semester grading:

- Written exam (minimum 50% score),
- Oral exam.

Contributions to the final grade:

- Score in two preliminary exams,
- Grade in the seminar assignment,
- Grade in seminar assignment and oral exam.

Required literature:

1. Radujković, M.,*Construction management II*, lectures – hard copy of PPT slides, University of Zagreb, 2008,
2. Marušić , J.,*Construction management*, University of Zagreb, 1994,
3. Lončarić, R*., Organization of execution construction projects*, HDGI, Zagreb, 1995,
4. Radujković M., Burcar I., Vukomanović M.,*Solved assignment examples from Construction mangement I and Scheduling methods*, University of Zagreb, FCE, 2008,
5. Radujković M., Izetbegović J., Nahod M..M., *Construction law regulation*, University of Zagreb, 2008

Optional literature:

1. Radujković, M et. al.,*Planning and control of project*, University of Zagreb, 2012,
2. Vukomanović, M. and Radujković, M,*Business excellence in construction industry*, University of Zagreb, 2011,
3. Harris, F; McCaffer, R. and Edum-Fotwe, F.,*Modern Construction Management*, 7th Edition, Willey, 2013

BUILDING MAINTENANCE MANAGEMENT

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures: 30 hours
- Exercises: 15 hours/ Project assignments
- E-learning: All students participate in discussion groups on assigned topics

Course objectives:

- Developing students' knowledge about the building maintenance management, and its economic and social significance. The course covers building failures inspection, maintenance standards, maintenance planning and building maintenance project design. Particular emphasis is on choosing the appropriate building maintenance strategy using different multi-criteria analyses. Student learn how to use IT support for setting priorities in building maintenance management. The impact of climate change on building maintenance planning with respect to energy efficiency standards is introduced.

Learning outcomes:

- Ability to identify failures on a building using different inspection methods,
- Ability to choose an appropriate building maintenance strategy,
- Ability to prepare building maintenance project documentation,
- Ability to make the priority list of maintenance works using multi-criteria analysis,
- Ability to use commercial computer program „Expert Choice“ in decision making processes,
- Ability to design building repair and maintenance plan according to energy efficiency standards,
- Developing building maintenance management of corporate building portfolios.

Course content:

- Lectures:
  1. Introduction to building maintenance management [2]
  2. Maintenance management regulations [2]
  3. Regular maintenance, reconstructions and repairs [2]
  4. Maintenance management strategies [4]
  5. Planning and organisation of maintenance works [4]
  6. Maintenance of listed buildings [2]
  7. Models for setting priorities in building maintenance [4]
  8. IT support for decision making in setting priorities in building maintenance [2]
  9. Energy efficiency and building maintenance [2]
  10. Building maintenance management and facilities management: interconnections [4]
  11. The role of maintenance management in corporate real estate management [2].
- Exercises:
  1. All students are obliged to complete project assignments in 15 hours + homework.

Student responsibilities:

- Attendance in lectures and exercises,
- Completion of project assignments.

Grading and evaluation of student work over the course of instruction:

- Two pre-exams.

End of semester grading:

- Final written exam.

Contributions to the final grade:

- Written exams,
- Completion of project assignments,
- Active participation in discussion groups.

Required literature:

1. Ceric, A., *Building Maintenance Management Textbook*, 2012
2. Lee, R. *Building Maintenance Management*, Oxford, Blackwell Science, 1987
3. Chanter, B. and P. Swallow, *Building Maintenance Management*, Oxford, Blackwell Science, 1996
4. Barrett, P., *Facilities Management*, Oxford, Blackwell Science, 2000

Optional literature:

1. Mills, E., *Building Maintenance & Preservation*, Oxford, Architectural Press, 1996
2. R. Flanagan and C. Jewell, *Whole Life Appraisal for Construction*, Oxford, Blackwell Science, 2005
3. Pfüner, A., *Moderni menadžment nekretnina: Facility Management and Corporate Real Estate Management*, Koraci: Zagreb, 2005 (translation from Germany)

OPTIMISATION METHODS IN CONSTRUCTION

Credit value (ECTS): 6

Number of hours (in semester):

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

Course objectives:

- Acquisition of knowledge on methods of operation research and their application in optimisation of organisation and technology in construction,

Entry competences (foreknowledge, descriptive):

- Understanding the basics of organisation and technology in construction, linear algebra, mathematical statistics.

Learning outcomes:

- Ability to solve the problem of linear programing using graphics and simplex method,
- Ability to solve the problems of dynamic deterministic and probabilistic programming,
- Ability to use the methods of decision making under certainty, under risk and under uncertainty,
- Ability to create Monte Carlo simulation.

Course content:

- Lectures:
  1. Introduction [2]
  2. Models of linear programing with two variables, graphical solution, graphical sensitivity analysis [2]
  3. Transition from graphical to algebraic solution [2]
  4. Artificial starting solutions [2]
  5. Definition of the dual problem, primal – dual relationship [2]
  6. Post-optimal and sensitivity analysis[2]
  7. Transportation models and network models [2]
  8. Deterministic dynamic programming [2]
  9. Deterministic inventory models [2]

10. Nonlinear programing [2]
11. Decision making under certainty, decision under risk, decision under uncertainty [2]
12. Probabilistic dynamic programing [2]
13. Probabilistic inventory models, queuing systems [2]
14. Monte Carlo simulation, generation of random numbers [2]
15. Simulation languages [2].

- Exercises (auditory):
    1. Graphical solution[2]
    2. Simplex method [2]
    3. Graphical solution [2]
    4. Artificial starting solution, special cases in simplex method application [2]
    5. Definition of the dual problem, primal – dual relationship, interpretation of duality [2]
    6. Post-optimal analysis and sensitivity analysis [2]
    7. Transportation problems and network models [2]
    8. Deterministic dynamic programing, deterministic inventory models [2]
    9. Nonlinear programming [2]
    (pre-exam)
    10. Decision making under certainty, decision under risk, decision under uncertainty[2]
    11. Probabilistic dynamic programming, probabilistic inventory models, queuing systems [2]
    12. Monte Carlo simulation, generation of random numbers[2]
    13. Simulation languages[2]
    (pre-exam)

Student responsibilities:

- Attendance in lectures and exercises,
- 2 pre-exams – minimum 25% score in each.
- A make up exam.

Grading and evaluation of student work over the course of instruction:

- Students with minimum 60% score in each pre-exam are exempt from the written part of the exam.

End of semester grading:

- Written exam – minimum 50% score,
- Oral exam.

Contributions to the final grade:

- Pre-exams or written exam60%,
- Oral exam 40%.

Required literature:

1. Z. Lukač, L. Neralić*, Operacijskaistraživanja*, Element, Zagreb, 2012
2. D. Kalpić, V. Mornar,*Operacijskaistraživanja*, Zeus, Zagreb, 1996

Optional literature:

1. Lj. Martić: *Matematičkemetodezaekonomskeanalize II*, Narodnenovine, Zagreb, 1965
2. W. Jurecka, H.J. Zimmermenn,*Operation Research in Bauwesen*, Springer Verlag, 1972
3. N. Limić,*Linearnoinelinearnoprogramiranje*, Informator, Zagreb, 1978
4. V. Čerić,*Simulacijskomodeliranje*, Školskaknjiga, Zagreb, 1993
5. V. Žiljak,*Simulacijaračunalom*, Školskaknjiga, Zagreb, 1982
6. H.A. Taha: *Operations research*, Prentice Hall, 2003

STUDY OF WORK

Credit value (ECTS): 4.5

Number of hours (in semester):

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

Course objectives:

- Mastering the methods and techniques of study of work which may increase the productivity in construction.
- Enhancing theoretical knowledge about: organization of work, theories of organization, development of management, building, application of IT in construction, administration of construction projects, managerial approach to project management, human resources management, rationalization in construction projects, organization and preparation of construction production, organizational design.

Entry competences (foreknowledge, descriptive):

- Knowledge about the following major technological processes in construction: earthworks, carpentry work, concrete work, reinforcement work, reinforcement of concrete work, masonry, asphalt works, hydrotechnical work.
- Computer literacy.

Learning outcomes:

- Knowledge about the methodological procedures in the preparation of the study of work,
- Mastering the calculation of building standards through the application of methods of work-study,
- Application ofsimulation methodsinconstruction.

Course content:

- Lectures:
  1. Work organization: Historical development of work organization. Development of Construction. Organization of work. Four Taylor's principles. The principles of work organization. Future studies of work. Two basic fields in development of the science of work. The organization of production: Concept of production. Objectives of production. Scientific discipline of the production. Five typical stages in the development of production [3]
  2. The development of the theory of organization: Disadvantages in classical approach to the organization. The neoclassical theory of organization. Modern theories of organization. A systematic approach to the theory of organization. Theories of general management: Newer contributes to the development of general management. Development of general management. Three recent approaches to the development of general management. Criticism of the new theories of general management [3]
  3. Construction production as construction industry. The characteristics and limitations of the development of civil engineering and construction. Construction in "a broader sense." Construction in the "narrow sense ". Technological processes in production. Work study and productivity. Distribution of technological processes. The basic structure of technological process. The indicators of technological process. The capacity of technological systems. Information in construction: Management of construction. General development of modern information technology and information systems in construction companies. Execution of construction projects: The life cycle of construction endeavour. Regulatory models of construction projects. Regulatory Model in preparation for construction. Regulatory Model in defining projects. Project management: Students are instructed to use the literature [3]
  4. Human resources in production: Man in construction. The psychological effects on man. Psychology of work. The person in psychology. Important psychological traits building. Important psychological methods in the study of man as a person [3]

5. The physiological effects on humans. Sociological influences on man. Impacts of the working environment on people [3]
6. Rationalization of production. Modeling of construction production. The procedures for construction production rationalization. The algorithm for the rationalization of construction production [3]
7. The organization of construction: Preparation of construction. Terms of reference for the preparation of construction production. The tasks in the preparation of production. The methodological approach in the design of production preparation. Modeling future production and construction products. Design approach preparation of construction production. Simulation of construction: Definition of simulation. The application of the most popular simulation methods (Queuing theory , Monte Carlo method , the software package Micro - Cyclone , stroboscope and EZStrobe) [3]
8. Organization design (aspects and applications in construction industry) : Introduction and philosophy of multidisciplinary design: a methodological approach to design: systems thinking , system engineering, system dynamics. Planning, construction and engineering design: Integration. Phase and a parallel model multidisciplinary design. Planning based on multiple scenarios [3].

- Exercises (auditory, design):
  1. Auditory presentation of systematic analysis of a complex technological process of building production. Students divided in working groups do problem-solving [3]
  2. Auditory display standardization methods of construction production. Students numerically solve individual piece of work in the field of standardization of building industry [3]
  3. Students learn about the possibilities of using all the available simulation programs: EZStrobe - one example of its application in the construction operational [3]
  4. The conclusion of the course and final consultations with students.

     Attending lectures and exercises in a computer laboratory at the Department of Construction Management (212 classrooms).
- Seminars:
  1. If student want to improve their final grade, they can write a paper,
  2. The paper should be presented and defended before the course teacher and fellow students,
  3. Only in case of more than 10 applicants wanting to write a paper, the presentation can be done electronically on the official Internet site of the Faculty.

Student responsibilities:

- Attendance in lectures and exercises,
- Doing four construction exercises,
- Pre-exams in college computer lab.

Grading and evaluation of student work over the course of instruction:

- Assessment of four assigned tasks,
- Two pre-exams,
- Positive attitude to the preparation and presentation of research papers.

End of semester grading:

- Pre-exams,
- Design exercises,
- Term paper or
- The final exam on the course content.

Contributions to the final grade:

- Oral exam.

Required literature:

1. J. Izetbegović, V. Žerjav, O*rganizacija građevinske proizvodnje*, Hrvatska udruga za organizaciju građenja i Građevinski fakultet Sveučilišta u Zagrebu, Zagreb, 2009

2. J. Izetbegović,*Proučavanje graditeljske proizvodnje*, GF-Zagreb, 200., http://www.og.grad.hr
3. I. Tunjić, An excerpt from a graduation thesis, titled *Optimisation of construction production*, defended in September 2011 at The Faculty of Civil Engineering, Zagreb, mentor J. Izetbegović (*EZStrobe mogućnosti modela, preuzeto sa internetske stranice* www.ezstrobe.com).

Optional literature:

1. V. Žerjav, Process- *and Project-Level Issues of Design Management in the Built Environment* doctoral thesis, Vienna University of Technology (http://www.ub.tuwien.ac.at/diss/AC07812616.pdf, 2012
2. J. Marušić,*Organizacija građenja*, university textboo, FS, Zagreb, 1994,
3. D. Taboršak,*Studij rada*, Orgdata, Zagreb,1994

Elective courses

MATHEMATICS 3

Look in **Shared courses**

STOHASTIC PROCESSES

Look in **Shared courses**

1st year, 2nd semester

Compulsory courses

CONSTRUCTION EQUIPMENT

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises: 26 (auditory - 10, design – 16)
- Seminars: 4
- E-learning: 120

Course objectives:

- Understanding the basic concepts ofconstruction machinery, and classes and particular types of machines and their characteristics.

Entry competences (foreknowledge, descriptive):

- Bachelor degree in civil engineering.

Learning outcomes:

- Knowledge about construction machines for earth works and other types of engineering construction,

- Ability to estimate the efficiency of different types of machines,
- Ability to organize and plan machinery.

Course content:

- Lectures:
  1. Selection and planning the operation of construction machines[1]
  2. Selection and application of construction machinery, selection of machines[1]
  3. Application of machinery for earth works[1]
  4. Logistics of construction works[2]
  5. Logistics, elements of logistics, construction transportation, complexity of logistics[2]
  6. Problems in logistics, solving the problems in logistics[2]
  7. Working system of construction work and plants[2]
  8. Working system construction machines[2]
  9. Construction machines reliability system[2]
  10. Working system construction plants[2]
  11. Construction machines maintenance[2]
  12. Productivity of construction machines and transportation machines in the building process[2]
  13. Work and technological processes[2]
  14. Time classification of machinery working cycles[2]
  15. Efficiency of machinery and earth works transportation systems[2]
  16. Construction machines under the conditions of usage, analyses of construction machines usage[1]
  17. Working time losses, exchange of construction machines[1]
  18. Procurement of construction machines[1].
- Exercises (auditory, design, laboratory):
  1. Section of the equipment[4]
  2. Designing machine systems[4]
  3. Calculation of the efficiency[4]
  4. Calculation of equipment cost[4]
  5. Calculation of equipment reliability [4]
  6. Alternatives in machine systems[6]
- Seminars:
  1. Current trends in construction equipment: procurement, maintenance, operation, optimization and IT systems.

Student responsibilities:

- 80 % attendance in lectures and exercises,
- Completed and presented work assignment.

Grading and evaluation of student work over the course of instruction:

- Positive attitude during the semester,
- Reaching deadlines for work assignments,
- Presentation quality of seminar assignments.

End of semester grading:

- Two pre-exams,
- Work assignment and 1 presented seminar paper
- Or final written and oral exams.

Contributions to the final grade:

- Two pre-exams,

- Work assignment grade,
- Seminar and oral exam grades.

Required literature:

1. Linarić, Z, *Leksikon strojeva i opreme za proizvodnju građevinskih materijala*, University of Zagreb, 2011
2. Linarić, Z., *Učinci strojeva i vozila pri zemljanim radovima*, Biblioteka Mineral, Business Media Croatia d.o.o., Zagreb, 2008
3. Eduard S., *Strojevi u građevinarstvu*, Hrvatsko društvo građevinskih inženjera, Zagreb, 1995
4. Žaja, M.*, Ekonomika proizvodnje*, Školska knjiga, Zagreb, 1991

Optional literature:

1. Harris, F; McCaffer, R. and Edum-Fotwe, F.,*Modern Construction Management*, 7th Edition, Willey, 2013

MANAGEMENT FOR THE CONSTRUCTION INDUSTRY

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures: 30
- Exercises (auditory): 8
- Seminars: 7
- E-learning: 2nd level

Course objectives:

- Gainingtheoreticalknowledgeabout the basicprinciplesof management, project managementandbusiness decision making,
- Understanding theconcept ofcompanies, business activities, business resultsandthe concept ofmarket.

Entry competences (foreknowledge, descriptive):

- Basic knowledge about the basicsof economyinthe courseBusiness economics(elective course inthe first yearof undergraduatestudies).

Learning outcomes:

- Understanding the purpose and key concepts of management (vision, mission statement, the role and functions of managers/ project managers,
- Understanding the role and the relevance of management and its participants,
- Learning about business decision making,
- Understanding the functioning of the market,
- Ability to direct business processes,
- Mastering the skills of analytical thinking and presenting the facts through seminar papers,
- Communicating complex ideas concisely and clearly in written form.

Course content:

- Lectures:
    1. Basic principles of management
        - 1.1. Introduction [2]
        - 1.2. Who are Managers?[2]
        - 1.3. Management functions[2]

1.4. A Management development[2]
1.5. Schools of Management[2]

2. Management as a Process
   2.1. Planning[2]
   2.2. Organizing[2]
   2.3. Leading[2]
   2.4. Controlling[1]
3. Business decision making
   3.1. Defining decision making[1]
   3.2. Process of decision making[1]
   3.3. Styles and modes of decision making[1]
   3.4. Methods of decision making[1]
   3.5. Communication in business decision making[1]
4. Basics of management organization
   4.1. Companytypes[1]
   4.2. Basics of reproduction process[1]
   4.3. Business assets[1]
5. Costs, price and price calculation[1]
6. Business results
   6.1 Financial reports [1]
   6.2 Business success measures (cost-effectiveness, productivity, profitability)[1]
7. Project management[1]
8. Economic system and its surroundings[1]

- Auditory exercises :
  1. How to write an essay ?
  2. How to make a presentation?
  3. *Who are leaders?*
  4. Movie – *Decision, decision*
  5. Movie – *Project management*
- Seminars:
  1.-7. Students presenting seminar papers– discussion.

Student responsibilities:

- Attendance in morethan 75% of lectures,
- Minimum 25% score in each of thethree pre-exams,
- Writing and presenting a seminar paper,
- Using*Merlin*.

Grading and evaluation of student work over the course of instruction:

- Writing and presenting a seminar paper,
- Three pre-exams(students who earn in every pre-exam minimum 3 are exempt from the written part ofthe exam, students who earn in every pre-exam minimum grade4 are exempt from the entire exam).

End of semester grading:

- Written exam,
- Oral exam.

Contributions to the final grade:

- Pre-exams75%,
- Seminar paper 15%,
- *Merlin*10%

Required literature:

1. Mariza Katavić, *Osnove ekonomike za graditelje*, Hrvatska sveučilišna naklada, Zagreb, 2009,
2. Lecture notes (handouts on *Merlin*).

Optional literature:

1. H.Weihrich, H.Koontz, *Menadžment*, (10th ed.) MATE d.o.o. ,Zagreb, 1998,
2. Stephen Lavender, *Management for the Construction Industry*, Longman and The Chartered Institute of Building, Elookx, England 1996

CONSTRUCTION PROJECT MANAGEMENT

Credit value (ECTS): 9

Number of hours (in semester):

- Lectures: 60
- Exercises: 25 (auditory - 10, design - 15)
- Seminars: 5
- E-learning: 180

Course objectives:

- Theoretical knowledge about technical, contextual and personal skills necessary for the project management process.
- Special competences in project management knowledge areas such as: forming project teams and coalition, stakeholder management, conflict management, risk and change management, communication management and quality management.
- Introduction to multidisciplinary aspects of project management in every day engineering processes,
- Understanding the basic methodologies and tools that can be used when managing projects,
- Insight into practical cases in order to simulate real life scenarios
- Understanding the profession of 21st century – being a project manager.

Entry competences (foreknowledge, descriptive):

- Bachelor degree in civil engineering.

Learning outcomes:

- Theoretical and practical knowledge about project management, according to key international standards, e.g.: strategies, objectives, deliverables, project life cycle, interested parties, critical success factors, success criteria, project management during the definition and execution phase, project manager, teamwork, risk management, change management, human resource management, quality management, time management, cost management, total quality management, communicat
- ion, information management, etc
- Competence in applying advanced tools and skills in project management to construction projects.
- Knowledge necessary to act as project managers throughout project lifecycle

Course content:

- Lectures:
    1. Introduction [4]
    2. Fundamentals of Project management [4]
    3. Project management in concept and definition phase [4]
    4. Project management in execution phase [4]
    5. Project manager [4]
    6. Teamwork [4]
    7. Risk management [4]
    8. Change management [4]
    9. Human Resource management [4]
    10. Cost/Time/Quality management [4]
    11. Communication in construction projects [4]
    12. Knowledge and contract management [4]
    13. International Project Management Standards/methodologies/approaches [4]
    14. Strategic Management and Project Management [4]
    15. New trends in project management [4].
- Exercises (auditory, design):
    1. Designing the concept phase [3]
    2. Designing the planning phase [3]
    3. Designing the execution phase [3]
    4. Designing the turnover phase [2]
    5. Designing Project manager development plan [2]
    6. Teamwork stages and team building assignments [2]
    7. Risk management plan [2]
    8. Change management process concept [2]
    9. Designing communication plan [2]
    10. Designing an integrated Strategic Performance Management systems [2]
    11. Designing project management plan [2].
- (Seminars:)
    1. Seminar I:technical competences in project management,
    2. Sseminar II:behavioral competences in project management,
    3. Seminar III: international project management standard/methodology.

Student responsibilities:

- 80 % attendance in lectures and the exercises,
- Work assignment completed,
- Successfully presented seminar paper.

Grading and evaluation of student work over the course of instruction:

- Active participation,
- Meeting deadlines with work assignments,
- Quality presentations of seminar papers.

End of semester grading:

- Three pre-exams,
- Work assignment and 3 presented seminar papers,
- Or the final written and oral exam at the end of semester.

Contributions to the final grade:

- Three pre-exams,
- Work assignment grade,
- Seminar paper grade,
- Oral exam.

Required literature:

1. Radujković, M et. al, *Planning and control of project0073*, University of Zagreb, 2012
2. Vukomanović, M. and Radujković, M.,*Business excellence in construction industry*, University of Zagreb, 2011
3. Lončarić, R.,*Organization of execution construction projects*, HDGI, Zagreb, 1995
4. IPMA: *IPMA Competence Baseline 3.0*., International Project Management Association, Van Haren Publishing, 2006
5. PMI: *A guide to the Project Management Book of Knowledge*, 4th Edition, 2008
6. Stationery Office; *An introduction to PRINCE2: managing and directing successful projects*, The Stationery Office Series 2009.
7. APM; *APM Body of Knowledge 6th edition*, APM Publishing, 2012

Optional literature:

1. Radujković M., Izetbegović J., Nahod M.M., *Construction law regulation*, University of Zagreb, 2008
2. Radujković, M.: *Construction management II*, lectures – hard copy of PPT slides, University of Zagreb, 2008
3. Radujković M., Burcar I., Vukomanović M., Solved *assignment examples from Construction mangement I and Scheduling methods*, University of Zagreb, FCE, 2008
4. Marušić , J.,*Construction management*, University of Zagreb, 1994
5. Harris, F; McCaffer, R. and Edum-Fotwe, F.,*Modern Construction Management*, 7th Edition, Willey, 2013
6. Kerzner, H.,*Project Management: A Systems Approach to Planning, Scheduling, and Controlling* 10th edition, Willey, 2009

Elective courses

ENVIRONMENTAL PROTECTION

Look in **Hydraulic Engineering**

ENGLISH IN CIVIL ENGINEERING 2

Credit value (ECTS): 4.5

Number of hours (in semester):

- Exercises (auditory): 45

Course objectives:

- Developing skills in writing expert reports, CVs, summaries and information from technical fields,
- Independent presentations in foreign language.

Entry competences (foreknowledge, descriptive):

- English language competence on intermediate and upper intermediate level.

Learning outcomes:

- Understanding technical texts,
- Independent report writing on technical procedures and heir performance,
- Coherent and structured speking competence and clear presentation of ideas with accurate pronunciation,
- Using technical terms in efficient communication.

Course content:

- Auditory exercises:
  1. Civil Engineering – Subspecialties [2]
  2. A Day in the Life of a Construction Manager [2]
  3. Mission to Accomplish [2]
  4. Projects [2]
  5. Creating a CV – How to write a CV? [2]
  6. Writing a letter of application [2]
  7. Design Solutions [3]
  8. Job Interview Questions [2]
  9. 1st colloquium [2]
  10. Tender Action [3]
  11. Professional Development [3]
  12. Planning and building Permission [2]
  13. Preparing for the Interview Skills – Techniques, Tips and Advice [2]
  14. Selection of Contractors [2]
  15. Single presentations – Case studies [2]
  16. 2nd colloquium [1]
  17. Career Job Hunting – avoiding potential job (interview) disasters – Tips and Advice [2]
  18. Joint presentations [2]
  19. The Company [2]
  20. Formal and Informal Meetings [2]
  21. Construction Site Organization – vocabulary [2]
  22. 3rd pre-exam [1]

Student responsibilities:

- Attendance in lectures – 75%,
- Developing a presentation,
- 3 pre-exams.

Grading and evaluation of student work over the course of instruction:

- By continous work during semester students can be made exempt from the whole exam or the part of it,
- Knowledge of each unit is checked in every class in oral and writeen form,
- Regular check of the adoption of professional vocabulary and competence in professional texts,
- Understanding texts, developing summaries, adopting grammar structures in professional language.

End of semester grading:

- Pre-exam results,
- Participation in lectures,

- Grammar checks,
- Translations into foreign language,
- Translations to Croatian language,
- Checks of professional vocabulary,
- Pre-exam – maximum 20 points (it is multiplied by 4),
- Grading:
    - 50 – 62 points = satisfactory (2),
    - 63 – 75 points = good (3),
    - 76 – 88 points = very good (4),
    - 89 – 100 points = excellent (5).

