UNDERGRADUATE AND GRADUATE UNIVERSITY STUDY

OF CIVIL ENGINEERING

Study programms

Publishers:

University of Zagreb
Faculty of Civil Engineering

Hrvatska sveučilišna naklada d.o.o., Zagreb

Editor:

prof. dr. sc. Mladen Radujković

Editorial board:

prof. dr. sc. Vesna Dragčević
Davor Rajčić, dipl. iur.
Anita Šikić, prof.

Technical editor:

Darija Kovačić
Marija Milić

Language review:

Ivan Martinčić

Translation:

Vida Kostrenčić-Lukić

Printed by:

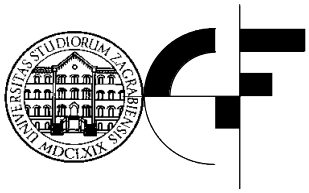
Tiskara Zelina d.d.
Sveti Ivan Zelina

UNIVERSITY OF ZAGREB
FACULTY OF CIVIL ENGINEERING

Fra Andrije Kačića Miošića 26, Zagreb

UNDERGRADUATE AND GRADUATE UNIVERSITY STUDY OF CIVIL ENGINEERING

Study programmes



Zagreb, 2007

GENERAL INFORMATION

Address:..... Fra Andrije Kačića Miošića 26

Tel:..... + 385 1 4639 222

Fax:..... + 385 1 4828 050

e-mail:..... ured@grad.hr

url:..... http://www.grad.hr

giro account: 2360000-1101219412

registration number:..... 3227120

Dean's office

Dean: .....prof. dr. sc. Mladen Radujković

Vice Dean for Education:.....prof. dr. sc. Vesna Dragčević

Vice Dean for International
Cooperation: .....prof. dr. sc. Darko Dujmović

Vice Dean for Financies: .....prof. dr. sc. Meho-Saša Kovačević

Vice Dean for Science: .....prof. dr. sc. Neven Kuspilić

Secretary: .....Davor Rajčić, dipl. iur.

Student office

Ana Antolović, head.....aantolovic@grad.hr

Sandra Fruk Pintar .....sandraf@grad.hr

Ivana Požgajčić.....ivanapo@grad.hr

CONTENTS

INTRODUCTION

1. 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 study of civil engineering in Croatia started with the establishment of Technical Polytechnic in Zagreb which enrollied its first students in 1919. The Civil Engineering Department, at the time one of the four departments of the Technical Polytechnic, had its premises on the first floor of the converted school building at 6, Roosevelt Square. The Technical Polytechnic grew into the Technical Faculty within the University of Zagreb in 1926. In 1940 the Technical Faculty moved to a 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 technical 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 8 July 2003.

Since the very start of the civil engineering studies, the study programmes have been innovated and adapted to the needs of the economy, changing their nominal duration from four to five years. Every new development of study programmes 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, and about 6 700 students to date have graduated from the Faculty. They have all become highly esteemed engineers, appreciated in Croata and abroad, of whom many have attained international reputation either by significant construction work or by contribution to science. They have always been on demand and the profession has never recorded unemployment.

The Faculty started with post-graduate studies in civil engineering in the academic year 1963/64. Until the present day it has produced 495 masters of science and 189 doctors of science. The first doctoral dissertation was presented in 1922.

The Faculty has taken the year of 1919 as its founding year. The Day of The Faculty is celebrated on February 21.

2. The Faculty today

The seat of the Faculty is at 26 Fra Andrije Kačića-Miošića Street Zagreb. 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 sub-departments which are run by heads. At present there are the following departments:

Geotechnical Engineering Department

- Sub-department of rock mechanics and research
- Sub-department of soil mechanics and foundation work

Water Research Department

- Sub-department of fundamental hydraulic engineering
- Sub-department of water management
- Sub-department of health hydraulic and environmental engineering

Structures Department

- Sub-department of concrete and masonry structures
- Sub-department of timber structures
- Sub-department of metal structures
- Sub-department of bridges

Mathematics Department

- Physics Sub-department
- Geometry Sub-department
- Mathematics Sub-department

Materials Department

- Sub-department of materials research
- Sub-department of technology of materials

Construction Management and Economics Department

- Sub-department of social sciences
- Sub-department of organisation and construction
- Sub-department of construction technology

Transportation Engineering Department

- Road construction Sub-department

- Railway Sub-department

Engineering Mechanics Department

- Sub-department of materials mechanics and structure testing
- Sub-department of statics, dynamics and stability of structures

Buildings Department.

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

The Faculty employs a staff of 180: 73 lecturers, 32 junior researchers, 23 expert associates and 52 non-teaching staff. 64 lecturers hold the positions of assistant to full professors.

With the purpose of keeping a high standard of tuition the Faculty occasionally organises lectures by visiting lecturers, top scientists and professionals in their fields. There are 1500 full 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, a computer network with 700 terminals and lecture rooms fitted for modern multimedia instruction. The library houses 25 000 titles and is subscribed to 36 domestic and foreign journals. A number of foreign scientific journals is available on-line through the center of on-line data bases of the Croatian Ministry of Science, Education and Sports. Seven computer classrooms are equipped with 100 modern computers. The Faculty is linked to the Internet via Croatian academic network CARNET.

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

In recent years Croatia has seen extensive development infrastructure construction work, from the construction of road network to intensive urbanisation and sustainable develpment and environmental protection projects. It means that, in the long run, civil engineers with a degree will be on high demand.

The Faculty has, in accordance to the Act on Scientific Activities and Higher Education, brough about new curicculums pursuant to the guidelines and standards of the Bologna Declaration. The standards of the Bologna Declaration and new study programmes can be read on page 165.

The undergraduate study of civil engineering is the first of the three cycles of university studies in civil engineering. It is an integrated, general, three-year university study simultaneously offering instruction on the basics of civil engineering science and expert konwledge essential to the candidates finishing their higher education at this level. Undergraduate degree holders will be qualified to proceed and succesfully graduate from the second cycle of study in civil engineering.

Two-year graduate study of civil engineering is the second cycle of academic study of civil engineering. Holders of undergraduate degree in civil engineering can specialise in one of the following fields of civil engineering:

- geotechnical engineering
- materials
- water research
- structures
- construction management
- transport engineering
- engineering mechanics

The studies offer highest quality instruction and training in one of the above mentioned fields of civil engineering, qualify first rate experts in the chosen field, they are the pre-condition for obtaining certification in civil engeneering, for development and scientific research or for further expert or scientific work.

The Faculty of Civil Engineering of the Zagreb University offers a three-year postgraduate study which is a logical continuation of the graduate civil engineering study, but can also be attended by students with relevant education from different faculties.

The basis for setting up undergraduate and graduate study programmes at the Faculty of Civil Engineering is the following:

1. The study programmes by the best universities from EU: Delft University of Technology, Delft, The Netherlands, Technical University; Zurich, Switzerland, Technical Universities, Hannover and Stuttgart, Germany, University, Trieste and Politechnic in Milan, Italy, Imperial College, London and Glasgow University, Great Britain.
2. The guidelines for study programmes by two large European projects on higher education in civil engineering – SOCRATES and ERASMUS

Thematic Networks: EUCEET – European Civil engineering Education and Training, http://www.euceet.utcb.ro/, and E4 - Enhancing Engineering Education in Europe, http://www.unifi.it/tne4/ .

3. Guidelines by German Association of Accreditation of Higher Curriculums in civil engineering – AS-Bau – Akkreditirungsverbund für Studinengänge des Bauwesens: Akkreditirung und Qualitätssicherung zeitgemässer Studiengänge des Bauingenieurwesens and deutschen Hochschulen. ASByu e.V., Berlin, 2003. http://www.asbau.org.

The undergraduate and graduate study programmes have been coordinated with the guidelines by Bologna Declaration on quality assurance of instruction and the contents of study programmes, student and teacher mobility in the process of education and recognition of qualifications.

UNDERGRADUATE UNIVERSITY STUDY

Pursuant to Article 51, subsection 2, of the Act on Scientific Activity and Higher Education („Official Gazette“, no. 123/03; 105/04 and 174/04), at the proposal of the National Council for Higher Education, the Minister of Science, Education and Sports issued, on June 2, 2005, the accreditation to the Faculty of Civil Engineering, the University of Zagreb, for the implementaion of undergraduate study programme of civil engineering.

1. GENERAL

Duration of study

Three-year undergraduate studies with 180 ECTS credits.

Entry requirements

All four-year secondary school programmes qualify for civil engineering undergraduate studies.

Organization of Study

The study is organized and carried out as full time study in semesters.

Acquired competences and jobs that can be taken upon the study completion

Personal competences

A student with a degree is capable to:

- exchange information, ideas, problems and solutions with experts and laymen
- adapt to changes in technology and working methods within the concept of life-long education
- efficiently participate in the teamwork and adjust to working environment requirements
- understand the impact of engineering to the society and environment as a moral and ethical approach to the solution of engineering problems
- apply acquired knowledge and habits in further professional and academic education
- critically assess arguments, suggestions, abstract concepts and data on decision making and contribute to the solving of complex problems in a creative way
- show understanding for insecurity, lack of clarity, and limitations in knowledge

Academic competences

A student with a degree is capable to:

- apply knowledge in math, sciences and engineering in construction work
- prepare and conduct experiments, analyze and interpret results
- recognize, describe and solve engineering problems
- recognize interactions between designing, construction, marketing, user's requirements and removing of the building work
- use common numerical tools for the elaboration of documents, presentation, internet page, calculation procedure and simulation
- design structures at the basic level
- direct and inspect minor construction work
- dimension minor building structures to static loadings
- participate in planning and design of hydro engineering facilities and transportation routes
- accept the role of responsible engineer in the sections of major projects like highways bridges, tunnels, harbours and buildings.

Criteria and transfer pre-requisites of ECTS credits

Students earn ECTS credits according to the regulations of the Faculty curriculum regardless of the ECTS credit value in the core curriculum.

Conditions under which the students who interrupted the study or lost right to study in one of study programmes can resume the study.

Students who interrupted the study can resume it provided that it is coordinated with the curriculum they enrolled into.

Students who lost right to study in some other course can enroll into this one by coordinating the ECTS credits collected in the curriculum of the Faculty. If there is a significant difference an entry exam is required.

Degree awarded

Bachelor's degree (baccalaureus) in civil engineering.

Documents issued

Diploma certifying their qualification and degree is issued to students who have succesfully qualified for BSC in civil engineering. A diploma supplement attached to it describes, in Croatian and English, completed courses, grades achieved and ECTS credits earned.

Graduate courses that may be chosen upon the completion of a three year programme

- civil engineering graduate course at the Faculty of Civil Engineering, University of Zagreb, or equivalent studies at other colleges from Croatia or abroad
- graduate vocational civil engineering study at the accredited colleges
- with minor or major additional study obligations the student can transfer from any technical or vocational technical college from Croatia or abroad.

2. COURSE TIMETABLE BY SEMESTER

I. year 1. semester

Course			Hours per week		Exam	ECTS
			Lectures	Practice		
1	Elective subjects	Introduction to Civil Engineering History of Building Construction	2	0	1	3
2	Mathematics 1		4	4	1	9
3	Descriptive Geometry		2	3	1	6
4	Physics		4	1	1	6
5	Basics of Engineering Informatics 1*		1	2	0	3
6	Elective subjects	Sociology of Work and Professional Ethics Outline of Civil Engineering Legislation Business Economics Foreign Language	2	0	1	3
Total			**15**	**10**	**5**	**30**

I. year 2. semester

Course		Hours per week		Exam	ECTS
		Lectures	Practice		
1	Mathematics 2	4	3	1	8
2	Mechanics 1	2	2	1	5
3	Building Construction	3	3	1	7
4	Probability and Statistics	2	1	1	4
5	Materials Science	2	1	1	4
6	Basics of Engineering Informatics 2*	1	1	0	2
Total		**14**	**11**	**5**	**30**
Total ECTS credits I. year		**60**			

* without final assignment (students are graded in practices)

II. year 3. semester

	Course		Hours per week		Exam	ECTS
			Lectures	Practice		
1	Strength of Materials 1		3	3	1	7
2	Geodesy		2	2	1	5
3	Fluid Mechanics		3	2	1	6
4	Mechanics 2		2	1	1	4
5	Elective subjects	Construction Materials	2	2	1	5
		Basics of Concrete Technology				
6	Hydrology		2	0	1	3
	Total		**14**	**10**	**6**	**30**

II. year 4. semester

	Course		Hours per week		Exam	ECTS
			Lectures	Practice		
1	Elective subjects	Applied Geology	2	0	1	3
		Environmental Protection				
2	Strength of Materials 2		3	2	1	6
3	Structural Analysis 1		4	3	1	8
4	Soil and Rock Mechanics		3	2	1	6
5	Elective subjects	Water Supply and Sewerage 1	2	1	1	4
		Water Protection				
6	Law in Construction		2	0	1	3
	Total		**16**	**8**	**6**	**30**
	Total ECTS credits II. year		**60**			

III. year 5. semester

	Course		Hours per week		Exam	ECTS
			Lectures	Practice		
1	Concrete and Masonry Structures		4	3	1	8
2	Geotechnical Engineering		3	2	1	6
3	Roads		3	2	1	6
4	Elective subjects	Building Technology	2	0	1	3
		Technology of Heavy Construction				
5	Elective subjects	Structural Analysis 2	2	2	1	5
		Numerical Modelling of Structures				
6	Railways		2	0	1	3
	Total		**16**	**9**	**6**	**31**

III. year 6. semester

	Predmet		Hours per week		Exam	ECTS
			Lectures	Practice		
1	Construction Management		3	3	1	7
2	Metal Structures		2	1	1	4
3	Bridges		2	1	1	4
4	Elective subjects	Timber Structures	2	1	1	4
		Leightweight Structures				
5	Hydraulic Engineering Structures		3	0	1	4
6	Education on Construction Site		0	3	0	3
7	Final Assignment		0	0	1	3
	Total		**12**	**9**	**6**	**29**
	Total ECTS credits III. year		**60**			
	Total ECTS credits I. + II. + III. year		**180**			

Classes in Physical Education and Health Culture are held outside course schedule as obligatory without ECTS credits.

3. ORGANISATION OF STUDY

Organisation of instruction and student timetable

Full-time students' timetable is 40 hours a week. It includes instruction, field work, exercises and other types of instruction and necessary time for student preparation.

Instruction is organised in semesters in accordance to the regulations of curriculums.

Academic year consists of 44 working weeks, of which 30 are dedicated to instruction, while 14 are reserved for consultations, exam preparation and exams.

Students' maximum weekly course load is 26 hours.

The share of practical/field work is determined by ECTS credits.

Full-time students enrol 25 to 35 ECTS credits.

Excellent students can enrol more than 35 ECTS credits to qualify for early graduation or extended education.

Instruction and extra-curriculum student activities in PE and health education do not constitute part of the weekly timetable. They are compulsory in the first and second years of undergraduate study, and optional on further levels of study. They do not earn ECTS credits.

Curriculum

The study is conducted according to the curriculum.

The curriculum sets the following:

1. lecturers and associates conducting instruction according to the study programme,
2. locations of instruction,
3. instruction timetable,
4. types of instruction (lectures, seminars, exercises, consultations, field work, testing etc.),
5. administration of exams, examination periods and performance evaluation,
6. list of reference books for study and exam taking,

7. instruction in foreign languages,
8. distance learning,
9. other requirements for regular instruction.

Reference books for particular courses and exams must be in line with the scope of study programmes.

Curriculum is announced before the start of instruction in the relevant academic year and is accesible on the Faculty of Civil Engineering, University of Zagreb internet pages.

List of courses and/or modules offered by other faculties

Instead of optional courses in social studies, students can enrol in social courses offered by other studies of higher education at the University of Zagreb.

List of courses and/or modules conducted in foreign languages

The following courses can be conducted in English:

- geotechnical engineering
- materials
- soil and rock mechanics
- construction management
- basic technology of concrete
- building materials
- applied geology
- work sociology and professional ethics.

Further enrolment

Students must be qualified to complete the programmes to which they are admitted and meet the requirements to qualify for enrolment to a higher study year.

The requirements for exam taking and lecture attendance at undergraduate study are determined by the Faculty Council.

Undergraduate students are entitled to enrolment into a higher year of study upon passing the ECTS credits which they undertook upon the enrolment into the previous year of study.

Students who have not met the above mentioned requirements can continue their education by taking on study requirements they have not met in the previous year and take on new requirements without exceeding their semester course load of 25 to 35 ECTS credits. They can enrol for courses which are not within the programme of the courses they have not passed.

Lectures and exercises

Students are required to attend all types of instruction stipulated by study programme and curriculum which, together with meeting other requirements and having their performance evaluated in testing, is a condition for lecturers' signatures.

Student performance evaluation

Students knowledge can be tested and evaluated during instruction (pre-exams, practical tasks etc.) and final grade is assigned in the exam.

Exam in the same course can be taken maximum four times. The fourth time the exam is taken before an examining board. Students who have not passed the exam in the same course for the fourth time are obliged to enrol in the same course in the following year. If they do not pass the exam after repeated enrolment, they are denied the right to study.

Study programme can stipulate that some forms of instruction are implemented without grading, or that grading is descriptive, or that the final grade can be assigned by testing and evaluation during instruction, or that the grades for particular types of instruction are calculated into the final grade achieved in the exam or other forms of testing.

Lecturers implementing instruction have the right to test and evaluate students' performance in the course of every form of instruction.

Examination administration and examination periods

Examinations are administered in three periods: winter, summer and autumn. The minimum lenght of examination period is 4 weeks. Every course examination is administered twice in each examination period with a 2 week interval.

The Faculty Council has decreed that every course examination of the study programme, regardless if it is winter or summer course, can be taken by students in three consecutive examination periods.

The Faculty Council can schedule additional examination periods on valid grounds.

If students are continuously evaluated during a course, the Faculty Council determines the examination timetable with the number of examination periods.

The examinations are administered to the students who have meet all the requirements stipulated by the curriculum . Admited to exam taking are the students who have registered for the particular course and whose attendance has been proved by the lecturers' signatures in students' documents.

Graduation

Students are granted a degree upon passing the final examinations in civil engineering courses.

Final examinations

The theme of the final examinations is defended before a three member board appointed by the Committe for degrees and final examinations.

4. CURRICULUMS

4.1. Obligatory subjects

21678 Mathematics 1 (4+4) 9,0

Linear algebra. Vectors. Vector calculus. Analytical geometry in space. Abstract Rn vector space. Matrices. Basics of matrix algebra. Rank of matrix. Determinants. Inverse matrix. System of linear algebraic equations. Gauss method. Eigenvalues and eigenvectors of a matrix. Calculus. Sequences and series of real numbers. Real functions of a real variable. Trigonometry functions. Arkus functions. Exponential and logarithmic functions. Hyperbolic and areahyperbolic functions. Limit of function. Continuity of function. Derivative of a function. Derivative rules. Differential of function. Taylor' s series. Extremes of function. Points of inflexion. Asymptotic function. Function flow. Indefinite integral. Definite integral. Newton-Leibniz formula. Integration by substitution. Integration by parts. Application of definite integral. Improper integral. */ Compulsory references:* S.Kurepa, Matematička analiza I i II, Tehnička knjiga, Zagreb 1989,1990.; S.Kurepa, Uvod u linearnu algebru, Školska knjiga, Zagreb, 1978.; Ž. Pauše, Matematički priručnik, Školska knjiga, Zagreb, 2003. / *Optional references:* L.Krnić, Z.Šikić, Račun diferencijalni i integralni, Školska knjiga, Zagreb, 1992. B.P.Demidović, Zadaci i riješeni zadaci iz više matematike s primjenama na tehničke nauke, Tehnička knjiga, Zagreb, 1986.

21679 Descriptive geometry (2+3) 6,0

Curves of second order Projective plane and projective space. Central co-linear and affine transformations. Second order curves. (I colloquium)II. Monge method Projection types. Orthogonal projection. Monge projection. Point, line and surface projection. Solving of site and metric tasks with view in projections. Additional projections, side elevation, side view. Plane rotation. Complex space relationships. View of geometric bodies in a general position. (II colloquium)Axonometry Oblique projection. Axonometric methods. Pohlke theorem. Eckart procedure. Axonometric view of objects with applied to construction work. Cross sections Polyhedron cross sections by planes. Cross sections of rollers and conics. Cross sections of spheres and rotation surfaces. Tangent planes and normals. (III colloquium) Intersection of surfaces. Intersection of oblique planes. Spatial algebraic curves. Visualization by means of a computer. (IV colloquium)Terrains Theoretical fundamentals of projection with heights.

Scales. Topographic surfaces. Contour lines and gradient curves. Cross sections of topographic surface by a plane. Route design. Cross section of a terrain. Construction of embanked and cuts surfaces by means of elementary geometric facts. Geometrical site view of earthworks on the terrain by means of contour lines. Drainage. Profile in cross section. (V colloquium). / *Compulsory references*: Szirovicza, V. ; Jurkin, E.: Deskriptivna geometrija (Compact Disc), Zagreb, 2006.; Horvatić-Baldasar, K.; Babić I.: Nacrtna geometrija. Zagreb : SAND d.o.o. , 2001.; Babić, I.; Gorjanc, S.; Sliepčević, A.; Szirovicza,V.: *Nacrtna geometrija – zadaci*. Zagreb: HDKGIKG, 2005. / *Optional references:* Babić, I.; Gorjanc, S.; Sliepčević, A.; Szirovicza, V.: Konstruktivna geometrija – Practice. Zagreb: HDKGIKG, 2002.; Hohenberg, F.: Konstruktivna geometrija u tehnici (prijevod s njemačkog). Beograd: Građevinska knjiga, 1996.; Strubecker K.: Nacrtna geometrija (prijevod s njemačkog). Zagreb: Školska knjiga, 1969.

21681 Physics (4+1) 6,0

Mehanics of material particles and rigid bodies with experiments during lectures. Dynamics, work, energy, strength, conservation laws. Vibrations, curvilinear motion, nutation, precession, gravitation, relative systems. Mechanics of fluids with experiments during lectures. Euler's method, fluid statics. Laminar flows, body motion. Fluid viscosity, vortices, model testing. Capillarity, surface tightness. Electro-magnetism with experiments during lectures. Coulomb law, energy, potential, voltage, condensers, electric dipole, dielectrics, current. Magnetic field. Alternating current, law of induction, work, power. Transformers, electric resonance, electromagnetic waves. Optics with experiments and computer simulations during lectures. Fermat's principle, plane waves, spherical waves, spreading of waves. Spreading of waves through media, ideal and spheric diopter, spherical aberration, colors, photometry, vision. .Geometrical and physical optics, interference, diffraction, polarion, lasers. Acoustics with experiments and computer simulations during lectures. Longitudinal waves, creation and spreading of waves in media, supersonic wave fronts. Hearing. Heat with experiments and computer simulations during lectures. Temperature, kinetic-molecular theory, work.Heat, thermodynamic properties of bodies, calorimeters, Joule's equivalent. Thermodynamics, 1st and 2nd law. Thermodynamic cycles, Otto cycle, Diesel cycle, Carnot cycle, heat engine, heat pump. . Phases. Conduction, convection, and radiation and their combinations, properties of substances. Atomistics, structure and testing of materials with tests and computer simulations during lectures. Matter waves, photoelectric effect, line spectra, Franck-Hertz experiment, Bohr model. of atoms and molecules, structure of materials, properties of materials, properties of chemical bindings. Properties of materials. / *Compulsory*

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

21680 Basics of Engineering Informatics 1 (1+2) 3,0

Basics of information technology (IT); Using of computer and data manging. Basics of computer graphics (8+16) representation of pictures with pixels, 2D elements, 3D elements, 3D i 4D objects, the difference between drafting and object oriented drawing; presentation of 3D entities with wireframes, surfaces and different kinds of solid odels, visual reality; working with painting applications (Corel Photopaint); work with vector applications (Corel Draw); work with CAD applications (AutoCAD 2D) Office systems (5+14) text processing (basic operations, block operations, creating of page layout, automatic generation of content, graphic and other files import, creating of templates); spreadsheet calculations (basic operations, block operations, cell programming, 2D and 3D graphs drawing, fitting) ; Databases (database, tables, relations, queries, reports, output formatting); Presentations (presentation development, text and pictures, graphs, diagrams, object drawing, presentation effects, output formatting); informations and communications (internet, web navigation, web searching, e-mail). / *Compulsory references:* Algebra myCDL: eLearning sustav – http://www.grad.hr/myCDL; Delić, Zulbeari: AutoCAD praktikum web skripta – http://info.grad.hr/praktikum/acad / *Optional references:* Kučinac, R.; Borovac, I.: Osnove računala i Windows XP, Miš 2002.; Habraken J. 10 min Vodič kroz Office XP, Miš 2002.; Vičić, Z.: Internet ukratko, Miš 2002.; Finkelstein, E. AutoCAD 2002 biblija, Miš 2002.; Miljaš, N.: PC-Škola – CorelDraw, PRO-MIL, 2002.

21894 Physical Education

Aerobics. Fitness. Athletics. Basketball. Football. Volleyball. Handball. Swimming. Waterpolo. Competitions at university championship. Lectures for students by National Institute of Public Health. Swimming courses. Elective programmes: skating and sailing. Walking tours.

21682 Mathematics 2 (4+3) 8,0

Ordinary differential Equations. Separation of variables. Linear differential equation of 1^{st} order. Linear differential equation of 2^{nd} order. Linear differential equations of higher order. Functions of several variables. Sets in R^n. Continuity

and limit function of several variables. Derivation - differential of functions of several variables. Theorem of mean value. Taylor' s theorem of mean value. Function extremes of several variables. Multiple integrals. Double integrals. Tripple integrals Integration by substitution. Integral application. Fields. Scalar and vector fields. Gradient . Divergence and curl. Special fields. Curves and line integrals, Vector functions. Curves. Curvilinear integral of the 1st type. Curvilinear integral of the 2nd type. Curves in space. Surface integrals. Surfaces. Surface integral of 1st type. Surface integral of 2nd type. Divergence theorem. Stokes theorem. / *Compulsory references:* Kurepa, S.: Mathematics analiza I, II i III. Zagreb: Tehnička knjiga, 1990.; Pauše, Ž.: Matematički priručnik. Zagreb: Školska knjiga, 2003.; Suljagić S.: Mathematics II (web skripta), 2001; http://www.grad.hr/ nastava/Mathematics/mat2/index.html / *Optional references:* Demidović, B. P.: Zadaci i riješeni zadaci iz više matematike s primjenama na tehničke nauke. Zagreb: Tehnička knjiga, 1986.

21685 Mechanics 1 (2+2) 5,0

Subject, tasks and methods of statics. Basic concepts and laws. Introduction to the equilibrium analysis. Reduction of a system of forces and couples. Equivalent systems. Central axis. Equilibrium analysis of a system of forces acting on a particle. Equilibrium analysis of a general system of forces and couples acting on a rigid body in two dimensions. Analytical and graphical methods. Parallel forces and adjoining couples acting on a rigid body. Center of a system of parallel forces. Center of gravity. Equilibrium analysis of a system of forces and moments acting on a rigid body in three dimensions. Distributed forces (line-, area- and volume forces and gravity centers for parallel distributed forces). Distributed moments. Contact forces and friction. Equilibrium analysis of rigid body systems. Types of supports, connections and joints. Analysis of plane rigid body systems. Classification of systems. Statically determinated systems, elementary systems, reducible systems, trusses. Introduction to 3D analysis of statically determinated systems. Equilibrium analysis of a beam element. Internal forces. Axial, shear and bending –moment diagrams, relations among load, shear and bending moment. Differential equilibrium equations of a beam element. Analysis of beam systems. Equilibrium of a mechanisms. Equilibrium of flexible cables. Catenaries. Energy based equilibrium formulations. */ Compulsory references:* Werner, H.; Bjelajac, N.; Raduka V. Bilješke Lectures; Muftić, O. Mehanika i statika. Zagreb : Tehnička knjiga, 1991. / *Optional references:* Kiričenko, A. Mehanika I. PBI,d.o.o., 1976.; F.P. Beer, E.R. Johnston: Vector Mechanics for Engineers – Statics, McGraw-Hill 1988.

21688 Building Construction (3+3) 7,0

Structural characteristics of elements related to building materials, statics and physics law of buildings . Earth works in building construction, foundations, formwork. Concrete and reinforced concrete elements and formworks. Stone, artificial stone, combined masonry walls. Brick walls. Openings in walls, formworks. Wall linings, composite walls. Partition walls. Ceilings. Chimneys and ventilations. Roofs. Roofings. Flat roofs. Floors. Staircases. / *Optional references:* Peulić, Đ.: Konstruktivni elementi zgrada I. i II., Tehnička knjiga, Zagreb, 1980.; Neufert, P.: Elementi arhitektonskog projektiranja, Golden marketing, Zagreb, 2002.

21690 Probability and Statistics (2+1) 4,0

Events and probability. Space of elementary events. Space of probability. Event. Statistical definition of probability. Classical definition of a priori probability. Geometric definition of probability. Algebra of sets. σ-algebra. Probability space. Discrete space of probability. Conditional probability. Independent events. Formula of probability products.Total probability. Bayes' formula. Random variables. Discrete random variables . Function of probability. Function of probability distribution. Expectancy, variation and standard deviation. Function of a discrete random variable. Examples of discrete distributions. Discrete uniform distribution. Binomial distribution. Poisson' s distribution. Continuous random variables. Probability density function of a random variable. Distribution function of the random variable. Expectation, variance and standard deviation. Continuous random variable function. Examples of continuous distributions. Continuous uniform distribution. Normal distribution. Exponential distribution. Two-dimensional random variables. Two-dimensional random variables (Two-dimensional random vector). Function of two-dimensional random vector. Two-dimensional continuous random variable (two-dimensional random variable). Function of a two-dimensional continuous random variable. Correlation. Statistical method. Point estimations. Random sample of the n-th order. Sample arithmetic mean value. Sampling variance. Chebyshev inequality. Law of large numbers. Trust intervals. Interval expectancy estimation of normal distribution. Interval estimation of normal distribution variance. Interval probability estimation. Testing of hypothesis. Concept of statistical test. Hypothesis tests on expectancy. Hypothesis tests on variation. Hypothesis tests on probability. / *Compulsory references:* Pauše, Ž. Vjerojatnost, Školska knjiga, Zagreb, 1988.; Pauše, Ž. Uvod u matematičku statistiku, Školska knjiga, Zagreb, 1993.; Sarapa, N. Teorija vjerojatnosti, Školska knjiga, Zagreb, 1992.; Pauše, Ž. Riješeni primjeri, zadaci iz vjerojatnosti i statistike, Školska knjiga, Zagreb, 1989. / *Optional references:* Grinstead, C.M.,

Snell, J. L. Introduction to Probability, AMS, 1997.; web book (www.dartmouth.edu/%7Echance/teaching_aids/books_articles/probability_books/amsbook.mac.pdf); Rice Virtual Lab in Statistics (www.raf.rice. edu/%7Elane/stat_sim/index.html); Virtual Laboratories in Probability and Statistics (www.math.uah.edu/stat)

21692 Materials Science (2+1) 4,0

Introduction. Classification of materials and their properties. Standardization. Atom bonding: ionic, covalent, metallic, Van der Waals. Electrochemical properties of materials. Structure of solid body: crystal state, states of matter, polymeric state. Development of microstructure: hardening, changes in phases, diagrams of phases. Surface properties: surface stress, adsorption, capillary phenomena, colloids. Physical parameters of materials: thermal, acoustic, optical and electrical properties of materials. Reaction of materials to action of external forces: pressure, tension, bending, torsion, material fatigue. Deformations under short-term and long-term loading. Theories of material failure: mechanics of failure. Rheology of liquids and solid bodies: viscosity. Fatigue of materials. Long term deformations. Practice description. Physical parameters of materials: porose structure of materials, surface tension, diffusion, osmosis, gas permeability, water permeability. Electrochemical testings of materials. Analysis of material parameters (physical, physical-mechanical, thermal, rheological). Laboratory testings of material parameters. / *Compulsory references:* Young, J.; Mindess, S.; Gray, R.J.; Bentura: *The Science and Technology of Civil Engineering Materials*, Prentice Hall, 1998.; Ukrainczyk, V: *Poznavanje gradiva*, Institut građevinarstva Hrvatske, Alcor, Zagreb, 2001.; Beslać, J.: *Materijali u arhitekturi i građevinarstvu*, Školska knjiga, Zagreb, 1989. / *Optional references:* Ashby, M. F.; Jones, D. R.: *Engineering Materials 1*, Butterworth Heinemann 1996.; Illston, J. M., Domone, P. L. J. (ed.): *Construction materials – their nature and behaviour,* E & FN SPON Chapman & Hall, 1994.

21693 Basic of Engineering Informatisc 2 (1+1) 2,0

Basics of the program Mathematica Numerical Calculator (arithmetic operations, functions, the precision of results, nonlinear equations, systems of linear and nonlinear equations, average values, median, variance); Symbolical Calculator (lists, the operations with lists, vectors and matrices, polynomial and rational function, elementary functions, defining functions, limits, series, derivatives, integration); Visualization System for Functions and Data (2D graphics, 3D graphics, animations). Basics of programming. Programming

paradigms and programming languages; syntax and semantics. Data (types and variables), basic operations. Control structures: loops and branching. Functions, introduction into object-oriented programming. Data structure (array). Examples: Quadratic equation (branching, precision); solution method for solving nonlinear equations, min/max, sorting (loops); vectors and matrices. / *Compulsory references:* S. Wolfram : The Mathematica Book, Help za Mathematicu 5.0; S. Suljagić: Praktičan uvod u programski paket Mathematica, webskripta, http://tesla.vtszg.hr/~suljagic/Graditeljski%20odjel/racunala/; S. Alagić: Principi programiranja, Svjetlost, Sarajevo, 1985. / *Optional references:* V. Benić, J. Beban-Brkić, V. Čuljak, S. Gorjanc: Odabrana poglavlja geometrije i matematike za inženjere pomoću Mathematice, web skripte, http://www.grad.hr/itproject_math/index.html; B. Motik, J. Šribar: Demistificirani C++, Element, Zagreb, 2002.

21740 Strenght of Materials 1 (3+3) 7,0

General assumptions and basic design elements. External and internal forces. General approach to solving problems in the science of resistance of a material. Stress analysis. Stress tensor. Differential equations of balance and transformation equations. Major stresses. Stress ellipsoid. Mohr's stress circle. Octahedral stresses. Strain analysis. Concepts of displacement and strain. Strain tensor. Transformation equation. Major strains. Continuity condition. Deformability characteristics of rigid bodies – physical equations. Hook Law. Material elasticity constant. Law on superposition, Saint Venant principle. Permitted stresses, safety coefficient and recent explanation of structure safety. Axial beam loading – extension and pressure. Stress concentration. Structurally indeterminate beam systems. Heat and initial stresses. Extension of catenary cable. Stress and strain of thin walled vessel. Shear (cutting force). Design of elements under thrust load. Geometric characteristics of flat beam cross sections – moment of inertia. Torsion of flat beams. Prandtl's membrane analogy. Statically indeterminate tasks with torsion. Bending of flat beams. Pure bending. Bending under forces. Strength design under bending. Bending of compound and composite girders. Skew bending. Differential equations of second and fourth order of girder elastic line and solving procedure. Deflections due to tranrse force. Influence of temperature on deflection. / *Compulsory references:* Šimić, V. Otpornost materijala I. Zagreb : Školska knjiga, 2002. / *Optional references:* Alfirević, I. Nauka o čvrstoći I. Zagreb: Tehnička knjiga, 1995.; Bazjanac, D. Nauka o čvrstoći. Zagreb : Tehnička knjiga, 1967.; Brnić, J.; Turkalj, G. Nauka o čvrstoći I. Rijeka : Tehnički fakultet Sveučilišta u Rijeci, 2004.

21716 Geodesy (2+2) 5,0

Introduction: The figure and size of the Earth and its projection to maps and plans. Geodetic measurements. Theory of errors and adjustment calculus. Coordinate systems in geodesy, Gauss-Krüger projection. Fundamental geodetic works – control networks. Levelling. Cartography. Calculating areas and volumes. Land surveying methods. Geoinformation systems – GIS. C cadastre and land registry. Geodetic works in designing and construction. Geodetic works in individual construction disciplines. Design and layout of traffic routes. Determination of movements and deformations by means of geodetic methods. / *Compulsory references*: Brankica Cigrovski-Detelić; Geodezija, pisana Lectures (Kopiraonica AGG fakulteta), Zagreb, 2004/05.; Boško Pribičević, Damir Medak; Geodezija u građevinarstvu, V.B.Z. d.o.o. Zagreb, 2003.

21720 Fluid Mechanisc (3+2) 6,0

Basics on fluids. Fields of physical quantities. Physical properties of fluids. Rheological diagram. Forces acting on fluids. Fluid statics. Balance equation (Euler) and its solving. Accelerating fluid. Pressure force on surface. Buoyancy. Floating. Body stability. Fluid kinematics. Fluid particle motion. Vorticity. Streamline. Pathline. Steady flow. Uniform flow. Conservation of flow. Total derivative. Field maintenance principle (Reynolds). Law of mass maintenance (continuity equation). Fluid dynamics. Linear momentum equation. General law of real fluid flow (Saint-Venant and Navier- Stokes equation). Law of kinetic energy conservation. Bernoulli' s equation for ideal and viscous fluid. Laminar flow. Turbulent flow. Boundary layer. Resistance to flow. Losses of energy. Calculation ofminor and friction looses. G,P,E lines. Potential flow. Potential flow equations (Laplace). Boundary conditions. Source. Sink. Doublet. Fluid flow modeling. Law of similarity. Velocity, pressure and discharge measurements. Application to hydraulic Engineering Systems under pressure. Pumps. Turbines. Outlets. Small and large opening. Sluice gate. Water flows over sharp-crested weirs and spilllways. Open channel flow. Bottom bump. Hydraulic jump. Sediment transport. Ground water flow. Darcy law. Filtration. Dupuit 's assumptions. Wells. Forces exerted on the body in the fluid stream. Dynamically stable and unstable forms. / *Compulsory references:* Andročec, V.: Interna skripta; Fancev: Mehanika fluida, Tehnička enciklopedija,sv 8. / *Optional references:* Bilo koja knjiga koja ima u naslovu "Fluid mechanics"; Lectures I, zadaci iz predmeta Fluid Mechanics poznatijih Sveučilišta publiciranih na INTERNETU.

21741 Mechanics 2 (2+1) 4,0

Kinematics: Kinematics of particle:Basic concepts: position of a particle, velocity, acceleration. Choise of coordinate axis(or frame of reference. Determination of the motion of a particle in vector form, parametric form and along the known trajectory Special types of motion, angular velocity, angular acceleration. Analitical and grapho-analitical problem solutions) Apsolute and relative motion of a particle. Coriolis acceleration. System of particles: dependent motion of the particles. Kinematics of rigid bodies: translation, rotation about fixed axis, rotation about fixed point, plane motion, instantenous center of rotation and velecity Degrees of freedom of a rigid body in plane motion, definition of motion by generalised coordinates. Mechanisms. Kennedy´ s theorem). Velocity and acceleration diagrams, small displacement diagrams and its application to solution of static problems according to the wirtual work principle. Dynamisc / Kinetics: Dynamics of a particle: differential equations of free and limited motion of a particle.D´Alambert ´s principle. Linear momentum and angular momentumof a particle, rate of change of linear and angular momentum of a particle) Relative motion. Work done by a force, conservative forces. Potential and kinetic energy, principle of work and energy, coservation of energy Dynamics of systems of particles: position of the mass center, motion of the mass center, linear and angular momentum of a system of particles Kinetic energy , energy principles Application of Newton´s laws to the motion of the system of particles. Basic impact theory. Dynamics of rigid bodies: mass moments of inertia, main inertia axis, Steiner´s Law of parralel axis. Types of motion of a rigid body.Translation: differential equations of translational motion. Rotation about a fixed axis: angular momentum of a rigid body in rotation about a fixed axis, analysis of inertia loads, dynamic reactions. Kinetic energy. Rate of change of linear and angular momentum of a rigid body.Plane motion of a rigid body: differential equations of plane motion, D´Alambertś principle. Rate of change of linear and angular momentum of a rigid body in plane motion. Energy principles and their application in plane motion of a rigid body and a system of rigid bodies. Theory of small vibrations of a single-degree-of-freedomsystems, free and forced vibrations with and without damping. / *Compulsory* references: Werner, H.; Bjelajac, N. ; Raduka, V. Bilješke Lectures; Jecić, S. Mehanika II (Kinematika i dinamika). Zagreb : Tehnička knjiga, 1989. / *Optional references:* A. Kiričenko, MEHANIKA II, PBI,d.o.o., 1976., Mehanika III, PBI,d.o.o., 1996.; Andrejev, V. : Kinematika, dinamika. Zagreb : Tehnička knjiga, 1973. ; Beer, F.P.; Johnston, E.R. Vector Mechanics for Engineers – Dynamics, McGraw-Hill 1988.

21721 Hydrology (2+0) 3,0

General information on water: Water and its natural properties, Global distribution and circular water motion in nature – hydraulic cycle. Atmosphere, processes, and measurements in atmosphere: structure, properties and processes in atmosphere, meteorological measurements - temperature, pressure, moisture, condenon, precipitations, evapotranspiration, elaboration of measured meteorological data . Water in and on the ground: Run off processes, subsurface flow and surface runoff, hydrography, catchment area, river valleys and river beds. Hydrometry: Water stage and gauges, water temperature measurement, ice occurrence, water level measurement, depth and streamflow measurement, sediment measurement in natural watercourses. Hydrometric data elaboration: Streamflow rating curve, water level hydrograph and discharge hydrograph, frequency and duration of stage and flow, small, medium and large water. Trend analysis and linear correlation in hydrology. Probability and statistics in hydrology: Empirical and compromising probability, application of theoretical probability distribution functions in hydrology, cumulative distribution functions and recurrence interval, time series of hydrologic and meteorological data, formation of representative statistical collection of hydrologic data, homogeneity tests and adjustments, statistical parameters failures. Parametric hydrology: Parametric methods for runoff determination, runoff coefficient, rational method, empirical methods for runoff calculation according to various authors. / *Compulsory references:* Srebrenović, D. Primijenjena hidrologija. Zagreb : Tehnička knjiga,1986.; Žugaj, R. Hidrologija, udžbenik. Zagreb : Sveučilište u Zagrebu, Rudarsko-geološko-naftni fakultet, 2000. / *Optional references:* Vuković, Ž.: Osnove Hidrotehnoke – Knjiga I, Poglavlje 2: Hidrologija, str. 19-133, udžbenik Sveučilišta u Zagrebu, Zagreb 1944.; Čavlek, E.: Osnove hidrologije, Geodetski fakultet Sveučillišta u Zagrebu, 1992.; Hrelja, H.: Vjerovatnoća i statistika u Hidrologiji, Građevinski fakultet Univerziteta u Sarajevu, 2000.; Ven Te Chow: Handbook of Applied Hydrology, McGrow-Hill book Company, New york, 1964.; Viessman, W.Jr., Lewis. L.G.: Introduction to Hydrology, Harper-Collins-College-Publishers, New York, 1996.; Bonacci, O.: Meteorološke i hidrološke podloge, Priručnik za hidrotehničke melioracije, Društvo za odvodnjavanje i navodnjavanje Hrvatske, Zagreb, 1984.

21742 Strenght of Materials 2 (3+2) 6,0

Simple statically indeterminate systems. Girder on an elastic base. Safety coefficient determination at multiaxial state of stress. Equivalent stress according to strength theories. Comparison and application of strength theory. Complex loading of flat beams. Bending and axial loading. Bending and torsion.

Eccentric loading of short beams. Cross section core. Application of cross section core. Stresses in cross section with exclusion of tension zone. Bending and axial loading of a compound girder. Thin walled cross section. Shear center. Curved beams theory. Stress and strain due to longitudinal and tranrse force. Bending. General case of bending. Rational shapes of curved beam cross section under bending. Potential energy. Theorem on reciprocity effects of work and displacement, Castigliani' s theorems, Crotti – Engesser 's theorem. Principle on strain minimum potential energy. Principle on stationary condition of system potential energy. Buckling, elastic stability loss. Beam buckling in plastic area. Euler s critical force. Beam buckling in plastic area. Euler's formula extension for a critical force by introducing a tangent module. Slender column under common exertion of longitudinal and tranrse loading. Dimensioning of beams under buckling load stability condition. Design of structures according to plasticity theory. Model of ideal elastoplastic material. Plasticity condition. Plastic torsion and plastic bending of a flat beam. Influence of load release. Residual stress. Analysis of boundary condition of statically indeterminate structures. Static and kinematic theorems. Dimensioning according to boundary conditions theory. / *Compulsory references:* Šimić, V. Otpornost materijala II. Zagreb: Školska knjiga, 2002. / *Optional references:* Alfirević, I. Nauka o čvrstoći II. Zagreb : Golden marketing, 1999.; Bazjanac, D. Nauka o čvrstoći. Zagreb : Tehnička knjiga, 1967.; Timošenko, S. Otpornost materijala I i II. Beograd: Građevinska knjiga, 1965.

21743 Structural Analysis 1 (4+3) 8,0

Lectures: Subject, aims and methods in structural analysis. Model of a structure. Basic assumptions and principles. Differential and integral equations of equilibrium. Simple beams. Multispan statically determinate beams; analytical and graphical methods of analysis. Trusses; statical determinacy and geometrical stability: analytical and graphical methods. Three-hinged and similar girders: Three-hinged girders and girders with tie rods; analytical and graphical methods. Trussed beams, supported and suspended girders; analytical and graphical methods. Work. Virtual displacements. Virtual work for rigid bodies. Applications. Influence functions and influence lines. Critical loading. Elastic systems. Displacements and deflection lines. Variational procedures. Spatial statically determinate systems. Practice: Multispan statically determinate beams and truss girders. Three-hinged and similar girders. Applications of a virtual work principle. Influence functions. Deflection lines. 3 colloquia. / *Compulsory references:* V. Simović: *Građevna statika I,* Građevinski institut, Zagreb, 1988.; M. Anđelić: *Građevna statika II,* Građevinski fakultet, Zagreb, 2005.; Građevna statika. Primjeri, zadaci, bilješke..., www.grad.hr/nastava/gs, 1998.-2004. / *Optional*

references: L. P. Felton & R. B. Nelson: Matrix Structural Analysis, Wiley, New York, 1997.; J. C. McCormac & J. K. Nelson: Structural Analysis. A Classical and Matrix Approach, Addison-Wesley, Reading, 1997.; W. Wunderlich & W. D. Pilkey: Mechanics of Structures. Variational and Computational Methods, CRC Press, Boca Raton, 2003.

21718 Soil and Rock Mechanics (3+2) 6,0

Basic soil properties: composition of soils, origin of soils, phase relationships, density, particle size distribution, index tests, soil classification. Soil water: water pressure, capillarity, seepage, effective stresses. Soil stiffness: oedometer, soil moduli, consolidation. Soil strength: direct shear, Mohr-Coulomb failure criterion, drained and undrained strength. Shallow foundations: induced stresses, settlement, bearing capacity. Basic rock properties: heterogeneity, anisotropy, discontinuity, properties of discontinuities. Rock classification and categorization. Basics of rock strength and stiffness. Field investigations of soils and rocks. */ Compulsory references:* Nonveiller, E. (1981): Mehanika tla i temeljenje građevina, II. izdanje. Školska knjiga, Zagreb; Goodman, R.E. (1989): Introduction to Rock Mechanics, John Wiley & Sons, New York, USA / *Optional references:* Craig, R. F. (1997): Soil Mechanics. Spon Press. London.; Coduto, D. P. (1998): Geotechnical Engineering, Principles and Practices. Prentice Hall, NJ, USA.

21733 Law in Construction (2+0) 3,0

Legal elements. Basic terminology. Legal norms. Legal system, origin of law, subjects of law. Legal relationships and procedures. Construction law. Multidisciplinary elements of a construction project. Control systems. Direct and indirect factors in the construction projects. The role of construction law in construction projects. Construction law. Professional norms. Life-cycle of construction projects. Feasibility studies. Urban planning. Building site preparation. Regulation models and the key activities in construction projects. Preparation for the project and project documentation. Conceptual design. Project design. Detailed design. Internal and external control of project documentation. Construction tendering. Constructing. Complete final account. Building operation and maintenance. Demolition of buildings. Project of building demolition. The participants in construction project and legal obligations. Investor. Designer. Reviewer. Contractor. Engineer. Tender documents. Bill of quantities. Drawings. Technical conditions. The obligatory site documentation. Building permission. Building diary book. Design details. Bill of quantity. Certificates about the quality of performed works, and products. Basic legal documents. Purposes, ways and

methods of building permission obtaining. The detailed special plan extract. Building pre-permission. The general building permission. The building permission for the part of the building, or for the whole building. Using permission. Permission for building demolition and evacuation. Inspections and governmental inspections. Professional associations. Croatian chamber of architects and engineers in construction. FIDIC. Goals. Documents. System of acting. Commercial law bases. The corporation. The kind of securities, and their uses. Contracts. Contracts in: construction, concession, selling and leasing, patents, investments, transport, deposit. Guaranties. / *Compulsory references:* Bienenfeld, J., Kasabašić, Š., Mrduljaš, D., Sarvan, D.: Komunalno gospodarstvo, gradnja i prostorno uređenje, Novinformator, Zagreb, 2004. / Gorenc, V.: Trgovačko pravo-poduzeće, ŠK, Zagreb, 1992. / Gorenc, V.: Trgovačko pravo-ugovor, ŠK, Zagreb, 1993. / http://www.nn.hr/ / *Optional references:* FIDIC: Ugovaranje radova u graditeljstvu, Koprojekt, Zagreb, 1997. / Murdoch, J., Huges, V.: Construction Contracts / Law and management, E and FN Spon, London, 1993.

21726 Concrete and Masonry Structures (4+3) 8,0

Generally of concrete structures – relevance and use, history and development, advantages and disadvantages of reinforced concrete. Documentation for design of concrete structures. Physical and mechanical properties of concrete and reinforcing steel, strength and types of concrete and reinforcement. Bond between concrete and reinforcement, anchorage, connection and shape of reinforcement, protection coating. Basic concepts of dimensioning of concrete reinforced structures according to limit state design, subjected to flexure. Actions on structure. Examples. One-way slabs, cantilever slabs, staircase, continuous slabs. Minimum and maximum reinforcement. Reinforcement design and plan. Rectangular beam design and T-beam design. Principles and methods of centrically loaded structural elements design (columns and walls). Basic concepts of prestressed concrete. Basic concepts of prefabricated structures. Introduction and history of masonry structures. Masonry structures as "energy saving " buildings. Units and symbols. Basic concepts of masonry structures design. Basic requirements. Actions on structure. Engineering materials of masonry structures. Masonry units. Mortar. Concrete infill. Steel reinforcement. Unreinforced masonry. Behaviour of structures and stability. Masonry strength design. Reinforced masonry. Reinforced walls, masonry girders and floor structures. Prestressed masonry and new types of masonry. Practical work: during semester students make project for design of one reinforced concrete structure. During semester there will be two mid-term exams. / *Compulsory references:* Tomičić, I. Betonske konstrukcije. Zagreb: Društvo Hrvatskih

građevinskih konstruktora, 1996.; Tomičić, I. Priručnik za proračun armiranobetonskih konstrukcija. Zagreb : Društvo Hrvatskih građevinskih konstruktora, 1996.; Sorić, Z.: "Zidane konstrukcije I", (drugo, prošireno izdanje). Zagreb, travanj 2004. / *Optional references:* Hrvatske norme HRN ENV 1992, norme za betonske konstrukcije (Eurokod 2), Hrvatske norme HRN ENV 1996, norme za zidane konstrukcije (Eurokod 6), Hrvatske norme HRN ENV 1991, norme za opterećenja konstrukcija (Eurokod 1), Hrvatske norme HRN ENV 1998, norme za seizmička područja, Lectures i Practice.