Required literature:

1. Alemka Kralj Štih, *English for Construction Management*, course materials, Zagreb, 2011

Optional literature:

1. Williams, *English for Science and Engineering*, Thomson ELT, USA, 2007,
2. V. Lambert, W. Murray, *Everyday Technical English,* Essex, 2003,
3. V. Hollet, *Tech Talk,* Oxford, 2005

GERMAN IN CIVIL ENGINEERING 2

Look in **Construction Materials**

CONSTRUCTION TECHNOLOGY 1

Credit value (ECTS): 6 ECTS

Number of hours (in semester):

- Lectures:45
- Exercises: 30 (auditory - 6, design - 24)
- E-learning: 100% of lectures and examination is supported with e-learning but it is not normalized

Courseobjectives:

- Introduction to thetechniquesandtechnologiesofearthworksinsoilandrock, logisticsandtechnologyof construction waste, equipment for recyclingof construction waste, techniqueandtechnologyofblastingworks, earthworksandprotectionofbuildings, excavations beneaththesurface, tunneling, pipework.
- Ability to understand that help in real situations about construction technology for earth works should be asked from the professionals in the area of construction management.

Entry competences (foreknowledge, descriptive):

- Familiarity with specific literature, prior knowledge, skills or participation in preparatory modules of Bachelor degree program (area: Technology of heavy construction).

Learningoutcomes:

- Recognitionoftheterrainandtheproperselectionofmachines for work,
- Determining themachines for demolitionandrecyclingfacility,
- Identifying the issues of work anddetermining thetechnology and techniqueofundergroundworks on pipelines,

- Identifying theissuesanddetermining the type andthedimensionoftechnologyandtechniqueof work on theexcavationofthetunnel,
- Determining themethodanddimensionofblastingoperations at thequarry.

Coursecontent:

- Lectures:
  1. Introduction. Principle of module study (principle of teaching, learning and examination of the module). Review of literature [3]
  2. Technique and technology of earthworks in soil and rock, construction technique and technology[3]
  3. Excavation in soil and rock. Transportation of earth material and embankment works [3]
  4. Preliminary (pre)works (pre-production activities) for earth works, preliminary works (pre-production activities) for construction. Logistic of stone-ware[3]
  5. Technique, technology and logistic of construction waste treatment. Environmental protection. Construction waste. Collecting of construction waste. Construction waste recycling. Use of recycled construction material[3]
  6. Technique and Technology of rock blasting. Mining (rock blasting) works. Explosives, detonators, fuse and cord. NONEL – system detonate. Blasting theory. Planning of blasting works. Perimeter blasting[3]
  7. Technique and Technology of stone-ware production. Production of construction materials for embankment structures. Crushing and crusher. Screening. Screens surface calculation. Aggregate washing. Mobile crushing and screening plants[3]
  8. In site lecture of earthworks (or recycling or blasting or stone-ware production)) [3]
  9. Protection of earthworks and structures. Ground and soil stable and consolidation. Jet-grouting. Protection of excavation structures perimeter (slope)[3]
  10. Trench-channel slope system of protection. Protection of construction site hole or basin slope. Diaphragm wall[3]
  11. Technique and Technology of underground excavations. Technique and Technology of Underground Excavations. NATM (New Austrian Tunneling Method) TBM (Tunnel Boring Machines). Technique and technology of buried pipelines („micro tunneling“)[3]
  12. In site lecture of earthworks and structures protection or tunneling[3]
  13. Selection and planning of technique and technology for earthworks[3]
  14. Productivity of equipment and transportation for earthworks. Earth work costs. Planning of technique and technology for earthworks[3]
  15. Timetable and program (contents) of construction (design) practice for students [3].
- Exercises (auditory, design, laboratory):
  1. Design of construction technology based on case study.

Student responsibilities:

- Attendance in minimum 75% lecturesand 100% exercises,
- Minimum 25% score in the pre-exam,
- Case study.

Grading and evaluation of student work over the course of instruction:

- 3 pre-exams, one make up exam,
- A case study.

End of semester grading:

- Oralexam

Contributions to thefinal grade:

- The finalscoreis theaveragescore earned in all three pre-exams and the presentation of the case study.

Required literature:

1. Coursehandoutsavailable on e-learning system
2. Božić, B., *Miniranje u rudarstvu, graditeljstvu I geotehnici*, UdžbeniciSveučilišta u Zagrebu, Geotehničkifakultet u Varaždinu, Varaždin, 1998,
3. Ester, Z.,*Miniranje I,eksplozivnetvari, metode I svojstvaispitivanja*, UdžbeniciSveučilišta u Zagrebu, RGN fakultet, Zagreb, 2005,
4. Linarić, Z., *Leksikonstrojeva I opremezaproizvonjugrađevinskihmaterijala. Učincizastrojeve I vozilaprizemljanimradovima*, biblioteka Mineral, Business Media Croatia, Zagreb, 2007,
5. Linarić, Z.: *Postrojenjazaproizvodnjusipkih I povezanihmineralnihgradiva. Drobilane.Tvornicebetona.Asfaltnebaze,* biblioteka Mineral, Bussines Media Croatia, Zagreb, 2009,
6. Roje-Bonacci, T.,*Potpornegrađevine I građevinskejame*, Građevinsko-arhitektonskifakultet u Splitu, Sveučilište u Splitu, IGH d.d. Zagreb, Split 2005

Optional literature:

1. Electronic books:
   - *Knjiga 1 (Troškovistrojnograda u građenju; Izborstrojeva I planiranjestrojnograda u građenju)*
   - *Knjiga 2 Tehnologijagrađenja I.*
   - *Knjiga 3 Sustavigrađevinskihstrojeva*
   - *Tehnologijaniskogradnja* – teaching material (mppprezentacijapredavanja)
   - *Tehnologija građenja I* – teaching material (mppprezentacijapredavanja).
2. *LIFE05 TCY7CRO/OO114,CONWAS*, *razvojodrživogsustavaupravljanjagrađevinskimotpadom u RepubliciHrvatskoj,* www.igh.hr/CONWAS/index.htm;

SUPERVISING AND MONITORING CONSTRUCTION PROJECTS

Credit value (ECTS): 3

Number of hours (in semester):

- Lectures: 30

Course objectives:

- Acquisition and linking knowledge on construction low, quality management and organisation theory for supervising and monitoring of construction projects.

Entry competences (foreknowledge, descriptive):

- The basics of construction low, the basics of construction technology.

Learning outcomes:

- Explaining the legislative and contractual bases of supervising and monitoring of construction projects,
- Listing and describing responsibilities of supervision engineers during the phases of the project,
- Describing the principles of quality control, as well as the cost and time control in construction process,
- Explaining the activities of technical consultancy for investors

Course content:

- Lectures:
  1. Normative basis of construction works supervision, laws and rules[2]

2. Contractual basis of supervision. Supervision and other participants in a project. Supervision team structure and mutual relationships [2]
3. The role and the obligations of supervision in the phases of a project: designation, introducing the contractor with work, verification of technical documentation, stakeout study [2]
4. Quantity control, methods of measurement and billing [2]
5. Quality control [2]
6. Time control[2]
7. Cost control, estimate of additional work [2]
8. Interim valuations, final valuation [2]
9. Technical inspection, handover of a building [2]
10. Official communication and documentation [2]
11. Normative basis of technical consultancy. Selection of the consultant, elements of contract on technical consultancy[2]
12. Role of the consultant in the phases of a project [2]
13. Monitoring the project in terms of cost, time and quality. Consulting investors [2]
14. Annexes to the agreement and related documentation [2]
15. Consultant’s liability, professional associations and norms [2].

Student responsibilities:

- Attendance in lectures,
- 2 pre-exams: minimum 25% score in each pre-exam, make up pre-exam.

Grading and evaluation of student work over the course of instruction:

- Students with minimum 60% in each pre-exam are exempt from the written part of the exam.

End of semester grading:

- Written exam, minimum 50% score,
- Oral exam.

Contributions to the final grade:

- Pre-exams or written exam50%,
- Oral exam 50%

Required literature:

1. Construction Act, Official Gazette 153/13, Zagreb, 2013

Optional literature:

1. L. Fučić, *Zakon o prostornomuređenjuigradnjiipratećizakoni*, Kigen, Zagreb, 2005

NUMERICAL MATHEMATICS

Look in **Shared courses**

PERSPECTIVE

Look in **Shared courses**.

BASICS OF DIFFERENTIAL GEOMETRY

Look in **Shared courses**

WAVES AND VIBRATIONS

Look in **Shared courses**

2nd year, 3rd semester

Compulsory courses

CONSTRUCTION BUSINESS SYSTEM

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Auditory exercises:15
- Seminars:15

Course objectives:

- Acquisition of knowledge on the basics of organisation theory and on the methods and techniques of organisational design and their implementation in construction companies.

Entry competences (foreknowledge, descriptive):

- Understanding the basics of construction technology and knowledge about the basics of Construction Act.

Learning outcomes:

- Explaining basic terms of the organisational theory,
- Explaining the procedure of organisational design,
- Explaining the characteristics of particular organisational functions in a construction company,
- Demonstrating the procedure of organisational design on the example of a construction company.

Course content:

- Lectures:
  1. Basics of general system theory: system, system approach, structure of the system [2]
  2. Typology of companies in construction [2]
  3. The basics of organisation and organisational theory[2]
  4. Organisational structure, presentation of elements of organisational structure [2]
  5. Elements of organisational structure in construction company: human resources, machinery and equipment[2]
  6. Elements of organisational structure in construction company: material, information[2]
  7. Organisational functions in construction company: research and development, human resource management[2]
  8. Organisational functions in construction company: procurement, sales, marketing[2]
  9. Organisational functions in construction company: improvement of organisation, quality management[2]
  10. Organisational functions in construction company: production[2]
  11. Organisational functions in construction company: finances and accountancy, planning [2]
  12. Factors of organisational design. Shaping the organisational structure of construction company [2]
  13. Organisational changes. Re-engineering [2]
  14. Legal forms of companies [2]
  15. Forms of cooperation and integration among construction companies[2].

- Exercises (auditory):
    1. Organisation of tuition [1]
    2. General system theory [1]
    3. Companies in construction [1]
    4. Theory of organisation [1]
    5. Organisational structure [1]
    6. Elements of organisational structure [1]
       (pre-exam)
    7. Organisational functions in construction company [4]
    8. Shaping the organisational structure [1]
    9. Organisational changes. Re-engineering [1]
    10. Forms of cooperation among construction companies [1].
       (pre-exam)
- Seminars:
    1. Choosing the seminar topic [1]
    2. General system theory [1]
    3. Companies in construction [1]
    4. Theory of organisation [1]
    5. Organisational structure [1]
    6. Elements of organisational structure [1]
    7. Organisational functions of construction company [4]
    8. Shaping the organisational structure [1]
    9. Organisational changes, re-engineering [1]
    10. Forms of cooperation among construction companies[1].

Student responsibilities:

- Attendance in lectures and exercises,
- 2 pre-exams: minimum 25% score in each pre-exam, make up pre-exam,
- Presentation of seminar paper.

Grading and evaluation of student work over the course of instruction:

- Evaluation of seminar papers,
- Students with minimum 60% score in each pre-exam are exempt from the written part of the exam.

End of semester grading:

- Written and oral exam.

Contributions to the final grade:

- Seminars 10%,
- Pre-exams or written exam50%,
- Oral exam 40%.

Required literature:

1. P. Sikavica, T. Hernaus,*Dizajniranjeorganizacije*, Novi informator, 2011,
2. P. Sikavica, M. Novak: *Poslovnaorganizacija*, Informator 1999

Optional literature:

1. G. Jones*, Organizational Theory, Design and Change*, Pearson, 2007,
2. .J. Hatch: *Organization Theory*, Oxford, 1997

3. M.Žaja,*Poslovnisustav*, Školskaknjiga, 2001,
4. S.Kapustić: *Metodikaorganizacijskogprojektiranja*, Zagreb, 1989

PLANNING AND SCHEDULING METHODS

Credit value (ECTS): 6 ECTS

Number of hours (in semester):

- Lectures:30
- Exercises: 30 (auditory - 10, design - 20):
- E-learning: 100% of lectures and examinations is supported with e-learning but it is not normalized.

Course objectives:

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

Entry competences (foreknowledge, descriptive):

- Knowledge about the basic methods of planning for construction projects,
- Knowledge about the theoretical knowledge of the construction, such as network planning, resource planning, organizational charts, organizational theory, building regulations, cost analysis, etc.

Learning outcomes:

- Understanding and applying the methods of planning and control of projects,
- Drawing up a detailed baseline time schedule baseline ,
- Developing a plan for the resources and costs,
- Analyzing the baseline project plan,
- Conducting optimization of the use of resources and shortening the duration of the project,
- Designing a system for monitoring and control of the project,
- Assessing the state of progress of the project,
- Identifying the essential elements of the system of multi project planning.

Coursecontent:

- Lectures:
  1. Introduction to planning and scheduling [2]
  2. Methods and techniques of linear planning - the basics [2]
  3. Methods and techniques of network planning - the basics [2]
  4. CPM network planning methods [3]
  5. PERT method for network planning with uncertainty [3]
  6. Resource planning [3]
  7. Analysis of plans and shortening the duration of the project [3]
  8. Cost planning [3]
  9. Monitoring and control [3]
  10. Planning at management levels [3]
  11. Planning projects of the company [3].

- Exercises (auditory, design):
    1. Introduction
    2. ExercisesPart I – developmentofbasic plan using MS Project
    3. ExercisesPart II – developmentofbasic plan withresourcesusing MS Project
    4. ExercisesPart III –making theinitial plan withlevelledresourceswiththe use of MS Project
    5. ExercisesPart IV – making a basic plan withlevelledresourcesinmulti-projectenvironmentusingPrimavera Project Manager.

Student responsibilities:

- Attendance in lecturesandexercises,
- Developing a casestudyassignmentaccording to plan exercises,
- Bookofexercises as plannedlectures.

Grading and evaluation of student work over the course of instruction:

- Bookofexercisesandcasestudyassignmentevaluation,
- 2 pre-exams: minimum60% score for the exemptionfrom the final exam.

Endofsemestergrading:

- Written and oral exam.

Contributions to the final grade:

- Written and oral exam 100% ,
- Casestudyassignment 20%,
- 2 pre-exams 60 %,
- Bookofexercises20%.

Required literature:

1. Radujković, M. Et al.,*Planiranje i kontrola projekata*, Zagreb, 2012,
2. Radujković, M., Burcar, I., Vukomanović, M.,*Riješeni primjeri zadataka iz Organizacije građenja i Met a planirana*, Građevinski fakultet 2008,
3. Radujković, M.,*Metode planiranja* (mimeographed lecture notes).

Optional literature:

1. Osmanagić-Bedenik, N.,*Operativnoplaniranje*, Školskaknjiga, Zagreb, 2002,
2. O'Brien and Plotnick: *CPM in Construction Management*, McGraw-Hill, Boston, 2003

CONSTRUCTION SITE PRACTICE

Credit value (ECTS): 6 ECTS

Number of hours (in semester):

- Exercises. 60 (auditory - 2, field – 50, design - 8)

Course objectives:

- Introduction to the building site, construction site management, organization of work, technological processes at the site, the planning process of construction, procurement of materials.

Entry competences (foreknowledge, descriptive):

- Mastered knowledge about the construction organization**.**

Learning outcomes:

- Getting along at the site in terms of the organization of work,

- Getting along at the site with respect to the procurement of materials,
- Getting along at the site in terms of planning works,
- Getting along at the site in terms of cooperation with the staff.

Course content:

- Exercises:
    1. Students spend three hours each week at the selected site and observe the processes, events, technology, technique and organization of work.

Student responsibilities:

- Presence at the construction site,
- Presentation of a seminar paper on the selected site.

Grading and evaluation of student work over the course of instruction:

End of semester grading:

- Seminar paper grade.

Contributions to the final grade:

- Grade of the seminar paper100%

Elective courses

HUMAN RESOURCES MANAGEMENT

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises: 20 (project assignments)
- Seminars: 10
- E-learning: discussion groups on relevant topics

Course objectives:

- Developing knowledge about the human resources management (HRM) issues in the construction companies. It covers human resources theory and contemporary issues of human resources management. It focuses on different human resources strategies in companies, human resources planning and development, communication issues, and international human resources aspects with special emphasis on multiculturalism.

Learning outcomes:

- Understanding the importance of HRM,
- Identifying contemporary issues in HRM,
- Developing HRM strategy in small construction companies,
- Applying different techniques for the selection of employees,
- Developing communication and negotiation skills as an important factor for many aspects of HRM strategy,
- Working on a team building programs in the company,
- Understanding HR issues in the international context,
- Using IT support for HRM.

Course content:

- Lectures:
    1. Introduction to human resource management [2]
    2. Development of human resource management theory (4)
    3. The concept of Human resource management [2]
    4. The importance of HRM for business success in construction companies [2]
    5. Strategic human resource development [4]
    6. HRM strategy and corporate strategy [2]
    7. Human resource planning [2]
    8. The challenges of communication in the construction project environment [2]
    9. Communication risk: Application of Principal-Agent Theory [2]
    10. Effective teamwork, Motivation and Rewards [4]
    11. International human resource aspects [2],
    12. IT support for HRM [2].
- Exercises:
    1. students are obliged to work on project assignments.
- Seminars:
    1. students are obliged to write seminar papers.

Student responsibilities:

- Attendance in lectures,
- Working on project assignments and seminar papers.

Grading and evaluation of student work over the course of instruction:

- Two written exams.

End of semester grading:

- Final written exam.

Contributions to the final grade:

- Project assignment, seminar and written exams, discussion group activities.

Required literature:

1. Bahtijarević-Šiber, F.,*Management ljudskih potencijala*. Zagreb: Golden marketing, 1999,
2. Dainty, A., M. Loosemore and H. Lingard*, Human Resourse Management in Construction Projects,* London: Spon Press, 2003

Optional literature:

1. Dainty, A., D. Moore and M. Murray, *Communication in Construction*, Oxford: Taylor& Francis, 2006,
2. Emmitt, S. And Gorse, Ch., *Communication in Construction Teams*, Oxford: Taylor& Francis, 2007.

CONSTRUCTION TECHNOLOGY 2

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises: 30 (auditory - 4, design - 26)

Course objectives:

- Acquisition of knowledge on scaffolding and formworks, their types, methods of assembling and erecting. Acquisition of knowledge on production, transportation and assembling of precast concrete elements for houses, bridges and other. Dimension of tools for assembling of precast concrete structure.

Learning outcomes:

- Specifying the scaffolding for a construction,
- Specifying the formwork for a construction,
- Organising and dimensioningthe production of precast elements,
- Organising and dimensioningthe transportation of precast elements,
- Organising and dimensioning the assembling of precast elements.

Course content:

- Lectures:
  1. Formworks in general[2]
  2. Traditional formwork system [2]
  3. Engineered formwork system [2]
  4. Sliding formwork [2]
  5. Climbing formwork [2]
  6. Tunnel formwork [2]
  7. Scaffolding in general [2]
  8. Tower and heavy scaffolding[2]
  9. Precast construction technology in general[2]
  10. Precast halls production [2]
  11. Precast elements transportation[2]
  12. Technology of assembling, selection and dimension of cranes [2]
  13. Auxiliary tools for assembling [2]
  14. Precast bridges [2]
  15. Tools for assembling of bridges [2].
- Auditory exercises:
  1. Allocating programs, selecting the manner of their execution and the selection of models [4].
- Design exercises:
  16. Execution of programs and their presentations.

Student responsibilities:

- Attendance in lectures and exercises,
- Seminar papers,
- 2 pre-exams – minimum 25% score in each, make up exam.

Grading and evaluation of student work over the course of instruction:

- Seminar paper,
- Students with minimum 60% score in pre-exams are exempt from the written part of the exam.

End of semester grading:

- Written exam - minimum 60% score,
- Oral exam.

Contributions to the final grade:

- Seminar paper 30%,
- Pre-exams or exam 70%,

Required literature:

1. Rudolf Lončarić,*Organizacijaizvedbegraditeljskihprojekata*, Sveučilište u Zagrebu, Zagreb, 1995,

Optional literature:

1. Handbook PERI,
2. Handbook DOKA.

INVESTMENTS APPRAISALS IN CONSTRUCTION

Credit value (ECTS): 6.0

Number of hours (in semester):

- Lectures: 30
- Exercises: 30
- E-learning: 2nd level

Course objectives:

- Acquisitionof theoreticalknowledgeabout the strategyof enterprise development, investment policyandtypes ofinvestments,
- Creating aninvestment study.

Learning outcomes:

- Explainingthe foundationsof investingin the companyand thetypesof investments,
- Analyzinginvestorsandinvestment,
- Analyzing the marketanddevelopingtechnicaland technological analysis,
- Designing financial statements, economicandfinancialflowsof the project,
- Checkingthe feasibilityof the project,
- Conductinga sensitivity analysisof the project.

Course content:

- Lectures:
  1. Investment study – an introduction [2],
  2. Types of Investments – joint venture, BOT, foreign direct investments [2],
  3. Information about Entrepreneurs – Investors [3],
  4. Market Analysis [2],
  5. Technical and Technological Elements of Investments [3],
  6. Location [2],
  7. Environment Protection [2],
  8. Dynamics of Investment Realization [3],
  9. Economic and Financial Analysis [4],

     9.1. Financial flow

     9.2. Economic flow
  10. Economic and Market Evaluation [4],

      10.1. Static methods of investment appraisal

      10.2. Dynamic methods of investment appraisal
  11. Sensitivity Analysis [3].

- Exercises:
    1. Information about Entrepreneurs – Investors [4]
        - 1.1. Former Business Activities of Investors
        - 1.2. Existing Investors' Property
        - 1.3. Financial Analysis of Current Business
    2. Market Analysis [4]
        - 2.1. Purchasing Market
        - 2.2. Sales Market
        - 2.3. Summary of Market Analysis and Assessment of Income Generation
    3. Technical and Technological Elements of Investments[4]
        - 3.1. Description of technical and technological process
        - 3.2. The consumption of raw materials and energy
        - 3.3. Technical structure of investment
        - 3.4. Construction characteristics of the building
        - 3.5. Organisation structure and human resources
            - 3.5.1. Analysis of the necessary human resources
            - 3.5.2. Budget of annual gross salaries
    4. Location [2]
    5. Environment Protection [4]
    6. Dynamics of Investment Realization [2]
    7. Economic and Financial Analysis [4]
        - 7.1. Investment in fixed assets
        - 7.2. Investments in working capital
        - 7.3. Investment structure (fixed and working capital)
        - 7.4. Resources of financing and loan terms
            - 7.4.1. Resources of financing
            - 7.4.2. Calculation of loan obligations
        - 7.5. Depreciation calculation
        - 7.6. Calculation of costs and price calculation
        - 7.7. Budgeted Profit and Loss Account
        - 7.8. Financial flow
        - 7.9. Economic flow
        - 7.10. Budgeted Balance Sheet
    8. Economic and Market Evaluation [4]
        - 8.1. Static methods of investment appraisal
        - 8.2. Dynamic methods of investment appraisal
            - 8.2.1. Investment Payback Period
            - 8.2.2. Net Present Value of Investment
            - 8.2.3. Relative Net Present Value of Investment
            - 8.2.4. Internal Rate of Return
    9. Sensitivity Analysis [2].

Student responsibilities:

- Attendance in minimum 75% lectures,
- Attendance in minimum 75%exercises,

- Minimum25% score in every pre-exam,
- Writing and presenting an investment study.

Grading and evaluation of student work over the course of instruction:

- Written and presented investment study,
- Three pre-exams (studentswith minimum grade 3, are exempt from thewritten part ofthe exam, students with minimum grade 4 in each pre-exam are exempt from the entire exam).

End of semester grading:

- Written exam,
- Oral exam.

Contributions to the final grade:

- Pre-exams 70%,
- Investment study30%.

Required literature:

1. HBOR, I-V
2. Mariza Katavić, *Osnove ekonomike za graditelje*, Hrvatska sveučilišna naklada, Zagreb, 2009,
3. Lecture notes (handouts on *Merlin*)

Optional literature:

1. Ekonomski Institut Zagreb (1993),*Planiranje investicijskih projekata*, knjiga I-IV,
2. J.C.Francis, (1986),*Investment Analysis and Management*, McGraw Hill International, 4th edition, Singapore

2nd year, 4th semester

Compulsory courses

BUSINESS STRATEGIES FOR THE CONSTRUCTION INDUSTRY

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures: 45
- E-learning: 2nd level

Course objectives:

- Gainingtheoreticalknowledgeabout business strategies, analyzing business ethics in construction industry, analyzingconstruction environment andunderstanding different types of business strategies.

Entry competences (foreknowledge, descriptive):

- Basic knowledge onthe basicsof economyinthe courseBusiness economics (elective course inthe first yearof undergraduatestudies).

Learning outcomes:

- Understanding the purpose and key concepts of business strategies and principles of marketing strategies,
- Formulating company's mission statement, vision statement and main goals,

- Analyzing the business environment and evaluating the contribution of factors affecting the performance of an enterprise,
- Creatinga SWOT matrix and a stakeholder analysis,
- Formulating business strategies – corporation, generic and function strategies.

Course cfontent:

- Lectures:
  1. Definition of a business strategy ([5]
  2. Mission, vision and company's goals[5]
  3. Business environment[5]
  4. Factors affecting construction industry[5]
  5. Business ethics[5]
  6. Construction environment analysis[5]
     - 6.1. SWOT analysis
     - 6.2. Stakeholder analysis
  7. Organisation structure of construction companies[5]
  8. Formulating strategy [5]
     - 8.1. Corporation strategy
     - 8.2. Generic strategy
     - 8.3. Funkcion strategy
       - 8.3.1. Marketing strategy
  9. Students presenting seminars [5].