21719 Geotechnical Engineering (3+2) 6,0

Slopes: limit analysis, stability, and influence of seepage. Embankments, cuts, excavations, soil compaction and control, drains, filters, seepage control. Lateral stresses in soils: at rest pressure, active and passive pressure. Retaining structures: types, anchors, stability calculations. Shallow foundations: single footings, rafts, grillages, soil-structure interaction, bearing capacity, settlement. Deep foundations: types, piles, bearing capacity and settlement, negative skin friction, pile groups. Rock engineering: wedge stability, analysis of deformations, interaction matrix. Underground structures: primary and secondary support, methods of excavations, influence on surface structures. Monitoring of geotechnical structures. Soil and rock improvement. / *Compulsory references:* Nonveiller, E. Mehanika tla i temeljenje građevina, II. izdanje. Zagreb : Školska knjiga,1981.; Hoek, E. (2000): Rock Engineering, A Course Notes, http://www.rocscience.com / *Optional references:* Tomlinson, M. J. 1995): Foundation Design and Construction. Longman Scientific and Technical, Harlow ; Bowles, J. E. (1982): Foundation Analysis and Design. McGraw Hill, NY.; Coduto, D. P. (1994): Foundation Design, Principles and Practices. Prentice Hall, NJ.

21738 Roads (3+2) 6,0

Historical development, terminology, division. Road vehicles, dimensions, axes load. Vehicle motion, speed, motion resistance. Traffic, traffic volume, flow capacity. Cross section, traffic cross section and clearance. Horizontal alignment, straight line, clothoid, circular arch, elements of stakeout. Vertical alignment, grade, vertical curves. Three-dimensional alignment. Vehicle movement geometry, offtracking, pavement screwing, sight distance. Road drainage, gutters, ditches, drainage works, culverts. Road construction materials. Substructure, earth works, mass lines, walls. Pavement structures, basecourses, wearing courses. Road intersections, at-grade intersections, interchanges. Traffic areas, parking areas, service facilities. Road equipment, road signing and marking, safety

equipment. / *Compulsory references:* Korlaet Ž. Uvod u projektiranje i građenje cesta, Zagreb: Građevinski fakultet Sveučilišta u Zagrebu, 1995., udžbenik Sveučilišta u Zagrebu, str. 208.; Dragčević V.; Korlaet Ž.: Osnove projektiranja cesta, Zagreb: Građevinski fakultet Sveučilišta u Zagrebu, 2003. udžbenik Sveučilišta u Zagrebu, str. 93./ *Optional references* sadržana je u popisima navedenim u obveznoj literaturi.

21739 Railways (2+0) 3,0

Basics of railways: historical development, division of railways. Railway vehicles: wagons, locomotives, types of tractions, common systems of railway vehicles. Route design and: railway line types, horizontal and vertical curse. Railway stations: station classification (passenger and goods station), equipment of a station. Track loads: forces in the plane of track, forces vertically on the plane of track. Elements of track superstructure: rails, slippers, fastenings, ballast. Permanent way elements: turnouts, turntables, traveling platform. Basic requirements for a track arrangement: straight track, track in curve. Inspection works and track maintenance: control types, track geometry maintenance. Special railways: rack railways, suspension railways, funiculars, humps, cable railways. / *Compulsory references:* Prister, G.; Pollak, B. Željeznice – gornji stroj i specijalne željeznice. Zagreb : Građevinski Institut, 1988.; Lakušić, S. Željeznice. Interna skripta. / *Optional references:* Eld, C. Modern Railway Track, *Second Edition*. MRT Productions, Zaltbommel, 2001.

21736 Construction Management (3+3) 7,0

Introduction into construction work organization. (Development of organization, Principles of organization, Special features of construction production, Types of construction production). System and project. (Application of system analysis on the project research, Project as a term, Distribution of projects, Stages of projects, Difference between project and production). Basics of construction project management. (Construction project, Construction project management, Stages of construction project, Feasibility of construction project, Construction management, Construction project leader, Teamwork, Quality-time-costs management). Construction organization design (COD). (Reasons for COD, Methodological approach to COD, COD tasks, Basic outlines for the COD elaboration, COD contents, Elaboration of COD). Organization of construction processes. (Working methods research, Fundamental work elements in construction, Standstill and loses, Measuring and standardization of work, Working processes variants). Construction site organization. (Temporary barracks and settlements on the

construction site, Storage and warehouses, Plants and workshops, Outdoor and indoor transports, Construction site roads, Electrical energy on construction site, Water supply and drainage on construction site, Fences on construction site, Scheme of construction site arrangement). Construction site planning. (Planning process, Plan elaboration procedure, Linear planning methods, grid planning method PDM, Plan execution monitoring). Calculation of construction work costs and prices. Construction costs structure; Working power costs, Material costs, Machines and equipment costs, Indirect construction costs structure, Company management costs, Additional calculation, Costs distribution factor, Prices analyses, Construction work costs calculation). Organization of participants in the construction process. (Participants in the construction process, Relationships among participants, Organization structure, Documentation of construction process management, Obligatory construction site documentation). Protection at work on the construction site (pwcs). (Rules and codes of pwcs, Study of pwcs and construction site arrangement, Marking of dangerous places and spaces, Electric installations, machines and gadgets, Scaffolding, Work at heights and in the depths, Personal protection means, Fire-protection on construction site, First aid organization, Measures of pwcs in earth, carpentry, concrete and steel bending works). / *Compulsory references:* Radujković M. – Organizacija građenja, 2004. (trenutno nerecenzirana skripta, do početka novog programa bit će knjiga); Lončarić R. – Organizacija izvedbe graditeljskih projekata, HDGI, Zagreb, 1995. / *Optional references:* Marušić J. – Organizacija građenja, FS, Zagreb, 1994.; Harris F., McCaffer R. – Modern Construction Management, Blackwell Scientific Publication, Oxford, 2004.

21727 Metal Structures (2+1) 4,0

Terminology and defining the contents of the course. Properties of steel as an engineering material. Types of construction steel, production and properties. Protection from corrosion and fire. Reliability concept of steel structures. Action on structures. Cross section strength and strength of structural elements. Fundamentals of hall and multi storey design. Computer application in design. Coordination of structural properties of elements and connections. Structural design. Construction and assembly of steel structures. Experiment supported design. Aluminium alloy structures. / *Compulsory references:* Androić, B.; Dujmović, D.; Džeba, I. Metalne konstrukcije 1. Zagreb : IGH, 1994.; Androić, B.; Dujmović, D.; Džeba, I. Metalne konstrukcije 2. Zagreb : IA Projektiranje, 1995.; Džeba, I.; Androić, B.; Dujmović, D. Metalne konstrukcije 3. Zagreb: IA Projektiranje, 1998. / *Optional references:* Hirt/Bez: Stahlbau, Ernst und Sohn, 1998., Dowling, P.: Structural Steel Design, 1988.

21728 Bridges (2+1) 4,0

Introduction, definitions, elements, materials. Bridge types. Main requirements on bridges. Traffic conditions. Actions on bridges. Dynamical effects. Reliability factors. Layout elements. Load bearing structures. Substructures. Bridge equipment. Bridge erection methods. Bridge maintenance. Bridge history overview. Limit achievements in bridge engineering. / *Compulsory references:* Radić, J.: Mostovi, Dom i svijet, Zagreb 2002.; Radić, J.; Mandić, A.; Puž, G.: Mostovi – priručnik (u tisku) / *Optional references:* K. Tonković: Mostovi, Liber Zagreb 1981.; Wai-Fah, Chen, Lian Duan: Bridge Engineering Handbook, CRC Pres 2000.

21725 Hydraulic Engineering Structures (3+0) 4,0

Introduction: The significance and the role of water in human society development; Water resources engineering and hydraulic structures in water resources management; Hydraulic structures – purpose, definition, division. Fundamentals of hydraulic structures design. Calculation types and hydraulic structures load and budget types: Functionality; Mechanical resistance; Stability; Water and surroundings load determination; load schemes for concrete and foundation work. Pipelines and accompanying devices: Pipelined under pressure; Pipelines with free water surface; Drainages. Canals and canal structures. Hydroengineering tunnels and accompanying devices: pressure tunnels and free-flow tunnels. River flood protection structures . Structures for river course training. Road culverts and structures for road drainage. Maritime structures. Navigation locks. Dams and weirs. Reservoirs and accompanying devices. Hydropower plants. Other hydraulic structures: Aquaducts; Siphons; Plugs; Culverts. / *Compulsory references:* Stojić P. Hidrotehničke građevine I, II i III. Split : Građevinski fakultet Sveučilišta u Splitu, 1997,1998 i 1999.; Đorđević B. Korištenje vodnih snaga – objekti hidroelektrana. Beograd : Naučna knjiga i Građevinski fakultet, 1989. / *Optional references:* Savić: Uvod u hidrotehničke građevine; Beograd, Građevinski fakultet, 2003.

21737 Education on Construction Site (0+3) 3,0

The auditory practices introduce students into manufacturing plants and construction sites they will visit as a part of their field practice. 4 outdoor activities are planned in a semester: 2 visits to manufacturing plants(brickwork plant and concrete-mixing plant with separation and 2 construction sites. Construction sites are chosen according to needs and existing conditions.

4.2. Elective subjects

21677 Introduction to Civil Engineering (2+0) 3,0

Basic data and concepts in civil engineering. Definitions and characteristics of building structures. Origins and development of civil engineering profession and a vocation of a civil engineer. Civil engineers in Croatia. Beginning of civil engineering education, history of the Faculty of Civil Engineering. Great Croatian civil engineers and their work. Bearing structures. Transportation facilities. Hydraulic engineering structures. Bridges. Construction under earth and under water. Principles of economy in civil engineering. Sustainability and construction. Esthetic in civil engineering. Special state of the art achievements in civil engineering. / *Optional references:* R.S. Narayanan, A.W. Beeby: Introduction to Design for Civil Engineers, Spon Press, London 2001.; D. Doran: Eminent Civil Engineers, Whittles Publishing, Caithness 1999. J. Radić: Spomen knjiga 125 year HIS-a, Zagreb, 2003.; K. Tonković: Priče o građenju, Građevinski fakultet, Zagreb 1976.

21687 Hystory of Building Constructions (2+0) 3,0

Art and history of construction. Building construction as an independent process, structural elements, forms through history. Construction work as an organism. Construction work in Mesopotamia. Construction work in Egypt. Construction work of Aegeus. Construction work of Greece. Construction work of Rome. Construction work of Late Antiquity and Early Christianism. Construction work of Middle Ages: pre-romanesque, Romanesque. Construction work of Gothics. Moder Age I – Humanism and Renaissance. Construction work of Baroque and Classicism.Modern Age II – Foundations of new architecture. Present time: trends and tendencies. / *Optional references:* Müller, W.; Vogel. G.: Atlas arhitekture 1 i 2. Zagreb : Golden marketing, 1999.

21683 Sociology of Work and Professional Ethics (2+0) 3,0

Core terms (work, sociology, sociology of work, professional ethics. History of work. Classic theory of work. Theory of “human relationships”. sfaction at work. Working career. Professionalism. Professional ethics. Working groups. Conflicts at work. Specific aspects of civil engineering work. Psychological and sociological aspects of work in civil engineering. Future of work. / *Compulsory references:* Haladin, S.: Tehnologija i organizacija: uvod u sociologiju rada i organizacije. Zagreb: Društvo za organizaciju građenja Republike Hrvatske, 1993. / *Optional references:* Vecchio, R. P. Organizational behavior: core concepts. Mason, Ohio:

Thomson/South-Western, 1966.; Miller, D.C.; Form. V.H. Industrijska sociologija. Zagreb: Panorama, 2003.; Taylor, F. W. Naučno upravljanje. Beograd: Rad, 1967.; Šporer, Ž. Sociologija profesije: ogled o društvenoj uvjetovanosti profesionalizacije. Zagreb: Sociološko društvo Hrvatske. 1990.; Parkinson, C.; Northcote; Rustomji M. K. Biblija za menadžere. Zagreb: Privredni vjesnik, 1984.

21764 Outline of Civil Engineering Legislation (2+0) 3,0

Outline of legislation, its origins, hyerarchy of legislation, most important legal instruments of Republic of Croatia and European integrations. Basic legislation, origins and hyerarchy of legal instruments. Relevant sections from statutory law (regulation of legal status). Relevant sections from obligation law. Relevant sections from real estate law. Relevant sections from land registry law. Relevant sections from tax regulations. Relevant sections from labor law. Basic concepts of standardion. / Compulsory references: Osnove prava za građevinare – skripta, Zakoni, podzakonski akti i odgovarajući udžbenici profesora Pravnog fakulteta.

21684 Business Economics (2+0) 3,0

Business environment; concept of earning, indicators of economic development, factors of economic development, technical structure of economy. Enterprise, entrepreneurship and entrepreneur; the concept of enterprise and its function, entrepreneurship – significance and role of entrepreneurship in construction industry, entrepreneur. Market (concept and function, market structure); demand (concept, elasticity,) supply (concept, elasticity), law of supply and demand, process of reproduction. Course of reproduction; input elements, output elements. Production chain; working capital; basic assets, capacity, amortization, working assets. Costs and price calculation; price, purchase price, supply price. Business success measures; cost-effectiveness, productivity, profitability. */ Compulsory references:* Dragana Grubišić, Poslovna ekonomija, Ekonomski fakultet Sveučilišta u Splitu, Split 2004. / *Optional references:* J.E. Manser, Economics – a foundadtion course for the built environment, E&FN Spon,London,UK 1995.

21675 English in Civil Engineering (2+0) 3,0

Career Paths for Engineers. Employment Opportunities in Government. Motivation, Performance and Job sfaction. Initial Career Profiles. Civil Engineering Graduates. The Engineer as a Professional Characteristics and Responsibilities of Professional Engineers. Professional Civil Engineering. Organizations. Engineering Ethics .Case Studies in Engineering Ethics. Learning and Creative

Thought. The Successful Engineering Student. Hindrances to Problem Solving. Stepping from Ideation to Preliminary Designs. How Engineers Find Information and the Information Seeking Process. Engineering Approach to Problem Solving. Engineering Team. Learning from Failures. Decision Making. / *Compulsory references*: Alemka Kralj Štih: English in Civil Engineering. Zagreb : Hrvatska učilišna naklada, 2004.; A.Prager: Trojezični građevinski rječnik, Masmedia, Zagreb, 2002.; V. Simović: Leksikon građevinarstva, Masmedia, Zagreb, 2002. / *Optional references*: M. Frank: Modern English – A Practical Reference Guide, Prentice Hall,INc., London; R.Eldwar: Understanding Building, MIT Press, Massachussetts, 1998.; Cecil D. Elliott: The Development of Materials and Systems for Buildings, MIT Press, Cambridge,1994.

21910 German Language in Civil Engineering (2+0) 3,0

Bauingenieurwesen.Was ist Bauingenieurwesen? Wie wird man ein(e) Bauingenieur(in). Bauingenieure haben ein weites Feld.Hochhäuser. Erfindungen veränderten das Aussehen von Bauten. Die Entwicklung der ersten Wolkenkratzer. Der erste Wolkenkratzer - Die Kathedrale des Handels. Wie sicher sind Hochhäuser? Hochhauskonstruktion. Die Brücken. Ein Brückenmodellbau. Der Ablauf eines Brückenmodellbaus.Die größte Drehbrücke der Welt. Das Beispiel eines Damms. Die Geschichte der Tunnelkonstruktion. Tunnelbauverfahren. Der Straßenbau. Türme und Kuppeln. Kuppelbau. Alexandre Gustav Eiffel - ein Mann der Perfektion. Flughäfen. */ Compulsory references:* Alemka Kralj Štih: Deutsch im Bauingenieurwesen, učilišna skripta, Zagreb, 2004. / *Optional references:* F. Leonhardt: Ingenieurbau: Bauingenieure gestalten die Umwelt, Carl Habel Verlag, Darmstadt, 1994., www. bau.de

21731 Construction of Materials (2+2) 5,0

Granular composites: mechanics of granular composites, composition, structure and properties. Aggregate: types of aggregates; composition and structure, characteristics. Binders: inorganic and organic binders. Cement: composition and hydration of portland cement, microstructure and properties of hydration products, portland cement of various compositions, porosity and pore structure. Concrete: properties of fresh and hardened concrete, concrete durability. Asphalt concrete: bitumen, liquid asphalts, bitumen mixtures. Metals: composition and structure, hardening mechanism, mechanic properties, corrosion and protection from corrosion. Timber: structure of timber, engineering properties of timber, engineering production, damages in timber and their impact on mechanic properties. Glass. Ceramics: composition and properties, production.

Polymers and plastics: classification and properties, additives and fillers. Glues, colours and varnishes. Fibre reinforced concrete composites: mechanics of fibre reinforced composites, fibres and matrixes. Insulation materials.Contents of practices.Physical and mechanical cement testings. Aggregate properties for concrete. Fresh concrete testing. Physical and mechanical testing of bitumen mixtures. Mechanical and electric and chemical properties of metal. Physical and mechanical properties of glass. Mechanical properties of polymeric materials. Non-destructive materials testing. / *Compulsory references*: Young, J.; Mindess, S.; Gray, R. J., Bentura: The Science and Technology of Civil Engineering Materials, Prentice Hall, 1998.; Ukrainczyk, V.: Poznavanje gradiva, Institut građevinarstva Hrvatske, Alcor, Zagreb, 2001.; Ukrainczyk, V.: Beton – struktura, svojstva, tehnologija, Alcor, Zagreb, 1994.; Bjegović, D. i dr.: Auditorne Practice, Praktikum, Aktivna nastava, Građevinski fakultet Sveučilišta u Zagrebu, 1994.; Beslać, J.: Materijali u arhitekturi i građevinarstvu, Školska knjiga, Zagreb, 1989.; Đureković, A.: Cement, cementni kompozit i dodaci za beton, Školska knjiga, Zagreb, 1996. / *Optional references:* Ashby, M. F.; Jones, D. R.: Engineering Materials 1, Butterworth Heinemann 1996.; Illston, J. M., Domone, P. L. J. (ed.): Construction materials – their nature and behaviour, E & FN SPON Chapman & Hall, 1994.; Taylor, G.D.; Materials in Construction, second edition, Longman Group UK Limited, 1994.

21732 Basics of Concrete Technology (2+2) 5,0

Introduction. History of concrete. Aggregate. Aggregate: types of aggregates, composition and structure, characteristics. Binders: inorganic and organic binders. Cement: composition and hydration of portland cement, microstructure and hydration products properties, portland cement of various composition, porosity and pore structures. Concrete: properties of fresh and hardened concrete, durability of concrete; asphaltic concrete: bitumen, liquid asphalts, bitumen mixtures; concrete embedding; assurance and concrete quality control. Practice contents: Physical and mechanical cement investigation; aggregate properties for concrete; fresh concrete testing; testing of hardness and hardened concrete deformation; physical and mechanical testing of bitumen mixtures; programmes of quality control. / *Compulsory references:* Ukrainczyk, V.: *Poznavanje gradiva*, Institut građevinarstva Hrvatske, Alcor, Zagreb, 2001.; Ukrainczyk, V.: Beton – struktura, svojstva, tehnologija, Alcor, Zagreb, 1994.; Bjegović, D. i dr.: *Auditorne Practice, Praktikum, Aktivna nastava*, Građevinski fakultet Sveučilišta u Zagrebu, 1994.; Beslać, J. : *Materijali u arhitekturi i građevinarstvu*, Školska knjiga, Zagreb, 1989.; Đureković, A.: *Cement, cementni kompozit i dodaci za beton*, Školska knjiga, Zagreb, 1996. / *Optional references:* Ashby, M. F.; Jones, D. R.: *Engineering Materials 1*, Butterworth Heinemann 1996.; Illston, J. M., Domone, P.

L. J. (ed.): *Construction materials – their nature and behaviour,* E & FN SPON Chapman & Hall, 1994.; Taylor, G.D.; *Materials in Construction*, second edition, Longman Group UK Limited, 1994.

21717 Applied Geology (2+0) 3,0

Introducing in geology. Mineralogy: Investigation methods, physical and chemical properties of minerals, crystallography, systematic mineralogy. Petrology: igneous, sedimentary and metamorphic rocks, structures and textures of rocks. Physical geology: exogenic and endogenic processes in Earth, Seismic activity, beds, tectonics: faults, folds, nappes, fissures, seismic activity. Hydrogeology: water on Earth, types of ground waters, porosity and permeability of rocks. Engineering geology: EG classification of rocks, slides, quarries, tunnels. Properties of karst and non karst areas. / *Compulsory references:* Herak, M. : Geologija, 1990.; Šestanović, S.: Osnove geologije i petrologije, 2001. / *Optional references:* T.West: Geology Applied to Engineering, 1994.; Monroe, J. & Wicander, R.: Physical geology, 2004.; Plummer, C., McGeary, D. & Carlson, D. : Physical Geology, 2004.

21722 Environmental Protection (2+0) 3,0

Introduction.Basic ecological concepts. Ecology.Biotop. Ecosystem. Biodiversity. Changes in biosphere. Changes in atmosphere. Pollution of pedosphere. Pollution of hydrosphere. Pollution through energy discharge. Reduction of biodiversity. Impact of construction industry on environment. City impact. Impact of disposals of waste. Transportation facilities impact. Impact of water structures and works. Transportation facilities impact of water structures and works. Sustainable development and construction industry. Sustainable development. Principles of sustainable development in construction industry. Measures and environmental protection procedures. Political and sociologic approach. Legal measures. Planning and environment management. Economic and financial measures. Scientific approach and technological measures. Institutional measures. / *Compulsory references:* Vuković, Ž.: Interna skripta / *Optional references:* Odum, P.E.: Fundamentals of Ecology, W.B.S.C., 1971.; Gondie, A.: The Human Impact of the Naturel Enviromental, 1990.; Carpenter, T.G.: Environment, Construction and Sustainable Development, Volume 1 and 2, John Wiley & Sons, 2001.

21723 Water Supply and Sewerage 1 (2+1) 4,0

Water Supply: Introduction. Water supply system. Water consumption. Springs. Water – intakes. Pumping stations. Water conditioning. Water tanks. Water supply networks. House water supply networks. Sewerage: Introduction. Sewerage systems. Design water quantity. Sewerage networks. Sewerage facilities. Waste water treatment. Outlets. House sewerage. / *Compulsory references:* Skripte s Lectures; J. Margeta: Kanalizacija naselja, Sveučilište u Splitu, Split 1998. / *Optional references:* Steel, E. W., Mc Ghee T.J.: Water Supply and Sewerage, Mc Graw Hill Book Company, London 1991.

21724 Water Protection (2+1) 4,0

Basic ecological principles. Water properties: physical, chemical microbiological. Water status and pollution degree indicators. Chronic and acute pollution – total maximum daily load, effluent standard approach and combined approach. Integral management of water quality in catchment area. Control of point and non-point pollution sources, water treatment technologies, water quality models (basic Streeter-Phelpsa model and QUALL mathematical model, water discharge into water bodies (model CORMIX). Road runoff impact mitigation impact. Environment impact assessment; scientific, technological, economic, legal and sociologic issues. Direktive EU instructions on water protection. / *Compulsory references:* Interna skripta na CD-u; Tedeschi S.: Zaštita voda, udžbenik Sveučilišta u Zagrebu, 1997. / *Optional references:* Metcalf &Eddy; Wastewater Engineering, Treatment Disposal, Reuse, McGraw-Hill International Editions, 2002.

21734 Building Technology (2+0) 3,0

Construction work in building. Technique and technology of construction. Construction mechanization. Technology of earth works in building. Earth works machines. Vehicles. Boring equipment at rock blasting. Machine impact on earth works. Mobile crushing plants. Productivity of machines on earth works. Planning of earth works technology in building. Concrete mixers. Technology of transported concretes in building. Concrete plants. Steel bending plants. Concrete transportation vehicles. Tower cranes. Tower cranes impact. Working plinths and construction cranes. Equipment of building in of concrete. Technique and technology of production, transportation and embedding of plaster. Scaffoldings and formworks in construction. Formwork systems. Scaffolding systems. Selection of scaffoldings and formworks. Concrete mixers. Concrete plants. Concrete transportation vehicles. Equipment of building in of concrete. Scaffoldings and

formworks in construction. Formwork systems. Scaffolding systems. Selection of scaffoldings and formworks. Planning of concrete works technology in building. / *Compulsory references:* www.grad.hr → djelatnici → dr.sci. Zdravko Linarić → Dokumenti raspoloživi za download " - «Leksikon osnovne građevinske mehanizacije»; «Učinak građevinskih strojeva»; «Postrojenja za proizvodnju gradiva», I.dio, Drobilane, Tvornice betona (betonare), Asfaltne baze (asfaltna postrojenja)» / *Optional references:* Gorazd Bučar: «Tesarski, armirački i betonski radovi na gradilištu», Građevinski fakultet J. J. Strossmayera u Osijeku, 1997.; Rudolf Lončarić: «Organizacija izvedbe graditeljskih projekata», HDGI, 1995.; Freddy L. Roberts i dr.: «Vruće asfaltne mješavine», HSGI, 2003.; Eduard Slunjski: «Strojevi u građevinarstvu», HDGI, Zagreb, 1998.

21735 Technology of Heavy Construction (2+0) 3,0

Construction work in civil engineering. Technique and technology of heavy construction. Heavy construction equipment. Technology of earth works. Earth works machines. Vehicles. Boring equipment at rock blasting. Mobile crushing plants. Productivity. Planning of earth works technology. Asphalt works technology. Asphalt plants. Asphalt works and asphalt balast renewal machines. Technology of transported concretes in construction. Concrete mixers. Concrete plants. Concrete transportation vehicles. Equipment of building in of concrete. Pavers for concrete pavements. Scaffoldings and formworks in construction. Formwork systems. Scaffolding systems. Selection of scaffoldings and formworks. Working plinths and construction cranes. Planning of concrete works technology in construction. / *Compulsory references:* www.grad.hr → djelatnici → dr.sci. Zdravko Linarić → Dokumenti raspoloživi za download «Leksikon osnovne građevinske mehanizacije»; «Učinak građevinskih strojeva»; «Postrojenja za proizvodnju gradiva, I. dio, Drobilane, Tvornice betona (betonare), Asfaltne baze (asfaltna postrojenja)» / *Optional references*: Gorazd Bučar: «Tesarski, armirački i betonski radovi na gradilištu», Građevinski fakultet J. J. Strossmayera u Osijeku, 1997., Rudolf Lončarić: «Organizacija izvedbe graditeljskih projekata», HDGI, 1995; Freddy L. Roberts i dr.: «Vruće asfaltne mješavine», HSGI, 2003.; Eduard Slunjski: «Strojevi u građevinarstvu», HDGI, Zagreb, 1998.

21744 Structural Analysis 2 (2+2) 5,0

Lectures: Statically indeterminate structures. Basic assumptions and methods of analysis. Method of forces: Transformation into determinate structures. Equations of the force method. Solution procedures. Flexibility matrix and transformation matrix. Forced displacements and heat influence. Displacement

calculation. Symmetry and antisymmetry. Elastic centre. Fixed arch. Displacement method: Equations of general displacement method. Matrix formulation. Static and kinematic condenon. Displacements. Symmetry and antisymmetry. Slope-deflection method. Relaxation methods: Cross method. Werner and Csonka method. Influence functions and influence lines for indeterminate structures. Spatial structures. Grids Open walls. Introduction to finite element method. Auditory practice**:** Force method. Displacement method. Influence functions.3 colloquia Construction practice: Application of computers in structural analysis. / *Compulsory references:* Simović, V. *Građevna statika I.* Zagreb : Građevinski institut, 1988.; Anđelić, M. *Građevna statika II.* Zagreb : Građevinski fakultet*,* 2005.; Građevna statika. Primjeri, zadaci, bilješke*...,* www.grad.hr/nastava/gs, 1998.-2004. / *Optional references:* L. P. Felton & R. B. Nelson: Matrix Structural Analysis, Wiley, New York, 1997.; J. C. McCormac & J. K. Nelson: Structural Analysis. A Classical and Matrix Approach, Addison-Wesley, Reading, 1997.; W. Wunderlich & W. D. Pilkey: Mechanics of Structures. Variational and Computational Methods, CRC Press, Boca Raton, 2003.

21745 Numerical Modelling of Structures (2+2) 5,0

A concept of discretization. Strong and weak formulation of a problem. Displacement method. Engineering displacement method. Relaxation and gradient procedures. Cross procedure, Procedures of Werner and Csonke. Spatial systems. Grid systems. Walls with openings. Ritz method. Introduction to finite element method. Basic concepts of geometric and material nonlineariry. Concept of computation model. Displacement method. Relaxation procedures. Computational programmes for structural design. / *Compulsory references:* J.S orić: Metoda konačnih elemenata, Golden marketing, Zagreb, 2004.; M. Anđelić: *Građevna statika II,* Građevinski fakultet*,* Zagreb, 2005. / *Optional references*: L. P. Felton & R. B. Nelson: Matrix Structural Analysis, Wiley, New York, 1997.; D. Lazarević, J. Dvornik: PLOŠNI NOSAČI: Bilješke s Lectures; W. Wunderlich & W. D. Pilkey: Mechanics of Structures. Variational and Computational Methods, CRC Press, Boca Raton, 2003.

21729 Timber Structures (2+1) 4,0

General review of timber structures: historical development, systems, methodology. Wood as a material: full wood properties, laminated gluelam wood and wood-based plates; timber classification in structural engineering. Fire fighting safety, protection and durability of timber structures. Design procedures of timber structures: relevant standards and EUROCOD 5 Joints in timber structures: nails,

screws, picks, timber bolts, clamps, glues, patented connectors, connectors with thin sheets,. Bearing capacity of joints according to relevant regulations and EC5. Complex cross sections: compressive elements and prone bending elements. Yielding. Traditional timber carpentry structures. Principles of members design, shaping and detail design of members joints. Traditional and current roofings. Truss girders. Design principles, shaping and detail design in traditional and present performance. Force transfer in detail design. Laminated girders: fundamentals of standard laminated girders dimensioning of parallel and trapezoid shaped girders. Design and characteristic details. Design basics of plane frame systems. Design principles, detail design. Spatial stability of timber structures. / *Compulsory references:* Bjelanović, A.; Rajčić, V. Drvene konstrukcije prema europskim normama. Zagreb: Hrvatska učilišna naklada, 2005.; Eurocode 5: Prijevod EC5 propisa na hrvatski jezik, interno Katedra za drvene konstrukcije, Zagreb, 1998.; Žagar, Z. Drvene konstrukcije I i II. Zagreb: Pretei d.o.o., 2003. / *Optional references* (na stranom jeziku): DIN 1052: Teil 1, Teil 2, Teil 3, Teil 4, 2000.; 2. Informationdienst Holz: Düsseldorf, 1995.

21730 Leightweight Structures (2+1) 4,0

Geodesic domes: geometry, rod and pane bearing systems, coverings, connector details in knots, construction and assembly, modeling. Pneumatic structures: pneumatic balloons, pneumatic cushions, pneumatic beams, arches and discs, modeling. Lightweight membrane structures: types of structures, modes of membrane stabilization, supporting, modeling. Synergetic structures: behaviour principles at overtaking external stresses, surveying and management systems (capacity and stability regulation). Tensional integrity systems: ultimately light spatial structures, integrated systems of tension and compression elements, modeling. Examples of completed structures: types, spatial effects, construction and assembly details, design models and behaviour simulation. / *Compulsory references:* Žagar, Z. Drvene konstrukcije II. Zagreb: Pretei d.o.., 2003. / *Optional references:* Fuller, B.: Sinergetics, McMillan Publ. Co. Inc., New York, 1975.; Mathys, P.I., Jing, T.F.: Floating Saddle Connections for Georgia Dome, USA, SEI Journal, Vol. 4., No. 3, 1994.; Motro, R.: Tensegrity Systems and Geodesic Dome, Space Structure Jnrl, Special Issue on Geodesic Forms, Vol. 5., No. 3&4, 1990.; Internet stranice.

GRADUATE UNIVERSITY STUDY

Pursuant to Article 51, subsection 2, of the Act on Scientific Activity and Higher Education („Official Gazette“, no. 123/03; 105/04 and 174/04), at the proposal of the National Council for Higher Education, the Minister of Science, Education and Sports issued, on June 2, 2005, the accreditation to the Faculty of Civil Engineering, the University of Zagreb, for the implementaion of graduate study programme of civil engineering the following courses:

- geotechnical engineering
- water research
- structures
- construction management
- materials
- transportation engineering
- structures theory and modelling

1. GENERAL

Duration of study

Two-year graduate studies with 120 ECTS credits

Entry requirements

Admitted are all the students who have completed undergraduate civil engineering studies, practice-oriented undergraduate civil engineering studies, as well as those from closely related technical studies fulfilling additional conditions.

Organization of Study

The study is organized and carried out as full time study in semesters.

Acquired competences and jobs that can be taken upon the study completion

Personal competences (along with those needed for an undergraduate student)

A graduate student is capable to:

- adopt an analytical approach in his (her) work based on deep and broad understanding of science,
- accept a leading role in companies and research institutions, and contribute innovations,
- plan, inspect and carry out professional, development and scientific projects,
- make clear his (her) ideas and projects to the colleagues,
- find solutions to technical and human problems in his (her) surroundings,
- apply acquired knowledge and qualities in decision making at responsible working places,
- work at the international level considering language, cultural, social and economical impacts,
- accept responsibility for one's own decisions,

- accept demands of other professions and participate in interdisciplinary activities.

Academic competences (along with those needed for an undergraduate student)

A student with a degree is capable to:

- understand comprehensively general phenomena and civil engineering problems, especially in his (her) specialised field
- find ways to enhance knowledge in his (her) specialised field considering data from other scientific disciplines as well as existing limitations
- apply acquired skills and knowledge in designing, building, inspection and maintenance of intricate structures, undertakings and systems in his (her) specialised field from the standpoint of stability, safety, usage, environment protection and costs
- explain social aspects of construction and building feats as well as their social context
- apply his (her) entire personal knowledge and scientific approach in realization of above mentioned goals
- show a high level of professional knowledge and behaviour in his (her) specialised field
- apply acquired skills and knowledge needed for recognition, formulation, and analysis of the problems, and find one or several acceptable solutions in his (her) specialised field
- continually follow and enhance his (her) knowledge.

Criteria and transfer pre-requisites of ECTS credits

Students are approved ECTS credits according to the regulations of the Faculty curriculum regardless of the ECTS credit value in the core curriculum.

Conditions under which the students who interrupted the study or lost right to study in one of study programmes can resume the study

Students who interrupted the study can resume it provided that it is coordinated with the curriculum they enrolled into.

Students who lost right to study in some other course can enroll into this one by coordinating the ECTS credits collected in the curriculum of the Faculty. If there is a significant difference an entry exam is required.

Degree awarded

Master's degree in civil engineering (MEng C.E.).

Documents issued

Diploma certifying their qualification and degree is issued to students who have succesfully qualified for BSC in civil engineering. A diploma supplement attached to it describes, in Croatian and English, completed courses, grades achieved and ECTS credits earned.

2. COURSE TIMETABLE BY SEMESTER

GEOTECHNICAL ENGINEERING PROGRAMME

I. year 1. semester

	Course		Hours per week		Exam	ECTS
			Lectures	Practice		
1	Elective subjects	Mathematics 3	3	2	1	7,5
		Stohastic Processes				
2	Researche Methods*		1	0	0	1,5
3	Geotechnical Laboratory		2	3	1	7,5
4	Flow Processes in Soil and Rock		2	2	1	6,0
5	Soil Mechanics		3	2	1	7,5
	Total		**11**	**9**	**4**	**30**

I. year 2. semester

	Course		Hours per week		Exam	ECTS
			Lectures	Practice		
1	Structures		2	2	1	6,0
2	Rock Mechanics		2	2	1	6,0
3	Foundation Engineering		3	2	1	7,5
4	Nummerical Moldelling in Geotechnics		2	3	1	7,5
5	Elective subjects	Applied Geology	2	0	1	3,0
		Environmental Protection				
	Total		**11**	**9**	**5**	**30**
	Total ECTS credits I. year		**60**			

* seminar assignment

II. year 3. semester

Course			Hours per week		Exam	ECTS
			Lectures	Practice		
1	Field Investigation and Monitoring		2	2	1	6,0
2	Earthfill and Retaining Structures		2	2	1	6,0
3	Hydrogeology and Engineering Geology		2	0	1	3,0
4	Dynamics of Structures		2	1	1	4,5
5	Elective subject					
6	Elective subject					
Total						**30**
Elective subjects: 3. semester						
1	Elective subjects for 5. and 6.	Underground Structures	2	2	1	6,0
2		Geotechnics and Environmental Protection	2	1	1	4,5
3		Foreign Language	0	3	1	4,5
4		Basics of Differental Geometry	2	2	1	6,0
5		Other Electives **				

** Courses of other programmes or electives of other studies.

II. year 4. semester

Course			Hours per week		Exam	ECTS
			Lectures	Practice		
1	Geotechnical Design		2	2	1	6,0
2	Elective subject					
3	Final Assignment		0	12	1	18,0
Total						**30**
Total ECTS credits II. year			**60**			
Total ECTS credits I. + II. year			**120**			
Elective subjects: 4. semester						
1	Elective subjects for 2.	Improvement of Soil and Rock	2	2	1	6,0
2		Numerical Mathematics				
3		Perspective				
4		Waves and Vibrations				
5		Dynamics of Soil				
6		Theory of Elasticity and Plasticity	3	2	1	7,5
7		Earthquake Engineering	2	0	1	3,0

HYDRAULIC ENGINEERING PROGRAMME

I. year 1. semester

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

I. year 2. semester

Course			Hours per week		Exam	ECTS
			Lectures	Practice		
1	Elective subjects	Water Supply and Sewerage 1	2	1	1	4,0
		Water Protection				
2	Ports and Waterways		3	3	1	9,0
3	Drainage and Irrigation 1		3	2	1	8,0
4	Sturctures		2	2	1	6,0
5	Elective subjects	Applied Geology	2	0	1	3,0
		Environmental Protection				
Total			**12**	**8**	**5**	**30**
Total ECTS credits I. year			**60**			

* Seminar assignment.

II. year 3. semester

	Course		Hours per week		Exam	ECTS
			Lectures	Practice		
1	Water Resources Engineering		3	1	1	6,0
2	Water Supply and Drainage 2		2	2	1	6,0
3	Elective subject					
4	Elective subject					
5	Elective subject					
	Total					**30**
Elective subjects: 3 semester						
1	Elective subjects for 3., 4. and 5.	Urban Hydrology	2	2	1	6,0
2		Potable and Wastewater Treatment	2	2	1	6,0
3		Modeling in Hydraulic Engineering	2	2	1	6,0
4		Drainage and Irrigation 2	2	2	1	6,0
5		Flood Protection	2	2	1	6,0
6		Basics of Differential Geometry	2	2	1	6,0
7		Other Electives**				
8		Dynamics of Structures	2	1	1	4,5

** Courses of other programmes or electives of other studies.

II. year 4. semester

Course			Hours per week		Exam	ECTS
			Lectures	Practice		
1	Water Power Development		2	2	1	6,0
2	Elective subject					
3	Final Assignment		0	12	1	18,0
Total						**30**
Total ECTS credits II. year			**60**			
Total ECTS credits I. + II. year			**120**			
Elective subjects: 4. semester						
1	Elective subjects for 2.	Design in Hydraulic Engineering	0	4	0	6.0
2		Vegetative Water Facilities	2	2	1	6.0
3		Road Runoff Treatment and Disposal	2	2	1	6.0
4		Experimental Hydraulics	2	2	1	6.0
5		Special Water Power Projects	2	2	1	6.0
6		Maritime Structures	2	2	1	6.0
7		Foreign Language	0	3	1	4,5
8		Numerical Mathematics	2	2	1	6,0
9		Perspective	2	2	1	6,0
10		Waves and Vibrations	2	2	1	6,0
11		Earthquake Engineering	2	0	1	3,0

STRUCTURAL ENGINEERING PROGRAMME

II. year 1. semester

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

II. year 2. semester

	Course	Hours per week		Exam	ECTS
		Lectures	Practice		
1	Concrete and Masonry Structures II	2	2	1	6,0
2	Metal Structures III	2	2	1	6,0
3	Timber Structures II	2	2	1	6,0
4	Durability of Structures I	2	2	1	6,0
5	Precast Reinforced Concrete Structures	2	2	1	6,0
	Total	**10**	**10**	**5**	**30**
	Total ECTS credits I. year	**60**			

* Seminar assignment.

II. year 3. semester

Course			Hours per week		Exam	ECTS
			Lectures	Practice		
1	Concrete Structures III		2	2	1	6,0
2	Bridges III		2	2	1	6,0
3	Structural Testings		2	1	1	4,5
4	Dynamics of Structures		2	1	1	4,5
5	Elective subject					
6	Elective subject					
Total						**30**
Elective subjects: 3. semester						
1	Elective subjects for 5. and 6.	Stability of Structures	2	1	1	4,5
2		Durability of Structures II	2	1	1	4,5
3		High - rise Buildings	2	1	1	4,5
4		Basics of Differential Geometry	2	2	1	6,0
5		Foreign Language	0	3	1	4,5

II. year 4. semester

Course			Hours per week		Exam	ECTS
			Lectures	Practice		
1	Special Engineering Structures		2	1	1	4,5
2	Composite Structures		2	1	1	4,5
3	Elective subject					
4	Final Assignment		0	12	1	18,0
Total						**30**
Total ECTS credits II. year			**60**			
Total ECTS credits I. + II. year			**120**			
Elective subjects: 4. semester						
1	Elective subjects for 3.	Earthquake Engineering	2	0	1	3,0
2		Numerical Mathematics	2	2	1	6,0
3		Perspective	2	2	1	6,0
4		Waves and Vibrations	2	2	1	6,0
5		Other Electives**	2	0	1	3,0

** Courses of other programmes or electives of other studies.

CONSTRUCTION MATERIALS PROGRAMME

I. year 1. semester

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

I. year 2. semester

	Course		Hours per week		Exam	ECTS
			Lectures	Practice		
1	Elective subjects	Applied Geology	2	0	1	3,0
		Environmental Protection				
2	Theory of Elasticity and Plasticity		3	2	1	7,5
3	Durability of Structural Materials		2	2	1	6,0
4	Special Concrete and Technologies		3	2	1	7,5
5	Concrete Structures II		2	2	1	6,0
	Total		**12**	**8**	**5**	**30**
	Total ECTS credits I. year		**60**			

* Seminar assignment.

II. year 3. semester

Course			Hours per week		Exam	ECTS
			Lectures	Practice		
1	Precast Systems		2	2	1	6,0
2	Non-destructive Testings		2	2	1	6,0
3	Fire Protection		2	2	1	6,0
4	Elective subject					
5	Elective subject					
Total						**30**
Elective subjects: 3. semester						
1	Elective subjects for 4. and 5.	Technology of Repair and Strengthening	2	2	1	6,0
2		Quality Management	2	2	1	6,0
3		Work and Production Organization	2	0	1	3,0
4		Production Technology of Materials	2	0	1	3,0
5		Basics of Differential Geometry	2	2	1	6,0
6		Metal Structures II	2	2	1	6,0
FOR OTHER PROGRAMME						
1	Elective subjects	Transportation Facility Concrete	2	1	1	6,0
2		Hydraulic Concrete	2	2	1	6,0

II. year 4. semester

Course			Hours per week		Exam	ECTS
			Lectures	Practice		
1	Numerical Modeling in Engineering Materials		2	2	1	6,0
2	Elective subject					
3	Final Assignment		0	12	1	18,0
Total						**30**
Total ECTS credits II. year			**60**			
Total ECTS credits I. + II. year			**120**			
Elective subjects: 4. semester						
1	Elective subjects for 2.	Design of Experiments	2	2	1	6,0
2		High Performance Concrete	2	2	1	6,0
3		Applied Metalurgy	2	2	1	6,0
4		Numerical Mathematics	2	2	1	6,0
5		Perspective	2	2	1	6,0
6		Numerical Mathematics	2	2	1	6,0
7		Foreign Language	0	3	1	4,5

CONSTRUCTION MANAGEMENT PROGRAMME

I. year 1. semester

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

I. year 2. semester

Course			Hours per week		Exam	ECTS
			Lectures	Practice		
1	Technology of Civil Engineering 1		3	2	1	7,5
2	Management for Construction Industry		2	1	1	4,5
3	Construction Project Management		4	2	1	9,0
4	Elective subjects	Environmental Protection	2	0	1	3,0
		Foreign Language	0	3	1	4,5
5	Elective subjects	Construction Equipment	2	2	1	6,0
		Facility Management	2	2	1	6,0
		Supervision and Monitoring of Construction Process	2	0	1	3,0
		Numerical Mathematics	2	2	1	6,0
		Perspective	2	2	1	6,0
		Waves and Vibrations	2	2	1	6,0
		Other Electives**				
Total						**30**
Total ECTS credits I. year			**60**			

* Seminar assignment.

** Courses of other programmes or electives of other studies.

II. year 3. semester

	Course		Hours per week		Exam	ECTS
			Lectures	Practice		
1	Construction Business Systems		2	2	1	6,0
2	Planning and Scheduling Methods		2	2	1	6,0
3	Construction Site Practice *		0	4	0	6,0
4	Elective subject					
5	Elective subject					
Total						**30**
Elective subjects: 3. semester						
1	Elective subjects for 4. and 5.	Human Resource Management	2	2	1	6,0
2		Technology of Civil Engineering 2				
3		Investment Appraisals in Construction				
4		Basics of Differential Geometry				
5		Other Electives**				

* Seminar assignment.

** Courses of other programmes or electives of other studies.

II. year 4. semester

Course			Hours per week		Exam	ECTS
			Lectures	Practice		
1	Business Strategies in Construction		3	0	1	4,5
2	Organizational Behaviour		2	1	1	4,5
3	Elective subject					
4	Final assignement		0	12	1	18,0
		Total				**30**
		Total ECTS credits II. year	**60**			
		Total ECTS credits I. + II. year	**120**			
Elective subjects: 4. semester						
1	Elective subjects for 3.	Construction Equipment	2	2	1	6,0
2		Facility Management	2	2	1	6,0
3		Supervision and Monitoring of Construction	2	0	1	3,0
4		Numerical Mathematics	2	2	1	6,0
5		Perspective	2	2	1	6,0
6		Waves and Vibrations	2	2	1	6,0
7		Other Electives**				

** Courses of other programmes or electives of other studies.

TRANSPORTATION ENGINEERING PROGRAMME

I. year 1. semester

Course			Hours per week		Exam	ECTS
			Lectures	Practice		
1	Elective subjects	Mathematics 3 Stohastic Processes	3	2	1	7,5
2	Traffic Noise		2	1	1	4,5
3	Transportation Engineering		2	2	1	6,0
4	Highway Design		2	2	1	6,0
5	Railway Design and Construction		2	2	1	6,0
Total			**11**	**9**	**5**	**30**

I. year 2. semester

Course			Hours per week		Exam	ECTS
			Lectures	Practice		
1	Management in Civil Engineering		2	0	1	3,0
2	Elective predmet	Applied Geology Environmental Protection	2	0	1	3,0
3	Pavements Structures		2	2	1	6,0
4	Permanent Way		3	1	1	6,0
5	Earthworks		2	2	1	6,0
6	Road Intersections		2	2	1	6,0
Total			**13**	**7**	**6**	**30**
Total ECTS credits I. year			**60**			

II. year 3. semester

Course			Hours per week		Exam	ECTS
			Lectures	Practice		
1	Research Methods *		1	0	1	1,5
2	Traffic Tunnels		2	2	1	6,0
3	Airports		2	1	1	4,5
4	Transportation Facility Equipment		3	0	1	4,5
5	Traffic Systems		3	0	1	4,5
6	Elective subject					
7	Elective subject					
Total						**30**
Elective subjects: 3. semester						
1	Elective subjects for 6. and 7.	Drainage of Transportation Facilities	2	1	1	4,5
2		Traffic Buildings	2	1	1	4,5
3		Soil - improvement Methods	2	1	1	4,5
4		Foreign Language	0	3	1	4,5
5		Basics of Differential Geometry	2	2	1	6,0
6		Other Electives**				

* Seminar assignment.

** Courses of other programmes or electives of other studies.

II. year 4. semester

Course			Hours per week		Exam	ECTS
			Lectures	Practice		
1	Pavement Management		2	0	1	3,0
2	Elective subject					
3	Elective subject					
4	Final Assignment		0	12	1	18,0
		Total				**30**
		Total ECTS credits II. year	**60**			
		Total ECTS credits I. + II. year	**120**			
Elective subjects: 4. semester						
1	Elective subjects for 2. and 3.	Urban Transportation Facilities	2	1	1	4,5
2		Parking Lots	2	1	1	4,5
3		Track Maintenance	3	0	1	4,5
4		Numerical Mathematics	2	2	1	6,0
5		Perspective	2	2	1	6,0
6		Waves and Vibrations	2	2	1	6,0
7		Other Electives**				

** Courses of other programmes or electives of other studies.

THEORY AND MODELLING OF STRUCTURES PROGRAMME

I. year 1. semester

	Course		Hours per week		Exam	ECTS
			Lectures	Practice		
1	Elective subjects	Mathematics 3	3	2	1	7,5
		Stohastic Processes				
2	Research Methods*		1	0	0	1,5
3	Elective subjects	Prestressed Concrete	2	2	1	6,0
		Bridges 2				
4	Mechanics of Materials		2	1	1	4,5
5	Nonlinear Analysis of Rod Structures		2	1	1	4,5
6	Metal Structures II		2	2	1	6,0
	Total		**12**	**8**	**5**	**30**

I. year 2. semester

	Course	Hours per week		Exam	ECTS
		Lectures	Practice		
1	Theory of Elasticity and Plasticity	3	2	1	7,5
2	Dynamics of Structures and Earthquake Engineering	3	2	1	7,5
3	Experimental Methods I	2	2	1	6,0
4	Theory of Composites	2	1	1	4,5
5	Concrete and Masonry Structures II	2	1	1	4,5
	Total	**12**	**8**	**5**	**30**
	Total ECTS credits I. year	**60**			

* Seminar assignment.