Student responsibilities:

- Attendance in minimum 75% lectures,
- Minimum25% score in every pre-exam,
- Writing and presenting a seminar paper,

Grading and evaluation of student work over the course of instruction:

- Written and presented seminar paper,
- Three pre-exams (studentswith minimum grade 3 in all three pre-exams are exempt from thewritten part ofthe exam, students with minimum grade 4 in each pre-exam are exempt from the entire exam).

End of semester grading:

- Written exam,
- Oral exam.

Contributions to the final grade:

- Pre-exams 75%,
- Seminar papers 25%

Required literature:

1. Mariza Katavić, *Osnove ekonomike za graditelje*, Hrvatska sveučilišna naklada, Zagreb, 2009,
2. Lecture notes (handouts on *Merlin*).

Optional literature:

1. *M*H.Weihrich, H.Koontz, *Menadžment*, (10^{th} ed.) MATE d.o.o., Zagreb, 1998,
2. Stephen Lavender, *Management for the Construction Industry*, Longman and The Chartered Institute of Building, Elookx, England 1996

SOCIOLOGY OF ORGANIZATION

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures: 30
- Seminars: 15
- E-learning:10

Course objectives:

- Learning how to manage the organizational culture and design and how to manage organizational changes.

Learning outcomes:

- Development of “soft skills”, especially ability to change the organizational culture of an organization.

Course content:

- Lectures:
  1. Introduction (3)
  2. Definitions of basic terms [2]
  3. Group behavior [2]
  4. Organizational culture [10]
  5. Power in organizations [2]
  6. Business ethics [2]
  7. Leadership [2]
  8. Influence of globalization on organizations [2]
  9. Influence of technology on organizations [2]
  10. Life circle of organizations [2]
  11. Final lecture [1].
- Seminars:
  1. Animal organizations [1]
  2. Milgram’s experiments [1]
  3. Modern organizational designs [1]
  4. Symbols of organizational cultures [2]
  5. Organizational culture of Ben and Jerry [1]
  6. Organizational culture of Faculty of Civil Engineering [1]
  7. Changing of organizational culture [1]
  8. The main issues in business ethics [2]
  9. Power in animal world [1]
  10. Psychological and social qualities of great leaders [1]
  11. Establishment and development of the company“Amazon” [1]
  12. General discussion 00000000000000[2].

Student responsibilities and contributions to the final grade:

- Discussion on the Internet and presentations in class 20%,
- Activities in class and class attendance 10%,
- Pre-exam 20%,
- Final exam 50%.

Required literature:

1. Sikavica, Pere,*Organizacija,* Zagreb, Školska knjiga, 2011

Optional literature:

1. Handel, Michael J. (ed.),*The Sociology of Organizations*, London: Sage Publications, 2003
2. Aronson, Elliot, Timothy D. Wilson, Robin M. Akert,*Socijalna psihologija,* Mate, Zagreb, 2005
3. Zvonarević, Milan,*Socijalna psihologija,* Školska knjiga, Zagreb, 1989
4. Jones, Gareth R.,*Organizational Theory, Design and Change*. Upper Saddle River, USA: Pearson Education, 2004
5. Antić, Miljenko, Antita Cerić i Maja Lazić, *Organizational culture of the department of construction management and economics*, Faculty of Civil Engineering, University of Zagreb, *Organization, Technology & Management in Construction*, Vol. 2:1, pp.136-144, 2010
6. Buchanan, David i Andrzej Huczynski,*Organizational Behavior: An Introductory Text*. Harloww: Pearson Education, 1997
7. Haladin, Stjepan,*Tehnologija i organizacija: uvod u sociologiju rada i organizacije*. Društvo za organizaciju građenja Republike Hrvatske, Zagreb,1993
8. Vecchio, Robert P., *Organizational behavior: core concepts,* Thomson/South-Western, Mason, Ohio, 2003
9. Kendall, Dina,*Sociology in Our Times: The Essentials*. Belmont, USA: Wadsworth, 2003
10. Miller, D.C. i V.H. Form,*Industrijska sociologija,* Panorama, Zagreb, 1996

Elective courses

Same as in 1st year, 2nd semester (except: Environment protection, English language, German language and Construction technology).

TRANSPORTATION ENGINEERING

1st year, 1st semester

Compulsory courses

TRAFFIC NOISE

Credit value (ECTS): 4.5

Number of hours (in semester): 45

- Lectures: 30
- Exercises (design): 15

Course objectives:

- Acquiring theoretical and practical knowledge on road and rail traffic noise emission and propagation and itsharmful effects,
- Overview on traffic noise protection measures,
- Acquiring basic knowledge on noise mapping.

Entry competences:

- Understanding the basic principles of road design.

Learning outcomes:

- Describing the effects of traffic noise, noise mitigation and protection measures,
- Understanding the generation mechanisms of trafficnoise and protection measures,
- Analysing the traffic noise levels according to Croatian and EU regulations,
- Application of specialised software for noise prediction, noise mapping and noise barrier optimisation (Lima),
- Evaluation of assumptions, arguments and noise protection solutions,
- Solving simple traffic noise protection problems (noise barrier design),
- Ability to understand scientific and professional papers and to collect and present the data used to solve practical problems in everyday engineering practice.

Course content:

- Lectures:
    1. Introduction: Environmental noise. Historical perspectives [1]
    2. Fundamental concepts and definitions used in the field of acoustics [2]
    3. Noise sources. Effects of noise [1]
    4. The Environmental Noise Directive (2002/49/EC) [2]
    5. Noise regulations in Croatia [2]
    6. Noise mapping [2]
    7. Road traffic noise – basic parameters [1]
    8. Noise calculation methods [4]
    9. Noise reduction methods related to noise sources [4]
    10. Noise protection barriers [2]
    11. Other noise reduction and protection measures [2]

12. Practical examples [3].

- Exercises (design):
  1. Digital Terrain Model. Data import. Object attributes [3]
  2. Object attributes [2]
  3. Noise level calculations [2]
  4. Noise protection – barrier optimisation [5]
  5. Calculation results [2]
  6. Technical description [1].

Student responsibilities:

- Lecture and exercise attendance (minimum 75% of lectures and 100% of exercise classes),
- 2 pre-exams -(minimum 25% core, 1 additional make up pre-exam,
- Completion of design exercises.

Grading and evaluation of student work over the course of instruction:

- Design exercises grade,
- Pre-exams (students with a 60% score or higher in each pre-exam are exempt from the written exam).

End of semester grading:

- Written exam (minimum 50% score for a pass).
- Oral exam.

Contributions to the final grade:

- Design exercises 20%,
- Pre-exams or written exam 40%,
- Oral exam 40%.

Required literature:

1. V. Dragčević, S. Ahac, *Prometnabuka* – lecture notes, Zagreb, 2008,`http://merlin.srce.hr`
2. S. Ahac, Ž. Pintar, *Prometnabuka* – exercise handbook, Zagreb, 2008,`http://merlin.srce.hr`

Optional literature:

1. *Općitehničkiuvjetizaradovenacestama*, HrvatskecesteiHrvatskeautoceste, Zagreb, 2001
2. Uputstvazakorištenjesoftverskogpaketa (instructions for use of software package) LIMA™ *Environmental Noise Calculation and Mapping Software*,Version 5.1,Denmark, 2006,
3. Kotzen, Benz,Englih, Colin,*Environmental Noise Barriers*, London, 1999

TRANSPORT TECHNOLOGY

Credit value (ECTS): 6

Number of hours (in semester): 60

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

Course objectives:

- Acquiring knowledge in the field of the theory of traffic flow,
- Ability to apply the theory of traffic flow in calculation procedures for throughput capacity and level of service for various transport facilities.

Entry competences (foreknowledge, descriptive):

- Basic driving dynamics settings relevant to the determination of horizontal, vertical and longitudinal road elements.

Learning outcomes:

- Ability to analyze traffic flow on various types of roads using contemporary methods and criteria,
- Ability to design various elements of road network,
- Ability to determine the basic principles of the development of road traffic system,
- Ability to estimate, investigate and apply the existing data on roads and road traffic,
- Ability to develop the concept of traffic flow,
- Ability to organise, monitor and control traffic,
- Ability to manage traffic flows on road networks.

Course content:

- Lectures:
    1. Introduction to traffic [2]
    2. Definition of transport technology terms [2]
    3. Introduction to the theory of traffic flow: development of motorization and the theory of traffic flow [2]
    4. Defining the basic variables of traffic flow: flow, speed and density of traffic flow [2]
    5. Relations between basic variables of traffic flow [2]
    6. Macroscopic models of traffic flow [2]
    7. Microscopic models of traffic flow [2]
    8. Trhroughput and level of service: development of the concept, definition of elements and their impact [2]
    9. Traffic load on roads: traffic counting, traffic flows in a network, processing and application of data [2]
    10. Characteristics of road traffic volume [2]
    11. Throughput of highways [4]
    12. Throughput of multi-lane roads [2]
    13. Throughput of two-lane roads [2].
- Exercises (auditory, design, laboratory):
    1. Introduction to exercises. Elements and forms of intersections [2]
    2. Traffic control at intersections [2]
    3. Introduction to the program [2]
    4. Recording intersections in the field [2]
    5. Intersection drafting [2]
    6. Traffic counting at intersections [2]
    7. Processing data on traffic load [2]
    8. Recording light signaling at intersections [2]
    9. Developing timing for light signaling [2]
    10. Calculation of the level of service of the existing state [2]
    11. Calculation the optimal cycle and phase plans [2]
    12. Proposal to improve the traffic flow [2]
    13. Calculation of the level of service for the new condition of an intersection [2]
    14. Drafting a new state of an intersection [2]

15. Program submission [2].

Student responsibilities:

- Attendance in lectures and exercises,
- Program development,
- Two pre-exams – minimum 40% score in each.

Grading and evaluation of student work over the course of instruction:

- Program development,
- Pre-exams.

End of semester grading:

- Grading a program,
- Pre-exam results,
- Oral exam.

Contributions to the final grade:

- Program 20%,
- Pre-exams 50%,
- Oral exam 30%.

Required literature:

1. *Highway Capacity Manual*, TRB, Washington, D.C., 2000
2. D. L. Gerlough, M.j. Huber, *Traffic Flow Theory*, A Monograph, TRB, Special Report 165, Washington, D.C., 1975
3. L. J. Pignataro, *Traffic Engineering, Theory and Praktice*, Prentice-Hall, Inc. Englewood Cliffs, New Jersey, 1973
4. P. Rožić, *Mimeographed lecture notes*

Optional literature:

- *Transportation and Traffic Engineering Handbook*, The Institute of Traffic Engineers, Washington, D.C., 1976

HIGHWAY DESIGN

Credit value (ECTS): 6

Number of hours (in semester):

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

Course objectives:

- Acquisition of theoretical knowledge about road design,
- Acquisition of practical skills for road design.

Entry competencies (foreknowledge, descriptive):

- Practical skills in technical drawing – CAD skills.

Learning outcomes:

- Ability to master the principles of geometric design of roads (horizontal and vertical alignment) considering road safety requirements,
- Ability to follow-up „stateoftheart“ procedure in the field of road design,
- Skill in route planning,

- Ability to evaluate multiple road solutions,
- Ability to use a software specialized for road design.

Course content:

Lectures:

1. Introductory course[2]
2. The design rules[4]
3. Modeling solutions. Spatial restriction [2],
4. Digital Elevation Model. Digital Terrain Model [2]
5. Operations with models[2]
6. Horizontal alignment[2]
7. Vertical alignment[2]
8. Road visualization[2]
9. Road cross section [2]
10. Sight distance [3]
11. Earthworks –volume calculation[2]
12. Road contours plan [2]
13. Evaluation of road variants [2]
14. Procedures for making certain project level [1].

Exercises (auditory, design):

1. Introduction [1]
2. Overview of the software for road design[1]
3. Creating a digital elevation model [2]
4. Geometric road design [2]
5. Situation [8]
6. Long section [2]
7. Cross section [2]
8. Sight distance testing [4]
9. Evaluation of road variants[2]
10. Road visualization [2]
11. Creating drawings [4].

Student responsibilities:

- Attendance in lectures and exercises,
- Completion of design exercises and design submission.

Grading and evaluation of student work over the course of instruction:

- Design exercises grade.

End of semester grading:

- Oral exam.

Contributions to the final grade:

- Design exercise grade50%,
- Oralexam50%.

Required literature:

1. Ž. Korlaet, *Uvod u projektiranje i građenje cesta*, udžbenik Sveučilišta u Zagrebu, 1995, pp. 208 (textbook by the University of Zagreb),

2. Dragčević, V., Korlaet, Ž.,*Osnove projektiranja cesta*, udžbenik Sveučilišta u Zagrebu, 2003, pp. 93 (textbook by the University of Zagreb),
3. Pribičević, B., Medak,D.,*Geodezija u građevinarstvu*, V.B.Z., Zagreb, 2003 (paragraph 13,*Geodetski radovi pri projektiranju i trasiranju prometnica*, paragraph 14,*Određivanje površina i zemljanih masa*).
4. Pravilnik o osnovnim uvjetima kojima javne ceste izvan naselja i njihovi elementi moraju udovoljavati sa stajališta sigurnosti prometa (Regulations on the basic conditions for public roads out of settlements have to meet) (NN110, prosinac 2001, Official Gazette, December, 2001)
5. Merlin, web pagehttp://moodle.srce.hr

Optional literature:

1. H.Lorenc,*Projektovanje i trasiranje puteva i autoputeva*, IRO građevinska knjiga, Beograd, 1980

RAILWAY DESIGN AND CONSTRUCTION

Credit value (ECTS): 6

Number of hours (in semester):

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

Course objectives:

- Acquisition of theoretical knowledge about haul calculation (rail track and vehicle resistance, train mass, haul force, braking force),
- Acquisitionoftheoreticalandpracticalknowledgeaboutrailtrackdesign,
- Acquisition of practical knowledge about rail project creation phases,
- Acquisitionoftheoreticalandpracticalknowledgeaboutvarioustrackdesignsolutionevaluation,
- Acquisition of theoretical knowledge about track capacity calculation,
- Acquisition of practical knowledge about second track design.

Entry competences (foreknowledge, descriptive):

- Basic knowledge of transport infrastructure design,
- Knowledge of rail track cross sections and clearances,
- Basic knowledge of transport infrastructure substructure.

Learning outcomes:

- Knowledge about rail track and vehicle resistance,
- Knowledge about train mass, haul force and braking force calculations,
- Knowledge about rail track construction elements,
- Knowledge about rail track designs of ware application,
- Knowledge about various track design solutions evaluation,
- Knowledge about track capacity calculation,
- Knowledge about second track construction procedure.

Course content:

- Lectures:
  1. General characteristics of railways [2]
  2. The basics of haul calculation: rail vehicle resistance, haul force [3]
  3. The basics of haul calculation: train mass, braking forces [2]

4. Rail traffic indicators [2]
5. Rail transport indicators: freight and passenger transport volume [2]
6. Rail alignment elements: horizontal and vertical alignment elements [3]
7. Rail alignment design: route alignment modes, railway engineering software [2]
8. Design stages: feasibility study, preliminary design, main and detailed design [2]
9. Variant solution evaluation: methods for variant evaluation, exploitation costs [2]
10. Track capacity calculation: capacity of the line, carrying capacity of the line [3]
11. Reconstruction of single track railway lines: basic principles, decisions on route design elements [3]
12. Second track design: second track design modes, location related to other objects [2]
13. High speed tracks: specific features, horizontal and vertical alignment elements [2].

- Exercises (auditory, design):
  1. Introduction to the exercises, software and program assignment, route and station element calculation [2]
  2. Developing a digital terrain model (triangulation and contour lines) [2]
  3. Developing zero polygons [2]
  4. Developing a horizontal tangent polygon [2]
  5. Developing rail track horizontal alignment elements: arcs and transition curves [2]
  6. Developing rail track horizontal alignment elements: lines [2]
  7. Developing a longitudinal profile of the terrain [2]
  8. Developing rail track vertical alignment elements: tangents [2]
  9. Developing rail track vertical alignment elements: arcs and super elevation [2]
  10. Defining rail track cross sections [2]
  11. Developing rail track cross sections [2]
  12. Developing rail track design project reports [2]
  13. Driving-dynamic analysis and calculation [2]
  14. Calculation of train stopping distances [2]
  15. Calculationoflinetransport capabilities [2].

Student responsibilities:

- Attendance in lectures and exercises.
- Program design.
- Pre-exams -minimum 25% score in each, 1 additional make up exam.

Grading and evaluation of student work over the course of instruction:

- Assessment of the program,
- Pre-exams - students with a minimum 60% score in each pre-exam are exempt from the written exam.

End of semester grading:

- Written exam – minimum 50% score,
- Oral exam.

Contributions to the final grade:

- Program 10%,
- Pre-exams or written exam 50-60%,
- Oral exam 30-40%.

Required literature:

1. Lakušić, S., Ahac, M.,*Projektiranje i građenje željeznica* – lectures, Zagreb, 2009,
2. Lakušić, S., Ahac, M.: *Projektiranje i građenje željeznica*–exercise handbook, Zagreb, 2011

Optional literature:

1. Marušić, D.,*Projektiranje i građenje željezničkih pruga*, Građevinski fakultet Split, Split, 1994 (Faculty of Civil Engineering, Split).

Elective courses

MATHEMATICS 3

Look in **Shared courses**

STOHASTIC PROCESSES

Look in **Shared courses**

1st year, 2nd semester

Compulsory courses

MANAGEMENT FOR THE CONSTRUCTION INDUSTRY

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures: 30
- E-learning: 2nd level

Course objectives:

- Gainingtheoreticalknowledgeabout the basicprinciplesof management, project managementandbusiness decision making,
- Understanding theconcept ofcompanies, business activities, business resultsandthe concept ofmarket.

Entry competences (foreknowledge, descriptive):

- Basic knowledge about the basicsof economyinthe courseBusiness economics(elective course inthe first yearof undergraduatestudies).

Learning outcomes:

- Understanding the purpose and key concepts of management (vision, mission statement, the role and functions of managers/ project managers,
- Understanding the role and the relevance of management and its participants,
- Learning about business decision making,
- Understanding the functioning of the market,

- Ability to direct business processes,
- Mastering the skills of analytical thinking and presenting the facts through seminar papers,
- Communicating complex ideas concisely and clearly in written form.

Course content:

- Lectures:
  1. Basic principles of management
     - 8.1. Introduction [2]
     - 8.2. Who are Managers? [2]
     - 8.3. Management functions [2]
     - 8.4. A Management development [2]
     - 8.5. Schools of Management [2]
  9. Management as a Process
     - 9.1. Planning [2]
     - 9.2. Organizing [2]
     - 9.3. Leading [2]
     - 9.4. Controlling [1]
  10. Business decision making
      - 10.1. Defining decision making [1]
      - 10.2. Process of decision making [1]
      - 10.3. Styles and modes of decision making [1]
      - 10.4. Methods of decision making [1]
      - 10.5. Communication in business decision making [1]
  11. Basics of management organization
      - 11.1. Companytypes [1]
      - 11.2. Basics of reproduction process [1]
      - 11.3. Business assets [1]
  12. Costs, price and price calculation [1]
  13. Business results
      - 13.1. Financial reports [1]
      - 13.2. Business success measures (cost-effectiveness, productivity, profitability) [1]
  14. Project management[1]
  15. Factors affecting the performance of a company [1]

Student responsibilities:

- Attendance in morethan 75% of lectures,
- Minimum 25% score in each of thethree pre-exams,
- Writing and presenting a seminar paper,011
- Using *Merlin*.

Grading and evaluation of student work over the course of instruction:

- Writing and presenting a seminar paper,
- Three pre-exams(students who earn in every pre-exam minimum 3 are exempt from the written part ofthe exam, students who earn in every pre-exam minimum grade 4 are exempt from the entire exam).

End of semester grading:

- Written exam,
- Oral exam.

Contributions to the final grade:

- Pre- exams 75%,
- Seminar paper 20%,
- *Merlin* 5%

Required literature:

1. Mariza Katavić, *Osnove ekonomike za graditelje*, Hrvatska sveučilišna naklada, Zagreb, 2009,
2. Lecture notes (handouts on *Merlin*).

Optional literature:

1. H.Weihrich, H.Koontz, *Menadžment*, (10^{th} ed.) MATE d.o.o. ,Zagreb, 1998,
2. Stephen Lavender, *Management for the Construction Industry*, Longman and The Chartered Institute of Building, Elookx, England 1996

PAVEMENT STRUCTURES

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises (design): 30

Course objectives:

- Acquisitionof basic knowledge about:materialsusedin pavement construction; material properties and their behaviour in pavement layer as well as the behaviour of pavement as a whole,design and constructionof flexiblepavements,design and constructionof rigidpavements.

Entry competences (foreknowledge, descriptive):

- Basicknowledgein the field ofgeomechanics,
- Basic knowledge about construction materials,
- Understanding theconceptsof stress, strainandinternal forces.

Learning outcomes:

- Understanding thebehaviorof individualcomponentsas well as thepavement structureas a whole,
- Analyzing andsolvingproblems related to thedesign and construction ofpavementsfrom theengineeringpoint of viewby use ofthe latest knowledgeandsolutions,
- Designing pavementsinaccordancewith domesticandinternationalengineering practices,
- Using a specialized software for pavement design (BISAR, CIRCLY, PAVERS),
- Critical evaluation, analysisandappropriate selection ofthe appropriate types ofpavements inaccordancewith the purpose oftraffic areas,
- Participating in works related tothe constructionandmaintenance of pavementsin a creative way.
- Following the scientific literature in the field of pavement design and construction, and applying the acquired knowledge in further education.

Course content:

- Lectures:
  1. Introduction (basic terms and definitions, types of pavements, historical development) [2]
  2. Construction materials (aggregates, mixtures, binders, additives, water) [4]
  3. Generally on flexible pavements [1]
  4. Subgrade [1]

5. Unbound pavement base layers [2]
6. Hydraulically bound pavement base layers [2]
7. Asphalt layers (basic terms, classification, asphalt mixtures) [1]
8. Production,transportationand construction ofasphalt mixtures [2]
9. Physical andmechanical properties ofasphalt mixtures [2]
10. Types of asphalt mixtures (for base, bind, surface and protective layers) [2]
11. Types of asphalt mixtures (asphalt concrete, split mastic asphalt, porous asphalt, thin asphalt layers, mastic asphalt) [2]
12. Generally on rigid pavements [2]
13. Design of flexible pavements [2]
14. Design of rigid pavements [2]
15. Pavement properties (surface) [1],Pavement properties (structural) [1]
16. Pavement maintenance (reconstruction, rehabilitation, recycling) [1]

- Exercises (design):
  1. Introduction to pavement design [2]
  2. Methods for flexible pavement design (AASHO method) [6]
  3. Methods for flexible pavement design (HRN.U.C4.012) [6]
  4. Pavement stress-strain analysis (BISAR) [6]
  5. Pavement stress-strain analysis (CIRCLY) [6]
  6. Calculation of frost depth [2]
  7. Program submission [2].

Student responsibilities:

- Attendance inminimum 75% lectures and 100% exercises,
- 2 pre-exams – minimum 25% score in each,
- One make up exam,
- Program submission.

Grading and evaluation of student work over the course of instruction:

- Program grade,
- Pre-exam - students with minimum 60% score in each pre-exam are exempt from the written exam.

End of semester grading:

- Written exam – minimum 50% score,
- Oral exam.

Contributions to the final grade:

- Program 30%,
- Pre-exam or written exam 40%,
- Oral exam 30%.

Required literature:

1. B.Babić, *Pavement design*, University of Zagreb, Zagreb, 1997,
2. B. Babić, Z. Horvat, *Pavement construction and maintenance*, University of Zagreb, Zagreb,1983,
3. T. Rukavina, J. Domitrović, *Pavement structures* (lectures, exercise guide), Zagreb, 2012, http://merlin.srce.hr

Optional literature:

1. General technical requirements for road works, Croatian Roads & Croatian Motorways, Zagreb, 2001
2. Roberts, F. L., Kandhal, P. S., Brown, E. R., Lee, D. Y. Kennedy, T. W. *Hot Mix Asphalt- Materials, MixtureDesign, and Construction*, NAPA Education Foundation Lanham, Maryland, 1996

3. AASHTO Guide for Design of Pavement Structures, Published by American Association of State Highway and Transportation Officials, Washington D.C., USA, 1993
4. N. Thom, *Principles of pavement engineering*, Thomas Telford Ltd, UK, 2008

PERMANENT WAY

Credit value (ECTS): 6

Numberofhours (insemester):

- Lectures: 45
- Exercises (auditory, design): 15

Courseobjectives:

- Acquisition of practical knowledge about the basic track superstructure elements (rails, sleepers, ballast bed, fastening systems),
- Acquisition of theoretical and practical knowledge about permanent way calculation methods,
- Acquisition of theoretical and practical knowledge about different track structures,
- Acquisition of practical knowledge about rail welding methods,
- Acquisition of practical knowledge about rail turnouts.

Entry competences (foreknowledge, descriptive):

- Knowledge about materials mechanical properties testing methods,
- Knowledge about the concepts of stress, deformation and internal forces,
- Knowledge about the concepts of structure stability and dynamic loading.

Enrolment requirements (correlated courses):

- Teacher signatures: Railway design and construction.

Requirements for examination taking (correlated courses):

- Examinations passed: Railway design and construction.

Learning outcomes:

- Detailed knowledge about rail track permanent way elements: rails, sleepers, ballast bed, fastening systems (material properties, testing methods, behaviour during exploitation),
- Knowledge about permanent way calculation methods,
- Detailed knowledge about ballasted and ballast less rail track structures,
- Detailed knowledge about rail welding methods, weld testing and continuous welded rails,
- Detailed knowledge about rail track characteristics in horizontal curves,
- Detailed knowledge about rail track turnouts (manufacturing, installation, safety features).

Course content:

- Lectures:
    1. Basic concepts of permanent way elements: rails, fastenings, sleepers, ballast [2]
    2. Rails: shape, strength, testing and inspection [2]
    3. Rails: deterioration, lubrication[2]
    4. Fastenings: tasks and fastenings testing, rigid and elastic as tenings [2]
    5. Sleepers: timber sleepers, reinforced-concrete sleepers, manufacturing and testing [4]
    6. Ballast: tasks, shapes and dimensions of ballast prism, bearing increase of ballast prism [4]
    7. Track arrangement: track gauge, super elevation, transition curve and gradient [4]
    8. Permanent way design: static and dynamic track design [4]
    9. Ballast less permanent way structures: structure requirements, application [4]
    10. Continuous welded rails (CWR): temperatures and stresses [4]

11. Rail welding procedures: termite welding, electrical resistance welding, weld testing [4]
12. High speed railways: characteristics, horizontal and vertical alignment elements [3]
13. Turnouts: elements, types, function, crossings (frogs) and guiderails [6]

- Exercises (auditory and design):
  1. Station track plan calculation [1]
  2. Calculation of characteristic points of turn outs [1]
  3. Defining turn out geometry [1]
  4. Routing of turn outs on the horizontal alignment of the main transit track [1]
  5. Developing elements of horizontal alignment of side tracks [1]
  6. Defining shunt position [1]
  7. Developing the report for the characteristic points of turnouts [1]
  8. Developing situation and survey plan of station layout [1]
  9. Construction of curved transition gradient [1]
  10. Control of non-compensated later al acceleration [1]
  11. Graphical representation of non-compensated lateral acceleration [1]
  12. Control of continuous welded rail stability at high temperatures [1]
  13. Control of continuous welded rail stability at low temperatures [1]
  14. Calculation of rail stresses according to Zimmermann-Diehl [1]
  15. Developing a technical report [1].

Student responsibilities:

- Lecture and exercise attendance,
- Program design,
- Pre-exams - minimum 25% score in each, 1 additional make up exam.

Grading and evaluation of student work over the course of instruction:

- Assessment of the program,
- Pre-exams: students with a 60% score in each pre-exam are exempt from the written exam.

End of semester grading:

- Written exam - minimum 50% score,
- Oral exam.

Contributions to the final grade:

- Program 10%,
- Pre-exams or written exam 50-60%,
- Oral exam 30-40%.

Required literature:

1. G.Prister, B. Pollak, *Gornji ustroj i specijalne željeznice*, Građevinski institut, Zagreb, 1988,
2. S. Lakušić, *Gornji ustroj željeznica*, lecture notes, Faculty of Civil Engineering, http://www.grad.unizg.hr/predmet/guz.

Optional literature:

1. C.Esveld, *Modern Railway Track, SecondEdition,* MRT Productions, Zaltbommel, 2001,
2. Pravilnik o održavanju gornjeg ustroja željezničkih pruga HŽ (Službeni vjesnik, br. 20/91) (Regulations on the maintenance of permanent way, Official Gazette, no. 20/91).

EARTHWORKS

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises (design): 30

Course objectives:

- Acquisition of theoretical and practical knowledge about the design of earthwork elements,
- Choosing the optimal constructive solutions to road cross section elements,
- Elaborating the elements of preliminary road design (cross sections and mass account) started in course Road design,
- Acquisition of basic practical skills required in engineering design practice and earthwork facilities construction.

Entry competences:

- Knowledge about the rules and criteria for road design,
- Basic knowledge about road cross section elements.

Enrolment requirements (correlated courses):

- Teachers signatures: Road design.

Learning outcomes:

- Designing road earthwork elements: cuts and embankments, road drainage, design and protection of slopes, retaining walls,
- Solving simple road drainage and cut and embankment slope stability problems on suburban roads,
- Understanding the behavior of earthwork components and structures as a whole, as well as the importance of sufficient and accurate performance of investigations and timely execution of certain construction phases,
- Using the specialized software for road design MXROAD and slope stability calculation W-SLOPE (GEOSTUDIO), and other common computational tools for drawing and presentation and document creation,
- Conducting works related to road construction and maintenance, and thereby solving engineering problems in a creative way,
- Following scientific literature in the field of road design and construction, and applying the acquired knowledge to further education.

Course content:

- Lectures:
  1. General information about earthwork structures [1]
  2. Earthwork elements – basic terms and definitions [1]
  3. Cross sections [1]
  4. The choice of cross section [1]
  5. Previous works in road construction – investigative and preliminary works [2]
  6. Soil classification procedures for the purposes of road construction [1]
  7. Soil classification procedures according to freezing sensitivity [1]
  8. The selection of slope inclination [1]
  9. Cut and embankment slope shaping [1]
  10. Slope protection - soil and mixed materials [2]
  11. Slope protection - rock materials [1]
  12. Slope protection with geosynthetic materials [1]
  13. Surface drainage [1]
  14. Subsurface drainage [1]
  15. Culverts [2]
  16. Retaining walls [2]
  17. Calculation and balancing of masses [2]

18. Mass curve, Mass haul [2]
19. Cut construction, embankment construction [2].

- Exercises (design):
  1. Examination of cut and embankment slope stability [4]
  2. Detailed elaboration of road cross section [4]
  3. Typical cross sections [6]
  4. Longitudinal and cross section of one culvert [4]
  5. Retaining wall cross section in cut [2]
  6. Retaining wall cross section in an embankment [2]
  7. Calculation of masses [2]
  8. Mass curve and balancing of masses [4]
  9. Technical report [1]
  10. Design submission [1].

Student responsibilities:

- Lecture and exercise attendance (minimum 75% of lectures and 100% of exercise classes),
- 2 pre-exams -minimum 25% score in each, one make up exam,
- Completion of design exercises and design submission.

Grading and evaluation of student work over the course of instruction:

- Design exercises grade,
- Pre-exams (students with a minimum 60% score in each pre-exam are exempt from the written exam).

End of semester grading:

- Written exam - minimum 50% score,
- Oral exam.

Contributions to the finalgrade:

- Design exercises grade 20%,
- Pre-exams or written exam 40%,
- Oral exam 40%.

Required literature:

1. V. Dragčević, T. Rukavina, *Donjiustrojprometnica*, Sveučilište u Zagrebu, Zagreb, 2006,
2. V. Dragčević, Ž. Korlaet, *Osnoveprojektiranjacesta*,Sveučilište u Zagrebu, Zagreb, 2003,
3. D. Brajković, I.Stančerić,S. Ahac, *Donjiustrojprometnica– priručnikzavježbe*, Zagreb, 2008 http://merlin.srce.hr

Optional literature:

1. Općitehničkiuvjetizaradovenacestama, HrvatskecesteiHrvatskeautoceste, Zagreb, 2001,(Technical conditions for roadworks, Croatian roads and Croatian highways, Zagreb, 2001),
2. Instructions for use of MxRoad software package
3. J. Mikulić, a. Stipetić, *Željezničkepružnegrađevine*, InstitutIGH, Zagreb, 1999

ROAD INTERSECTIONS

Credit value (ECTS): 6

Numberofhours (insemester):

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

Course objectives:

- Acquisition of theoretical knowledge and practical skills for intersection design.

Entry competencies (foreknowledge, descriptive):

- Practical skills for technical drawing – CAD skills.

Enrolment requirements (correlated courses):

- Teacher signatures: Transportation engineering.

Learning outcomes:

- Ability to understand traffic flow at road intersections and interchanges,
- Ability to meet safety requirements at road intersections and interchanges,
- Ability to use existing national and international guidelines for road intersections and interchanges design,
- Ability to follow professional and scientific literature for the design of road intersections and interchanges,
- Ability to choose the type of intersection with respect to the status and traffic conditions on the road network,
- Ability to shape individual intersection elements (islands, curbes, left and right turn lane) based on the assumptions related to driving speed and vehicle movement geometry,
- Ability to make intersection projects,
- Ability to make horizontal and vertical signalization projects on intersections.

Course content:

- Lectures:
  1. Traffic flowat intersections, channelization [2]
  2. Intersection classification and selection criteria [2]
  3. Intersection types [2]
  4. Intersection design [2]
  5. Traffic lane design at intersections [2]
  6. Intersection elements (traffic island, curbes) design [2]
  7. Horizontal and vertical alignment, visibility and sight distance at intersections [2]
  8. Design vehicles and their trajectories[2]
  9. Interchange types [2]
  10. Interchange design [2]
  11. Interchange ramp design [2]
  12. Roundabout and hybrid intersection design [2]
  13. Guidelines and standards for intersection and interchange design [2]
  14. Road markings – horizontal signalization [2]
  15. Vertical signalization and light signal sat intersections [2]
- Exercises (auditory, design):
  1. Intersection design guide lines [2]
  2. Design of intersection elements (traffic islands) [6]
  3. Design of traffic lanes at intersections (minor direction)[4]
  4. Design of traffic lanes at intersection(major direction) [4]
  5. Off tracking control [4]
  6. Horizontal and vertical signalization at intersections [4].

Student responsibilities:

- Attendance in lectures and exercises,

- Completion of design exercises and design submission.

Grading and evaluation of student work over the course of instruction:

- Design exercises grade.

End of semester grading:

- Written exam - minimum 50% score,
- Oral exam.

Contributions to the final grade:

- Design exercise grade30%,
- Writtenexam40%,
- Oralexam30%.

Required literature:

1. Ž. Korlaet*, Cestovna čvorišta* (mimeographed lecture notes), 2009,
2. I. Stančerić, T.Džambas, *Cestovna čvorišta u razini* (mimeographed program notes for the course Road intersections, 2014),
3. Priručnik za izradu vježbi i diplomskih radova iz kolegija Cestovna čvorišta za studente sveučilišnog diplomskog studija – Prometni smjer (Pravilnik o prometnim znakovima, signalizaciji i opremi na cestama (NN 33/05, NN 64/05 i 155/05), Horizontalna signalizacija – JUS U.S4.221 – U.S4.234), 2009, (Handbook for exercises and graduate papers in the course Road intersections for graduate students, Regulations on traffic signs, signalization and road equipment),
4. Merlin, web page`http://moodle.srce.hr`

Optional literature:

2. A. Klemenčić, *Oblikovanje cestovnih čvorišta izvan razine,* Građevinski institut Zagreb, Zagreb, 1982, pp.110.

Elective courses

APPLIED GEOLOGY

Look in **Shared courses**

ENVIRONMENT PROTECTION

Look in **Hydraulic Engineering**

2nd year, 3rd semester

Compulsory courses

RESEARCH METHODS

Look in **Shared courses**

TRAFFIC TUNNELS

Credit value (ECTS): 6

Number of hours (in semester):

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

Course objectives:

- Acquisition of theoretical knowledge and practical skills about traffic tunnel design,
- Acquisition of theoretical knowledge about excavation methods and tunnel lining support,
- Acquisition of theoretical knowledge about rock mass classification methods,
- Acquisition of theoretical knowledge and practical skills about safety systems in tunnels.

Entry competencies (foreknowledge, descriptive):

- Practical skills for technical drawing – CAD skills,
- Understanding equilibrium of forces in the plane.

Learning outcomes:

- Ability to monitor scientific literature inthefieldoftunneldesignandconstructionandapplicationofacquiredknowledgeinpractice,
- Theoretical knowledge about trockmass classification methods,
- Knowledge about historical and modern tunnel excavation methods,
- Knowledge about tunnel support systems,
- Ability to design tunnels for road, railway and metro,
- Ability to work in the tunnel construction field.

Course content:

- Lectures:
  1. Introductory course[2]
  2. Features of international and Croatian tunnels [4]
  3. Parameters for the design of road, railway and metro tunnels[4]
  4. Rock mass classification - RMR, Q [2]
  5. Rock mass classification -NATM[3]
  6. Excavation methods and rock support systems–traditional and modern [6]
  7. ADECCO – rock excavation method[4]
  8. Tunnel portals[2],
  9. Tunnel safety systems [3].
- Exercises (auditory, design):
  1. Introduction [2]
  2. Tunnel lining design[4]
  3. Rock load estimation for tunnel according to Protodyakonov's theory[4]

4. Load calculation [3]
5. Grafo-statical testing of tunnel lining[4]
6. Tabular and graphical representation of tensions in tunnel lining[3]
7. Cross section [2]
8. Excavation method (scheme and implementation phases)[4]
9. Design of safety niches[2]
10. Textual description of tunnels [2].

Student responsibilities:

- Attendance in lectures and exercises,
- Writing and presentation of a research paper on the topics of traffic tunnels,
- Completion of design exercises and design submission.

Grading and evaluation of student work over the course of instruction:

- Research paper evaluation (written and public presentation),
- Design exercise grade.

End of semester grading:

- Oral exam.

Contributions to the final grade:

- Design exercises grade30%,
- Research paper(written and public presentation)30%,
- Oralexam40%.

Required literature:

1. Ž. Stepan, *Mimeographed lecture notes*, 2012,
2. J. Mikulić, A. Stipetić, *Željezničke pružne građevine (Railway track construction)*, IGH, Zagreb. 1999, (Tunnels, pp. 150-197)
3. I. Banjad, *Tuneli (Tunnels)*, GF, Zagreb, 1986, (Methos of tunnel construction, pp.163-194)
4. D. Marušić, *Projektiranje i građenje željezničkih pruga*, (Design and construction of railroads), Građevinski fakultet Sveučilišta u Splitu, 1994. (Usponi u tunelu pp.135-137) ,
5. P. Lunardi, *2000. Design&constructingtunnels - ADECO-RS approach*, T&Tinternationalspecialsupplement, May 2000, http://www.rocksoil.com/ingindex3.html
6. I. Majstorović, Ž. Stepan, *Mimeographed lecture notes on programs in transportation tunnels*, 2009,
7. Merlin, web pagehttp://moodle.srce.hr

Optional literature:

1. I.Vrkljan, *Podzemne građevine i tuneli (Underground buildings and tunnels*)(mimeographed lecture notes, textbook),. Građevinski fakultet Sveučilišta u Rijeci, Institut IGH d.d., Zagreb, 2003,
2. *The World's LongestTunnel Page*, http://www.lotsberg.net
3. *AlpTransitGotthard* AG, http://www.alptransit.ch/

AIRPORTS

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures: 30
- Exercises (design): 15

Course objectives:

- Acquisition of basic knowledge about design, construction and maintenance of airport operational area, design and construction of rigid pavements.

Entry competences (foreknowledge, descriptive):

- Basic knowledge in the field of geomechanics,
- Basic knowledge about construction materials,
- Understanding the concepts of stress, strain and internal forces.

Enrolment requirements (correlated courses):

- Teacher signatures: Pavement structures,
- Examinations passed: Pavement structures.

Learning outcomes:

- Participation in the preparation of project documentation for all essential elements in airport maneuvering area, geometry, lighting, signalling, as well as pavements (flexible or rigid),
- Analysing and solving problems related to the design and construction of airports from the engineering point of view by applying the latest knowledge and solutions,
- Designing pavements for airport manoeuvre in area in accordance with the international engineering practices,
- Using specialized software for pavement design (PAVERS),
- Critical evaluation, analysis and appropriate selection of the appropriate types of pavements in accordance with the purpose of maneuvering areas,
- Creative participation in works related to the construction and maintenance of airport maneuvering area,
- Following scientific literature in the field of airport pavement design and construction, and application of acquired knowledge in further education.

Course content:

- Lectures:
    1. Introduction (history of aviation) [2]
    2. Civil air traffic and its organization [4]
    3. Air traffic system, airports and its elements [1]
    4. Terms used in standards and recommendations – according to ICAO [1]
    5. Basics of meteorology for research, position in grand exploitation of airports [2]
    6. Airports-definition, development, division, classification and codification according toICAO [2]
    7. Airport maneuvering area, runway, shoulder [1]
    8. Stop way, clearway, declared distances, runway safety area [2]
    9. Taxiway [2]
    10. Apron [2]
    11. Obstacle restrictions[2]
    12. Marking of the airport maneuvering area [2]
    13. Obstacles and marking of obstacles [2]

14. Airport pavement classification (loads, methods of classification) [2],
15. Airport pavement design (flexible and rigid) [1].

- Exercises (design):
  1. Introduction to airport pavement design [2]
  2. ACN-PCN classification, determination of relevant aircraft; determination of relevant pavement thickness (flexible and rigid)[4]
  3. Classification according to LCN method [2]
  4. Determining equivalent number of passes for relevant aircraft [2]
  5. Preliminary design of flexible and rigid pavements [2]
  6. Design of rigid pavement in accordance with Westergaard method [2]
  7. Program submission [1].

Student responsibilities:

- Attendance in minimum 75% lectures and 100% exercises,
- Pre-exam – minimum 25% score,
- One make up pre-exam,
- Program submission.

Grading and evaluation of student work over the course of instruction:

- Program grade,
- Pre-exam - students with a minimum 60% score are exempt from written exam.

End of semester grading:

- Written exam -minimum 50% score,
- Oral exam.

Contributions to the final grade:

- Program 30%,
- Pre-exam 40%,
- Oral exam 30%.

Required literature:

1. Z. Horvat, *Airports I*, Zagreb, 1982,
2. A. Prager, *Airports I – amendments*, Zagreb, 1990,
3. S. Pavlin, *Airports I*, Faculty of Transport and Traffic Sciences, Zagreb, 2006,
4. T. Rukavina, J. Domitrović, *Airports* (lectures, exercises guide), Zagreb, 2012, http://merlin.srce.hr

Optional literature:

1. *Aerodromes,* Annex 14 to the Convention on International Civil Aviation, ICAO, 1999
2. *Airport Pavement Design and Evaluation*, Federal Aviation Administration, 1995

ROAD EQUIPMENT

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures:45

Course objectives:

- Acquisition of theoretical and practical knowledge about installing traffic signs and other relevant road equipment that increases safety and comfort of traffic flow.

Entry competencies (foreknowledge, descriptive):

- Knowledge about road design rules,
- Knowledge about road cross section elements.

Learning outcomes:

- Ability to describe types, operations and maintenance of road equipment (traffic signs, safety fences, pavement marking equipment, trafficcal ming equipment, lighting),
- Ability to understanddesignandinstallationmethodologyofroadequipmentrespectingthe behaviour of road users (physical and psychological characteristics of driver), traffic conditions and vehicle characteristics,
- Evaluation of assumptions, argument sand design solutions,
- Ability to monitor scientific and professional literature related to the design and installation of road equipment and to apply acquired knowledge for further specialization.

Course content:

- Lectures:
  1. Introduction. Road equipment. Basic principles for installing traffic signs [2]
  2. Traffic performance [2]
  3. Vehicle movement. Stopping sight distance. Visibility [3]
  4. Vertical signs. Road signs –form and setting up [6]
  5. Road markings – visibility and design recommendations [3]
  6. Road markings – materials and colors, construction [3]
  7. Horizontal and vertical signs application examples[3]
  8. Traffic lights [2]
  9. Variable Message Signs [2]
  10. Equipment for road pavement marking [2]
  11. The guardrails [4]
  12. Other types of fences and comfort pads [3]
  13. Other road equipment [3]
  14. Road lighting [3]
  15. Animal crossings [2]
  16. Wind protection barriers [2].

Student responsibilities:

- Attendance in lectures (minimum 75%),
- Writing a research paper on the topics of road equipment,
- Research paper presentation.

Grading and evaluation of student work over the course of instruction:

- Research paper evaluation – students with minimum 60% score are exempt from the written exam,
- Research paper presentation evaluation - students with minimum 60% score are exempt from the oral exam.

End of semester grading:

- Written exam -minimum 50% score,
- Oral exam.

Contributions to the final grade:

- Research paper or writtenexam50%,
- Researchpaperpresentationororalexam50%.

Required literature:

1. V. Dragčević, S. Stančerić, *Prometna oprema*, predavanja, (*Road Equipment*, mimeographed lecture notes(, Zagreb, 2009, `http://moodle.srce.hr`
2. *Zakon o sigurnosti prometa na cestama* (*Law on Road Traffic Safety*, Official Gazette, 6772008), NN 67/2008,
3. *Pravilnik o prometnim znakovima, signalizaciji i opremi na cestama* (*Regulations on traffic signs, signalisation and road equipment*, Official Gazette)(NN 33/05, NN 64/05 i 155/05)
4. *Horizontalna signalizacija* (*Horizontal signalisation*) - JUS U.S4.221 -U.S4.234, Priručnik za izradu vježbi i diplomskih radova iz kolegija Cestovna čvorišta za studente sveučilišnog diplomskog studija (handbook) - Prometni smjer.

Optional literature:

1. *Opći tehnički uvjeti za radove na cestama*, Hrvatske ceste i Hrvatske autoceste, Zagreb, 2001, (*General technical requirements for road works*, Croatian Roads and Croatian Highways, 2001)

TRANSPORT SYSTEMS

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures: 45

Course objectives:

- Multidisciplinary approach to planning, design and maintenance of integral transportation systems.

Entry competences (foreknowledge, descriptive):

- Practical knowledge in the field of traffic flows,
- Practical knowledge in the field of transportation technology.

Enrolment requirements (correlated courses):

- Examinations passed: Transportation technology.

Requirements for examination taking (correlated courses):

- Examinations passed: Transportation technology.

Learning outcomes:

- Ability to determine the main features of basic elements in transportation systems and various types of transport,
- Participation in the analysis of the performance of entire transport system and its elements,
- Ability to design various elements in transport system,
- Ability to analyze the basic principles of functioning and development of road traffic system,
- Ability to evaluate and investigate the existing data on road traffic system and their application,
- Participation in developing the concepts of transport system functions,
- Participation in creating and maintaining transport systems.

Course content:

- Lectures:
  1. Traffic: definitions, divisions, historical development [3]
  2. Main characteristics of vehicle, roads and travelling [4]
  3. Main characteristics of drivers and pedestrians [4]

4. General traffic characteristics [4]
5. Traffic loads [4]
6. Traffic flows [4]
7. Urban areas [4]
8. Urban public transportation [4]
9. Regional traffic [2]
10. Paratransit[2]
11. Pedestrian traffic [2]
12. Cycle traffic [2]
13. Traffic safety [2]
14. Traffic studies [2]
15. Traffic planning [2].

Student responsibilities:

- Attendance in lectures,
- Two pre-exams – minimum 40% score in each.

Grading and evaluation of student work over the course of instruction:

- Pre-exams.

End of semester grading:

- Pre-exams,
- Oral exam.

Contributions to the final grade:

- Pre-exams 60%,
- Oral exam 40%.

Required literature:

1. W.R. McShane, R.P. Roess, *Traffic Engineering*, Prentice-Hall, Inc. Englewood Cliffs, New Jersey, 1990
2. J. Pađen, *Metode prostorno-prometnog planiranja*, (*Methods of urban transport planning*), Informator, Zagreb, 1978
3. J.V. Korte, *Osnove projektiranja gradskog i međugradskog putnog saobraćaja (Basics of design of urban and interurban traffic)*, Građevinska knjiga, Beograd, 1968
4. L.J. Pignataro, *Traffic Engineering, Theory and Practise*, Prentice-Hall, Inc. Englewood Cliffs, New Jersey, 1973
5. P. Rožić, Mimeographed lecture notes.

Optional literature:

1. *Trasportation and Traffic Engineering Handbook*, the Institute of Traffic Engineers, Washington, D.C., 1976

Elective courses

DRAINAGE OF TRANSPORTATION FACILITIES

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures: 30
- Exercises (design): 15

Course objectives:

- Acquiring theoretical and practical knowledge on pavement and subgrade drainage principles,
- Understanding the advantages and disadvantages of different types of drainage systems,
- Acquiring basic knowledge needed in design practice concerning the choice of drainage elements and systems.

Entry competences (foreknowledge, descriptive):

- Good understanding of the road design principles,
- Holistic approach to drainage design.

Learning outcomes:

- Knowledge on surface and sub-surface drainage design in urban and rural areas,
- Solving basic drainage problems on urban and rural roads,
- Analysis of rainfall runoff and groundwater flow influence on road safety, bearing capacity and stability of superstructure and substructure elements,
- Application of specialised road design software MX ROAD in drainage design,
- Evaluation of assumptions, arguments and design solutions for drainage of transportation facilities,
- Ability to understand scientific and professional papers and to collect and present the data used to solve practical problems in everyday engineering practice.

Course content:

- Lectures:
    1. Hydrological conditions, data and procedures, Hydraulic criteria [6]
    2. Protection from rainfall runoff and groundwater flow [2]
    3. Pavement surface drainage [2]
    4. Pavement surface drainage systems [4]
    5. Subgrade drainage systems [2]
    6. Urban drainage [4]
    7. Culverts [4]
    8. Design discharge [2]
    9. Environmental considerations and criteria [2].
- Exercises (design):
    1. Detailed cross sections [5]
    2. Horizontal alignment [1]
    3. Vertical alignment [2]
    4. Surface drainage design [3]
    5. Sub-surface drainage design [3]
    6. Technical description [1].

Student responsibilities:

- Lecture and exercise attendance (minimum 75% of lectures and 100% of exercise classes).
- Two pre-exams - minimum 25% score,
- One make up exam,
- Completion of design exercises.

Grading and evaluation of student work over the course of instruction:

- Design exercise grade,
- Pre-exams - students with a minimum 60% score in each pre-exam are exempt from the written exam.

End of semester grading:

- Written exam - minimum 50% score,
- Oral exam.

Contributions to the final grade:

- Design exercise grade 20%,
- Pre-exams or written exam 40%,
- Oral exam 40%.