II. year 3. semester

	Course		Hours per week		Exam	ECTS
			Lectures	Practice		
1	Shell Structures		2	2	1	6,0
2	Stability Theory		2	1	1	6,0
3	Structural Testings		2	2	1	6,0
4	Elective subject					
5	Elective subject					
	Total					**30**
Elective subjects: 3. semester						
1	Elective subjects for 4. and 5.	Numerical Methods in Structural Analysis	2	1	1	4,5
2		Selected Topics on Strength of Materials	2	1	1	4,5
3		Finite Element Method	2	1	1	4,5
4		Programming of Structure Analysis Procedures	2	1	1	4,5
5		Polymers	2	1	1	4,5
6		Foreign Language	0	3	1	4,5
7		Basics of Differential Geometry	2	2	1	6,0
8		Other Electives**				

** Courses of other programmes or electives of other studies.

II. year 4. semester

Course			Hours per week		Exam	ECTS
			Lectures	Practice		
1	Elective subject					
2	Elective subject					
3	Elective subject					
4	Final Assignment		0	12	1	18,0
Total						**30**
Total ECTS credits II. year			**60**			
Total ECTS credits I. + II. year			**120**			
Elective subjects: 4. semester						
1	Elective subjects for 1., 2. and 3.	Methods of Theory of Elasticity and Plasticity	2	1	1	4,5
2		Stochastic Analysis of Structures	2	1	1	4,5
3		Selected Topics on Theory of Stability	2	1	1	4,5
4		Basics of Fracture Mechanics	2	1	1	4,5
5		Foreign Language	0	3	1	4,5
6		Numerical Mathematics	2	2	1	6,0
7		Perspective	2	2	1	6,0
8		Waves and Vibrations	2	2	1	6,0
9		Other Electives**				

** Courses of other programmes or electives of other studies.

3. ORGANISATION OF STUDY

Organisation of instruction and student timetable

Full-time students' timetable is 40 hours a week. It includes instruction, field work, exercises and other types of instruction and necessary time for student preparation.

Instruction is organised by semester in accordance to the regulations of curriculums.

Academic year consists of 44 working weeks, of which 30 are dedicated to instruction, while 14 are reserved for consultations, exam preparation and exams.

Students' maximum weekly course load is 20 hours.

Full-time students enrol 25 to 35 ECTS credits.

Excellent students can enrol more than 35 ECTS credits to qualify for early graduation or extended education.

Curriculum

The study is conducted according to the curriculum.

The curriculum sets the following:

1. lecturers and associates conducting instruction according to the study programme,
2. locations of instruction
3. instruction timetable
4. types of instruction (lectures, seminars, exercises, consultations, field work, testing etc.)
5. administration of exams, examination periods and performance evaluation
6. list of reference books for study and exam taking
7. instruction in foreign languages
8. distance learning
9. other requirements for regular instruction.

Reference books for particular courses and exams must be in line with the scope of study programmes.

Curriculum is announced before the start of instruction in the relevant academic year and is accesible on the Faculty of Civil Engineering, University of Zagreb internet pages.

List of courses and/or modules offered by other faculties

Instead of optional courses in social studies, students can enrol in social courses offered by other studies of higher education at the University of Zagreb.

List of courses and/or modules conducted in foreign languages

The following courses can be conducted in English language:

- biological hydraulic engineering
- soil dynamics
- eperimental hydraulics
- geotechnical laboratory
- geotechnical design
- permanent way
- hydraulics
- hydrogeology and engineering geology
- pavement structures
- soil mechanics
- rock mechanics
- planning and schedulling methods
- model testing in hydro-engineering
- earthfill and retaining structures
- numerical modelling in geotechnics
- strengthening of soil and rocks
- construction management 2
- underground structures
- flow processes in stoil and rock

- traffic noise
- organisation behaviour
- foundation engineering
- theory and technology of concrete
- field testing and observation
- duration of structural elements
- construction project management
- quality management
- fire protection

The following courses can be conducted in German language:

- road intersections
- urban transport facilities
- parking lots
- traffic tunnels

Enrolment to the second year of study

Students must be qualified to complete the programmes to which they are admitted and meet the requirements to qualify for enrolment to a higher study near.

The requirements for exam taking and lecture attendance at graduate study are determined by the Faculty Council.

Graduate students are entitled to enrolment into a higher year of study upon passing all ECTS credits from the winter semester, minimum 20 ECTS credits from the summer semester and have met all other requirements.

Students who have not met the above mentioned requirements can continue their education by taking on study requirements they have not met in the previous year and take on new requirements without exceeding their semester course load of 25 to 35 ECTS credits. They can enrol for courses which are not within the programme of the courses they have not passed.

Lectures and exercises

Students are required to attend all types of instruction stipulated by study programme and curriculum which, together with meeting other requirements and having their performance evaluated in testing, is a condition for lecturers' signatures.

Student performance evaluation

Students knowledge can be tested and evaluated during instruction (pre-exams, practical tasks etc.) and final grade is assigned in the exam.

Exam in the same course can be taken maximum four times. The fourth time the exam is taken before an examining board. Students who have not passed the exam in the same course for the fourth time are obliged to enrol in the same course in the following year. If they do not pass the exam after repeated enrolment, they are denied the right to study.

Study programme can stipulate that some forms of instruction are implemented without grading, or that grading is descriptive, or that the final grade can be assigned by testing and evaluation during instruction, or that the grades for particular types of instruction are calculated into the final grade achieved in the exam or other forms of testing.

Lecturers implementing instruction have the right to test and evaluate students' knowledge during every form of instruction.

Examination administration and examination periods

Examinations are administered in three periods: winter, summer and autumn. The minimum lenght of examination period is 4 weeks. Every course examination is administered twice in each examination period with a 2 week interval.

The Faculty Council has decreed that every course examination of the study programme, regardless if it is winter or summer course, can be taken by students in three consecutive examination periods.

The Faculty Council can schedule additional examination periods on valid grounds.

If students are continuously evaluated during a course, the Faculty Council determines the examination timetable with the number of examination periods.

The examinations are administered to the students who have meet all the requirements stipulated by the curriculum. Students who have registered for the particular course and

whose attendance has been proved by the lecturers' signatures in students' documents are entitled to exam taking.

Graduation

Students are due to submit a request for writing a degree thesis at the latest before the beginning of the fourth semester of graduate study programme.

Scholarship holders or loan users can choose a thesis in line with the needs of the company, i.e.legal entity that has granted the scholarship or loan.

Lecturers can advise students to write theses from the scope of research projects conducted at the Faculty of Civil Engineering, University of Zagreb.

Only theses within the scope of courses that students have taken will be approved.

Students can submit requests for writing degree theses after they have met all other study requirements.

The volume or task of degree theses should not prevent students from writing them in the period of 45 to 90 days.

The Committee for degree and final examinations can approve of a degree thesis, invention, technical improvement and the like if they meet the requirements of a degree thesis.

The Committe for degree and final examinations is in charge of the proceedings in execution and presentation of degree theses.

If a candidate does not successfully defend their degree thesis, the Committe advises them about the proceedings of submitting a new thesis.

The Faculty of Civil Engineering keeps records of degree examination in accordance to the rules stipulated by the minister.

4. CURRICULUMS

4.1. SHARED COURSES

4.1.1. OBLIGATORY SUBJECT

21822 Research Methods (1+0) 1,5

Collecting, study and systematisation of literature and information. Role of Hypothesis and objective testing of hypothesis. Writing papers, critiques and essays. Data collection and data analysis. Choosing the research methodology. Research methods. Modelling, statistical methods, mathematical methods, experimental design, system theory, case study, questionnaire design, interview and Delphy technique. Reporting the results. Citing references. Bibliography. / *Compulsory references:* Zelenika, R. Metodologija i tehnologija izrade znanstvenog i stručnog djela. Rijeka: Ekonomski fakultet Sveučiliša u Rijeci, 1999. / *Optional references:* Fellows, R., Liu, A. Research Methods for Construction. Oxford: The Blackwell Science, 1997. Holt, D.G. A guide to successuful dissertation study for students of the built environment. Wolverhampton: University of Wolverhampton, 1997; Robert, K.Y. Case study reserach, design and methods: SAGE Publications, 1994.

4.1.2. ELECTIVE SUBJECTS

21802 Mathematics 3 (3+2) 7,5

Function series: Fourier series. Convergence. Odd and even functions. Boundary problems: Partial differential equations. Wave equation. Boundary problem for transverse wire vibrations. Wire vibration. Boundary problem for longitudinal beam vibrations. Equations of heat conduction. Boundary problem of conducting heat trough a beam. Fourier method (method of separation of variables). Variation methods. Multidimensional problem.Wave equation. Boundary problem for oscillations of a membrane. Laplace equation. Poisson equation. Boundary problem of equilibrium of membrane. Equation of heat conduction through a body. Boundary problem for heat conduction through a body. Numeriacal methods for solfing boundary value problems: Solving of ordinary differential equations: Cauchy problem (Euler method, Runge Kutta). Boundary problem for equilibrium of a wire in a lossy matter (Method of finite differences,

Ritz method, Finite element method). Solving of partial differential equations. Boundary problem of wire oscillations (Mesh method for wave equation). Boundary problem of heat conduction through a beam (Mesh method for conduction equation). Boundary problem for membrane equilibrium (Method of finite differences, Ritz method, Finite element method). / *Compulsory references: S*uljagić, S., Mathematics III, web skripta (www.grad.hr/nastava/Mathematics /mat3/index.html), Građevinski fakultet, Zagreb, 2001.; Polić, S., Numeričke Researche, skripta, Građevinski fakultet, Zagreb, 1992.: Beban, Benić, Čuljak, Gorjanc, Odabrana poglavlja geometrije i matematike za buduće inženjere pomoću programskog sustava *Mathematica*, web materiali (www.grad.hr/itproject_math.hr/hrvatski/index.html), IT project, MZT, Zagreb, 2002.; Drmač, Marušić, Singer, Hari, Rogina, Singer, Numerička analiza, web skripta, (www.math.hr/~rogina/2001096/num_anal.pdf), PMF-Matematički odjel, Zagreb, 2003. / *Optional references>:* Kreyszig, E., Advanced Engineering Mathematics, John Wiley and Sons Ltd.,1999.; Scheid, F., Numerical Analysis, Schaum's outline series in mathematics, McGraw-Hill Book.; Cheney, Kincaid, Numerical Mathematics and Computing, Books/Cole Publishing Comp. 1994.; Demidovič, P. B., Maron, I. A., Computational Mathematics, Mir Publishers, Moscow, 1976.; Kurepa, S., Funkcionalna analiza, Školska knjiga, Zagreb, 1988.

21803 Stochastic Processes (3+2) 7,5

Stochastic processes: Random sequence and random function. Definition of the stohastic process. Function of distribution of n^{th} dimensional distribution function of stochastic process. Expactations, dispersion, correlation (autocorrelatic) function of the stochastic process. Stochastic process with independent stationary increments. Markov processes. Homogeneous Markov processes with discrete set of states. Finite Markov chains: Matrix of transition probabilities. Stationarity of finite Markov chain. Properties of stochastic matrices. Regural chains. Elements of the theory of queues: Markov models of the wainting and servicing processes. / *Compulsory references:* Ž. Pauše, Vjerojatnost. Informacija. Stohastički procesi, Školska knjiga, Zagreb, 1988, 2003. / *Optional references:* W. Bryc, Applied Probability and Stochastic Processes, 1995., www. math. uc.edu /~brycw/probab/books/applprob.pdf

21752 Applied geology (2+0) 3,0

Introducing in geology. Mineralogy: Investigation methods, physical and chemical properties of minerals, crystallography, systematic mineralogy. Petrology: igneous, sedimentary and metamorphic rocks, structures and textures

of rocks. Physical geology: exogenic and endogenic processes in Earth, Seismic activity, beds, tectonics: faults, folds, nappes, fissures, seismic activity. Hydrogeology: water on Earth, types of ground waters, porosity and permeability of rocks. Engineering geology: EG classification of rocks, slides, quarries, tunnels. Properties of karst and non karst areas. / *Compulsory references:* Herak, M.: Geologija, 1990.; Šestanović, S.: Osnove geologije i petrologije, 2001. / *Optional references:* T. West: Geology Applied to Engineering, 1994.; Monroe, J. & Wicander, R.: Physical geology, 2004.; Plummer,C., McGeary,D. & Carlson, D.: Physical Geology, 2004.

21722 Environmental Protection (2+0) 3,0

Introduction.Basic ecological concepts. Ecology.Biotop. Ecosystem. Biodiversity. Changes in biosphere. Changes in atmosphere. Pollution of pedosphere. Pollution of hydrosphere. Pollution through energy discharge. Reduction of biodiversity. Impact of construction industry on environment. City impact. Impact of disposals of waste. Transportation facilities impact. Impact of water structures and works. Transportation facilities impact of water structures and works. Sustainable development and construction industry. Sustainable development. Principles of sustainable development in construction industry. Measures and environmental protection procedures. Political and sociologic approach. Legal measures. Planning and environment management. Economic and financial measures. Scientific approach and technological measures. Institutional measures. / *Compulsory references:* Vuković, Ž.: Interna skripta / *Optional references:* Odum, P.E.: Fundamentals of Ecology, W.B.S.C., 1971.; Gondie, A.: The Human Impact of the Naturel Enviromental, 1990.; Carpenter, T.G.: Environment, Construction and Sustainable Development, Volume 1 and 2, John Wiley & Sons, 2001.

21675 English in Civil Engineering (0+3) 4,5

Career Paths for Engineers. Employment Opportunities in Government. Motivation, Performance and Job Satisfaction. Initial Career Profiles. Civil Engineering Graduates. The Engineer as a Professional Characteristics and Responsibilities of Professional Engineers. Professional Civil Engineering. Organizations. Engineering Ethics .Case Studies in Engineering Ethics. Learning and Creative Thought. The Successful Engineering Student. Hindrances to Problem Solving. Stepping from Ideation to Preliminary Designs. How Engineers Find Information and the Information Seeking Process. Engineering Approach to Problem Solving. Engineering Team. Learning from Failures. Decision Making. /

Compulsory references: Paul H. Wright: Introduction to Engineering, J.Wiley & Sons,Inc,2002. / *Optional references:* D.Grant and R.McLarty: Business Basics, ELT, Oxford University Press; J.Stoner, E.Freeman: Management, Prentice-Hall International, 1992.; Longman Dictionary of Contemporary English.

21910 German Language in Civil Engineering (0+3) 4,5

Bauingenieurwesen.Was ist Bauingenieurwesen? Wie wird man ein(e) Bauingenieur(in). Bauingenieure haben ein weites Feld.Hochhäuser. Erfindungen veränderten das Aussehen von Bauten. Die Entwicklung der ersten Wolkenkratzer. Der erste Wolkenkratzer - Die Kathedrale des Handels. Wie sicher sind Hochhäuser? Hochhauskonstruktion. Die Brücken. Ein Brückenmodellbau. Der Ablauf eines Brückenmodellbaus.Die größte Drehbrücke der Welt. Das Beispiel eines Damms Die Geschichte der Tunnelkonstruktion. Tunnelbauverfahren. Der Straßenbau. Türme und Kuppeln. Kuppelbau. Alexandre Gustav Eiffel - ein Mann der Perfektion. Flughäfen. / *Compulsory references:* Alemka Kralj Štih: Deutsch im Bauingenieurwesen, Sveučilišna skripta, Zagreb, 2004. / *Optional references:* F. Leonhardt: Ingenieurbau: Bauingenieure gestalten die Umwelt, Carl Habel Verlag, Darmstadt, 1994. www. bau. de

21804 Basics of Differential Geometry (2+2) 6,0

Curves in Euclidean Space (8+8) The parametric representation of a curve; the equations of a curve. Tangent vector. Singular points. Arc length. Natural parametrization. Vector fields; unit tangent, principal normal, binormal. Frenet's trihedron. Osculating, normal and rectifying plane. Curvature and torsion of a curve. Serret-Frenet's formulas. Planar curves. Evolutes and involutes. Graphics and calculus by using *Mathematica* and *webMathematica*. Surfaces in Euclidean Space (10+10) The definition of a surface and a parametrization. The equations of a surface (parametric, implicit, explicit). The implicit equations of a space curve. Gaussian coordinates on a surface. Curves on a surface. Tangent plane and a normal. Singular points. The orientation of a surface. The surfaces of second degree. Ruled surfaces – developables and scrolls. Surfaces of revolution. The arc length of a curve on a surface. The first fundamental form of a surface. The angle between curves on a surface. Area on a surface. The Deviation of the surface from the tangent plane. The second fundamental form of a surface. The classification of point on a surface (elliptic, hyperbolic, parabolic and planar). Graphics and calculus by using *Mathematica* and *webMathematica*. Curvatures of Surfaces (6+6) Normal curvature. Meusnier's theorem. Principal directions. Principal curvatures. The curves of principal curvatures. Euler's formula.

Asymptotic direction. Asymptotic lines. Gaussian curvature. Mean curvatures. Relations between Gaussian and mean curvatures. Dupin's indicatrix. Weingarten's and Gaussian formulas. Geodesic lines. Geodesic curvature. Graphics and calculus by using *Mathematica* and *webMathematica*. Mappings of Surfaces (4+4) Mappings of surfaces in general. Isometric mappings. The mapping of developable surfaces into a plane. Theorema Egregium. Intrinsic geometry of a surface. The surfaces with constant curvatures. Isogonal (conformal) mappings. Isoareal mappings. Graphics and calculus by using *Mathematica* and *webMathematica*. Minimal Surfaces (4+4) The definition of a minimal surface. Lagrange's equation. Laplace's equation. The examples of minimal surfaces (catenoid, helicoid, Enneper's, Henneberg's, Bour's , Catalan's, Scherk's, Ricmond's). About tension structures. Graphics and calculus by using *Mathematica* and *webMathematica*. / *Compulsory references:* Beban-Brkić, Jelena: Matematika VI – Diferencijalna geometrija, web-skripta, (www.grad.hr/ itproject_math/Links/jelena /index.html); Kamenarović, Ivan: Diferencijalna geometrija. Sveučilište u Rijeci, Pedagoški fakultet - Rijeka, 1990.; Žarinac-Frančula, Blanka: Diferencijalna geometrija. Zbirka zadataka i repetitorij, Školska knjiga, Zagreb, 1990.; Gorjanc, Sonja: Pravčaste plohe. web-skripta, (www.grad.hr/itproject_math/Links/sonja/ pravcaste/pravcaste.html) / *Optional references:* Gray, Alfred: Modern Differential Geometry of Curves and Surfaces with Mathematica. CRC Press, Boca Raton,1998.

21805 Numerical mathematics (2+2) 6,0

Numerical linear algebra: Algorithms for solving systems of linear algebraic equations. (Jacobi method, Jacobi OR method, Gauss-Seidel method, Gauss-Seidel OR method). Algorithms for solving systems with large number of equations. Algorithms for solving eigenvalue problems (eigenvalue value and eigenvalue vectors). Graphical presentations of results from numerical methods (in discreet shape). First colloquium. Numerical analysis: Equation solving (Halving method Metoda polovljenja, iteration method, Newton method, secant method). Interpolation methods with polynoms (Spline-method). Numerical integration. Numerical methods for simple differential equations. (One-step and multistep). Nonlinear multistep methods. Systems of differential equations. Method of final differences. Numerical method of partial differential equations. Second colloquium. / *Compulsory references:* K.J. Bathe, E.L. Wilson: Numerical Methods in Finite Element Analysis, Prentice-Hall Inc., Englewood Cliffs, New Jersey, 1974.; B.P.Demidovič, I.A.Maron: Computational Mathematics, Mir Publishers, Moscow, 1976. / *Optional references:* Kurepa: Funkcionalna analiza, Školska knjiga,

Zagreb, 1988.; N.S.Bakhvalov: Numerical Methods, Mir Publishers, Moscow, 1977.

21806 Perspective (2+2) 6,0

Problems: Central projection, perspective. Projection of points, lines and planes in perspective. Simple and complex stereometric relationships. Perpendicularity. Rotation. Perspective of an object: Constructive methods in perspective. Perspective of a transportation facility on a terrain with free choice of a view point. Application of CAD program. Applied geometry: Point of intersection between straight line and surface. Intersection lines of combined pyramidal and prismatic surfaces. Spatial – arc - polygonal intersection lines of combined angular and rounded surfaces. Fundamentals of the theory of algebraic spatial curves. Construction of intersection lines of conic and cylindrical surfaces. Spherical intersections, general principle of intersection line construction. Introduction to projective theory of curves and surfaces, Pascal theorem. Survey of general surfaces. Fundamentals of differential geometry: tangent planes, normals, parametric lines on surfaces, element of arc, second fundamental differential form, principal curvatures, Gauss curvature. Formation of line surfaces as the intersection of three complexes. Constructive processing of line surfaces. Theoretical fundamentals of dimensional projection, clothoid, spiral. Topographic surfaces. Cross section of topographic surfaces by plane, slopes, location, profile. Situation in earthworks by the method of placing embanked and cuts planes: water flow, neutral lines, profile in final solution. / *Compulsory references:* P. Kurilj, N. Sudeta, M. Šimić: Perspektiva, Arhitektonski fakultet, Zagreb, 2005. / *Optional references:* V. Niče: Perspektiva, Šk. knjiga, Zagreb, 1978.

21807 Vibrations and Waves (2+2) 6,0

Basics of arriving at equations, given a problem situation. Examples: free vibrations of simple systems – wires, plates; waves and wave spreading in one, two and three dimensions; deformations. Physical basis of equations covered in specialized and mathematical subjects; Equation solutions by means of physical properties of problems: coupled oscillations and vibrations, acoustic wave spreading, acoustic insulation. Harmonic oscillator modelling. Computer modelling of some physical models for problems covered in specialized and mathematical courses. Physical properties of forced oscillations.Interference, Physical basis of chosen measurements covered in specialized courses. / *Compulsory references:* F. S. Crawford, Waves: Berkeley physics course v.3,

McGraw-Hill College, (1968). / *Optional references:* A. P. French, Vibrations and Waves, W. W. Norton & Company, New York, (1971).

21819 Transportation Facility Concrete (2+1) 6,0

Concrete elements on transportation facilities and airports. Pavements: concrete pavements; asphalt pavements. Analysis of temperature flow in concrete and risk of cracking estimate. Pavement joints: Surface treatment – roughness. Fibre reinforced concretes: High strength concretes; Polymer modified concretes. Shotcrete concrete: Concretes in tunnels; Grouting. Repair concretes and mortars. Technology of concrete production for transportation facilities. Concreting in extreme weather conditions. Vacuum concrete. Practice description. Technical requirements for concrete of structures on transportation facilities. Standardized procedures of testing and quality control of transportation facility concrete. Testing of fresh and hardened concrete. Concrete design. Seminar papers. / *Compulsory references:* Ukrainczyk V. Beton – struktura, svojstva, tehnologija, Alcor, Zagreb, 1994.; Beslać, J. Materijali u arhitekturi i građevinarstvu, Školska knjiga, Zagreb, 1989.; Opći tehnički uvjeti za radove na cestama, IGH Zagreb, 2001.; Korlaet, Ž. Uvod u projektiranje i građenje cesta, udžbenik, Sveučilište u Zagrebu, 1995. / *Optional references:*ACI Manual of Concrete Practice, ACI Publication, SAD; Derucher, K.N.; Korfiatis, G.P.: Materials for Civil & Highway Engineers, second edition, Prentice Hall, 1988.

21820 Hydraulic Concretes (2+2) 6,0

Introduction: characteristics and application of mass concrete. Hydratation heat: thermal stress and cracking; volume changes. Selection of production components of mass concrete and composition design in compliance with regulations. Transport, placing and curing of concrete: dynamics of concreting; concreting at extreme weather conditions. Strength and deformations: risk of cracking. Roller-compacted concrete: concrete with improved water impermeability; concreting under water. Protection of concrete elements. Practice description. Thermal stress and cracking: cracking risk calculations; concrete temperature control and temperature gradient. Guidelanes on choice of aggregate type, cement and concrete additives: influence of components on developing temperatures of concrete. Concrete placing and manner of curing. Schmidt's numerical method. Standardised procedures of testing relevant properties of mass concrete. Calculations of temperature flow in massive concrete and cracking risk estimate – program execution. / *Compulsory references:* ACI 207.1R-96 *Mass Concrete;* ACI 207.2R-95 (Reapproved 2002) *Effect of Reastraint, Volume*

Change, and Reinforcement on Cracking of Mass Concrete; ACI 207.3R-94 *Pracitises for Evaluation of Concrete in Existing Massive Structures for Service Conditions;* ACI 207.4R-93 (Reapproved 1998) *Cooling and Insulating Systems for Mass Concrete;* ACI 207.5R-99 *Roller-Compacted Mass Concrete / Optional references: The Prevention of Thermal Cracking in Concrete in Early Ages,* RILEM Report, Ed. R. Springenschmid, E & FN Spon, 1998.; Proceedings of the Eighteenth Congress on Large Dams, Durban, 1994., Vol. I-V.

4.2. COURSE SUBJECTS

4.2.1. GEOTECHNICAL ENGINEERING PROGRAMME

4.2.1.1. OBLIGATORY SUBJECTS

21746 Geotechnical Laboratory (2+3) 7,5

Role of laboratory in geotechnical engineering. Laboratory investigation syllabus. Basic terms in measuring: accuracy, precision, resolution, sensitivity, linearity, hysteresis, noise, measuring errors. Determination of natural humidity and density of hard particles. Classification tests: sieving, areometering, flow boundary, plasticity boundary. Determination of permeability coefficient: test with constant fall and test with variable fall. Determination of soil compactness: standard and modified Proctor test. Determination of rigidity and strength of ground and rocks: oedometer tests, direct shear tests, uniaxial and triaxial tests. Determination of point strength of rock monollith, PLT test. Determination of parameters of weathered rock mass, Slake durability test. Determining the contents of calcium carbonate in rock samples. Geophysical methods: mesurement of expansion velocity of longitudinal and shear waves in soil and rock samples. Reporting on laboratoy results. / *Compulsory references:* Head, K.H. (1998): Manual of Soil Laboratory Testing, Volume 1, 2 i 3, John Wiley & Sons, West, Sussex, UK. / *Optional references:* Bardet, J.P. (1997): Experimental Soil Mechanics. Prentice Hall, New Jersey, USA.