Required literature:

1. RAS, *Entwässerung*, FGSV, Boon, 1987,
2. RAS, *TabellenfürBemessung von Entwässerungsrinnrn undmulden in befestigenVerkehrsflächen*, FGSV, Bonn, 1987,
3. Richard K. Untermann, *Principles and practices of grading, drainage and road alignment: An ecologic approach*, Prentice-Hall, Inc., 1978

Optional literature:

1. Opći tehnički uvjeti za radove na cestama, Hrvatske ceste i Hrvatske autoceste, (*General technical requirements for road works*, Croatian Roads and Croatian Highways, 2001), Zagreb, 2001

TRAFFIC BUILDINGS

Credit value (ECTS):4.5

Number of hours (in semester):

- Lectures: 30
- Exercises: 15 (auditory: 1, design: 14)

Course objectives:

- Learning about traffic buildings, their main features and planning methodology.

Learning outcomes:

- Ability to use professional literature and apply acquired knowledge in further training,
- Ability to analyze the methodology of planning and design of traffic buildings,
- Planning traffic buildings and designing traffic systems inside and out of traffic buildings,
- Ability to evaluate the assumptions, arguments and design solutions related to the location and selection of traffic building type,
- Ability to evaluate organisational principles and select optimal type of traffic buildings and creative application of acquired knowledge,
- Ability to present professional topic related to planning and design of traffic buildings.

Course content:

- Lectures:
    1. Introduction – city and traffic [1]
    2. Basic characteristics of traffic building architecture [1]
    3. Pedestrian underpasses and overpasses [1]
    4. Car parks [1]
    5. Multi storey car parks [1]
    6. Petrol stations in towns. Service stations [1]

7. Accompanying facilities along highways, motels [1]
8. Bus stations in city traffic [1]
9. Bus stations in intercity traffic [1]
10. Typology of railway stations [2]
11. Typology of airport buildings [2]
12. Accompanying facilities in ports [1]
13. Accompanying facilities in marinas [1].

- Exercises:
  1. Auditory – instructions for making programs, pre-exam [1]
  2. Design – program making [14].

Student responsibilities:
- Attendance in lectures and exercises,
- Two pre-exams – minimum 25% score in each.

Grading and evaluation of student work over the course of instruction:
- Pre-exams,
- Program.

End of semester grading:
- Written exam.

Required literature:
1. S. Bašić, G. Poljanec, *Prometne zgrade* (*Traffic Buildings*), mimeographed lecture notes

Optional literature:
1. E. Eufert, *Osnove projektiranja* (*Basics of Design*), golden marketing, 2002

SOIL IMPROVEMENT METHODS

Credit value (ECTS): 4.5

Number of hours (in semester):
- Lectures: 30
- Exercises (design): 15

Course objectives:
- Acquiring basic knowledge about various procedures and methods for improving unstable soils, design and construction of various methods for stabilization of unstable soils.

Entry competences (foreknowledge, descriptive):
- Basic knowledge in the field of pavement geomechanics,
- Basic knowledge about construction materials.

Learning outcomes:
- Ability to understand the effects of materials used in improving soil characteristics (cement, lime, bitumen, geosynthetic materials, various commercial products) and ability to evaluate the advantages and disadvantages of their use in certain circumstances,
- Ability to analyze and solve problems related to design and construction of pavements on poor load bearing soil in accordance to European regulations,
- Ability to participate in design of mixture used to enhance poor load bearing soil performance in accordance with domestic and international engineering practice,
- Ability to analyze and select appropriate types of soil stabilization,
- Ability to apply engineering approach for design and construction of pavements on poor load bearing soils using knowledge on properties of weak soil and applied additives,

- Ability to participate in works related to soil improvement in a creative way,
- Ability to follow scientific literature in the field of soil improvement, and to apply the acquired knowledge in further education.

Course content:

- Lectures:
    1. Introduction (purpose, definition, application areas, stabilization, application for pavement infrastructure) [2]
    2. Concept of unstable soil and unstable soil types[3]
    3. Selection of procedures (determining parameters in decision making on soil improvement methods)[2]
    4. Mechanically stabilized soil [4]
    5. Stabilization with lime [5]
    6. Soil stabilization with a mixture of fly ash with lime or cement [3]
    7. Soil stabilization with bitumen [2]
    8. Thermal soil stabilization procedures [3]
    9. Soil stabilization with geosynthetics [2]
    10. Other ways of soil stabilization [4].
- Exercises (design):
    1. Introduction (seminar paper theme) [1]
    2. Preparation of seminar [8]
    3. Presentation of seminar [4]
    4. Submission of seminar paper [2]

Student responsibilities:

- Attendance in minimum 75% lectures and 100% exercises,
- Seminar paper (writing and presenting).

Grading and evaluation of student work over the course of instruction:

- Seminar paper grade.

End of semester grading:

- Seminar paper grade (writing and presentation),
- Oral exam.

Contributions to the final grade:

- Seminar paper 60%,
- Oral exam 40%.

Required literature:

1. B. Babić, Z. Horvat, *Pavement construction and maintenance*, University of Zagreb, Zagreb,1983,
2. B. Babić, *Geosynthetics in transportation infrastructure*, HSGI, Zagreb, 1995,
3. T. Rukavina, *Mimeographed lecture notes*,
4. *Generaltechnical specifications for road works*, IGH, Zagreb, 2001

Optional literature:

1. F. G. Bell, *Engineering Treatment of Soils*, Taylor & Francis, 2005

ENGLISH FOR CIVIL ENGINEERING 2

Look in **Geotechnical Engineering**

GERMAN FOR CIVIL ENGINEERING 2

Look in **Geotechnical Engineering**

2nd year, 4th semester

Compulsory courses

PAVEMENT MANAGEMENT

Credit value (ECTS): 3

Number of hours (in semester):

- Lectures: 30

Course objectives:

- Acquisition of basic knowledge about pavement properties that affect driving safety and comfort,
- Acquisition of knowledge about basic pavement maintenance methods, and pavement management systems.

Entry competences (foreknowledge, descriptive):

- Basic knowledge in the field of pavement design and construction,
- Basic knowledge about construction materials,
- Basic knowledge in the field of pavement geomechanics.

Learning outcomes:

- Understanding and actively participating in the implementation of pavement management systems from inspection and assessment to the final selection and application of appropriate solutions,
- Ability to analyze and solve problems related to the pavement maintenance from the engineering point of view by applying the latest know-how and solutions,
- Ability to apply the acquired knowledge to the creation of pavement management system in accordance with the international practice by using one of the specialized software types(Micro PAVER),
- Ability to assess (under the supervision of a mentor), analyze and select appropriate ways of pavement maintenance in accordance with the existing practice by respecting the principles of rational pavement management,
- Ability to apply engineering approach to the maintenance of pavement using knowledge about materials, construction technology and pavement performance gained in other courses that are directly related to the subject matter of pavements(Pavements, Airports, Methods of soil improvement),
- Ability to participate creatively in works related to the pavement maintenance,
- Ability to follow scientific literature in the field of pavement maintenance, and to apply the acquired knowledge in further education.

Course content:

- Lectures:
  1. Introduction [2]
  2. Fundamentals on pavement management systems[2]
  3. Pavement maintenance (definitions, objectives and economic aspects)[2]
  4. Pavement condition features (types of pavement distresses, methods of data acquisition, pavement condition evaluation on the basis of collected data) [4]
  5. Asphalt pavement maintenance [4]

6. Concrete pavement maintenance [2]
7. Reconstruction of asphalt pavements (reinforcement, total replacement of the existing pavement, a combination of reinforcement and total replacement) [3]
8. Reconstruction of concrete pavements [2]
9. Cuts and other damages/repairs caused by works on utility infrastructure [4]
10. Structure and elements of management systems [4]
11. Pavement management models (Micro PAVER, HDMIII system dTIMS/VIAPMS) [3].

Student responsibilities:

- attendance in minimum 75% lectures,
- Seminar paper.

Grading and evaluation of student work over the course of instruction:

- Seminar paper grade (writing and presentation),
- Oral exam.

End of semester grading:

- Oral exam.

Contributions to the final grade:

- Seminar paper 40%,
- Oral exam 60%.

Required literature:

1. M. Sršen, *Pavement maintenance*, HSGI, Zagreb, 2000,
2. V. Dragčević, Ž. Korlaet, T. Rukavina, *Flexible pavement distress catalogue*, GF, Zagreb, 2004,
3. M. Keller, *Pavement management*, GF, Transportation Days 2009, Zagreb, 2009,
4. T. Rukavina, M.Ožbolt, *Pavement Management System - Data Collection, Management of Transport Infrastructure*, Transportation Days 2009, Zagreb, 2009,
5. T. Rukavina, *Mimeographed lecture notes*.

Optional literature:

1. OECD (Scientific Expert Group): *Road Maintance Management Systems in Developing Countries*, Organization for Economic Co-operation and Development, Paris, 1995

Elective courses

PARKING FACILITIES

Credit value (ECTS): 4.5

Number of hours (in semester):

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

Course objectives:

- Acquisition of theoretical knowledge and practical skills for parking facilities design,
- Acquisition of theoretical knowledge and practical skills for the connection of parking facilities to road network.

Entry competencies (foreknowledge, descriptive):

- Practical skills in technical drawing – CAD skills,

Enrolment requirements (correlated courses):

- Teacher signatures: Traffic systems.

Learning outcomes:

- Ability to design parking facilities using existing national and international guidelines,
- Ability to determine the number of parking lots, type and size of parking facilities, based on urban-traffic needs,
- Ability to define internal traffic organization on parking facilities,
- Ability to define adequate connection between parking facilities and urban traffic network,
- Ability to work in parking facility y construction field.

Course content:

- Lectures:
  1. Introductory course [2]
  2. Basic settings for stationary traffic [3]
  3. Car parking [6]
  4. Parking garages [6]
  5. Motorcycle parking [2]
  6. Bicycle parking [2]
  7. Truck and bus parking [2]
  8. Parking facilities – design elements [5]
  9. Turnarounds [2].

  Exercises (auditory, design):
  1. Introduction [1],
  2. Defining internal traffic organization on a parking facility[8],
  3. Define adequate connection between parking facility and urban traffic network [4],
  4. Technical description [2].

Student responsibilities:

- Lectures and exercises attendance,
- Completion of design exercises and design submission.

Grading and evaluation of student work over the course of instruction:

- Design exercises grade.

End of semester grading:

- Oral exam.

Contributions to the final grade:

- Design exercises grade 50%,
- Oral exam 50%.

Required literature:

1. AASHTO: *A Policy on Geometric Design of high way sand Streets*, American Association of State Highway and Transportation Officials, Washington D.C., 2001
2. FGSV: *Richtlinien f die Anlagen von Staatsstraßen*, Forschungsgeselschaft für Straßen und Verkehrswesen, Köln, 2006
3. VSS: *Schweizer Norm (SN) Band 4,5* – Entwurf der Verkehrsanlagen, Zürich, 2007
4. M. Maletin, V. Andjus, J. Katanić, *Tehnička uputstva za projektovanje parkirališta* (*Technical guidelines for the design of car parks*)(PGS-P/08), Građevinski centar Beograd, 2010,

5. M. Maletin, V. Andjus, J Katanić, *Tehnička uputstva za projektovanje lokalne gradske putne mreže*(*Technical guidelins for the design of local city transport network*),(PGS-LM/08), Građevinski centar Beograd, 2010,
6. Merlin, web page`http://moodle.srce.hr`

Optional literature:

1. GIVT mbh Berlin, International Consulting, *Planning and Engineering Service for Parking and Traffic Development*, `http://www.givt.de/index.php/en/`.

TRACK MAINTENANCE

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures: 45

Course objectives:

- Acquisition of theoretical and practical knowledge about rail track maintenance,
- Acquisition of theoretical knowledge about track condition control,
- Acquisition of practical knowledge about manual and mechanical maintenance,
- Acquisition of theoretical knowledge about turnout maintenance,
- Acquisition of theoretical knowledge about track substructure,
- Acquisition of knowledge about control and reconstruction of railway facilities.

Entry competences (foreknowledge, descriptive):

- Knowledge about track construction types,
- Knowledge about turn out working principles,
- Knowledge about track substructure.

Enrolment requirements (correlated courses):

- Examinations passed: Permanent way.

Learning outcomes:

- Knowledge about rail track maintenance system,
- Knowledge about rail track condition control,
- Knowledge about rail track superstructure maintenance,
- Knowledge about rail track substructure maintenance,
- Knowledge about turnout maintenance,
- Knowledge about control and reconstruction of railway facilities,
- Knowledge about high speed rail ways maintenance.

Course content:

- Lectures:
  1. Basic concepts on track maintenance[2]
  2. Track condition inspection: track geometry, rails[4]
  3. Track condition inspection: structure clearances and ballast prism[4]
  4. Track maintenance work types: current track maintenance, track reconstruction[6]
  5. Permanent way maintenance: manual maintenance and mechanical maintenance [6]
  6. Track material regeneration: rails, turnouts, fastenings, sleepers, ballast [4]

7. Turnout maintenance: point blades, frogs, wing and guardrails [4]
8. Track substructure maintenance: track formation level, sub-base, drainage ditches [4]
9. Railway facility inspection: inspection of bridges, culverts, tunnels, level crossings [4]
10. Maintenance and reconstruction of railway facilities [4]
11. Track maintenance for high speed railways [3].

Student responsibilities:

- Lecture attendance.
- Writing a seminar paper on topics of track maintenance.

Grading and evaluation of student work over the course of instruction:

- Assessment of seminar paper.

End of semester grading:

- Written exam - minimum 50% core,
- Oral exam.

Contributions to the final grade:

- Seminar20%,
- Written exam 40%,
- Oral exam 40%.

Required literature:

1. Esveld, C.,*Modern Railway Track*, Second Edition, MRT Productions, Zaltbommel, 2001,
2. Mikulić, J., Stipetić, A.,*Željezničke pružne građev ine*, Institut građevinarstva hrvatske, Zagreb, 1999

Optional literature:

1. *Pravilnik o održavanju gornjeg ustroja željezničkih pruga HŽ*(Regulations on maintance of track railroads), (Pravilnik 314); *Pravilnik o održavanju donjeg ustroja željezničkih pruga HŽ*(*Regulations on subrstructure railroads*) (Pravilnik 315)

URBAN RAILWAYS

Credit value (ECTS): 4.5

Number of hours (in semester):

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

Course objectives:

- Acquisition of theoretical and practical knowledge about rail track maintenance,
- Acquisition of theoretical knowledge about track condition control,
- Acquisition of practical knowledge about manual and mechanical maintenance,
- Acquisition of theoretical knowledge about turnout maintenance,
- Acquisition of theoretical knowledge about track substructure,
- Acquisition of knowledge about the control and reconstruction of railway facilities,

Entry competences (foreknowledge, descriptive):

- Knowledge about track design and construction procedures,
- Knowledge about track superstructure,
- Knowledge about public transport systems.

Enrolment requirements (correlated courses):

- Examinations passed: Permanent way.

Learning outcomes:

- Knowledge about public transport system purpose,
- Knowledge about tramway public transport system,
- Knowledge about metro public transport system,
- Knowledge about light rail public transport system,
- Knowledge about suburban transport system,
- Knowledge about construction types of tracks in urban environment,
- Knowledge about urban rail traffic noise and vibrations mitigation measures.

Course content:

- Lectures:
    1. Basic concepts on urban railways[2]
    2. Tramway track[4]
    3. Light rail track [4]
    4. Metro track [4]
    5. Suburban rail track [4]
    6. Rail vehicles types in urban environment [2]
    7. Construction types of tracks in urban environment [3]
    8. Construction of tracks in urban environment[3]
    9. Urban rail traffic noise and vibrations[2]
    10. Revitalization of urban railways [2].
- Exercises (auditory, design): Creating program assignment on the topic of rail traffic in urban areas. Topics for the program are as follows:
    1. Reconstruction of tram stops (extension, relocation, modernization),
    2. Preliminary design of pedestrian under passes,
    3. Preliminary design of new tramlines in Zagreb and Osijek,
    4. Preliminary design of revitalization of urban railways,
    5. Preliminary design of rail road crossing denivelation,
    6. Rail traffic noise and vibration analysis in urban environments.

Student responsibilities:

- Lecture and exercise attendance,
- Program design.

Grading and evaluation of student work over the course of instruction:

- Assessment of the program.

End of semester grading:

- Written exam - minimum 50% score,
- Oral exam.

Contributions to the final grade:

- Seminar10-20%,
- Written exam 30-40%,
- Oral exam 40-50%.

Required literature:

1. Lakušić, S.,*Tramvajski kolosijeci* (*Tram rails*), Građevinski fakultet Zagreb, Faculty of Civil Engineering, Zagreb, 2006,
2. *Light RailIn Germany*, Federal Ministry of Transport, VDV Group, 2000

Optional literature:

1. Garbutt, P.,*World metro system*,
2. Taplin, M., Russel, M.,*Tramsin Western Europe*, Capital Transport.
3. Bennet, D.,*Metro*, Octopus Publishing, 2004

NUMERICAL MATHEMATICS

Look in **Shared Courses**

PERSPECTIVE

Look in **Shared Courses**

BASICS OF DIFFERENTIAL GEOMETRY

Look in **Shared Courses**

WAVES AND VIBRATIONS

Look in **Shared Courses**

THEORY AND MODELING OF STRUCTURES

1st year, 1st semester

Compulsory courses

MATHEMATICS 3

Look in **Shared courses**

RESEARCH METHODS

Look in **Shared courses**

MECHANICS OF MATERIALS

Credit value (ECTS): 4.5

Number of hours (in semester):

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

Course objectives:

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

Entry competences (foreknowledge, descriptive):

- Knowledge about differential and integral calculus. Knowledge about mechanics (statics and kinematics). Understanding the concepts of stress and strain. Knowledge about calculation stresses and strains in the elements loaded internal forces (longitudinal and transverse, to torque and bending moment).

Learning outcomes:

- Knowledge about strength, stiffness and stability of engineering structures. Dimensioning engineering structural members,
- Ability to solve different engineering problems in the field of mechanics of body deformability,
- Understanding the types of testing mechanical properties of materials, methods and standards for testing.
- Understanding the structure of matter, structurally sensitive and insensitive properties, selective and additive theory,
- Understanding and interpreting the method of determining the mechanical properties of materials,
- Understanding the strength of materials under cyclic loading,
- Identifying the meaning of rheology and fracture mechanics,
- Understanding the concept of hardness of materials and test methods.
- Understanding the manners of non-destructive testing of materials and applying them,
- Applying the experimental stress and strain analysis in determining the physical and mechanical properties of materials.

Course content:

- Lectures:
  1. The impact of a construction material structure on mechanical properties of a material, probabilistic character of mechanical properties and sensitivity structure, the theory of selectivity and the theory of addition.
  2. Modeling and measurement effect. Load, time temperature. Testing methodology, testing devices. Devices for strain measuring. Interpretation of testing results. Mechanical properties of material in static loads. Conventional work chart of a material in stretching and pressure. Characteristics of a material deformability. Ductility material. Brittle materials.
  3. Real material chart. Anisotropy of mechanical properties. Idealization of work material chart. Elastoplastic material with strengthening ideally elastoplatic material, solid plastic material, solid and plastic material with reinforcement.
  4. Impact of external factor on mechanical properties of material in static load. Backward stresses. Basic forms of material destruction in stretching and pressure. Long-term static loading. Statically durable strength of material. Creeping of material. Relaxation of stress.
  5. Strength of material in dynamic loading. Types of dynamic loading. Impact strength of material ductility. External factors affecting the impact strenth of material. Testing procedures. Strength of material in cyclically changeable loading.
  6. Fatigue in material. Determination of dynamic strength of material. The impact of factors on durable dynamic strength of material. Coefficient of safety and allowed stress.
  7. Fracture mechanics and strength of material. Basic shapes of crack development. Stress intensity factor. Criteria of fracture. Ductility of fracture. Material sensitivity on cuts and cracks.
  8. Rheological properties of material. Rheological condition equation of material. The principle of superposition of time and temperature. Rheological models. Hardness of material. Procedures of hardness testing: ripping, indenting and rebound. Hardness correlation of material and strength of material.
- Exercises (auditory, design, laboratory):
  1. Auditory– Strength of material in cyclically variable load. Fatigue of materials. Determination of the dynamic strength of materials. Fracture mechanics. The hardness of the material. Non-destructive testing.
  2. **Laboratory–**σ-εdiagram under static and dynamic loading. Bauschingerov effect. Elastic hysteresis. Determination of the tensile strength of brittle materials. Testing of pressure. Effect of sample size on the strength of the material. Testing of shear. Bending test. Testing of alternate folding. Testing of twisting. Charpy impact strength and Föpplu. Fatigue of materials. Hardness: Martens, Brinell, Poldi, Schmidt hammer. Fracture mechanics. Acoustic procedures. Determination of stress in the wire.

Student responsibilities:

- Attending lectures and exercises,
- One Colloquium: student should solve at least 25%,
- Writing a seminar paper.

Grading and evaluation of student work over the course of instruction:

- A colloquium: students who at the colloquium solve 50% are released from the written exam,
- Grading a seminar work.

End of semester grading:

- The written part of the exam: at least 50%,
- Oral exam.

Contributions to the final grade:

- Seminar work 20%,
- Colloquium or written exam 40%,
- Oral exam 40%.

Required literature:

1. J. Krolo, D. Šimić: *Mehanika materijala*, Sveučilište u Zagrebu, Građevinski fakultet, Zagreb, 2011.
2. Šimić, V.: *Otpornost materijala II*, Školska knjiga, Zagreb, 2002.

Optional literature:

1. Bazjanac, D., *Nauka o čvrstoći*, Tehnička knjiga, Zagreb, 1973.
2. Timošenko, S., *Otpornost materijala II*, Građevinska knjiga, Beograd, 1965.
3. Timošenko, S., *Mechanics of Materials*, Van Hostrand Reinhold Company, New York, 1972.

NONLINEAR ANALYSIS OF ROD STRUCTURES

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures: 30
- Exercises: 15 (auditory – 10, design – 5)

Course objectives:

- Definition of basic nonlinear relations,
- Explanation of structural nonlinearity,
- Solution of nonlinear equilibrium equation with structural nonlinearity.

Entry competences (foreknowledge, descriptive):

- Understanding and capability of applying equilibrium equations in 2D and 3D
- Knowledge of basic theoretical methods of linear static analysis for determination reactions, internal forces and displacements on statically determinate and indeterminate structures,
- Basic mathematical knowledge of differential equations.

Learning outcomes:

- Ability to solve nonlinear problems,
- Understanding the nonlinearity of structures,
- Ability to apply computational analysis of nonlinear problems in structural analysis.

Course content:

- Lectures:
    1. Idealization in linear statics of bar structures [2]
    2. Exact theory of geometry displacement and equilibrium on a deformed rod[2]
    3. Relationships between linear and nonlinear theory [2]
    4. Differential relations of forces and loadings in geometric nonlinearity [2]
    5. Relations between forces and displacements of bar ends in geometric nonlinearity [2]
    6. Equations of equilibrium knots [2]
    7. The concept of imperfection, derivations and solutions of differential equations of bars [2]
    8. Linearization of computation [2]
    9. P-delta analysis [2]
    10. Physical nonlinearity, basic concepts [2]
    11. Idealization in material nonlinearity [2]
    12. Approximation of physically nonlinear tasks [2]
    13. General bilinear approximation [2]

14. Interaction of internal forces in physical nonlinearity, simultaneous geometric and physical nonlinearity [2]
15. Iterative computation of bearing capacity by differential equations method, the general equation of a moment in plastic hinges [2].

- Exercises (auditory):

1. Idealization in linear statics of bar structures [2]
2. Realationships between linear and nonlinear theory, differential realtions of forces and loadings in geometric nonlinearity [4]
3. Realtions between forces and is placements of bar ends in geometric nonlinearity equations of equilibrium knots [2]
4. The concept of imperfection, derivations and solutions of differential equations of bars, linearization of computation, P-delta analysis [3]
5. Physical nonlinearity, basic concepts idealization in material nonlinearity [2]
6. Approximation of physically nonlinear tasks, general bilinear approximation [2]

Student responsibilities:

- Attendance in lectures and exercises,
- Solving various problems.

Grading and evaluation of student work over the course of instruction:

- Evaluation of solutions to assigned problems.

End of semester grading:

- Final seminar paper,
- Oral exam.

Contributions to the final grade:

- Solutions to assigned problems 40%,
- Final seminar paper 20%,
- Oral exam 40%.

Required literature:

1. H.Rothert, V.Gensichen: *Nichtlineare Stabstatik*, Springer, 1987,
2. M. Meštrović,*mimeographed lecture notes*, `http://www.grad.hr/predmeti/nssk`
3. K. Fresl: *Bilješke s predavanja*, `http://master.grad.hr/nastava/gs`

EXPERIMENTAL METHODS 1

Credit value (ECTS**):** 6

Number of hours (in semester):

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

Course objectives:

- Upgrading theoretical and practical knowledge on the application of the experiment as a basic research method in technical science,
- Introduction to modern measuring equipment and methods of experimental analysis of structural materials, structural elements and structures,
- Practical knowledge about metrology and standards in metrology.

Entry competences (foreknowledge, descriptive):

- Knowledge about basic elements in statistics and probability theory,
- Knowledge on data analysis and determination of basic statistical parameters,
- Knowledge about calculation of stresses and strains caused by longitudinal and shear forces, torque and bending moment.

Learning outcomes:

- Determining measurement errors, the precision of equipment and measurement uncertainty,
- Designing an experiment through basic stages of preparation, implementation and analysis of results,
- Selecting the equipment and methodology for implementation of experimental research on structural materials, elements and structures,
- Experimental determination of displacement, strain, banking, curvature and basic dynamic parameters,
- Analysis of structures and structural elements using modern experimental techniques.

Course content:

- Lectures:
    1. Introduction, historical overview of the development of metrology [2]
    2. International and Croatian metrology infrastructure, standardization and norms [2]
    3. Errors of measurement, measurement uncertainty, accuracy of measurement equipment [2]
    4. The measurement of physical quantities, measurement systems and their characteristics [2]
    5. Equipment and measurement methods of displacement and strain [2]
    6. Equipment and methods for measuring force, pressure and temperature [2]
    7. Methods of measurement on models and prototypes [2]
    8. Testing models and materials for manufacturing models [2]
    9. Dimensional analysis [2]
    10. Experimental determination of creep parameters, shrinkage and relaxation. [2]
    11. Methods for determining residual stress and strain [2]
    12. Instrumentation and methods of measurement during static or dynamic loading [2]
    13. Experiments under static loading [2]
    14. Experiments under dynamic loading [2]
    15. Evaluation of real structures under loading [2].

- Exercises (laboratory):
    1. Introduction to and an overview of measuring instrumentation and data acquisition systems [2]
    2. Introduction to and an overview of testing machines and their software and data acquisition software [2],
    3. Determination of measurement errors, measurement uncertainty for specific measurement instruments and systems [4],
    4. Preparation of and testing models under static loading [6]
    5. Preparation of and testing structural elements or structures under static loading [4]
    6. Preparation of and testing models for testing under dynamic loading [6]
    7. Preparation of and testing structural elements or structures under dynamic loading [4].

Student responsibilities:

- Attendance in lectures and exercises,
- Writing a seminar paper.

Grading and evaluation of student work over the course of instruction:

- Attendance in lectures and exercises,
- Seminar paper grading.

End of semester grading:

- Written exam – minimum 50% score,
- Oral exam.

Contributions to the final grade:

- Seminar paper 40%,
- Written exam 30%,
- Oral exam 30%

Required literature:

1. Lj. Herceg, *Eksperimentalne metode* – mimeographed lecture notes,http://www.grad.unizg.hr/predmet/eksmet1_a
2. D. Damjanović: *Eksperimentalne metode* – lecture notes, http://www.grad.unizg.hr/predmet/eksmet1_a
3. J. Krolo, D. Šimić,*Mehanika materijala*, Sveučilište u Zagrebu, Građevinski fakultet, Zagreb,(Civil Engineering Faculty, Zagreb University), 2011

Optional literature:

1. A. Kiričenko et al., *Mjerenje deformacija i analiza naprezanja konstrukcija*, DIT-Zagreb, 1982
2. Thomas G. Beckwith, Roy D. Marangoni, John H. Lienhard,*Mechanical measurements*, Addison-Weslwy Publishing company, New York, 1995,
3. John P. Bentley,*Principles of measurementsystems*, Pearson education, Edinburgh, 1995
4. V. Brčić, R. Čukić, *Eksperimentalne metode u projektiranju konstrukcija*, Građ. knjiga, Beograd, 1988
5. Papoulis, A.,*Probability, random variables and stohastic processes*, McGraw-Hill, Singapore, 1987

METAL STRUCTURES 2

Look in **Structural Enginnering**

1st year, 2nd semester

Compulsory courses

THEORY OF ELASTICITY AND PLASTICITY

Credit value (ECTS): 7,5

Number of hours (in semester):

- Lectures**:** 45
- Exercises (auditory): 30

Course objectives:

- Upgrade theoretical knowledge about the behaviour of real solid under loading in elastic and plastic region,

- Upgrading theoretical knowledge about displacement analysis, stress and strain of real solids,
- Acquisition of knowledge in the field of analitical and numerical methods of analysis of real solids.

Entry competences (foreknowledge, descriptive):

- Knowledge about differential and integral mathematics, partial differential equations, vectors and tensors analysis,
- Good knowledge on general theoretical mechanics and numerical mathematics,
- Knowledge about static, dynamic and strength of materials theory.

Enrolment requirements (correlated courses):

- Teachers signatures: Mathematics 3,

Requirements for examination taking (correlated courses):

- Examinations passed: Mathematics 3.

Learning outcomes:

- Recognizing appropriate boundary value problems of the theory of elasticity and plasticity,
- Explaining differential equations of equilibrium and compatibility in stress and strain analysis,
- Adequate formulation of boundary value problem. Solving problems using displacements or stress components,
- Choosing the optimal method for solving appropriate boundary value problems,
- Understanding the methods for solving boundary value problems in 2D and 3D region.
- Understanding the behavior law of materials in elastic and plastic region.

Course content:

- Lectures:
  1. Vector and tensor analysis[6]
  2. Deforming models of material continuum [3]
  3. Finite deformation tensors and infinitesimal deformation tensors [6]
  4. External and internal forces on solids, stress tensor and its properties [6]
  5. Thermodynamics of real solids, constitutive equations – general Hooke's low [3]
  6. Definition, formulation and solution of boundary value problems using displacement or stress components[3]
  7. Virtual work equations and energy principles[3]
  8. Analitical and numerical methods for solving problem in theory of elasticity [3]
  9. Plane problems, Airy's function, harmonic and biharmonic functions [3]
  10. 3D problems of the theory of elasticity (torsion, thin plates, infinite solid and semi-infinite solid) [3]
  11. Introduction to plasticity, yield criteria, plasticity parameters [3]
  12. Viscoelastic and viscoplastic models of materials, creep and relaxation [3].

  Exercises (auditory):
  1. Transformations of vectors and tensors, principal stress and principal strains [4]
  2. Analitical and numerical methods for solving boundary value problems (Ritz method, Galerkin's, finite elements, finite differences, Fourier's series and complex-variable methods [12]
  3. Solving plane problems, Airy's function, polynoms and infinite series [4]
  4. Solving 3D problems (torsion of beams, thin plates and semi-infinite solid) [4]
  5. Solving plastic problems, creep and relaxations [4].

Student responsibilities:

- Attendance in lectures and exercises,
- Writing a seminar paper.

Grading and evaluation of student work over the course of instruction:

- Attendance in lectures and exercises,
- Seminar paper grading.

End of semester grading:

- Seminar paper, written and oral exam.

Contributions to the final grade:

- Seminar paper 20%,
- Written exam 40%,
- Oral exam 40%.

Required literature:

1. M. Rak,*Teorija elastičnosti i plastičnosti* (http://www.grad.unizg.hr)

Optional literature:

2. T. Herman,*Teorija elastičnosti iplastičnosti*, Element, Zagreb, 2008
3. Z Kostrenčić,*Teorija elastičnosti*, Školska knjiga, Zagreb, 1982
4. S Timošenko, J.Gudier,*Teorija elastičnosti*, Građevinska knjiga, Beograd, 1962
5. I. Alfirević,*Uvod u tenzore i mehaniku kontinuuma*, Golden marketing, Zagreb, 2006
6. J. Brnić,*Elastomehanika i plastomehanika*, Školska knjiga, Zagreb, 1996
7. G.E. Mase,*Theory and Problems of Continuum Mechanics*, McGrow-Hill Company, 1970
8. Y.A. Amanzade,*Theory of Elasticity*, MIR, Publishers Moscow, 1979

DYNAMICS OF STRUCTURES AND EARTHQUAKE ENGINEERING

Credit value (ECTS): 7.5

Number of hours (in semester):

- Lectures: 45
- Exercises: 30 (auditory - 15, construction – 6, design - 9)

Course objectives:

- Acquisition of theoretical knowledge about analytic and numeric procedures regarding dynamic response systems with one degree of freedom of movement,
- Acquisition of knowledge about formulating mathematic models used for dynamic calculations of real structures,
- Gaining practical knowledge about designing earthquake resistant structures.

Entry competences (foreknowledge, descriptive):

- Competence in basic differential equation solving procedures,
- Competence in the basics of computer engineering (Sage program software or the like),
- Understanding the calculation procedures for statically determinate and indeterminate structures.

Enrolment requirements (correlated courses):

- Teachers signatures: Mathematics 3,

Requirements for examination taking (correlated courses):

- Teachers signatures: Mathematics 3

Learning outcomes:

- Recognizing and understanding the problems related to various dynamic actions on buildings,

- Applying knowledge on selection procedures of mathematical models for dynamic calculus of a structure: selection of degrees of freedom in dynamic systems, analysis of mass, rigidity and flexibility,
- Applying knowledge on maths in solving problems of own a shapes and frequencies,
- Applying the calculus of system response with more degrees of freed on to the effect of the known dynamic load,
- Understanding and application of spectrum calculus for frameworks and buildings related to earthquake effects,
- Applying software to calculate response to structure action.

Course content:

- Lectures:
  1. Simple harmonic oscillator, an overview of theory for free and forced vibration response with and without damping. Types of dynamic loadings in structural engineering: earthquake, wind, waves, explosions, machine operation [3]
  2. Occurrence and effect of resonance. Duhamel integral. Response spectrum function [2]
  3. Generalized system with one degree of freedom. Energy approach [2]
  4. Finite degrees of freedom systems vibration. Definition of coordinates (discrete, generalized), static condensation of system, matrix formulation of motion equations, influence of axial forces on dynamical characteristics of system (use of computer software)[4]
  5. Generalized coordinates and Hamilton's principle in forming Lagrange's equations of motion[3]
  6. Free-vibration systems with finite degree of freedom, solution of eigenvalue problem, eigenvectors orthogonality and normal coordinates. Matrix iteration methods[6]
  7. Dynamic response of finite degree of freedom system using modal superposition method. Buildings with symmetric and irregular plan disposition[2]
  8. Dynamic response of finite degree of freedom system using step by step methods, use of accelogrammes for determining earthquake load[4]
  9. Spectral analysis of buildings[2]
  10. Dynamics of engineering objects. Application of finite element method[2]
  11. Dynamic response of distributed mass systems (bending and axial deformations of a beam). Free-vibrations of plates, beams, console and a frame[4]
  12. Nonlinear vibrations. Sources of system nonlinearity. Mathematical modeling and determination of numerical solution using Runge-Kutta method (simple pendulum, Duffing equation). Parametric vibration[3]
  13. Earthquake phenomenon, seismic zones and fundamentals of earthquake load, response spectrum functions, equivalent static load[2]
  14. Basic rules and principles of earthquake building design in seismically active area[2]
  15. Wind and earthquake: corresponding regulations and the application of design rules [3].
- Exercises (auditory):
  1. One degree of freedom systems, definition of system mass, rigidly and flexibility[2]
  2. Free-vibration response of one degree of freedom system with and without damping[2]
  3. Forced-vibration response of one degree of freedom systems. Force transmission and vibration Isolation[2]
  4. Rayleigh method. Symmetry in multidegree of freedom systems[2]
  5. Free-vibration response of multi degree of freedom systems. Analysis of vibration mode shapes and vibration frequencies[3]
  6. Forced vibrations of multi degree of freedom systems[2]
  7. Distributed parameter systems response [2].

- Exercises (construction):
  1. Multi degree of freedom system in plane examples of modeling [2]
  2. Multi degree of freedom system in plane modeling by computer applications [4]
- Exercises (design):
  1. Response spectrum creating. Response spectrum analysis of plane frame[4]
  2. Modeling and response spectrum analysis of multi story buildings with symmetric and unsymmetrical plan [5].

Student responsibilities:

- Attendance in lectures and exercises,
- Soving 3 program assignments,
- 1 pre-exam, minimum 25% score, or a make up exam.

Grading and evaluation of student work over the course of instruction:

- Programs,
- Attendance in lectures increases pre-exam credits by 5%,
- Pre-exam – minimum 60% score is the requirement for the written exam.

End of semester grading:

- Seminar paper,
- Written exam,
- Oral exam.

Contributions to the final grade:

- Seminar paper and programs 35%,
- Pre-exam or written exam 30%,
- Oral exam 35%

Required literature:

1. A.Mihanović, *Dinamika konstrukcija*, Građevinski fakultet Sveučilišta u Splitu (Faculty of Civil Engineering, Split),
2. V.Raduka: *Lecture notes*, accessible online.

Optional literature:

1. A.K.Chopra, *Dynamics of Structures, Theory and Application to Earthquake Engineering*, Prentice Hall, 1995,
2. W. Clough, J. Penzien: *Dynamics of Structures*, McGraw-Hill, 1993

FINITE ELEMENT METHOD

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises: 30 (auditory - 10, design - 20)

Course objectives:

- Theoretical knowledge about structural modeling,
- Practical knowledge on structural analysis using FEM,
- Knowledge about discretisation for FEM modeling of structures,
- Practical knowledge about the interpretation of calculated results.

Entry competences (foreknowledge, descriptive):

- Understanding and ability to apply equilibrium equations in 2D and 3D,

- Knowledge about the basic theoretical methods of linear elasticity,
- Basic mathematical knowledge about the principle of virtual work and variational methods,
- Basic mathematical knowledge about partial differential equations.

Learning outcomes:

- Understanding the approach to solving structural problems with FEM,
- Understanding computation with standard software packages,
- Knowledge about the application of FEM for computational analysis in structural analysis.

Course content:

- Lectures:
  1. Numerical integration, 1D and 2D [2]
  2. Solving system of linear equations, banded[2]
  3. Optimization of discretization[2]
  4. Basic equation of elasticity, variational formulation [4]
  5. Rod finite element[2]
  6. Beam finite element, application on [4]
  7. Shell elements[4]
  8. Plate elements [4]
  9. Elements for heat equation, critical force and freqencies [4]
  10. About error of FEM [2].
- Exercises (auditory, design, laboratory):
  1. Numerical integration, 1D and 2D[2],
  2. Solving system of linear equations, banded matrices [4]
  3. Rod finite element [4]
  4. Beam finite element, application on frames[4]
  5. Shell elements [6]
  6. Plate elements [6]
  7. Elements for heat equation, critical force and frequencies [4].

Student responsibilities:

- Attendance in lectures and exercises,
- Solving different problems.

Grading and evaluation of student work over the course of instruction:

- Evaluation of solutions to assigned problems.

End of semester grading:

- Final seminar paper,
- Oral exam.

Contributions to the final grade:

- Solving assigned problems 40% ,
- Final seminar paper20%,
- Oral exam 40%.

Required literature:

1. R.D. Cook, D.S. Malkus, M.E. Plesha, R.J. Witt, *Concepts and Applications of Finite Element Analysis*, 4th Edition, John Wiley & sons, 2001
2. T.J.R. Hughes, *The Finite Element Method: linear Static and Dynamic Analysis*, Dover, 2000
3. W.B. Kraetzig, Y.Basar,*Tragwerke 3, Theorie und Anwendung der Methode der Finiten Elemente*, Springer, 1997
4. H.Werkle: *Finite elemente in der Baustatik*, Vieweg, 1995
5. J. Sorić: *Metoda konačnih elemenata*, Golden Marketing-Tehnička knjiga, 2004
6. M. Meštrović: *Mimeographed lecture notes*, http://www.grad.hr/predmeti/mke

THEORY OF COMPOSITES

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures: 30
- Exercises (auditory, design, laboratory):15
- Pre-exams:3

Course objectives:

- Theoretical knowledge of fundamental expressions and methods used in the design of composite structures; practical knowledge about composites used in civil engineering.

Entry competences (foreknowledge, descriptive):

- Familiarity with specific literature, prior knowledge of Strength of materials, skills or participation in preparatory modules.

Learning outcomes:

- Understanding the role of constituents in overall response of lamina (micromechanics) and how a set of laminae with different configurations affect the overall properties and response of laminates (macro mechanics). Students will be able to apply these concepts to analyze and design composite structures for engineering applications.

Course content:

- Lectures:
    1. Introduction to composite materials: matrix and reinforcement [6]
    2. Polymer matrix composites [3]
    3. Micromechanical Analysis of a Lamina: Rule of Mixtures, Halphin-Tsai expressions and elasticity approach [3]
    4. Macro mechanical Analysis of a Lamina [3]
    5. Macro mechanical Analysis of Laminates: A, B and D matrices [3]
    6. Macro mechanical Analysis of Laminates: different cases of laminates[4]
    7. Failure, Analysis and Design of Laminates [8]
- Exercises (auditory, design, laboratory):
    1. Auditory exercises following lectures
- Seminar:
    1. Design of a laminate.

Student responsibilities:

- Attendance in lectures and exercises,
- Pre-exam,
- Seminar paper.

Grading and evaluation of student work over the course of instruction:

- Pre-exam – minimum 25% score,
- Seminar paper.

End of semester grading:

- Written and/or oral final exam.

Contributions to the final grade:

- Attendance 10%,
- Pre-exam 50%,
- Seminar paper 40%

Required literature:

1. Kollár, L. P.; Springer, G. S.,*Mechanics of Composite Structures*, Cambridge University Press, 2003,
2. Kaw, A. K.,*Mechanics of Composite Materials*, 2nd edn, CRC Press, Taylor & Francis Group, 2006,
3. Smojver, I., Mechanics of Composite *Materials*, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, 2006

Optional literature:

1. Šimunić, Ž.: *Polymers in Civil Engineering*, University of Zagreb, Faculty of Civil Engineering, Zagreb, 2006

CONCRETE AND MASONRY STRUCTURES 2

Credit value (ECTS): 4.5

Number of hours (in semester):

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

Course objectives:

- Expanding theoretical knowledge about the dimensioning reinforced concrete and masonry elements and structures,
- Expanding practical knowledge about the dimensioning reinforced concrete elements and structures, developing more complex calculi of the former.

Entry competences (foreknowledge, descriptive):

- Theoretical and practical knowledge about the basics of the dimensioning reinforced concrete and masonry elements and structures.

Learning outcomes:

- Knowledge and skills necessary for designing structural elements of reinforced and masonry structures,
- Knowledge and skills necessary for application of basic principles of conceptual design,
- Ability to analyze the behaviour of structural elements and bearing systems made of reinforced concrete and masonry structures and ability to dimension them according to the ultimate bearing resistance states and usability,
- Ability to analyze structural elements of reinforced concrete and masonry structures using contemporary methods and European standards.

Course content:

- Lectures:
    1. Revision of masonry structures from undergraduate course Concrete and masonry structures. Structural details of masonry (beginning), [2]
    2. Types of walls, thickness and bonds. Reinforcement details. Connecting walls. Wall niches and channels. Thermal and long-term displacements. Walls in the ground. Calculus examples. Bricklaying. Materials and their storage. Preparation of mortar and filling concrete. Making masonry and concreting the fill. Construction of newly constructed wall. Permitted deviations from the designed values. Masonry control categories. Other structural measures at masonry. Fixing equipment on masonry [2]
    3. Masonry in buildings in seismic areas. Materials and masonry bond. Performance rules. Special rules for simple buildings [2]
    4. Masonry buildings in seismic areas (continued). Calculus models. Calculus examples. Simple rules for calculating masonry buildings [2]

5. Rules for seismic areas. Stability and robustness. Loads, strengths and limitation of dimensions. Wall thickness. Rules for stiffening walls, wall columns and chimneys. Walls exposed mainly to wind load. Non-bearing interior walls. Wall niches and channels. Outer walls of one-storey houses and fittings. Simplified calculus procedures and simple rules for masonry buildings. Calculus examples. Strengthening of masonry. Buildings damaged by an earthquake [2]
6. Building heritage. Connection of masonry structure elements. Investigation work. Strengthening of masonry buildings. Calculus examples [2]
7. Introduction to new European standards EN 1996 and EN 1998 (relating to masonry structures). Masonry structures under fire. (1st pre-exam: Masonry structures – bearing capacity of masonry on the force of earthquake) [2]
8. Revision of concrete structures in the undergraduate course Concrete and masonry structures. Connection of boards and beams. Beams of variable height. Limit states of usability. Creep and shrinkage of concrete [2]
9. Deflections in concrete slabs and beams. Calculation of deflection according to EC2 [2],
10. Cracks. Minimal reinforcement of slabs and beams for limiting cracks. Calculus of cracks according to EC2 [2]
11. Breach. Torsion of reinforced concrete section. Wall brackets. (2nd pre-exam: concrete structures – calculus of cracks and deflection of a reinforced concrete slab) [2]
12. Slender columns. Elements under longitudinal force and bending moment[2]

- Exercises (auditory, design:
  1. Introduction to the exercise curriculum. Introduction to the task and its execution. Definition of a bearing structure on a building and the analysis of the impact on the structure and marking respective positions which are to be calculated (auditory) [1]
  2. Calculation of Fert ceilings and reinforced roof rafters (auditory) [1]
  3. Calculation of staircases with the elaborate of reinforcement (auditory) [1]
  4. Design exercise [1]
  5. Calculation of reinforced concrete slab for a typical storey, bearing in two directions. Slab modeling by computer software. Developing the details of reinforcing ceilings and connection with tie beams (auditory) [1]
  6. Ceiling beam calculation in a typical storey (auditory) [1]
  7. Design exercise [1]
  8. Calculation of vertical and horizontal loads on masonry due to wind pressure perpendicular to the wall (auditory) [1]
  9. Introduction to the seismic analysis of buildings. Seismic analysis of a building and calculation of relevant seismic impacts on masonry for various types of masonry (confined and reinforced), (auditory) [1]
  10. Design exercise [1]
  11. Calculation of resistance of walls to horizontal action on the wall plane (auditory) [1]
  12. Design exercise [1]
  13. Calculation of vertical and horizontal load on masonry in basements, calculation of foundations (auditory) [1]
  14. Design exercise [1]
  15. Design exercise [1].

Student responsibilities:

- Attendance in lectures and exercises,
- Developing a program,
- Two pre-exams, minimum 25% score required one make up exam.

Grading and evaluation of student work over the course of instruction:

- Evaluation of programs,
- Pre-exams – students with a minimum 60% score in each are exempt from 40% of written exam.

End of semester grading:

- Written exam – minimum 55% score,
- Oral exam.

Contributions to the final grade:

- Programs 15%,
- Written exam (including pre-exams) 60%,
- Oral exam 25%.

Required literature:

1. SorićZ., Kišiček T., *Betonske konstrukcije 2. Projektiranje betonskih konstrukcija prema europskim normama EN*, Građevinskog fakulteta Sveučilišta u Zagrebu, Zagreb, 2012, mimeographed lecture notes, Faculty of Civil Engineering, Zagreb
2. Sorić Z., Kišiček T., Galić J., *Betonske i zidane konstrukcije 2 – Betonske konstrukcije prema EC2 – 2. dio*, skripta Građevinskog fakulteta Sveučilišta u Zagrebu, 308 str., Zagreb, 2009, 2010, 2011, mimeographed lecture notes, Faculty of Civil Engineering, Zagreb,
3. SorićZ., *Betonske konstrukcije 1. Betonske konstrukcije prema Europskoj prednormi (HRN ENV 1992-1-1)*, 220 pp., Zagreb 2010,
4. Sorić Z.; Kišiček T., *Betonske konstrukcije 1. Projektiranje betonskih konstrukcija prema europskim normama EN*, 324 str., Zagreb 2010,2011,
5. Sorić Z., *Zidane konstrukcije I*, (second edition), Zagreb, April, 2004,
6. Sorić Z. *Betonske i zidane konstrukcije 2 – Zidane konstrukcije*, mimeographed lecture notes, Građevinskog fakulteta Sveučilišta u Zagrebu, 2008, 2009, 2010, or 2011,
7. Sorić Z.,*Betonske i zidane konstrukcije 1 – Zidane konstrukcije*, mimeographed lecture notes, Građevinskog fakulteta Sveučilišta u Zagrebu, 2008, 2009, 2010 or 2011, Faculty of Civil Engineering, Zagreb,
8. SorićZ.,*Zidane konstrukcije, 11. poglavlje – Projektiranje zidanih konstrukcija prema europskim normama EN*, 177 pp., Zagreb 2009, 2010, 2011

2nd year, 3rd semester

Compulsory courses

SPACE STRUCTURES

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures:30
- Exercises (design):30

Course objectives:

- Acquisition of theoretical knowledge related to numerical modeling of space structures as well as problems related to the creation of numerical models and their analysis,
- Acquisition of practical knowledge related to load-bearing capacity principles, primarily referring to static systems of space structures.

Entry competences (foreknowledge, descriptive):

- Knowledge about differential and integral calculus (including ordinary and partial differential equations) and linear algebra,
- Knowledge about analytical and numerical linear analysis procedures for frame structures,
- Understanding fundamental components of boundary value problems (continuum, geometric equations, equilibrium equations, constitutive laws and boundary conditions).

Enrolment requirements (correlated courses):

- Examinations passed: Concrete and Masonry Structures 2, Theory of Elasticity and Plasticity.

Learning outcomes:

- Applying principles of engineering and continuum mechanics,
- Applying knowledge related to technical and engineering informatics,
- Understanding load-bearing capacity principles of space structures,
- Designing static systems of space structures with large spans,
- Implementing structural analysis procedures,
- Creating suitable numerical models,
- Evaluating the results of structural analyses,
- Understanding scientific and professional literature in the field of structural analysis.

Course content:

- Lectures:
  1. Structural achievements and design principles throughout history [1]
  2. Mathematical models of structural systems – set of necessary approximations [2]
  3. Methods for solving boundary value problems [1]
  4. Strong formulation [1]
  5. Weak formulation [2]
  6. Approximation of displacement function [2]
  7. Week formulation in discrete form [1]
  8. Rayleigh – Ritz method [2]
  9. Some problems of finite element method [2]
  10. Verification of numerical analyses [2]
  11. Errors in the creation of numerical models and their analysis [2]
  12. Kinematic constraints [2]
  13. Grillage structures [2]
  14. Plates [2]
  15. Wall girders [2]
  16. Folded structures [2]
  17. Shells [2].
- Exercises (design):
  1. Modeling frame elements [2]
  2. Types of area elements in numerical models [2]
  3. Application of frame and (or) area elements [2]
  4. Modeling of plates [6]

5. Modeling of wall girders [2]
6. Soil interaction [2]
7. Modeling of solid elements [2]
8. Modellng of folded structures [2]
9. Modeling of domes [2]
10. Modelling of silos [2]
11. Modeling of light weight structures [2]
12. Structural design report [4].