21747 Flow Processes in Soil and Rock (2+2) 6,0

Introduction. Seepage in saturated soils: Darcy's law, continuum equations, flow quations, boundary conditions, stationary and nonstationary boundary conditions, flow nets. Permeability coefficient: laboratory and field tests. Solving flow equation: method of finite elements. Buoyancy and flow forces, effective stress and effective volume force, critical gradient. Application: flow nets, stability of slopes, drainage, filters. Consolidation: initial and boundary conditions, nonstationary flow, one-dimensional case, unbonded and bonded formulation, consolidation solution by method of finite elements. Flow in unsaturated soils: water permeability, stationary flow, nonstationary flow, water level, volume

humidity curve, laboratory tests, boundary and initial conditions, application. Basic spread of soil contamination: transport equation, advection and dispersion, diffusion, applications. / *Compulsory references:* GEO-SLOPE International (2001): SEEP/W Version 5 Users Guide. GEO-SLOPE International Ltd., Calgary, Alberta, Canada. / *Optional references:* Cedergren, H. R. (1989): Seepage, Drainage, and Flow Nets. John Wiley & Sons, New York.; Fredlund, D. G., Rahardjo, H. (1993): Soil Mechanics for Unsaturated Soils. John Wiley & Sons, NY.

21748 Soil Mechanics (3+2) 7,5

Modeling of soil mechanics: effective stress and pore pressures, volume variables, deformities, triaxial and other device. Traces of stress and tests on soil. Elasticity. Plasticity and yielding: yielding in sands and clays. Simple elastive-plastic soil model: elastic and plastic deformity, hardening, plastic potential, normality or associative flow, general formulation elasto-plasticity. Hardening elasto-plasticity model: Cam clay, drained and undrained triaxial tests. Critical conditions: clays and sands, critical conditions line, qualitative behaviour of soil. Soil strength: Mohr-Coulomb model, critical conditions line, nudrained strength, parameters of pore pressure, peak soil strength, stability and collapse, analysis of total and effective stresses, critical and residual strength, top limit and bottom limit theorem. Expansion at shearing, Row's equation, laws on flow, strength and expansion. Determination of soil parameters, indexes. Application and limitations of elasto-plasticity model. / *Compulsory references:* Wood, D. M. Soil Behaviour and Critical States Soil Mechanics. Cambridge University Press, Cambridge, 1990., Davis, R. O., Salvadurai, A. P. S. (Plasticity and geomechanics. Cambridge University Press, Cambridge, Velika Britanija, 2002./ *Optional references:* Wood, D. M. Geotechnical Modelling. Spon Press, London, 2004.

21801 Structures (2+2) 6,0

Basic principles in design of supporting structures. The basis of seismic calculation of structures. Engineering structures (silos, warehouses, water towers, water reservoirs, cooling towers, shimneys). Basis for prestressing concrete structures. Prestressing in bridge construction. Prestressing in building construction. Prestressing in soil mechanics. Prestressing in hydraulic engineering. New materials for structures. / *Compulsory references:* Pičulin, S.; Konstrukcije CD s predavanjima. Zagreb. / *Optional references:* Hiroyuki Aoyama. Design of Modern Highrise Reinforced Concrete Structurec. London : Imperial College Press, 2001.

21749 Rock Mechanics (2+2) 6,0

Program of investigation design and execution of geotechnical structures in rock masses. Classification of rock mass: Terzaghy classification. Laufer classification. RQD classification, RSR classification. RMR classification. Q classification. Strength criteria in rock mass: Coulomb criterion. Griffith criterion.Modified Griffith criterion, Original Hoek-Brown. Improved Hoek-Brown. Modified Hoek-Brown. General Hoek-Brown. Connection of Mohr-Coulomb i Hoek-Brown criteria. Strength of discontinuity. Deformability of rock mass. Provision of rock slope stability. Types of cracks. Stability analysis. Numerical modeling in rock mechanics. Rock slope stability estimate. Rheological rock models. Weathered rocks. Consistency. Presentation of geotechnical interventions in rocks. / *Compulsory references:* Hudson, J.A., Harrison, J.P. Engineering Rock Mechanics, An Introduction to the Principles, Pergamon Press, Oxford, UK, 1997. / *Optional references:* Hudson, J.A., Harrison, J.P. Engineering Rock Mechanics, Illustrative Worked Examples, Pergamon Press, Oxford, UK, 2000.

21750 Foundation Engineering (3+2) 7,5

Introduction: types of foundations and construction methods, shallow and deep foundations, pits and bracing, drainage, stabilisation and soil strenghtening. Shallow foundations: pad foundation, grillages and slabs, drainages and humidity insulation, settlement, bearing capacity, interaction structure-foundation-soil, shaping. Deep foundations: piles and pile groups, types of piles, negative friction, slabs with piles; wells. Retaining structures and abutments. Special foundations: foundations in rivers and seas, strenghtening of existing foundations. Selection of foundations and design principles: geotechnical investigative work, selection of foundation type, relation between bearing capacity and settlement developed from small deformations until failure, bearing capacity, interaction structure-foundation-soil, foundation design for uniform settlement, influence on adjacent structures, machinery foundations. Specification of foundation in relation to soil type: foundations in sand, settlement, excavations in sand, influence of vibrations, foundations in clay, shallow and deep foundations in clay, foundations in silty layers, foundations in uniform and mixed soils, foundations on rocks. Damages resulting from foundation building, observation of behaviour of foundation structures. / *Compulsory references:* Nonveiller, E. Mehanika tla i temeljenje građevina, II. izdanje. Školska knjiga, Zagreb, 1981. / *Optional references:* Peck, R. B., Hanson, W. E., Thornburn, T. H. Foundation Engineering. John Wiley & Sons, NY, 1953.; Tomlinson, M. J. Foundation Design & Construction. Longman Scientific & Technical, Harlow, 1995.; Coduto, D. P. Foundation Design –

Principles and Practices. Prentice Hall, Englewood Cliffs, NJ, 1994.; Bowles, J. E. Foundation Analysis and Design. McGraw Hill, NY, 1982.

21751 Numerical Modeling in Geotechnics (2+3) 7,5

Purpose and scope of numerical modeling in geotechnics. Methods of limit equilibrium: Bishop's, Specer's, Morgenstern-Price's, Application. Discreditation of seepage and equilibrium equations by finite element method: finite elements, interpolation functions, numerical integration, boundary and initial conditions. Non-linear analysis: tangential rigidity method, Newton-Raphson method, method of arch length. Boundary and initial conditions: set displacements, stresses, concentrated forces, volume forces, construction, excavation, pore pressures, initial conditions. Input data: network of finite elements, boundary conditions, soil layers, soil model, soil parameters, simulation of standard tests with selected material models, demonstration of initial stress and pore pressure condition, demonstration of construction phases, demonstration of convergence criterion. Output data: deformed network, displacement vectors, stress, pore pressure and deformation contours, stress level and condition variable contours. General guidelines on modeling: size of network area , selection of numerical analysis, selection of soil model, finite element selection, parameter analysis of input data. Modeling special structures: slope, retaining structure, embankments, pits, shallow foundations, piles, 2D i 3D analysis. Limitations and traps of numerical modeling: discreditation errors, network condensing, structural elements modeled in 2D, problems in construction simulation, underground construction, inconsistency of input data, calibration. / *Compulsory references:* GEO-SLOPE International : SLOPE/W Version 5 Users Guide. GEO-SLOPE International Ltd., Calgary, Alberta, Canada, 2001.; GEO-SLOPE International: SIGMA/W Version 5 Users Guide. GEO-SLOPE International Ltd., Calgary, Alberta, Canada, 2001. / *Optional references:* Cost Action 7, Working Group A : Guidelines for the use of advanced numerical analysis. Thomas Telford Ltd, London, Velika Britanija. 2002.; Potts, D. M., Zdravković, L.: Finite Element Analysis in Geotechnical Engineering: Tehory. Thomas Telford, London, Velika Britanija, 1999., Potts, D. M., Zdravković, L.: Finite Element Analysis in Geotechnical Engineering: Application. Thomas Telford, London, velika Britanija, 1999.

21753 Field Investigations and Monitoring (2+2) 6,0

Field investigation syllabus. Trial pits. Exploratory drilling. Determination of underground water level. Vane. Penetration tests: standard penetration test, static penetration test, light penetration probe. Pressuremeter tests: Menard

pressuremeter, self-drilling pressuremeter, dilatometer. Geophysical investigation: refraction, cross-hole, down-hole, spectral analysis of surface waves. Geotechnical structure monitoring syllabus. Measuring and monitoring of defomation of soil and rocks: topographical survey, vertical and horisontal inclination gauge, sliding deformer and micrometer, wedge gauge, measuring cracks. Measurement and monitoring of stress by pressure cells in soil and rocks. Testing the completness and bearing capacity of piles. Analysis of mesurement and monitoring results. Feedback analysis. / *Compulsory references:* Simons, N., Menzies, B., Matthews, M. A short course in geotechnical site investigation. Thomas telford, London, Velika Britanija, 2002.; Dunnicliff, J. Geotecnical Instrumentatio for Monitoring Field Performance, John Wiley & Sons, New York, USA, 1993. / *Optional references:* Nicholson, D., Tse, C.-M., Penny, C. The Observational Method in Ground Engineering. CIRIA . Report 185, London, UK, 1999.

21754 Earthfill and Retaining Structures (2+2) 6,0

Types of earth structures (hydrotechnical embankments and dams, traffic facilities embankments, waste disposals). Selection of earth materials, in situ and laboratory testing, compaction theory, properties of compacted material, compaction methods. Analysis of stability and deformation of earth structures (seepage analyses, limit equilibrium methods, FEM analyses using simple soil models, seismic stability, selection of relevant parameters). Selection of dam types, zoned embankments, variations of design solutions, presentation of major dams. Monitoring of earth structures, instability phenomena, damages and collapse of dams, influence of construction on stability and deformations. Industrial and municipal waste disposal. Application and types of retaining structures. Basis of earth pressure calculations (concepts of earth pressure description, Rankine states, Coulomb method and its precision, earthquake action, surface load near walls). Retaining walls, reinforced earth structures. Embedded retaining walls, Anchoring of retaining structures, basis of geotechnical anchors analysis. Analysis of embedded retaining walls (design and theoretical requirements, methods of analysis). / *Compulsory references:* Nonveiller, E. Mehanika tla i temeljenje građevina, II. izdanje. Školska knjiga, Zagreb, 1981.; Nonveiller, E. Nasute brane - projektiranje i građenje, Školska knjiga, Zagreb, 1983, 359 str. / *Optional references:* Nonveiller, E. Kliženje i stabilizacija kosina, Školska knjiga, Zagreb, 1987, 204 str.; Embankment Dam Engineering - Casagrande Volume, Eds. R.C. Hirschfeld and S.J. Poulos, John Wiley & Sons, New York, 1973, 454 str.; Wilson, S.D., Marsal, R.J. Current Trends in Design and Construction of Embankment Dams, ASCE, New York, 1979.; US Dept. of Interior, Bureau of Reclamation:

Design of small dams 3rd ed, 1987.; Dembicki, E.: Tlak, otpor i nosivost tla, Sveučilišna naklada Liber, Zagreb, 1982.; Gaba, A.R., Simpson, B.,Powrie, W., Beadman, D.R: Embedded retaining walls-guidance for economic design, Report CIRIA C580, London, 2003.

21755 Hydrogeology and Engineering Geology (2+0) 3,0

Hydrogeology. The role of hydrogeology in civil engineering. Classification of ground waters. Defining the regime of ground waters. Investigation methods. Water in karst. Defining protection zones. Interpretation of hydrogeological results. Engineering geology in civil engineering. EG classification of rocks. Investigation methods. Properties of rocks for civil engineering needs. . / *Compulsory references:* Weight, W. & Sonderregger, J. : Manual of Applied Field Hydrogeology, 2001.; Waltham,T. Founadtions of Engineering Geology, / *Optional references:* Fetter, C.W. Applied Hydrogeology, 2000.; Rahn, P. Engineering geology: An Environmental Approach, 1996.; T. West Geology Applied to Engineering, 1994.

21880 Dynamic of Structures (2+1) 4,5

Survey of dynamic impact on structures. System vibrations with one degree of freedom. System vibrations with more degrees of freedom. Resonance impact. Problem of eigenvalues. Stodola-Vianello method. Design recommendations. Quasi static building design. Spectral building design. Introduction into building calculation by excitation of an accelogramme. Interpretation of prescribed rules. Auditory practice: General information for solving each unit making up programme tasks. Design practice: Realization of auditory practice with computer. Construction practice: Every student will be aided in design practice. Seminar: Final assignment presentation. */ Compulsory references:* A. Mihanović: *Dimamika konstrukcija*, Split, 1995. / *Optional references:* R. W. Clough, J. Peinzien: *Dynamics of Structures*, McGraw-Hill, New York, 1993.; A. Chopra: *Dynamics of Structures,* Prentice Hall, New Jersey, 1995.

21759 Geotechnical Design (2+2) 6,0

General principles and specific characteristics of geotechnical and civil engineering design. Outline of reference regulations and general principles of Eurocode 7-Geotechnics (limit states, geotechnical data, design procedures and estimate of mechanical resistance and stability, typical geotechnical structures, seismic geotechnical engineering). Quality management and quality assurance in geotechnical design and execution. Design of field and laboratory investigation of

typical examples (choice of methods, schedule and depth of investigation, sampling density). Presentation of investigation results, geotechnical models, selection of referent geotechnical parameters. Variations of design solutions, choice of material and characteristics of construction technology. Presentation of complex geotechnical structures and case histories. Practical work in geotechnical design of typical geotechnical structures – foundation, construction pits and soil improvement, retaining structures, earth structures, cut protection and landslide stabilization (the work includes preparation of geotechnical data, geotechnical modeling of foundation soil, selection of parameters, choice of technical solution, geotechnical analysis, graphical presentation, technical conditions of construction and cost estimate). Presentation and discussion on design problems. / *Compulsory references:* Eurocode 7 – Geotehnika: Geotehničko projektiranje, 1. dio: Opća pravila; HRN ENV 1997-1: 2001.; Nonveiller, E. Mehanika tla i temeljenje građevina, II. izdanje. Školska knjiga, Zagreb, 1981. / *Optional references*: Tomlinson, M. J. Foundation Design and Construction. Longman Scientific and Technical, Harlow, 1995.; Bowles, J. E. Foundation Analysis and Design. McGraw Hill, NY.; Coduto, D. P. Foundation Design, Principles and Practices. Prentice Hall, NJ, 1994.; Winterkorn, H.F., Fang, H.-Y.: Foundation Engineering Handbook, Van Nostrand Reinhold Company, New York, 1982, 752 str.; Geotechnical Engineering Handbook Vol 1-3, Ed. U. Smoltzyck, Ernst&Sohn Verlag, Berlin, 2002.; Technical engineering and design guides adapted from the US Army Corps of Engineers, ASCE; CIRIA – design reports, London.

4.2.1.2. ELECTIVE SUBJECTS

21756 Underground Structures (2+2) 6,0

Short review and development of underground structures. Design procedure of underground structures. Elements of primary support system. Elements of secondary support system. Support loading: Theories of self-supporting vault. Spring washer. 2D i 3D stress-deformation analysis. Profile elaborate. Required time for support construction. Characteristic curves of rock mass and support. Design of support system based on RMR classification. Design of support system based on Q classification. Improvement of rock mass at underground structure excavation and methods of excavation. New Austrian Tunnel Method: principles, main guidelines, main principles and specific principles. Observations and measuring in underground structures. / *Compulsory references:* Hoek, E., Brown, E. T. Underground excavations in rock, The Institution of Mining and Metallurgy,

London, England, 1980. / *Optional references:* TA : 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.

21757 Geotechnics and Environmental Protection (2+1) 4,5

Basic principles of environmental protection (environmental science, environment on earth, concept and origins of soil, water and air pollution, current trends in solving ecological problems, concept of sustainable development, regulations). Demonstration and presentation of current problems in environmental protection. Waste and waste disposal, concept of covered waste landfills, components, harmful products. Geotechnical aspect of waste landfills, properties of waste as construction material. Landfill slope stability (static and seismic conditions, geosynthetic interfaces, influence of leachate). Properties of natural and artificial materials required for sealing and drainage layers, construction methods, application of geosynthetics. Monitoring of waste landfills and the environment, examples of landfill instability and slides. Industrial waste disposal. Transfer of contamination through soil and water, prevention of contamination and contaminated soil improvement. Protection from vibrations propagating through soil. / *Compulsory references:* Znidarčić, D., Kovačić, D., Kvasnička, P., Mulabdić, M.: "Geotehnologija pri odlaganju komunalnog otpada", Hrvatsko društvo građevinskih inženjera, Građevni godišnjak, 1996.; Z. Milanović: Deponij – trajno odlaganje otpada, ZGO-Zagreb, 1992.; Z. Milanović, S. Radović, V. Vučić: Otpad nije smeće, Gospodarstvo i okoliš, V. Gorica, 2002./ *Optional references:* M.L. McKinney, R.M. Schoch: Environmental Science (Systems and Solutions), 3rd ed., Jones and Bartlett Publishers, Boston, 2003.; ISSMFE Technical Committee TC 5: Environmental Geotechnics, Report, Bochum, 1997.; R.M. Koerner, D.E. Daniel: Final Covers for Solid Waste Landfills and Abandoned Dumps, ASCE Press & Thomas Telford, 1997.; R.M.Koerner: Designing with Geosynthetics, 4th edition, Prentice Hall, 1998.; R.K. Rowe, R.M. Quigley, J.R. Booker: Clayey Barrier Systems for Waste Disposal Facilities, E&FN SPON, 1995.

21760 Improvement of Soil and Rock (2+2) 6,0

Principles of ground and rock strengthening: increase in bearing capacity, inspection of total and differential settlement, decrease in deforming time, decrease in liquefaction potential, decrease in soil permeability, disposal of water from soil, increase in shear strength and slope stability, increase in erosion stability, creation of internal drain systems. Strenghtening methods for foundation soil and rocks: soil replacement, load reduction, vertical drainage, depth vibro

compaction, consolidation and jet grouting, initial loading, inundation, loading berms, anchorage constructions, soil reinforcement, chemical procedures, freezing, heating, vegetation. Strenghthened soil and rock quality control: laboratory reasearch, field research, measuring and observation methods. / *Compulsory references:* Mitchell, J. M., Jardine, F.M.: A Guide to Ground Treatment. CIRIA publication C573, London, UK, 2002. */ Optional references:* Bell, F.G.: Engineering Treatment of Soils, Spon Press, London, UK, 1993.; Moseley, M.P. Ground Improvement., CRC Pres, Boca Raton, Florida, USA, 1993.

21758 Dynamics of Soil (2+2) 6,0

Lectures: Introduction: vibration fundamentals (free and forced vibrations of damped and undamped simple oscillator), instruments for measurement of oscillations. Waves in elastic media: longitudinal and transversal waves in rods, reflection, waves in infinite media (longitudinal, transversal, reflection and refraction), surface waves (Rayleigh and Love waves), attenuation, dispersion. Properties of cyclic loaded soils: hysteresis, stiffness, damping, strength, cyclic volume strains and porewater pressures, laboratory tests, field tests. Foundation vibrations: vertical, lateral, torsional, rocking and coupled oscillations of shallow foundations, theory and measurements, pile foundation vibrations, vibration isolation. Dynamic bearing capacity of soils. Geotechnical earthquake engineering: seismic action on soils and structures, case histories. Seismic loading: definition of terms, seismic ground motion properties. Seismic waves propagation: vertical propagation through the layered medium, nonlinear soil behavior, amplification. Seismic behavior of retaining walls and earth slopes: Mononobe-Okabe theory for earth pressures, sliding block method, limited displacements based wall design, permanent displacements of slopes and embankments. Soil liquefaction: liquefaction in laboratory and in field, laboratory and field tests, improvement of liquefiable soil. / *Compulsory references:* Das, B. M.: Principles of Soil Dynamics. Brooks/Cole, Pacific Growe, CA, 1993. / *Optional references:* Kramer, S. L. Geotechnical Earthquake Engineering. Prentice Hall. NJ, 1996.; Prakash, S. Soil Dynamics. McGraw-Hill, NY, 1981.

21864 Theory of Elasticity and Plasticity (3+2) 7,5

Introduction and definition of deformability continuum (History and classification of continuum mechanics). Basics of vector and tensor calculus (Euclid's E^3space, Transformations of coordinates, Operations with tensors). Model of material continuum deformation (Lagrange's and Euler's principles of body deformation). Stress tensor and its properties. (Stress state surrounding the

point, Equilibrium equation, Statical acceptability, Component transformations, Eigen values). Deformation tensor and its properties (Displacement and deformity gradients, Finite deformations, Infinitesimal deformations, Kinematic acceptability, Compatibility equation). State and constitutive equations (Laws on states, Material rigidity and flexibility tensor, Potential of linear-elastic body). Boundary phenomena in theory of elasticity and their solutions (Boundary phenomenon formula, solutions and their properties). Potential energy of solid deformable body and energy principles and theorems. Numerical procedures applied in solving boundary phenomena in theory of elasticity.Plane conditions in theory of elasticity (Plane stress and deformation, Airy function of stress in rectangular and polar coordinates, Solution properties of plane phenomena and some potentials of boundary phenomena). Space phenomena in theory of elasticity (Torsion, Semi-space, Thin boards). Introduction to theory of plasticity and basic criteria of plasticity (Plasticity models, Principles of plastic flow, Plasticity constant). Constitution laws in material flow theory (Misses-Levy and Prandtl-Reuss equations, Incremental procedures in flow theory). Some potentials of plasticity. / *Compulsory references:* Z. Kostrenčić: Teorija elastičnosti, Školska knjiga, Zagreb, 1982.; J. Brnić: Elastomehanika i plastomehanika, Školska knjiga, Zagreb, 1996. / *Optional references:* S. Timošenko: Teorija elastičnosti, Građevinska knjiga, Beograd, 1962.; Y. A. Amenzade: Theory of Elasticity, MIR Publishers Moscow, 1979.; G. E. Mase: Theory and Problems of Continuum Mechanics, McGROW-HILL COMPANY, 1970.

21800 Earthquake Engineering (2+0) 3,0

Earthquake. Modal analysis: time history and response spectra. Regulations. Ductility. Problem of critical direction work of earthquake and appropriate extrem interior forces of construction. New methods for seismic protection of structures. Active and passive protection of structures. The most often seismic isolation systems. *I Compulsory references:* Separati s predavanja; Čaušević, M. Potresno inženjerstvo. Zagreb : Školska knjiga, 2001.; Chopra, A.K. Dynamics of structures, Theory and applications to earthquake engineering. New Jersey : Prentice Hall, Engle Wood Cliffs, 1995., Chopra, A.K. Dynamics of structures a primer. Eartquake engineering research institute, 1985.

4.2.2. HYDRAULIC ENGINEERING PROGRAMME

4.2.2.1. OBLIGATORY SUBJECTS

21761 Hydraulics (3+2) 7,5

Introduction, liquids, energy and energy forms transformation, modeling of hydrodynamic processes. Flow in open channels. non - uniform flow in open channels, non stationary flow in open channels, flow with gradual and flow with sudden changes, dam failure, short objects (spillway, outflow, stilling basin). Systems under pressure stationary flow in pipe networks, non stationary flow with gradual changes – water mass vibrations, non stationary flow with sudden changes – water hammer, pumps and turbines. Hydraulics of groundwater. Hydraulics of groundwater in the rocks of intergrained porosity, wells (stationary and non-stationary flow, experimental pumping), regional models, groundwater flow in the rocks of cracking porosity. Substance transport, transport mechanisms in aquifer layers, transport in sea. Wind impact on structures. / *Compulsory references: G*jetvaj G. Interna skripta; H. Rouse, Tehnička hidraulika. / *Optional references:* W. Kinzelbach; Groundwater modeling, Elsevir; Ven te Chow; Open Chanell Hydraulics, McGraw-Hill Book Company 1986. Internet.