Student responsibilities:

- Attendance in lectures and exercises,
- Completion of homework assignment,
- Completion of term project.

Grading and evaluation of student work over the course of instruction:

- Homework assignment evaluation,
- Term project evaluation.

End of semester grading:

- Oral exam.

Contributions to the final grade:

- Homework assignment 20%,
- Term project30 %,
- Oral exam 50%.

Required literature:

1. Lazarević D., Dvornik J. *Plošni nosači,* lecture notes
2. http://www.grad.unizg.hr/predmet/plonos/predavanja
3. Timošenko S., Woinowsky–Krieger S.,*Teorija ploča i ljuski*, Građevinska knjiga, Beograd, 1962
4. Girkman K., *Površinski sistemi nosača*, Građevinska knjiga, Beograd, 1965
5. Salvadori M.,*Nosive konstrukcije u arhitekturi*, UPI-2M, Zagreb, 1995
6. Senjanović I.,*Teorija ploča i ljuski*, Sveučilišna naklada Liber, Zagreb, 1973

Optional literature:

1. Sorić J.,*Metoda konačnih elemenata*, Golden Marketing, Tehnička knjiga, Zagreb, 2004,
2. Gordon J. E., *Structures, or why things don't fall down*, Da Capo Press, Inc, New York 1978,
3. Gordon J. E., *The New Science of Strong Materials, or Why You Don't Fall through the Floor*, second edition, Princeton University Press, Princeton, 1988

STRUCTURAL TESTING (TMK)

Credit value (ECTS**): 6**

Number of hours (in semester):

- Lectures:30
- Exercises (laboratory): 30

Course objectives:

- Upgrading theoretical and practical knowledge about the behavior of structures under realistic load effects,
- Introduction to modern measuring equipment and methods in the field of testing of CE structures.

Entry competences (foreknowledge, descriptive):

- Knowledge about procedures for *calculating* the internal *forces,*
- Knowledge about calculation of stresses and strains caused by longitudinal and shear forces, torque and bending moment,
- Knowledge about basic analysis methods and dimensioning of structures (concrete, metal, wood).

Enrolment requirements (correlated courses):

- Examinations passed: Experimental Methods 1

Learning outcomes:

- Analysis of structures and structural elements based on experimental testing results,
- Understanding the behavior of structures under static and dynamic loading, environmental influences and rheological changes in materials,
- Selection and application of equipment, procedures and methods for structural testing,
- Planning procedures for determination of structural safety,
- Validation of structures and structural elements based on experimental results of testing,
- Evaluating the ability of structure to carry the loading anticipated by design,
- Using and applying standards in testing of materials, structural elements and structures.

Course content:

- Lectures:
  1. Introduction. Purpose of structural testing. Classification of test research and investigation. Inspection. Laboratory. Statics and dynamics. Short term and long term testing [2]
  2. Mechanical and geometric parameters measured during structural testing**.** Absolute displacement of structural point. Change in the distance of structural points (strain). Banking angle. Curvature [2]
  3. Measuring mechanical and geometric parameters. Equipment and tools. Augmentation. Precision. Reliability. Hysteresis. Sensitivity. Measurement range. Errors [2]
  4. Measuring equipment for mechanical and geometric parameters. Displacement. Strain. Banking. Curvature. Force. Calibration [2]
  5. Strain measurement. Types of sensors: mechanical, optical and mechanical, optical, acoustic, electric [2]
  6. Electrical resistance strain gauges. Types. Installation and connection. Measuring instruments. Temperature compensation Devices for force measurement [2]
  7. Measuring strain and analysis of plane state stress**.** Uniaxial stress state. Biaxial stress state. Biaxial stress state with known major directions of stress. General biaxial stress state. Rosette. Triaxial strain and stress state [2]
  8. Analysis of strain and stress of structures and structural elements. Photoelasticimetry. Moire method. Procedure with brittle coating [2]
  9. Analysis of strain and stress of structures and structural elements. Geodesic surveys. Modelling [2]
  10. Determination of mechanical parameters of materials of existing structures. Ultrasound. Sclerometer. Radiographic recording. Drilling cores [2]
  11. Static testing of structures. Design. Implementation [2]
  12. Static testing of structures. Modes of loading. Result evaluation. Norms and conditions of structure validity [2]
  13. Dynamic testing of structures. Design. Implementation. Modes of loading and measured parameters [2]
  14. Dynamic testing of structures. Dynamic parameters. Experimental modal analysis. Results evaluation [4].

- Exercises (laboratory):
    1. Presentation and overview of instruments for static and dynamic testing[2]
    2. Measuring the same value using mechanical portable comparator (determining the accuracy of the instrument). Calibrating load cell (determining the constants of the instrument). Calibrating LVDT for displacement measurements(determination of the constant of the instrument) [4]
    3. Strain and deflection measurement on truss model [2]
    4. Strain and deflection measurement on model of wall with opening [2]
    5. Photo elasticity method [2]
    6. Vibration measurement [2]
    7. Demonstration and presentation of static testing of structural elements and models of structures [4]
    8. Demonstration and presentation of dynamic testing of structural elements and models of structures [4]
    9. Modal analysis and determination of modal parameters [4]
    10. Testing of real structure (in field) or visit to a structure that has a permanent monitoring system installed [2]

Student responsibilities:

- Attendance in lectures and exercises,
- Writing a seminar paper.

Grading and evaluation of student work over the course of instruction:

- Attendance in lectures and exercises,
- Seminar paper grading.

End of semester grading:

- Written exam – minimum 50% score,
- Oral exam.

Contributions to the final grade:

- Seminar paper 40%,
- Written exam30%,
- Oral exam 30%.

Required literature:

1. Lj. Herceg,*Ispitivanje konstrukcija* – mimeographed lecture notes, `http://www.grad.unizg.hr/predmet/ispkon`
2. D. Damjanović,*Ispitivanje konstrukcija* – lecture notes, `http://www.grad.unizg.hr/predmet/ispkon`
3. A. Kiričenko et al., *Mjerenje deformacija i analiza naprezanja konstrukcija*, DIT-Zagreb, Zagreb, 1982,
4. D. Aničić,*Ispitivanje konstrukcija*, Osijek, 2002

Optional literature:

- J. Krolo, D. Šimić,*Mehanika materijala*, Sveučilište u Zagrebu, Građevinski fakultet, Faculty of Engineering, Zagreb, 2011,
- I. Alfirević, S. Jecić,*Fotoelasticimetrija*, Liber, Zagreb, 1983,
- V. Brčić, R. Čukić, *Eksperimentalne metode u projektiranju konstrukcija*, Građ. knjiga, Beograd, 1988,
- Thomas G. Beckwith, Roy D. Marangoni, John H. Lienhard,*Mechanical measurements, Addison-Weslwy Publishing company*, New York, 1995

Elective courses

METHODS OF THEORY OF ELASTICITYAND PLASTICITY

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures**:** 30
- Exercises (auditory): 15

Course objectives:

- Upgrading theoretical knowledge about the behavior of real solid under loading in elastic and plastic region,
- Upgrading theoretical knowledge from displacement analysis, stress and strain of real solids,
- Acquisition of knowledge in the field of analytical and numerical methods of analysis of real solids.

Entry competences (foreknowledge, descriptive):

- Knowledge about differential and integral mathematics, partial differential equations, vectors and tensors analysis,
- Good knowledge on general theoretical mechanics and numerical mathematics,
- Knowledge about statics, dynamics and strength of materials theory.

Enrolment requirements (correlated courses):

- Teachers signatures: Mathematics 3, Theory of elasticity,

Requirements for examination taking (correlated courses):

- Examinations passed: Mathematics 3, Theory of elasticity.

Learning outcomes:

- Recognizing appropriate boundary value problems of the theory of elasticity and plasticity,
- Appropriate formulation of boundary value problem. Solving problems using displacements or stress components,
- Understanding analytical and numerical methods in the theory of elasticity and plasticity,
- Choosing optimal methods for solving appropriate boundary value problems,
- Application methods for solving boundary value problems in 2D and 3D region.

Course content:

- Lectures:
    1. External and internal forces on solid, stress and strain tensors with properties [3]
    2. Differential equations in theory of elasticity and their solving. [3]
    3. Definition, formulation and solution of boundary value problems using displacement or stress components [3]
    4. Virtual work equations and energy principles [3]
    5. Analytical and numerical methods for solving problem in theory of elasticity [6]
    6. Plane problems, Airy's function, harmonic and biharmonic functions [3]
    7. 3D problems of the theory of elasticity (torsion, thin plates, infinite solid and semi-infinite solid) [6]
    8. Methods of solving boundary value problems in plasticity (creep and relaxations) [3].
- Exercises (auditory):
    1. Determination of principal stress and strains and their directions [2]

2. Analytical and numerical methods for solving boundary value problems (Ritz method, Galerkin's, finite-elements, finite-differences, Fourier's series and complex-variable methods [4]
3. Solving plane problems, Airy's function, polynoms and infinite series [3]
4. Solving 3D problems (torsion of beams, thin plates and semi-infinite solid) [4]
5. Solving plastic problems, creep and relaxations [2].

Student responsibilities:

- Attendance in lectures and exercises,
- Seminar paper.

Grading and evaluation of student work over the course of instruction:

- Attendance in lectures and exercises,
- Seminar paper grading.

End of semester grading:

- Seminar paper,
- Oral exam.

Contributions to the final grade:

- Seminar paper 40%,
- Oral exam 60%.

Required literature:

1. M. Rak, *Metode teorije elastičnosti i plastičnosti* (http://www.grad.unizg.hr)

Optional literature:

1. T. Herman,*Teorija elastičnosti i plastičnosti*, Element, Zagreb, 2008
2. Z Kostrenčić, *Teorija elastičnosti*, Školska knjiga, Zagreb, 1982
3. S Timošenko, J.Gudier,*Teorija elastičnosti*, Građevinska knjiga, Beograd, 1962
5. I. Alfirević,*Uvod u tenzore i mehaniku kontinuuma*, Golden marketing, Zagreb, 2006
6. J. Brnić,*Elastomehanika i plastomehanika*, Školska knjiga, Zagreb, 1996
7. G.E. Mase,*Theory and Problems of Continuum Mechanics*, McGrow-Hill Company, 1970

POLYMERS

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures: 30
- Exercises: 9
- Midterm exams: 3
- Field trip: 3

Course objectives:

- Theoretical knowledge about production, types and properties of polymeric materials and composites used in civil engineering; practical skills in application, design and quality control of polymeric materials and composites used in civil engineering.

Entry competences (foreknowledge, descriptive):

- Familiarity with specific literature, prior knowledge of Strength of materials, skills or participation in preparatory modules.

Learning outcomes:

- Knowledge about basic types of polymeric materials and their properties as well as appropriate production processes,
- Understanding the advantages of using polymeric materials and composites in civil engineering over conventional materials;
- Learning about different application areas of polymeric materials and composites in civil engineering with the emphasis on bridge construction;
- Learning about the principles of quality control and certification of structural elements based on examples like structural bearings and expansion joints.

Course content:

- Lectures:
  1. General information on polymers: history; polymeric materials in civil engineering; composition; procedures of polymers: polymerisation, polycondensation, polyaddition, combined procedures; classification of polymeric materials on the basis of physical properties, conditions of processing, application [3]
  2. Major types of polymeric materials in construction of buildings[3]
  3. Processing: vulcanisation; extrusion; calendaring; pouring; pressing; sintering; blowing; laminating; rolling; injection [3]
  4. Properties. Mechanical properties: static and dynamic load; long-term and short-term load; fatigue; temperature depended properties; residual stresses and brittle fracture; permanent deformations; boundary states at unidirectional and multidirectional stresses; time depended properties; theory of linear and non-linear viscoelasticity; rheological models; testing procedures. Non-mechanical properties: density, thermal properties, diffusion, electrical properties, chemical resistance, toxicity, optical properties, resistance to biological influences. Testing procedures. Ageing. Characteristics under fire. Bonding [3]
  5. Reinforced polymeric materials: types; properties; production [3]
  6. Foam polymeric materials: types; properties; production [3]
  7. Application of polymeric materials in civil engineering: wall and roof elements; pipes and fitting elements; domes, shells and membranes; geosynthetic materials; sandwich elements; polymeric mortars and concretes; surface protection; waterproofing; environmental protection; supports; sealings; vibration and earthquake resistant isolation; design, production and installation. Polymeric materials in structure repair and maintenance [9]
  8. Quality control of polymeric products in civil engineering [3].
- Exercises (auditory, design, laboratory):
  1. Experimental testing of polymeric materials and structural elements.
- Field trip:
  1. Visiting companies that produce polymeric materials and composites used in civil engineering.

Student responsibilities:

- Attendance in lectures and exercises,
- Pre-exam.

Grading and evaluation of student work over the course of instruction:

- Pre-exam, minimum 25% score required.

End of semester grading: written and/or oral final exam

Contributions to the final grade:

- Attendance 10%,
- Exams 90%.

Required literature:

1. Ž. Šimunić, *Polymers in Civil Engineering*, University of Zagreb, Faculty of Civil Engineering, Zagreb, 2006

2. Ž. Šimunić, A. Dolanjski, *Elastomeric bearings*, University of Zagreb, Faculty of Civil Engineering, Zagreb, 2007

Optional literature:

1. N.G. McCrum, C. P. Buckley, B. Bucknall, *Principles of Polymer Engineering*, 2nd ed., Oxford University Press, New York, 1997,
2. F. Naeim, F.,J. Kelly, *Design of Seismic Isolated Structures*, Wiley & Sons, Inc., New York, 1999

BASICS OF FRACTURE MECHANICS

Credit value (ECTS): 4.5

Number of hours (in semester):

Lectures: 30

Exercises: 15 (auditory - 9, laboratory - 6)

Course objectives:

- Acquisitionof knowledgeabout the basicsof fracture mechanics as a special area of deformable solid mechanics,
- Acquisition of skills for predicting the response of engineering structure elements under various loadings.

Entry competences (foreknowledge, descriptive):

- Understanding the conceptsof stress andstrain analysis,
- Knowledge about the calculation of stresses and strainsin the elements subjected tointernal forces,
- Knowledge about the content ofmechanicsof materials.

Learning outcomes:

- Knowledge about the historical development offracture mechanics,
- Recognizing the importanceof fracture mechanicsandthe danger of the presence ofcracksinstructural elements,
- Understanding the influence ofcrackson stress concentration,
- Understanding the differencebetween thelinear elastic(LEFM) andelastoplasticfracture mechanics(EPFM),
- Understanding theexperimental methodsof determiningfracture mechanics parameters,
- Ability to analyze cracks and other defects in the structure of materials and their impact on safety of engineering structures.

Course content:

- Lectures:
  1. Introduction and historical development of fracture mechanics[3]
  2. Physics of fracture. The ideal strength of the material. Ductility and brittleness. Modes of propagation of cracks. Basic definitions[2]

  Linear Elastic Fracture Mechanics (LEFM)

  3. Basic equations. The influenceof crackson stress concentration[2]
  4. Griffith'sconditionforcrack development (energyapproach) and Irwin'smodification. Energy release rate(G). Crack instabilityand''R'' curves[2]
  5. Basic shapesof crack development. The fields of stress and displacementin the environment of the crack tip[2]
  6. Stress intensity factor(K) andits meaning. The functions ofgeometry(shape factors)[2]

7. Fracture criteria. Fracture toughness. Material toughness. The relationshipbetween stress intensity factorandenergy release rate[2]
8. Experimental methodsfor determiningthe parameters of LEFM[2]

Elastic-Plastic Fracture Mechanics (LEFM)

9. Plasticity field in the crack tip.Dugdale'smodelforelastic-plasticmaterials[2]
10. Crack tip opening displacement (CTOD). Rice's contour integral. The relationship betweenCTODandRice's contour integral[3]
11. Stable and unstablecrack development. Fracturecriteria[2]
12. Experimental methodsfor determiningthe parameters of EPFM.[2]
13. Fracture mechanics ofmetals, ductile fracture. Fracture mechanics ofnon-metals(plastics, ceramics, concreteandstone). Quasibrittle fracture[2]
14. Assignments forseminar papers [3].

- Exercises (auditory):
  1. Solvingsimplenumerical examplesin the field oflinear elasticfracture mechanics[9].
- Exercises (laboratory):
  1. Experimental methods for determining the parameters of LEFM [6].
- Pre-exam: all lectures.

Student responsibilities:

- Attendance in lectures and exercises,
- 1 pre-exam – minimum25% score,
- Seminar paper.

Grading and evaluation of student work over the course of instruction:

- Attendance in lectures and exercises,
- Pre-exam: students with a minimum 50% score are exempt from taking the written exam,
- Seminar paper presentation.

End of semester grading:

- Written exam – minimum 50% score,
- Oral exam.

Contributions to the final grade:

- Seminar paper20% ,
- Pre-exam or written exam 40% ,
- Oral exam40%.

Required literature:

3. T. L. Anderson,*Fracture mechanics: Fundamental and Aplications*, CRC Press LLC, N.W. Corporate Blvd., Boca Raton, Florida,2000
4. J. Krolo, D. Šimić, *Mechanics of Materials*, University of Zagreb, Faculty for Civil Engineering, Zagreb, 2011

Optional literature:

4. J. Brnić, G. Turkalj, *Science of Strength II*, Zigo, Rijeka, 2006,
5. D. Šumarac, D. Krajčinović, *Basic of Fracture Mechanics*, Naučna knjiga, Beograd, 1990,
6. J. F. Knott, *Fundamentals of Fracture Mechanics*, Butterworths, Cambridge University, 1981

PROGRAMMING STRUCTURAL ANALYSIS METHODS

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures: 30
- Exercises (computer room): 15

Course objectives:

- Understanding the basic structure of computer programs for structural design,
- Learning about the consequences of various approximations and limited accuracy of numerical calculations,
- Ability to develop independent simple programs and to cooperate with programming teams.

Entry competences (foreknowledge, descriptive):

- Knowledge about linear methods of analysis of structures, primarily the displacement method,
- Understanding the structure of computer programs (variables, branching, loops, and functions).

Learning outcomes:

- Understanding and explaining the structure of programs for analysis of structures,
- Understanding and explaining the consequences of inevitable approximations in structure modelling and limited (finite) accuracy of numerical calculations,
- Developing a simple computer program for the analysis of structures,
- Changing, adapting and upgrading a computer program for the analysis of structures accessible in source code,
- Cooperation within a team which develops a complex computer program for the analysis of structures.

Course content:

- Lectures:
    1. Program paradigms and programming languages, syntax and semantics, Turing machine [2]
    2. Basic data types and basic operations [1]
    3. Presentation of real numbers (IEEE norm), algebraic operations, rounding and accuracy [4]
    4. Program flow control: loops and branching [2]
    5. Mathematical and programming functions [2]
    6. Vectors and matrices (full and sparce):
        - 6.1 Data structures (arrays, lists, trees, dictionaries) [2]
        - 6.2 Implementation of the operation of linear algebra [3]
    7. Structure of the implementation of displacement method:
        - 7.1 Topological relations in a network of rod elements [1]
        - 7.2 Stiffness matrices of elements and structure, loading vector [2]
        - 7.3 Coordinate systems and coordinate transformation [2]
        - 7.4 Equilibrium equations and assembling the stiffness matrix of a structure [3]
        - 7.5 Solving systems of equations [1]
        - 7.6 Forces on the ends of rods [1]
    8. Form finding of prestressed cable structures :
        - 8.1 Force density method (analogy with displacement method) [2]
        - 8.2 Newton-Raphson-Gauss-Seidel procedure [2].

- Exercises:
    1. Exercises accompany lectures.

Student responsibilities:

- Attendance in lectures and exercises,
- Homework assignments.

Grading and evaluation of student work over the course of instruction:

- Homework assignments with oral explanations.

End of semester grading:

- Seminar paper presentation.

Contributions to the final grade:

- Seminar paper 60%,
- Presentation 40%.

Required literature:

1. K. Fresl, *Sage Worksheets PPPK_*,* http://sage.grad.hr.
2. J. J. C. Remmers, C. V. Verhoosel, R. de Borst: *PyFEM*, 2012., code in 1. in Optional literature, http://www.wiley.com/go/deborst

Optional literature:

1. R. de Borst, M. A. Crisfield, J. J. C. Remmers, C. V. Verhoosel:*Non-linear Finite Element Analysis of Solids and Structures*, Wiley, 2012,
2. M. L. Overton:*Numerical Computing with IEEE Floating Point Arithmetic*, SIAM, Philadelphia, 2001,
3. J. J. Barton, L. R. Nackman:*Scientific and Engineering C++*, Addison--Wesley, Reading, 1994

2nd year, 4th semester

Compulsory courses

STABILITY THEORY

Credit value (ECTS): 6

Number of hours (in semester):

- Lectures: 30
- Exercises (auditory): 30

Course objectives:

- Acquiring theoretical knowledge related to structural stability,
- Acquiring theoretical and practical knowledge related to stability analysis procedures,
- Developed understanding of structural design regulations,
- Developed understanding of computers codes for nonlinear analysis.

Entry competences (foreknowledge, descriptive):

- Knowledge about linear and nonlinear algebra,
- Knowledge about differential and integral calculus (including ordinary differential equations) and linear algebra,
- Knowledge about linear and nonlinear static analysis procedures for frame structures.

Enrolment requirements (correlated courses):

- Examinations passed: Metal Structures 2, Nonlinear Analysis of Rod Structures.

Learning outcomes:

- Applying the principles of stability theory,
- Carrying out nonlinear analyses of structures,
- Analysing the results of nonlinear procedures,
- Understanding scientific and professional literature in the field of structural stability.
- Designing engineering structures using computers and modern design directives.

Course content:

- Lectures:
  1. The basics of stability phenomena [2]
  2. Examples of the stability problem using the mechanical models [2]
  3. Problem of elastic stability of columns [2]
  4. Influence of imperfections on the stability of axial loaded columns [2]
  5. Stability of columns and beams simultaneously loaded by axial forces and bending [2]
  6. Stability of the moment resisting frames [2]
  7. Stability of arches [2]
  8. Application of energy methods in stability analysis [2]
  9. Stability of plates [2]
  10. Stability of thin elastic plates [2]
  11. Stability of shells [2]
  12. Stability of thin-walled beam cross sections [2]
  13. Stability in the plastic range [2]
  14. Clarification of the design codes [2]
  15. Problems of the stability in real structures [2].
- Exercises (auditory, design):
  1. The basics of stability phenomena [2]
  2. Simple models of stability loss [4]
  3. Computer codes for stability [4]
  4. Elastic stability of columns [2]
  5. Elastic stability of imperfect columns [2]
  6. Stability of eccentrically loaded beams and columns [2]
  7. Stability of frames [2]
  8. Stability of arches [2]
  9. Energy methods in structural stability [2]
  10. Stability of plates [2]
  11. Stability of shells [2]
  12. Stability of thin walled sections [2]
  13. Inelastic stability [2].

- Seminars: 1

Student responsibilities:

- Attendance in lectures and exercises,
- Seminar paper presentation.

End of semester grading:

- Seminar paper presentation,
- Oral exam.

Contributions to the final grade:

- Oral exam.

Required literature:

1. Lazarević, D., *Theory of stability with the introduction in structural stability*, mimeographed lecture notes, GF, Zagreb, 2014

Optional literature:

1. Timoshenko S. P., *Theory of elastic stability,* Građevinska knjiga, Belgrade 1959,
2. Mihanović A., *Structural stability,* DHGK, 1993

Elective courses

NUMERICAL METHODS IN STRUCTURAL ANALYSIS

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures: 30
- Exercises: 15 (auditory - 10, design -5)

Course objectives:

- Theoretical knowledge about different numerical methods,
- Practical knowledge about different numerical methods.

Entry competences (foreknowledge, descriptive):

- Understanding and ability to apply equilibrium equations in 2D and 3D,
- Knowledge about finite element method,
- Basic mathematical knowledge about numerical methods,
- Basic mathematical knowledge about partial differential equations.

Enrolment requirements (correlated courses):

- Examinations passed: Finite Element Method

Learning outcomes:

- Knowledge about the approach to solving structural problems with numerical methods,
- Knowledge about the application of numerical methods for computational analysis in structural analysis.

  Course content:
- Lectures:
  1. Newton's method of different rate of convergence[4]
  2. Euler and modified Euler method [2]

3. Runge-Kuta Methods[4]
4. Predictor-Corrector Methods[6]
5. Decomposition methods (Adomian) [2]
6. Numerical methods in Dynamics (Wilson, Newmark) [6]
7. Boundary element method [6].

- Exercises:
  1. Newton's method of different rate of convergence [2]
  2. Euler and modified Euler method [2]
  3. Runge-Kuta Methods[2]
  4. Predictor-Corrector Methods[2]
  5. Decomposition methods (Adomian)[2]
  6. Numerical methods in Dynamics (Wilson, Newmark) [3]
  7. Boundary element method [2].

Student responsibilities:

- Attendance in lectures and exercises,
- Solving different problems.

Grading and evaluation of student work over the course of instruction:

- Evaluation of solutions for given problems.

End of semester grading:

- Final seminar paper,
- Oral exam.

Contributions to the final grade:

- Solutions to given problems 40%
- Final seminar paper 20%
- Oral exam 40%

Required literature:

1. E. Stein, R. de Borst, T.J.R. Hughes,*Encyclopedia of Computational Mechanics*, Vol. 1
2. Z. Bittnar, J. Šejnoha, *Numerical Methods in Structural Mechanics*

SELECTED TOPICS ON STRENGTH OF MATERIALS

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures:30
- Exercises: 15 (auditory)

Course objectives:

- Expanding theoretical knowledge about the behavior of structures under impact stress - axial and torsion.
- Acquiring practical knowledge about the modeling of structures of nonlinear and bilinear elastic material.
- Acquisition of theoretical knowledge on calculation of contact stresses and strains.

- Acquisition of theoretical knowledge about the calculation stresses and strains in thick-walled tubes.

Entry competences (foreknowledge, descriptive):

- Understanding and determining the mechanical properties of materials.
- Knowledge about basic methods of determining the stresses and strains in construction elements of elastic, homogeneous, linear materials.
- Knowledge about differential and integral calculus (including ordinary differential equations) and linear algebra.

Enrolment requirements (correlated courses):

- Teachers signatures: Mechanics of Materials,

Requirements for examination taking (correlated courses):

- Examinations passed: Mechanics of Materials.

Learning outcomes:

- Explaining the transverse normal stress in bending rods under the transverse load.
- Calculating the stress in rods of non-linear and bilinear elastic material subjected to bending load.
- Calculating the stress and strain in rods at impact loading. Apply Herz 's formula for the calculation of contact stresses and strains.
- Analyzing the general case of two bodies in contact under pressure.
- Explaining and calculating the stress and strain in thick-walled tubes under the influence of internal and external pressure. The calculated stresses in composite thick-walled tubes and their optimal overlap.

Course content:

- Lectures:
  1. Beam bending of gradually variable cross section. A beam of equal strength. Transversal normal stresses in beam bending under transversal loading.
  2. Concentration of stresses. Axial load, torsion, bending.
  3. Modeling of structures made of nonlinear elastic material.
  4. Axial load of rod structure. Straight beam bending of bilinear elastic material. Torsion.
  5. Contact problems. General assumptions. Herz's formulas for contact stresses and strains.
  6. A sphere on a plane, a sphere on a sphere, a cylinder on a cylinder under pressure.
  7. General case of two bodies touching point under pressure.
  8. Thickwalled tubes. General definitions and assumptions.
  9. Differential equations and boundary conditions for axially symmetric body.
  10. Stresses and strains in thick- walled tubes under the action of internal and external pressures. Stresses and strains in composed thick- walled tubes. Thermal strains in thick-walled tubes.
  11. Dynamic problems. Stresses and strains in structural members at motion with acceleration.
  12. Inertia forces, internal forces.
  13. Bending Theory of impact. General assumptions. Stresses calculation and rod strain at impact load. Axial impact load. Impact load at bending.
  14. Torsion impact load. Stresses in longitudinal rod impact against a hard base. Stresses in transversal beam impact against stiff bearings.
  15. Calculation of strength in alternating stresses. Multiaxially alternating stresses. Application of theories of failure.
- Exercises (auditory):
  1. Beam bending gradually changing section.
  2. Beam of equal strength.

3. Transverse normal stresses in beam bending under transverse load. Rod bending of linear elastic materials.
4. Rod bending of bilinear elastic material.
5. Calculation of stress and strain at impact loading.
6. Axial impact load. Stresses in the longitudinal rod impact of rigid substrates.
7. Stress and strain girders at impact loading.
8. Stresses in the transverse girder impact on rigid bearings.
9. Calculation of strength in alternating stresses.
10. Variable multiaxial stress.
11. Applying the theory of strength.
12. Contact stresses and strains two balls under pressure.
13. Contact stresses and strains two rollers under pressure. Check the contact pressure.
14. Stresses and strains in a thick-walled tubes under the influence of internal and external pressure.
15. Stresses and strains in composite thick-walled tubes.

Student responsibilities:

- Attendance in lectures and exercises,
- Seminar paper.

Grading and evaluation of student work over the course of instruction:

- Seminar paper.

End of semester grading:

- Written exam – minimum 50% score,
- Oral exam.

Contributions to the final grade:

- Seminar paper 20%,
- Written exam 40%,
- Oral exam 40%.

Required literature:

1. V. Šimić, *Otpornost materijala I*, Školska knjiga, Zagreb, 2002,
2. V. Šimić, *Otpornost materijala II*, Školska knjiga, Zagreb, 2002,
3. I. Alfirević, *Nauka o čvrstoći II*, Golden marketing, Zagreb, 1999,
4. D. Bazjanac,*Nauka o čvrstoći*, Tehnička knjiga, Zagreb, 1973,
5. J. Brnić, G. Turkalj, *Nauka o čvrstoć II*, ZIGO, Rijeka, 2006

Optional literature:

1. Alfirević, *Nauka o čvrstoć I*, Tehnička knjiga, Zagreb, 1989,
2. Timošenko, S.: *Otpornost materijala I*, Građevinska knjiga, Beograd, 1965,
3. Timošenko, S.: *Otpornost materijala II*, Građevinska knjiga, Beograd, 1966,
4. J.Case, A. Chilver, *Strength of Materials and Structures*, Edward Arnold, 1985

STOCHASTIC ANALYSIS OF STRUCTURES

Credit value (ECTS): 4.5

Number of hours (in semester):

- Lectures: 30
- Exercises: 15 (auditory - 10, design - 5)

Course objectives:

- Theoretical knowledge about variability of input quantities in structural analysis
- Numerical analysis of variability using stochastic finite element method

Entry competences (foreknowledge, descriptive):

- Knowledge of basic probability
- Knowledge about FEM

Enrolment requirements (correlated courses):

- Examinations passed: Finite Element Method

Learning outcomes:

- knowledge about approach to solving uncertain structures understanding the uncertainty of structures knowledge about the application the uncertainties for computational analysis in structural analysis

Course content:

- Lectures:
    1. Revision of basic probability[2]
    2. Random variables and random fields[4]
    3. Uncertainty of input quantities (elastic modulus, cross section) [6]
    4. Variability response function[4]
    5. Stochastic finite element method (SFEM) [8]
    6. Application in structural analysis [6].
- Exercises (auditory, design, laboratory):
    1. Operations with random variables [2]
    2. Variability response function[4]
    3. Weighed integral method [4]
    4. Applications on beams and plates [5].

Student responsibilities:

- Attendance in lectures and exercises,
- Solutions to different problems.

Grading and evaluation of student work over the course of instruction:

- Evaluation of solutions to assigned problems.

End of semester grading:

- Final seminar paper,
- Oral exam.

Contributions to the final grade:

- Solutions to assigned problems 40%
- Final seminar work 20%
- Oral exam 40%

Required literature:

1. I. Elishakoff,*Probabilistic Theory of Structures* A. Haldar, A. Guran,
2. B.M. Ayyub, *Uncertainty Modelling in Finite Element, Fatigue and Stability of Systems*
3. A. Haldar, S. Mahadevan, *Reliability Assessment Using Stochastic Finite Element Analysis*
4. M. Meštrović: *skripta*, `http://www.grad.hr/predmeti/sak_a`(mimeographed lecture notes)

NUMERICAL MATHEMATICS

Look in **Shared courses**

PERSPECTIVE

Look in **Shared courses**

BASICS OF DIFFERENTIAL GEOMETRY

Look in **Shared courses**

WAVES AND VIBRATIONS

Look in **Shared courses**

SHARED COURSES

MATHEMATICS 3

Credit value (ECTS): 7.5

Number of hours (in semester):

- Lectures: 45
- Exercises (auditory): 30

Course objectives:

- Acquiring theoretical knowledge on basic linear models of mathematical physics and their applications in civil engineering,
- Acquiring basic theoretical and practical skills necessary for analytical and/or numerical analysis and solution of such models.

Entry competences (foreknowledge, descriptive):

- Understanding the calculus of one and several variables, including ordinary differential equations, and basic linear algebra.

Learning outcomes:

- Understanding the conditions and limits of applicability of linear models,
- Ability to recognize and choose a correct model,
- Ability to solve (analytically and/or numerically) simple linear models.

Course content:

- Lectures:
  1. Ordinary differential equations [3]
  2. Fourier series [3]
  3. Partial differential equations and linear models of mathematical physics [20]
  4. Numerical methods for solutions of ordinary and partial differential equations [16]
- Exercises (auditory) follow the lectures.

Student responsibilities:

- Regular attendance in lectures and exercises,

- Minimum 25 % score in the pre-exam.

Grading and evaluation of student work over the course of instruction:

- Pre-exam - minimum 60 % score to be entitled to the final written exam.

End of semester grading:

- Minimum 50% score in the written exam,
- Students passing the pre-exam take only the second part,
- Oral exam.

Contributions to the final grade:

- Pre-exam and/or written exam 50-60 %,
- Oral exam 40-50 %.

Required literature:

1. T. Došlić, D. Pokaz: *Matematika 3*, available on the course web-page.
2. T. Slijepčević-Manger: *Zbirka zadataka iz Matematike 3*, available on the course web-page.

Optional literature:

1. E. Kreyszig: *Advanced Engineering Mathematics*, John Wiley and Sons Ltd., 1999,
2. F. Scheid: *Numerical Analysis, Schaum's Outline Series in Mathematics*, McGraw-Hill

STOCHASTIC PROCESSES

Credit value (ECTS): 7.5

Number of hours (in semester):

- Lectures: 45
- Exercises (auditory): 30

Course objectives:

- Acquiring theoretical knowledge in basic characteristics of stochastic processes and their application in civil engineering,
- Acquiring theoretical and practical skills necessary for formulating and analyzing simple mathematical models of such processes. Entry competences (foreknowledge, descriptive):
  - Familiarity with the theory of probability, basics of calculus, and basic linear algebra.

Learning outcomes:

- Understanding conditions and limits of applicability of stochastic models,
- Ability to recognize and choose correct model.
- Ability to formulate and solve simple problems in terms of Markov chains and processes.

Course content:

- Lectures:
  1. Basic characteristics and examples of stochastic processes [3],
  2. Markov chains with discrete time and finite and countable set of states [27],
  3. Markov processes [6],
  4. Poisson processes and the theory of queues [6],
- Exercises (auditory: follow the lectures.

Student responsibilities:

- Regular attendance

- Minimum 25 % score in the pre-exam.

Grading and evaluation of student work over the course of instruction:

- Pre-exam,
- Minimum 60 % score as a part of the final written exam.

End of semester grading:

- Eliminatory written exam - minimum 50 % score,
- Students who pass the pre-exam take only the second part,
- Oral exam.

Contributions to the final grade:

- Pre-exam/or written exam 50-60 %,
- Oral exam 40-50 %.

Required literature:

1. N. Berglund, *Processus aleatoires et applications*, available as Croatian translation on the course web-page and originally at ArXiv.org.

Optional literature:

1. R. Durrett: *Essentials of Stochastic Processes*, Springer Texts in Statistics, Springer, New York, 1999,
2. D. P. Bertsekas, J. N. Tsitsiklis: *Introduction to Probability*, On line lecture notes, M.I.T., 2000.

RESEARCH METHODS

Credit value (ECTS): 1.5

Number of hours (in semester):

- Lectures: 15
- Seminars: Students are obliged to write a seminar paper on an assigned topic.

Course objectives:

- Developing students' knowledge about the research process and their preparation for writing master thesis. The focus is on research design, structuring the thesis, developing research questions and hypothesis, collecting data, data analysis, presentations of the results and main findings,
- Qualitative and quantitative research methods,
- Learning how to design research, and write research papers, essays and reviews.

Learning outcomes:

- Collecting literature from different sources,
- Defining the hypothesis,
- Choosing an appropriate research method and methodology,
- Using different techniques in data collection,
- Writing essays, papers and reviews,
- Presenting and discussing research findings.

Course content:

- Lectures:
    1. Collecting literature and information 1 (2)
    2. Role of hypothesis and general structure of the thesis 1 (1)

3. Writing papers, critiques and essays 2 (2)
4. Data collection 1 (1)
5. Research methodology 2 (1)
6. Research methods 3 (2)
7. Reporting the results 1 (2)
8. Citing references 2 (3)
9. Bibliography 1 (2)
10. Presentation skills 1 (1)

Student responsibilities:

- Writing a seminar paper or a positively graded test.

Grading and evaluation of student work over the course of instruction:

- Students are obliged to submit parts of the seminar paper during semester (minimum 3 times) on the Merlin e-system.

End of semester grading:

- Written paper,
- Written exam

Required literature:

1. Zelenika, R. *Metodologija i tehnologija izrade znanstvenog i stručnog djela*, Rijeka: Ekonomski fakultet Sveučilišta u Rijeci, 1999 (in Croatian)
2. Cerić, A., *Textbook for Civil Engineering Students*, 2012, (in Croatian)

Optional literature:

1. Fellows, R. And Liu, A., *Research Methods for Construction*, Oxford: The Blackwell Science, 1997
2. 2.Naoum, S.G., *Dissertation Research and Writing for Construction Students*, Oxford: Butterworth-Heinemann, 2007

NUMERICAL MATHEMATICS

Credit value (ECTS): 6

Number of hours (in semester): 60

- Lectures: 30
- Exercises (auditory): 30

Course objectives:

- Acquiring theoretical knowledge on basic numerical methods for solution of mathematical and/or computational problems in civil engineering,
- Acquiring basic theoretical and practical skills necessary for solution of simple problems in civil engineering.

Entry competences (foreknowledge, descriptive):

- Familiarity with the calculus, including ordinary differential equations, and basic linear algebra.

Learning outcomes:

- Understanding the conditions and limits of applicability of particular numerical methods,
- Ability to choose and successfully apply correct methods.

Course content:

- Lectures:

1. Sources and types of errors (5)

2. Methods for solving non-linear equations (5)
3. Interpolation and approximation (5)
4. Numerical integration (5)
5. Numerical methods for solutions of ordinary differential equations (5)
6. Numerical linear algebra (5)

- Exercises (auditory): follow the lectures.

Student responsibilities:

- Attendance in lectures and exercises.

End of semester grading:

- Correct solution of a pre-assigned problem,
- Oral exam.

Contributions to the final grade:

- Problem 40-50 %,
- Oral exam 50-60 %.

Required literature:

1. T. Došlić, Numerička *matematika*, available at the course web-page.

Optional literature:

1. E. Kreyszig: *Advanced Engineering Mathematics*, John Wiley and Sons Ltd., 1999,.
2. F. Scheid: *Numerical Analysis*, Schaum's Outline Series in Mathematics, McGraw-Hill

PERSPECTIVE

Credit value (ECTS): 6

Number of hours (in semester): 60

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

Course objectives:

- Developing the ability to determine appropriate parameters for perspective image of an object,
- Expansion of theoretical knowledge on geometric objects and their relations (especially quadric surfaces, surfaces of revolution, ruled surfaces),
- Application of acquired knowledge in computer CAD modeling.

Entry competences (foreknowledge, descriptive):

- Familiarity with the methods of parallel projection.

Learning outcomes:

- Mastering basic constructive procedures in perspective,
- Acquiring knowledge on methods of construction of perspective image of an object,
- Acquiring knowledge on geometric properties of algebraic surfaces of higher order,
- Ability to construct perspective image of objects from civil engineering.

Course content:

- Lectures:
  1. Central projection [8]
  2. Quadric surfaces [4]

   3. Ruled surfaces [6]
   4. Computer modeling of surfaces [8]
   5. Terrains in perspective [4]
- Exercises (constructive, in computer classroom):
   1. Central projection [8]
   2. Quadric surfaces [4]
   3. Ruled surfaces [6]
   4. Computer modeling of surfaces [8]
   5. Terrains in perspective [4]

Student responsibilities:
- 100% attendance in lectures and exercises,
- 4 projects,
- 1 seminar paper,
- 1 pre-exam.

Grading and evaluation of student work over the course of instruction:
- Grading projects and seminar paper,
- Pre-exam.

End of semester grading:
- Written exam - minimum 60% score,
- Oral exam,
- Students who have achieved a positive grade in projects, seminar paper and pre-exam are exempt from the written and oral exam.

Contributions to the final grade:
- Projects 30%,
- Seminar paper 30%,
- Pre-exam 40%,
- Written exam 60%,
- Oral exam 40%.

Required literature:
1. P. Kurilj, N. Sudeta, M. Šimić, *Perspektiva (Perspective)*, Arhitektonski fakultet, Zagreb, 2005

Optional literature:
1. V. Niče, *Perspektiva (Perspective)*, Školska knjiga, Zagreb, 1978,
2. B. Kučinić et al., *Oble forme u graditeljstvu*, Građevinar, Zagreb, 1992,
3. H. Brauner, W. Kickinger, *Geometrija u graditeljstvu*, Školska knjiga, Zagreb,1980

BASICS OF DIFFERENTIAL GEOMETRY

Credit value (ECTS): 6

Number of hours (in semester): 60
- Lectures:30
- Exercises (auditory, design, laboratory): 30

Course objectives:
- Expansion of theoretical knowledge about curves and surfaces in Euclidean space,
- Developing knowledge and skills related to computer solution of problems in differential geometry.

Entry competences (foreknowledge, descriptive):

- Familiarity with the basics of differential calculus and linear algebra.

Enrolment requirements (correlated courses):

- Teacher signatures: Mathematics 3 or Stohastic Processes,

Requirements for examination taking (correlated courses):

- Examinations passed: Mathematics 3 or Stohastic Processes

Learning outcomes:

- Acquiring basic knowledge about differential geometry of curves and surfaces in Euclidean space,
- Ability to solve tasks in differential geometry by using program Mathematica,
- Knowledge about the properties of minimal surfaces,
- The ability to apply the methods and content of differential geometry in civil engineering.

Course content:

- Lectures:
  1. Curves in Euclidean space [8]
  2. Surfaces in Euclidean space [10]
  3. Curvatures of surfaces [6]
  4. Mapping of surfaces [4]
  5. Minimal surfaces [4].
- Exercises (constructive, in computer classroom):
  1. Curves in Euclidean space [8]
  2. Surfaces in Euclidean space [10]
  3. Curvatures of surfaces [6]
  4. Mapping of surfaces [4]
  5. Minimal surfaces [4].

Student responsibilities:

- 100% attendance in lectures and exercises,
- 2 projects,
- 1 seminar paper,
- 2 pre-exams.

Grading and evaluation of student work over the course of instruction:

- Grading projects and seminar paper,
- Pre-exams.

End of semester grading:

- Written exam - minimum 60% score,
- Oral exam,
- Students who have achieved a positive grade in projects, seminar paper and pre-exam are exempt from written and oral exam.

Contributions to the final grade:

- Projects 30%,
- Seminar paper 30%,
- Pre-exam 40%,
- Written exam 60%,
- Oral exam 40%.

Required literature:

1. I. Kamenarović, *Diferencijalna geometrija*, Sveučilište u Rijeci, Pedagoški fakultet, Rijeka, 1990,
2. J. Beban-Brkić: web-scrip:http://www.grad.hr/itproject_math/Links/jelena/index.html

Optional literature:

1. Gray, A.: *Modern Differential Geometry of Curves and Surfaces With Mathematica*, CRS Press, Boston, London, 1998,
2. On-line Encyclopedia of mathematical concepts: MathWorldWolfram

WAVES AND OSCILLATIONS

Credit value (ECTS): 6

Number of hours (in semester):

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

Course objectives:

- Ability to set the equations of physical models of vibrations, oscillations and deformations,
- Ability to set physical tests and computer simulations of physical problems,
- Computer skills in setting and solving problems.

Entry competences (foreknowledge, descriptive):

- Undergraduate course mathematics, including differential equations,
- Basics of programming and use of Mathematics software.

Learning outcomes:

- Mastering equations on given problems: free vibrations of simple systems – wires, slabs; waves and wire extension in one, two or three dimensions, deformations,
- Understanding the physical background of the equations taught in professional and mathematical courses,
- Ability to find equations through physical properties of a problem – coupled oscillations and vibrations, acoustic wave spreading, acoustic insulation,
- Modeling by applying a harmonic oscillator,
- Computer modelling of individual physical models of the problems dealt with in professional and mathematical courses,
- Understanding physical properties of forced oscillation and interference,
- Understanding the physical basis for measurements in civil engineering.

Course content:

- Lectures:
    1. Basics of deriving equations from given problems (4)
    2. Waves and wave propagation in one, two or three dimensions, deformations (5)
    3. Physical background for the equations mastered in professional and mathematical courses (5)
    4. Finding solutions for the equations through physical properties of problems (5)
    5. Modeling by harmonic oscillator (2)
    6. Computer modeling of physical models for problems dealt with in professional and mathematical courses (3)
    7. Physical properties of forced oscillations, interferences (5)
    8. Physical basis of measurements in civil engineering (2).

- Exercises (auditory, laboratory):
    1. Free vibrations of simple systems – wires, slabs (4)
    2. Coupled oscillations and vibrations, acoustic wave spreading, acoustic insulation (9)
    3. Coupled oscillations and vibrations, acoustic wave spreading, acoustic insulation (7)
    4. Modeling: physical models (3)
    5. Forced oscillations, interferences (5)
    6. Physical measurements (2).
- Seminars: included in exercises.

Student responsibilities:

- Attendance in lectures and exercises,
- Three pre-exams – minimum 35% score in each,
- One make up exam.

Grading and evaluation of student work over the course of instruction:

- Pre-exam – students with a minimum 60% score are exempt from a part of the final exam (only final test is mandatory) End of semester grading:
- The final test is the requirement for the final exam.

Contributions to the final grade:

- Final test 20%,
- Final exam 80%.

Required literature:

1. F. S. Crawford, *Waves: Berkeley physics course v.3*, McGraw-Hill college, 1968

Optional literature:

1. A. P. French, *Vibrations and Waves*, W.W. Norton & Company, New York, 1971

ORGANISATION OF STUDIES

Organisation of instruction and student workload

The curriculum for full time students is based on the student workload of 40 hours a week, which includes instruction, practical exercises and other forms of instruction and the time needed for student preparation.

The instruction is organized in semesters according to the curriculum.

Academic year regularly consists of 44 working weeks, of which 30 are dedicated to teaching and 14 to consultations, exam preparation and exams.

Total weekly obligations of students in classes can reach a maximum of 20 hours.

A full time study load for students is 25 or 35 ECTS credits in a semester.

A full time study load for exceptionally successful students can be more than 35 ECTS credits for early graduation or extended education.

A list of courses and/or modules from other studies which students can choose

Students can enrol in elective courses in agreement with department heads.

Following courses can be conducted in English language:

- Vegetative water facilities,
- Soil dynamics,
- Experimental hydraulics,
- Geotechnical laboratory,
- Geotechnical project,
- Geotechnics and environmental protection,
- Permanent Way,
- Hydraulics,
- Hydrogeology and engineering geology,
- Pavement structures,
- Rock mechanics,
- Soil mechanics,
- Planning and scheduling methods,
- Modeling in hydraulic engineering,
- Earthfill and retaining structures,
- Numerical modeling in geotechnics,
- Improvement in soil and rock,
- Construction management 2,
- Underground structures,
- Flow processes in soil and rock,
- Traffic noise,
- Sociology of organisation,
- Foundation engineering,
- Theory and technology of concrete,
- Field investigation and monitoring,
- Durability of construction materials,

- Construction project management,
- Quality management,
- Fire protection.

Following courses can be conducted in German language:

- Road intersections,
- Urban roads,
- Parking facilities,
- Traffic tunnels.
-

Enrolment in the second year of study – progression requirements

Students can enrol in the courses for which they have met the requirements according to the curriculum and study program.

The Faculty Council's special decision regulates the requirements for taking exams and attending lectures in graduate study.

Students are entitled to the enrolment in the second year of study if they have earned all ECTS credits in winter semester and minimum 20 ECTS credits in the summer semester of the first year.

Students who have not met the above mentioned requirements may continue studying if they re-enrol in the courses which they have failed in the previous year of study, and can enrol in new courses on condition that their total workload in each semester is 25 to 35 ECTS credits. The students thereof can enrol in courses which are not connected to the courses they have failed.

Lectures and exercises

Students are required to attend the types of instructions set by the study program and curriculum, which is the requirement, besides achieving relevant results in knowledge evaluation, for instructors' signatures.

Exams and other knowledge evaluation

Students' knowledge may be assessed and evaluated during instruction (pre-exams, practical homework assignments etc.), and the final grade is determined in exams.

An exam in one course can be taken maximum four times in an academic year. For the fourth time the exam is taken before an examination board. The student who has failed the exam for the fourth time in the same course, is obliged to re-enrol in that course and has the right to take the exam four times, the fourth time before an examination board. If a student fails eight times he/she loses the right to study.

The curriculum may determine that some types of instruction are conducted without grading, or the grades are descriptive, or the final grade can be determined by assessment and evaluation during instruction, or that students' grades in different types of instruction are calculated into the final grade for students' knowledge achieved in the exam and/or other types of assessment.

The lecturer conducting instruction has the right to assess and evaluate students' knowledge in any type of instruction.

Examination periods and administering exams

The examination periods are as follows: winter, summer and autumn. Examination periods last minimum 3 weeks. In each examination period there are three examination terms with minimum 7 day interval.

For a good reason, the Dean can set extraordinary examination periods.

Exams can be taken by students who have met all the requirements set by the curriculum. Students who have enrolled in the course and have attended lectures (confirmed by teacher signature) are entitled to exam taking.

Completion of studies

Graduate study is completed by writing and defending a graduate thesis on a selected theme within the scope of an engineering course in the study program.

Graduate thesis

Students submit applications for graduate theses when enrolling in the fourth semester of graduate studies.

On teachers' proposals students can write graduate theses within the scientific research programs offered by the Faculty of Civil Engineering, the University of Zagreb.

A graduate thesis can be approved only within the scope of a student's specialization.

A mentor prepares the subject of graduate thesis, and a student must be informed about it 6 weeks after the start of instruction in the last semester at the latest.

Writing and defence of graduate thesis earns 18 ECTS credits, and the thesis, in difficulty and scope, should not require more than 540 effective working hours.

The Board for Graduate and Final Exams can recognize an invention, a technical advancement etc. as a graduate thesis if they meet the requirements of the graduate thesis.

The Board for Graduate and Final Exams monitors the writing and defence of graduate theses.

Candidates who do not defend their graduate theses are advised by the Board to defend them in the next period. Candidates who do not defend their graduate theses in the next period are advised by the Board to apply for the new thesis.

INDEX OF SUBJECTS