21762 Hydrology 2 (2+2) 6,0

Data analysis on precipitation: Space and climatic precipitation intensity changes, representative precipitation data array determination, creation of IDF curves (*Intensity, Duration, Repetition* Frequency). Hydrologic processes on land: Interception and evapotranspiration, percolating into soil and surface water flow, groundwater, soil humidity, saturated and non saturated zone. Groundwater level measurement, identification and types of aquifer, permeability and transmission of aquifer, Darcy' s filtration law, groundwater and surface water connection, base and direct runoff, separation and illustration of base and direct runoff at hydrograph. Direct runoff determination method: unit hydrograph (UH) method, synthetic unit hydrographs, Instantaneous Unit Hydrograph (IUH). Concentration time of direct runoff from catchment and time of hydrograph increase. S-hydrograph. T-hour unit hydrograph. Forecast hydrograph creation. Other parametric methods for runoff estimation: SCS method (*Soil Conservation Service*), reduction of the hydrograph from stormrains lasting shorter than the runoff concentration time, isochrone method, reservoir (tank) method, Srebrenović 's methods, Gavrliović 's methods. Mathematic modelling in hydrology: Model

types, theoretical, conceptual and system models, deterministic and stochastic models. GIS technology application in hydrology. / *Compulsory references:* Srebrenović, D. Primijenjena hidrologija, Tehnička knjiga, Zagreb, 1986.; Žugaj, R. Hidrologija, udžbenik, Sveučilište u Zagrebu, Rudarsko-geološko-naftni fakultet, Zagreb, 2000. / *Optional references:* Vuković, Ž. Osnove Hidrotehničke – Knjiga I, Poglavlje 2: Hidrologija, str. 19-133, udžbenik Sveučilišta u Zagrebu, Zagreb 1944.; Bonacci, O. Oborine glavna ulazna veličina u hidrološki ciklus, udžbenik Sveučilišta u Splitu, Geing, Split, 1994.; Polak, Z. Hidrogeologija za građevinare, udžbenik Sveučilišta u Zagrebu, Građevinski fakultet Zagreb, 1995.; Miletić, P., Heinrich Miletić, M. Uvod u kvantitativnu hidrogeologiju, RGN – fakultet Sveučilišta u Zagrebu, 1981.; Ven Te Chow: Handbook of Applied Hydrology, McGrow-Hill book Company, New york, 1964.; Viessman, W.Jr., Lewis. L.G. Introduction to Hydrology, Harper-Collins-College-Publishers, New York, 1996. Wilson, E.M. Engineering hydrology /fourth edition/, Macmillan Press LTD, London, 1990.; Srebrenović, D.: Problemi velikih voda, Tehnička knjiga, Zagreb, 1986.

21763 River Training (3+2) 7,5

Purpose, problems and training tasks, training role in water management. Morphology of a riverbed. Hydrologic properties of natural watercourses, water regime, sediment regime, ice regime. Hydraulic calculation of natural and artificial watercourses; flow analysis,sediment transfer, riverbed stability. Training works at watercourse bed, training facilities. Water regime training, operations in the catchment area and devices for water regime trainings, operability. Flood protection, technical defence of an embankment. Watercourse facilities. / *Compulsory references:* M. Gjurović: Regulacije rijeka / *Optional references:* Ž. Vuković: Osnove hidrotehnike, Prvi dio, druga knjiga, E. Svetličić: Otvoreni vodotoci – regulacije.

21766 Ports and Waterways (3+3) 9,0

Basics of engineering oceanology: Sea waves, ideal waves, real waves, sea streams. Construction in sea. Ships and manoeuvres in port . Ports: the terms of port and landing stage, transportation functions of port and landing stage, goods traffic in port, port types, port shapes, inside port facilities, port facilities, outside port maritime facilities. Inland navigable ways types and classification. Locks and similar activities on inland water ways. / *Compulsory references:* Tadejević, Z., Pršić, M. Pomorska hidraulika I, skripta, Građevinski fakultet Zagreb, 1977. / Pršić, M., Tadejević, Z. Riječni plovni putevi, skripta, Građevinski fakultet Zagreb, 1988. / *Optional references:* CERC – Shore Protection Manual; Coastal Engineering

Research Center, US Government Printing Office, Washington DC, 1984., CEM-Coastal Engineering Manual, US Army, Waterways Experimental Station, 2003., EAU Empfehlungen des Arbeitausschusses Ufereinfassungen, Ernst und Sohn, 1996., Technical standards and Commentaries for Port and Harbour Facilities in Japan, The Overseas Coastal Area Development Institute of Japan, 2002.

21767 Drainage and Irrigation 1 (3+2) 8,0

Basic tasks and design basis of drainage and irrigation: Hydro-melioration practices and hydroengineering soil – improvement practices; Hydro-melioration practices in Croatia; water regime in soil and plants production; Basic principles of hydro-melioration practices. Hydro-melioration facilities and surface drainage systems : Protection of land drainage areas from external floods; Natural characteristics impact on drainage canals of IV.th and III.rd order distances; Hydromodule of surface drainage – specific water inflow into drainage canals; Open canals – dimensioning; Systems, types and networks of open canals; Facilities on open canals; culverts, bridges, locks, stoppers, drops, pumping stations, siphons, chutes-flowings, bottom and slopes protection - basic elements of dimensioning and facility construction ; Essential technical and financial indicators of construction and maintenance of surface drainage canal network. Hydro-melioration systems of ground drainage – pipeline drainage: Purpose, aim and significance of pipeline drainage – for plant production; Basics of soil – pedology; Dimensioning of pipeline drainage; Network – systems of ground drainage; Facilities and construction mode of pipeline drainage; Application and drainage impact on agricultural soils. Hydro-melioration systems for irrigation: Need and aim of irrigation: Water intake for irrigation; Soil irrigation systems and types; Dimensioning of soil – improvement irrigation systems; Irrigation facilities and devices; Fish ponds – principal elements of design. Execution and regulations: Technology of construction and maintenance of soil – improvement facilities and drainage and irrigation systems. Machines for hydro-melioration; Law on waters and drainage and irrigation practices. / *Compulsory references:* Kos, Z. Hidrotehničke melioracije tla, I. dio – odvodnjavanje, 1989., II. dio – navodnjavanje, Školska knjiga, Zagreb, 1987.; Skupina autora: Priručnik za hidrotehničke melioracije, I. kolo, knjiga 2 i 3, Društvo za odvodnju i navodnjavanje Hrvatske, Zagreb, 1984., 1985. / *Optional references:* Priručnici za hidrotehničke melioracije, I. kolo, knjiga 4, 1987., knjige 5 i 6, 1989.-1991.; II. kolo, knjige 3, 4, 5, 6, *odabrana poglavlja*, Hrvatsko društvo za odvodnju i navodnjavanje, Zagreb i Građevinski fakultet, Rijeka, 1994. - 1997.

21801 Structures (2+2) 6,0

Basic principles in design of supporting structures. The basis of seismic calculation of structures. Engineering structures (silos, warehouses, water towers, water reservoirs, cooling towers, shimneys). Basis for prestressing concrete structures. Prestressing in bridge construction. Prestressing in building construction. Prestressing in soil mechanics. Prestressing in hydraulic engineering. New materials for structures./ *Compulsory references:* Pičulin, S.; Konstrukcije CD s predavanjima. Zagreb. / *Optional references:* Hiroyuki Aoyama. Design of Modern Highrise Reinforced Concrete Structurec. London : Imperial College Press, 2001.

21770 Water Resources Engineering (3+1) 6,0

Water and water resources. Basic terms: Systems; Processes;Water development projects, Water management; Hydroengineering. Place and tasks of water management in the state economy. Legal regulations. Water development projects and hydraulic structures: Purpose; Tasks . Multi-purpose water development projects management. Environmental changes in water development projects and hydraulc structures. Evaluation goals, criteria and measures. Decision making process – optimisation procedures . Water development project benefits and costs. Allocation of benefits and costs in multi-purpose systems. Examples of water development projects (explanation and visit). Water development projects maintenance. */ Compulsory references:* Linsley, P.K., Franzini, J.B. et all: Water-Resources Engineering; New York, McGraw Hill Book Com. 1991.; Đorđević, B.: Vodoprivredni sistemi; Beograd, IRO Građevinska knjiga, 1989.; Đordjević, B. Cybernetics in Water Resources Management; Water Resources Publication, 1993. / *Optional references:* Zakonska regulativa; Thuesen, G.J, Fabrycky W.J.: Engineering Economy; Prentice-Hall Int.Inc. 1989.; James, L.D., Lee, R.R.: Economics of Water Resources Planning; Mc Graw-Hill Inc, 1971.

21771 Water Supply and Sewerage 2 (2+2) 6,0

Legal frameworks of water supply and drainage regarding the European basic directives on waters. Environmental impact of water supply and drainage . Patterns of water demand and consumption. Alternative procedures of treatment and disposal of waste water. Engineering measures and facilities for treatment of runoff and combined sewer overflows of a mixed drainage system. Alternative drainage systems: pressure sewerage systems, vacuum sewerage systems, small diameter gravity sewers. Dimensioning and design of overflow structures in a

sewerage network. Mathematical models of water supply and drainage (EPANET and SWMM mathematical models. Water supply and drainage management systems in real time. Planning, construction and maintenance of wastewater treatment plants and water purification plants. Trenchless construction techniques and rehabilitation of pipelines. Economic and engineering analysis for selection of most suitable elements of water supply and sewerage system. Management and legal aspects of public utility companies. / *Compulsory references:* Interna skripta na CD-u. / *Optional references:* Metcalf &Eddy; Wastewater Engineering, Treatment Disposal, Reuse, McGraw-Hill International Editions, 2002.; Steel, E. W., Mc Ghee, T.J.: Water Supply and Sewerage, Mc Graw Hill Book Company, London 1991.

21768 Water Power Development (2+2) 6,0

Energy and water power in nature. Basic principles of water power development. Need for power and energy, water power role (1). Basic hydropower plants types. Investigation works related to water power usage. Hydroenergy calculations and water course analyses. Power and energy calculation in variable falls and flows. Hydropower plants economic properties. Environmental impact of hydropower plants . Size and choice of construction volume. Low - pressure hydropower plants. Medium and high - pressure hydropower plants. Major facility groups accompanying hydropower plants. Power turbines – basic properties and application. Other HP equipment (generators, transformers, generators, switchyards, management and maintenance). Hydropower plants utilisation and maintenance. Examples of given hydropower plants. / *Compulsory references:* Stojić P.: Hidroenergetika; Split, Građevinski fakultet Sveučilišta u Splitu, 1995.; Đorđević B.: Korišćenje vodnih snaga; Đorđević, B.: Korišćenje vodnih snaga – Objekti hidroelektrana; Nauč. knj. i GF Beograd; 1989. Žugaj, M.: Posebne analize u hidrotehnici; Zagreb, Građevinski institut, 1981./ *Optional references:* Mosony E.: Water Power Development, Vol. I-II, Budapest, Akademiai Kiado, 1987; Third, Ed. Civil Engineering Guidelines for Planning and Designing Hydroelectric Developments; Vol 1-3; New York, American Society of Civil Engineers, 1989.

4.2.2.2. ELECTIVE SUBJECTS

21764 Water Supply and Sewerage 1 (2+1) 4,0

Water supply: Introduction. Water supply system. Water consumption. Springs. Water – intakes. Pumping stations. Water conditioning. Water tanks. Water supply

networks. House water supply networks. Sewerage: Introduction. Sewerage systems. Design water quantity. Sewerage networks. Sewerage facilities. Waste water treatment. Outlets. House sewerage. / *Compulsory references:* Vuković, Ž.: Interna skripta / *Optional references:* Gulić, I.: Opskrba vodom, HSGI, 2000.; Margeta, J.: Kanalizacija naselja, GFS, 1998.; Steel, E. W. and Terence, J. McG.: Water Suplly and Sewerage, Mc Graw Hill Book Company, 1991.

22765 Water Protection (2+1) 4,0

Basic ecological principles. Water properties: physical, chemical microbiological. Water status and pollution degree indicators. Chronic and acute pollution – total maximum daily load, effluent standard approach and combined approach. Integral management of water quality in catchment area.Control of point and non-point pollution sources, water treatment technologies, water quality models (basic Streeter-Phelpsa model and QUALL mathematical model, water discharge into water bodies (model CORMIX). Road runoff impact mitigation impact. Environment impact assessment; scientific, technological, economic, legal and sociologic issues. Direktive EU instructions on water protection. / *Compulsory references:* Interna skripta na CD-u; Tedeschi, S.: Zaštita voda, udžbenik Sveučilišta u Zagrebu, 1997. / *Optional references:* Metcalf &Eddy; Wastewater Engineering, Treatment Disposal, Reuse, McGraw-Hill International Editions, 2002.

21772 Urban Hydrology (2+2) 6,0

Urbanization impact on hydrologic processes: Differences in urban and natural catchments, Hydrologic processes in urban catchments, precipitations, interception, infiltration, water retention in ground depressions, surface flow and retentioning in intercepting roof gutter, water-chutes and canals. Hydrologic and hydraulic features of urban systems: characteristics of rainwater drainage and mixed sewage system elements, flat and inclined roofs, asphalt surfaces, parks and non-asphalt surfaces, roof gutters and water-chutes, gullys and shafts, culverts under roads and other objects, sewage network, overflow, retentions and expansion basins, inlets and outlets facilities. Heavy stormwater runoff calculation: empirical equations and rational method, runoff concentration time, effective precipitation and runoff coefficient, correlation relationship of precipitation – runoff, snow melting runoff. IDF (Intensity Duration Frequency) rain curves creation and significance in urban areas(4). Runoff hydrograph determination methods: unit hydrograph of urban catchment, Los Angeles hydrograph, Chicago hydrograph, SCS method *(Soil Conservation Service Metod),* other methods. Estimation of the

rain occurrence relevant for urban drainage system design: floods in urban areas, economic aspects of design rain determination, selection of rain intensity and duration, design hydrograph specification. Hydrology of roads, highways and airports. Current principles of urban drainage. Water quality in urban catchments, collection and utilization of rainfall waters, inlets and filtration into underground. Mathematical modelling of runoff from urban catchment areas and urban drainage system management. / *Compulsory references:* Akan, A.O., Houghtalen R.J.: Urban Hydrology, Hydraulics, and Stormwater Quality – Engineering Application and Computer Modeling; John Wiley & Sons Ltd. 2003., http://eu.wiley.com; Maksimović, Č., Tejada-Guibert, J.A.: Frontiers in Urban Water Management. IWA Publishing, London, 2001. www.iwapublishing.com ; Ven Te Chow: Handbook of Applied Hydrology, McGrow-Hill book Company, New York, 1964. / *Optional references:* Okrugli stol: Urbana hidrologija, Split 25-26 travnja 2002., zbornik radova, Hrvatsko hidrološko društvo i Hrvatske vode; Petraš, J.: Urbana hidrologija – autorizirana predavanja, Građevinski fakultet, Zagreb, 2005.

21773 Potable and Water Treatment (2+2) 6,0

Potable water purificative unit operations: procedures: sedimentation, filtration, aeration, removal of metal and non-metal, taste, odour and colour, desalinization, desinfection, design and dimensioning of unit operations, raw water analysis and pilot facilities, monitoring of drinking water purification facility, by products treatment and disposal - sludges, chemicals. Municipal Wastewater Treatment: procedures: physical, chemical, biological, advanced technologies, alternative technologies, design and dimensioning of unit technological operation, raw water analysis, pilot device drive, monitoring of wastewater treatment efficiency (1), treatment and disposal of by products – sludges, solids, chemicals, energetic use, treated water re-use. / *Compulsory references:* Interna skripta na CD-u; Gulić, I. Kondicioniranje vode, udžbenik Sveučilišta u Zagrebu, 2003. / *Optional references:* Metcalf & Eddy; Wastewater Engineering, Treatment Disposal, Reuse, McGraw-Hill International Editions, 2002.

21774 Modeling in Hydraulic Engineering (2+2) 6,0

Fluid motion equations. Dominant forces, steady and unsteady processes. Boundary layer theory. Boundary layer model descriptions. Methods of fluid motion modelling. Importance in hydraulic engineering design. Model type and selection. Physical models. Laws of similarity. Limitations and advantages. Model types. Mathematical models. Numerical methods. Limitation and advantages. Stability and reliability of a model. Hybrid models. Far and close modeling field.

Other model types. Two – Phase models. Flowing phases. Mixed phases. Transfer of matter. Model – nature correlation analysis. / *Compulsory references:* Kobus: Hydraulic Modelling, Springer Verlag,1980.; Novak, Čabelka: Models in Hydraulic Engineering, Pitman 1981.; Jović: Uvod u modeliranje hidrauličkih procesa, Aqarius,1983. / *Optional references:* Dostupna references pod nazivom sličnim obaveznoj.

21775 Drainage and Irrigation 2 (2+2) 6,0

Basics of soil – improvement pedology: soil formation, soil classification, mechanical and physical soil properties, water in soil, soil – improvement problems of hydromorphic grounds, pedologic investigation. Ground characteristics impact of soil improved areas on design and executable elements of hydromeliorative facilities and surface and ground drainage and irrigation system. Regulation and maintenance of agricultural land water regime: optimal growth of plants, significance of maintenance of hydromeliorative facilities and optimal soil water regime system and their impact on growth of stable yields. Machines and equipment for the construction of hydromeliorative facilities and systems: surface, ground drainage and irrigation. Technology and costs of building drainage and irrigation structures and systems. Technology and costs of maintaining drainage and irrigation system. Hydromeliorative systems and multi-purpose water management facilities. *I Compulsory references:* Grupa autora: Priručnici za hidrotehničke melioracije, I. kolo, knjiga 5 i 6, 1989.-1991., II. kolo, knjiga 5, 1996., knjiga 7, 1999., odabrana poglavlja, Hrvatsko društvo za odvodnju i navodnjavanje Zagreb, Građevinski fakultet Rijeka. / *Optional references:* Vidaček, Ž. Gospodarenje melioracijskim sustavima odvodnje i natapanja, odabrana poglavlja, Agronomski fakultet, Zagreb i Hrvatsko društvo za odvodnju i navodnjavanje, Zagreb, 1998.; Priručnik za hidrotehničke melioracije, II. kolo, knjiga 4, 1995. i knjiga 6, 1997., Hrvatsko društvo za odvodnju i navodnjavanje, Zagreb i Građevinski fakultet Rijeka.

21776 Flood Protection (2+2) 6,0

Introduction, water management longitudinal watercourse profile, watercourses as elements of water management system. Investigation procedures in protection from water in the scope of water management baselines and plans. Investigations on small watercourse regulation with immobile wetted perimeter, approach to riverbed dimensioning by means of permitted flow velocity. Approach to optimal dimensions specification of riverbed by using permitted tractive force procedure. Scientific approach to riverbed protection modes from fluvial erosion

and to the calculation of technical and construction elements. Riverbed regime concept, stable bed dimensions in aluvium. Adjustment flood risk concept in flood protection, protection modes and ways. Analysis of floods protection system elements, flood relief channels and lateral channels, frontal and lateral retentions and retention areas in accumulations system. Water management facilities, dams, overflows, stoppers investigations. Approaches to protection embankment optimal dimensions specification, their construction and maintenance. / *Compulsory references:* Chang H.H: Fluvial processes in River Engineering, Krieger publishing company, 1998.; Jansen, P. Ph. et al: Principes of River Engineering - The non - tidal alluvial river, Pitman Publishing Limited, London, 1979. / *Optional references:* Water Resources Project Planning, UN Office of Tehnical Cooperation: Water Resources Series No. 41, NY, 1972.; Hemphil, R. & Bramley, M. E.: Protection of river and canal banks, CIRIA and Butterworths, London, UK, 1989.

21880 Dynamics of Structures (2+1) 4,5

Survey of dynamic impact on structures. System vibrations with one degree of freedom. System vibrations with more degrees of freedom. Resonance impact. Problem of eigenvalues. Stodola-Vianello method. Design recommendations. Quasi static building design. Spectral building design. Introduction into building calculation by excitation of an accelogramme. Interpretation of prescribed rules. Auditory practice: General information for solving each unit making up programme tasks. Design practice: Realization of auditory practice with computer. Construction practice: Every student will be aided in design practice. Seminar: Final assignment presentation. / *Compulsory references:* A. Mihanović: *Dimamika konstrukcija*, Split, 1995. / *Optional references:* R. W. Clough, J. Peinzien: *Dynamics of Structures*, McGraw-Hill, New York, 1993.; A. Chopra: *Dynamics of Structures,* Prentice Hall, New Jersey, 1995.

21777 Design in Hydraulic Engineering (0+4) 6,0

Creation of a conceptual project of a water building or any water related structure: Elaboration and survey of design basics, technological or functional solution, calculations, technical description, bill of costs, drawings. A design should suit the standards of Croatian legal system. A course project can be selected and agreed on between student and mentor of any hydraulic engineering professional subject. / *Compulsory references:* Zakon o gradnji RH, Zakon o vodama RH, Pravilnik o izradi studija utjecaja na okoliš, te drugi pravilnici vezani na Zakon o gradnji RH. / *Optional references:* Euronorma ENV 1991, razni međunarodni standardi.

21778 Vegetative Water Facilities (2+2) 6,0

Significance of vegetative water facilities construction and their planning fundamentals: Definition, purpose and significance of vegetative water facilities construction, basics of planning and design. Water regime impact on water vegetation**.** Duration curve of water level, water regime and vegetation period on open water courses and lakes, coastal vegetation profiles. Water and littoral vegetation – growth and preparation for water facility construction: Major coastal and littoral vegetation, growth and preparation of vegetation for vegetative water facility construction. Application of vegetation in water facilities construction: vegetation as a constitutive part of riverbed regulation structure, application of reed in the coastal protection, application of willows and live wicker, application of shrubby vegetation and soft - wood trees. Environment regulation and conservation: Regulation of inundations and river isles, growths and conservation of woods in the area of littoral watercourses and artificial lakes, parks and landscape architecture in the area of littoral watercourses and artificial lakes, re – naturalization of trained watercourses. Vegetative water facilities construction impact on preservation and protection of water. / *Compulsory references:* Coppin, N.J., Richards I.G.: Use of vegetation in Civil Engineering. CIRIA /Construction Industry Research and Information Association/, London, 1990.; Der biologische Wasserbau - an den Bundeswasserstrassen, Bundesanstalt fur Gewasserkunde Koblenc, Verlag eugen Uliner, Stuttgart, 1965.; Svetličić, E.: Otvoreni vodotoci - pokosi i njihova sigurnost, JVP Hrvatska vodoprivreda, Zagreb, 1979. Petraš, J.: Biološke vodogradnje – autorizirana predavanja, Građevinski fakultet Zagreb, 2000. / *Optional references:* Flusse und Bache erhalten - entwickeln - gestalten, Wasserwirtschaft in Bayern, Oberste Baubehoerde im Bayerschen Staatsministerium des Innern, Heft 21, Munchen, 1989.; Flusse - Bache - Auen.. pflegen und gestalten, Wasserwirtschaft in Bayern, Oberste Baubehoerde im Bayersichen Staatsministerium des Innern, Besonders Publication, Munchen, 1991.

21779 Road Runoff Treatment and Disposal (2+2) 6,0

Environmental impact of transportation facilities: emissions of pollution in car traffic, regular and accidental pollution, quality of runoff water from transportation facilities. Estimation of pollution volume – simulation of pollution build-up and washout by means of SVMM model. Legal directives that regulate problems of road runoff. Road runoff systems: collection and transport of precipitation and drained waters, drainage systems: open, closed, in tunnels, on bridges and viaducts, best management practice of collected water, structures for final discharge of treated water. Other constructive and non-constructive measures for

lowering negative environmental impact. Dimensioning and maintenance of runoff system. Operation and maintenance of drainage systems. / *Compulsory references:* Interne skripte na CD-u; Studija: Odvodnja prometnica - Zaštita okoliša od negativnog djelovanja, GF, 2000. / *Optional references:* HWA: Evaluation and Management of Highway Runoff Water Quality, FHWA-PD-96-032, 1996.

21780 Experimental Hydraulics (2+2) 6,0

Introduction; measurement systems, measurement planning, optimization of an experiment. Physical models; model establishment, basics of physical modeling and similarity criterion, hydroengineering laboratory, examples of physical modeling. Measurements in field; organization and measurement methods. Measuring technique; measuring of water level, speed measuring, flow measuring, pressure and force masuring, measuring of other parameters (temperature, substance concentration,...). Collection and elaboration of measured data, measuring setting, sensors and execution, signals elaboration, multiplexors, analogous digital convertor, results review, measurement failure. Correlation problems (analysis and use of obtained results). Students have to carry out their own experiment, set up and elaborate obtained results. / *Compulsory references:* Gjetvaj, G. Interna skripta, Kobus, H.: Hydraulic modeling, Verlag Paul Parey, Hamburg, 1980. / *Optional references:* Čabelka, Novak,...

21781 Special Water Power Projects (2+2) 6,0

Small hydropower plants (SHP): Definitions. Construction conditions. Use of SHP and fitting into the energetic system. Fundamentals and research work. Water intakes, headrace and tailrace. Powerhouses, equipment. Management and maintenance. Management role and SHP profitability. Changes in the environment. Pumped-storage hydropower plant (PSHP): Role in the electroenergy system. Construction conditions. Reservoirs – construction, maintenance and use. Water intakes, headrace and tailrace, hydraulic design. Powerhouse and equipment (turbines, pumps). Management and maintenance. Changes in the environment. Other modes of water resource uses: Tidal power projects. Use of wave power. Use of mechanic water energy (mills and other closely related plants and devices – historical survey). / *Compulsory references:* Civil Engineering Guidelines for Planning and Designing Hydroelectric Developments; New York, American Society of Civil Engineers, 1989, Vol. 4 – Small-scale Hydro; Vol. 5 – Pumped Storage and Tidal Power.; Stojić, P.: Hidroenergetika; Split, Građevinski fakultet Sveučilišta u Splitu, 1995. / *Optional references:* Zgradimo majhno hidroelektranu; Zveza organizacij za tehnično

kulturu Slovenije, 1986; Del 1-5.; Mosony, E.: Water Power Development, Vol. I-II, Budapest, Akademiai Kiado, 1987; Third Ed.

21782 Maritime Structures (2+2) 6,0

Quay: needed beddings, types and detailed design, loads, calculations, calculations of structure, detail design. Breakwaters: needed beddings, types and detailed design, loads, calculations, calculations of structure, detail design. Submarine pipelines: needed beddings, types and detailed design, loads, calculations, calculations of structure, detail design . Marinas. / *Compulsory references:* CERC – Shore Protection Manual; Coastal Engineering Research Center, US Government Printing Office, Washington DC, 1984., CEM-Coastal Engineering Manual, US Army, Waterways Experimental Station, 2003., EAU Empfehlungen des Arbeitausschusses Ufereinfassungen, Ernst und Sohn, 1996., Technical standards and Commentaries for Port and Harbour Facilities in Japan, The Overseas Coastal Area Development Institute of Japan, 2002.

21800 Earthquake Engineering (2+0) 3,0

Earthquake. Modal analysis: time history and response spectra. Regulations. Ductility. Problem of critical direction work of earthquake and appropriate extrem interior forces of construction. New methods for seismic protection of structures. Active and passive protection of structures. The most often seismic isolation systems. / *Compulsory references:* Separati s predavanja; Čaušević, M. Potresno inženjerstvo. Zagreb : Školska knjiga, 2001.; Chopra, A.K. Dynamics of structures, Theory and applications to earthquake engineering. New Jersey : Prentice Hall, Engle Wood Cliffs, 1995.; Chopra, A.K. Dynamics of structures a primer. Eartquake engineering research institute, 1985.

4.2.3. STRUCTURAL ENGINEERING PROGRAMME

4.2.3.1. OBLIGATORY SUBJECTS

21783 Prestressed Concrete (2+2) 6,0

General information on presstressed concrete: types of prestressing, types of prestressed concrete structures, systems of lifter anchoring, introducing prestressing force into structure, basic calculations of prestressed concrete structures, computer application, materials properties of prestressed concrete structures, dimensioning of sections - meeting the basic criteria, serviceability limits, stability of prestressed concrete elements, fatigue of prestressed concrete structures, behaviour of prestressed concrete structures under fire, production and assembly of prestressed concrete structures, prestressing in bridge construction, prestressing in industrial facilities, prestressing in building construction (frames, floor slabs, cupolas, shells), prestressing in geotechnics, maintenance and repair of prestressed concrete structures, application of new materials. / *Compulsory references:* Pičulin, S.; Dekanović, Đ.; Kindij, A. *Prednapete betonske konstrukcije*, CD s predavanjima 2001-2005., Zagreb. / *Optional references:* Leonhardt, V. *Vorlesungen űber Massivbau, Fűnfter Teil.* Berlin, Heidelberg, New York : Springer-Verlag, 1979.

21784 Bridges II (2+2) 6,0

Elements of structural planning. Structural planning of bridges. Bridge design – conceptual design. Optimization of alternative solutions. Combinations of bridge actions. Basic bridge statical analysis. Stability problem in bridges. Seismic analysis. Beam bridges (analysis and detailing). Plate main girders of metal bridges. Truss main girders. Beam bridges (construction). Slab bridges (statical analysis, design, construction). Decks of railway bridges. Bracings. Orthotropic steel decks. / *Compulsory references:* Radić, J. Mostovi. Zagreb : Dom i svijet, 2002.; Tonković, K. Masivni mostovi (Opća poglavlja). Zagreb : Školska knjiga 1977.; Tonković, K. Mostovi (Građenje). Zagreb : Školska knjiga 1979. / *Optional references:* Taly, N. Design of Modern Highway Bridges. New York : McGraw-Hill, 1992.; Bennett, D. The Creation of Bridges. New Jersey : Chartwell Books, 1999.

21785 Metal Structures II (2+2) 6,0

Properties of steel structures. Architecture and steel. Economic parameters of construction in steel. Design procedure – higher level. Introduction to engineering

reliability. Fatigure – dimensioning. Compound compressed elements. Stability of web plates due to transverse stresses. Thin walled profile structures.Design of plate elements and plate girders. Spatial structures systems. Bearing systems of multi storey buildings. Cable structures. Details of steel structures. / *Compulsory references:* Androić, B.; Dujmović, D.; Džeba, I. Metalne konstrukcije 3. Zagreb : IA Projektiranje 1998.; Androić, B.; Dujmović, D.; Džeba, I. Metalne konstrukcije 4. Zagreb : IA Projektiranje 2003.; Androić, B.; Dujmović, D.; Džeba, I. Modeliranje konstrukcija prema EC3. Zagreb : IA Projektiranje 2004. / *Optional references:* McKenzie, W. C. Design of Structural Steelwork. Macmillan 1998.

21786 Reliability of Structures (2+0) 3,0

Engineering reliability – the significance of the term. Definitions and fundamental concepts. Analysis and evaluation of structural damages. Hazards in construction and other risks. Recognizing hazards and planning measures for their removal. Data collection and analysis of structures. Stochastic modeling of structural response, action and resistance. Base variables and models. Reliability of members. Fundamental problem of limit state equation. A detailed problem of limit state equation. Dependability of reliability index and yielding probability. System reliability. Reliability proof with partial factors – European norms. / *Compulsory references:* Androić, B.; Dujmović, D.; Džeba, I. Metalne konstrukcije 4. Zagreb : IA Projektiranje 2003.; Separati s predavanja. / *Optional references:* Ditlevsen, O.; Madsen, H.O. Structural Reliability Methods. Wiley 1996.

21787 Concrete and Masonry Structures II (2+2) 6,0

Composite slabs. Complex slabs. Flat slabs, triangular slabs, slabs supported on two adjoining borders, slabs with opening. Design, theoretical concepts, legal regulations. Torsion of reinforced concrete sections. Serviceability limit states. Creep and shrinkage of concrete. Beam deflections. Crack design according to PBAB and EC2. Minimum slab and beam reinforcement for crack limitations. Deflection design according to PBAB and EC2. Slender columns**.** Elements under longitudinal force and bending moment. Design according to 2nd order theory**.** Interaction diagrams. Jackson&Moreland's diagrams for calculation of slenderness. Biaxial bending of columns. Hollow columns. Local compressive stresses. Short cantilevers. Joints and hinges of frameworks. Bearing systems of reinforced concrete walls. Full walls and walls with openings. Mixed bearing systems of frameworks and walls. Deep beams. Frame bearing systems. Foundation and retaining concrete reinforced structures. Structural elements of masonry. Examples of design. Masonry work. Materials and their storage.

Preparation of mortar and concrete for infill. Construction of masonry and concreting of infill. Protection of newly erected masonry. Masonry work categories. Masonry structures in seismic areas. Materials and masonry bond. Design models. Examples. Simple design rules for masonry buildings. Rules for seismic areas. Stability and robustness. Wall thicknesses. Strengthening of masonry structures. Structures damaged in earthquakes. Building heritage. Bonds of masonry structure elements. Research work. Examples. Practical work: during semester students will make project for design of one masonry structure. During semester there will be one mid-term exam. / *Compulsory references:* Tomičić, I. Betonske konstrukcije. Zagreb : Društvo hrvatskih građevinskih konstruktora, 1996.; Tomičić, I. Priručnik za proračun armiranobetonskih konstrukcija. Zagreb : Društvo hrvatskih građevinskih konstruktora, 1996.; Sorić, Z. Zidane konstrukcije (drugo, prošireno izdanje). Zagreb : vl. nakl., 2004. / *Optional references:* Hrvatske norme HRN ENV 1992, norme za betonske konstrukcije (Eurokod 2); Hrvatske norme HRN ENV 1996, norme za zidane konstrukcije (Eurokod 6), Hrvatske norme HRN ENV 1991, norme za opterećenja konstrukcija (Eurokod 1); Hrvatske norme HRN ENV 1998, norme za seizmička područja.

21788 Metal Structures III (2+2) 6,0

Theory of plasticity for steel structures: Modelling of steel structures, Analysis and dimensioning of frame systems. Classification of frames. Elastic critical load of frame for a laterally movable mode. Imperfections of frames. Methods of global elastic frame analysis. Methods of global plastic frame analysis Analysis and classification of connections. Modelling of actions on structures. Halls with the traffic of cranes. A hall project according to the Eurocode 3. Special types of steel structures. Bearing systems of steel structures. / *Compulsory references:* Androić, B.; Dujmović, D.; Džeba, I. Metalne konstrukcije 3. Zagreb : IA Projektiranje 1998.; Androić, B.; Dujmović, D.; Džeba, I. Metalne konstrukcije 4. Zagreb : IA Projektiranje 2003.; Androić, B.; Dujmović, D.; Džeba, I. Modeliranje konstrukcija prema EC3. Zagreb : IA Projektiranje 2004., Separati predavanja nastavnika. / *Optional references:* Davies, J.M.; Brown, B.A. Plastic Design. Blackwell Science 1996.

21789 Timber Structures II (2+2) 6,0

General review of timber structures: historical development, systems, methodology. Wood as a material: full wood properties, laminated gluelam wood and wood-based plates; timber classification in structural engineering. Fire fighting safety, protection and durability of timber structures. Design procedures of timber

structures: relevant standards and EUROCOD 5 Joints in timber structures: nails, screws, picks, timber bolts, clamps, glues, patented connectors, connectors with thin sheets,. Bearing capacity of joints according to relevant regulations and EC5. Complex cross sections: compressive elements and prone bending elements. Yielding.Traditional timber carpentry structures. Principles of members design, shaping and detail design of members joints. Traditional and current roofings. Truss girders. Design principles, shaping and detail design in traditional and present performance. Force transfer in detail design. Laminated girders: fundamentals of standard laminated girders dimensioning of parallel and trapezoid shaped girders. Design and characteristic details. Design basics of plane frame systems. Design principles, detail design. Spatial stability of timber structures. / *Compulsory references:* Bjelanović, A.; Rajčić, V. Drvene konstrukcije prema europskim normama. Zagreb : Hrvatska sveučilišna naklada, 2005.; Žagar, Z. Drvene konstrukcije I i II. Zagreb : Pretei d.o.o. 2002.; Žagar, Z. Drveni mostovi. Zagreb : Pretei d.o.o, 2003. / *Optional references:* DIN 1052: Teil 1, Teil 2, Teil 3, Teil 4, 2000.; Informationdienst Holz: Düsseldorf, 1995.; Halas, R.; Scheer, C. Holzbau-Tachenbuch . Berlin : IES Verlag, 2000.; Gütz-Mohler_Natterer. Holzbauatlas. München : CMA, 1999.

21790 Durability of Structures I (2+2) 6,0

Basic definitions in durability of structures. Calculation of optimal life span of structures. Sources of deterioration. Destruction mechanisms of structure durability. Influence of design on durability. Influence of construction on durability. Environment actions and its influence on durability. Methods of diagnostic for structures. Corrosion and its monitoring. Determination of remaining bearing capacity. Measures and procedures for protecting the structure. Lessons learned from disasters and collapses of structures. Durability in extraordinary circumstances. Preparation and temporary structures. Ethnical, ecological and aesthetic aspects. / *Compulsory references:* Radić, J.Trajnost konstrukcija II (skripta) / *Optional references:* Ryall, M.J. Bridge Management. Oxford : Butterworth Heineman, 2001.

21791 Precast Reinforced Concrete Structures (2+2) 6,0

What is precast concrete. Materials used in precast concrete structures. Precast frame analysis. Precast floor structures. Precast beams. Columns and bearing walls. Horizontal floor diaphragms. Joint and connection. Precast column and precast beam connection. Connections in precast concrete structures. A student's programme should feature a characteristic attitude with regard to

material, concept and construction mode. / *Compulsory references:* Separati s predavanja i auditornih vježbi; Twelmeier, H. Betonfertigteilkonstruktionen, TU Hannover, 1973.; Mokk, L. Montagebau in Stahlbeton, Akademiai Kiado, Budapest, 1968.; Elliott, K.S. Precast concrete structures, Butternwoorth-Heineman, 2002.; Elliot, K.S. Multi-storey precast concrete framed structures, Blackwell Science, 1996.; Seismic design of precast concrete building structures, State of art, FIB, October 2003. / *Optional references:* Precast concrete in mixed construction, State-of-art , FIB, June 2002.; Floor Connections – Precast Concrete Connection Details, Beton – Verlag, Düsseldorf, 1981. Structural Design Manual – Precast Concrete Connection Details, Beton – Verlag, Düsseldorf, 1978.

21793 Concrete Structures III (2+2) 6,0

Engineering buildings: brief revision of the subject "Concrete and Masonry Structures II". Hooped columns : columns hoped with spiral reinforcement ; steel enveloped columns (concrete column in steel tube) ; repair of columns with FRP – sheets. Silos: design; reinforcing and execution. Shells: barrel shells; conic roofs; polygonal shells. Domes: ribbed; conoidal; shallow. Fans: flexural and engineering theory of design. Bunkers: design and reinforcement. Water tanks and water towers of spherical and rectangular cross section. Overview of non-standard structures: underground structures ; landing stages ; locks ; shipyard ramps ; high rise reinforced concrete structures. Structural design, Design with respect to fire load according to HRN ENV 1992-1-2. Introduction to scientific work: minimal and maximal armature of reinforced concrete structures; fundamentals of usage of non-metallic armature in new concrete structures; arheology of concrete and arhelogical models of concrete structures; analysis of plastic connection and design of ductility of plastic connection; high strength concrete, analysis and usage in structures; micro-reinforced concrete, analysis and usage; FRP – a material for strengthening of structures. / *Compulsory references:* Tomičić, I. Betonske konstrukcije. Zagreb: Društvo hrvatskih građevinskih konstruktora, 1996.; Tomičić, I. Priručnik za proračun armiranobetonskih konstrukcija. Zagreb: Društvo hrvatskih građevinskih konstruktora, 1996.; Tomičić, I. Betonske konstrukcije – Odabrana poglavlja. Zagreb, 1996. / *Optional references:* Hrvatske norme HRN ENV 1992, norme za betonske konstrukcije (Eurokod 2); Hrvatske norme HRN ENV 1991, norme za opterećenja konstrukcija (Eurokod 1); Hrvatske norme HRN ENV 1998, norme za seizmička područja; Predavanja i vježbe; Objavljeni radovi u stranim i domaćim časopisima.

21794 Bridges III (2+2) 6,0

Arch bridges - detailing. Arch bridges - statical analysis. Arch bridges - construction. Frame and bracing type bridges, statical analysis. Composite bridges (concept and statical analysis). Cable stayed bridges (detailing and statical analysis). Cable stayed bridges (erection). Suspension bridges. Integral bridges. Special erection methods in bridge engineering: cantilever methods, longitudinal launching methods. Statical analysis and detailing of substructures. Construction of substructures. Achievements and limits reached design, construction. / *Compulsory references:* Horvatić, D.; Šavor, Z. Metalni mostovi. Zagreb : HDGK, 1998.; Radić, J. Masivni mostovi – skripta / *Optional references:* Šram, S. Gradnja mostova. Zagreb : Golden marketing, 2002.

21870 Structural Testings (2+1) 4,5

Introduction. Purpose of testing of structures. Classification of tests. Research and investigation. Inspection. Mechanical and geometric sizes measured at testing of structures**.** Absolute displacement of structural point. Change in the distance of structural points (strain). Rounding angle. Bent. Relative strains. Measuring tools for mechanical and geometric values. Tools elements. Augmentation. Precision. Reliability. Hysteresis. Sensitivity. Guaging area. Measuring tools for displacement, changes in length (strain gauges), angle alteration, change of bent. Guaging of tools. Tensometry. Tensometry types: mechanical, optical and mechanical, optical, acoustic, electrical. Electroresistive strain gauges (EOT). Types. Ways of installation and connection. Measuring instruments systems. Creation of supporting devices for gauging displacement, acceleration, thrust force etc. Analysis of plane state stress by strain gauging**.** Uniaxial stress state. Biaxial stress state. Biaxial stress state with known major directions of stress. General biaxial stress state. Rosette. Mohr s strain circle. Triaxial strain state and stress state. Relevant methods of strain state and strain of structures analysis and their members. Photoelasticimetry. Moire method. Procedure with brittle waves. Hollographic methods. Geodesic surveys. Modeling. Procedures of material checks and characteristics of tested structure. Hollowing out of cores. Utrasound. Sclerometry. Radiographic recording. Static testing of structures. Design. Performance. Modes of loading. Results evaluation. Norms and conditions of structure validity. Dynamic testing. Design. Performance. Modes of measured loading and values. Dynamic parameters of structures. Measuring outcome assessment. Norms. / *Compulsory references:* Kiričenko, A. i sur.: Mjerenje deformacija i analiza naprezanja konstrukcija, DIT-Zagreb, Zagreb, 1982.; Alfirević, I., Jecić, S.: Fotoelasticimetrija, Liber, Zagreb, 1983. / *Optional references:* Brčić, V., Čukić, R.: Eksperimentalne metode u projektiranju

konstrukcija, Građevinska knjiga, Beograd, 1988.; Aničić, D.: Ispitivanje konstrukcija, Građevinski fakultet SvSveučilišta u Osijeku, Osijek, 2002.

21880 Dynamics of Structures (2+1) 4,5

Survey of dynamic impact on structures. System vibrations with one degree of freedom. System vibrations with more degrees of freedom. Resonance impact. Problem of eigenvalues. Stodola-Vianello method. Design recommendations. Quasi static building design. Spectral building design. Introduction into building calculation by excitation of an accelogramme. Interpretation of prescribed rules. Auditory practice: General information for solving each unit making up programme tasks. Design practice: Realization of auditory practice with computer. Construction practice: Every student will be aided in design practice. Seminar: Final assignment presentation. / *Compulsory references:* A. Mihanović: *Dinamika konstrukcija*, Split, 1995. / *Optional references:* R. W. Clough, J. Peinzien: *Dynamics of Structures*, McGraw-Hill, New York, 1993.; A. Chopra: *Dynamics of Structures,* Prentice Hall, New Jersey, 1995.

21798 Special Engineering Structures (2+1) 4,5

Towers and masts. Chimneys. Structures for covering large areas : shells; domes; compressive and pneumatic structures. Sports facilities structures. Submarine structures. Structures above water. Movable structures. Pontoons. / *Optional references:* Walther, R. Bauen mit Beton. Ernst and Sohn, 1997.; Kelkar, V.S.; Sewell , R. T. Fundamentals of the Analysis and Design of Stell Structures. Prentice-Hall, 1987.; Irvine M. Cable Structures. MIT Press, 1981.

21799 Composite Structures (2+1) 4,5

Types and development of composite structures. The concept of effective width of concrete plate. Behaviour in positive and negative bending moment. Computational methods of internal forces and bending moment. Reliability proof for limit state and serviceability limit state. Resistance of bond with various types of Connection strength for various types of dowels. Types of composite plates. Reliability proof for ultimate limit state and serviceability limit state with plates. Composite column types. Dimensioning of columns, cross section resistance and the problem of beam buckling. Assurance the connection between steel and concrete parts of elements. Connection in composite structures. Fire protection. Structural details. / *Compulsory references:* Horvatić, D. Spregnute konstrukcije čelik-beton. Zagreb : Masmedia 2003.; Separati s predavanja. / *Optional*

references: Vayas, I. Verbundkonstruktionen auf der Grundlage des Eurocode 4. Ernst und Sohn 1999.

4.2.3.2. ELECTIVE SUBJECTS

21795 Stability of Structures (2+1) 4,5

General criteria for elastic stability. Estimation methods for critical load. Global and local instability of structural elements. Iterative methods for solving stability problems. Impact of imperfection on stability of structural elements and systems. Stability of structural elements under complex stress. Stability of real structural elements. Stability of real frame systems. Stability of real plates. Stability analysis of shells. Stability problems of systems with opening of plastic connections. Stability in European norms. Special problems of structural stability. Practical examples. / *Compulsory references:* Skripta iz stabilnosti konstrukcija, Građevinski fakultet Zagreb. / *Optional references:* Čaušević, M. Statika i stabilnost konstrukcija. Rijeka : Građevinski fakultet 2004.

21796 Durability of Structures II (2+1) 4,5

Programs for management of structures. Database. Maintenance methods. Modeling of durability of structures (numerical methods). Modeling of durability of structures (detailing). Integral bridges. Detailing important for structure durability. Reconstruction methodology after considerable deterioration. Strengthening of structures. Rehabilitation of structures. Adaptation and reconstruction of structures. Removal of structures, recycling. / *Compulsory references:* Radić, J. Trajnost konstrukcija II (skripta) / *Optional references:* Ryall, M.J. Bridge Management. Oxford : Butterworth Heineman, 2001.

21797 High - rise Buildings (2+1) 4,5

Overview of most famous high - rise buildings. Bearing structures of high - rise buildings. World achievements. World achievements of reinforced concrete high - rise buildings. Characteristics of engineering materials in high RC buildings. Basics of RC seismic design of high - rise buildings. Seismic resistance of RC high - rise buildings. Comparison of seismic forces in high - rise buildings and low buildings. Dimensioning for aircraft impact. Reinforced concrete cores and columns. Types of floor structures. Serviceability limit state. Problems of foundation work. Application of concrete of high and very high performance. / *Compulsory references:* Pičulin, S.; Mekjavić, I. *Visoke zgrade* CD s predavanjima.

Zagreb, 2004-2005. / *Optional references:* Hiroyuki Aoyama. Design of Modern Highrise Reinforced Concrete Structurec. London : Imperial College Press, 2001.

21800 Earthquake Engineering (2+0) 3,0

Earthquake. Modal analysis: time history and response spectra. Regulations. Ductility. Problem of critical direction work of earthquake and appropriate extrem interior forces of construction. New methods for seismic protection of structures. Active and passive protection of structures. The most often seismic isolation systems. / *Compulsory references:* Separati s predavanja; Čaušević, M. Potresno inženjerstvo. Zagreb : Školska knjiga, 2001.; Chopra, A.K. Dynamics of structures, Theory and applications to earthquake engineering. New Jersey : Prentice Hall, Engle Wood Cliffs, 1995.; Chopra, A.K. Dynamics of structures a primer. Eartquake engineering research institute, 1985.

4.2.4. CONSTRUCTION MATERIALS PROGRAMME

4.2.4.1. OBLIGATORY SUBJECTS

21808 Theory and Technology of Concrete (2+2) 6,0

Introduction: Hardened concrete properties and their significance. Modelling of concrete properties. Conditions of stress in concrete. Types of strength. Dymensional stability. Durability: Influences – special durability loads; Resistance to special durability loads – durability properties of concrete ; Durability properties of concrete – penetrating properties (absorption, diffusion, permeability). Fresh concrete. Fresh concrete properties. Components of concrete composition: Cement; Aggregate; Water; Additives. Cement: Production; Hydration; Hydration mechanism; Setting; Hardening; Special hydraulic cements; Cement quality assurance. Aggregate: Types of aggregate; Significance of intermediate layer of aggregate-cement; Significance of texture, mineralogy and grain size distribution; Quality control. Water: Function of water in concrete composition; Influence of water content on properties of concrete. Additives: Types of additives; Significance of additives for properties of concrete: Mechanism of additive action. Design of concrete composition. Transport and placing of concrete. Curing. Progress in technology of concrete: New types of concrete; New components in concrete composition; Improved properties of concrete. Progress in mechanics of concrete. Future of concrete. Project of concrete. / *Compulsory references:* Ukrainczyk, V. Beton – struktura, svojstva, tehnologija, Alcor, Zagreb, 1994.; Mehta, P. K., Paulo J. M. Monteiro Concrete, Microstructure, Properties and Materials, 2001, http://www.ce.berkeley.edu/~paulmont/book.pdf; Neville A. M. Properties of Concrete, Prentice Hall, 1995.; Bjegović D. i dr. Auditorne Practice, Praktikum, Aktivna nastava, Građevinski fakultet Sveučilišta u Zagrebu, 1994.; Đureković, A. Cement, cementni kompozit i dodaci za beton, Školska knjiga, Zagreb, 1996. / *Optional references:* Ashby, M. F., Jones, D. R. Engineering Materials 1, Butterworth Heinemann 1996.; Illston, J. M.; Domone P. L. J. (ed.) Construction materials – their nature and behaviour, E & FN SPON Chapman & Hall, 1994.; Maekawa, K.; Chaube, R. P.; Kishi, T. Modelling of Concrete Performance, Hydration, Microstructure and Mass Transport, Spon Press, 2000.; Dewar, J. Computer Modelling of Concrete Mixtures, Spon Press, 2000.

21809 Building Physics (2+2) 6,0

Introduction: Transport processes; Electric conductivity; Thermal conductivity. Heat: basic concepts of science on heat; heat transmission – conduction, convection, radiation; Thermal conductivity of construction materials; Thermal insulation of construction elements; Thermal curve; Heat Accumulation. Humidity: humid air; Condensation of water vapour on the internal surface of the outside elements of structures; Thermal bridges; Diffusion of water vapour through construction elements; Radiation of the sun; Thermal stability of external construction elements. Acoustics: Physical i psycho physical properties of sound; Sound waves in confined space; Transmission of airborne sound from room to room; Sound shock transmission from room to room; Noise; Sound insulation ; Calculation methods for sound insulation. Urban building physics; Emission of gases; Protection of air; Noise protection. Energy : Technologies of renewable energies; Consulting. Contents of auditory exercises. Examples of assignement solution. Introducing the standards of building physics. Design project phases. Description of construction practice. Individual execution of all phases of design project. Description of laboratory practice. A visit to a building physics laboratory. Conductiong an experiment. Interpretation of results. / *Compulsory references:* Šimetin, V. Građevinska fizika, Građevinski institut, Fakultet građevinskih znanosti Sveučilišta u Zagrebu, Zagreb 1983.; Galović, A. Nauka o toplini II, FSB, 1997.; *Optional references:* Brandt, J.: Bauphysik nach Maβ, Beton-Verlag GmbH, Dűsseldorf, 1995.; Cammerer, W. F.: Wärme-und Kälteschutz, Springer-Verlag, Berlin, 1995.; Hagentoft, C. E.: Introduction to Building Physics, University of Technology, Sweden, 2001.

21875 Polymers (2+1) 4,5

General information on polymers: history; polymeric materials in construction; composition; procedures of creation: polymerisation, polycondensation, polyaddition, combined procedures; classification of polymeric materials on the basis of physical properties, conditions of processing, application. Major types of polymeric materials in construction of buildings. Processing: vulcanisation; extrusion; rolling; pouring; pressing; coalescence; blowing; laminating; coiling; sprinkling. Properties. Mechanical properties: static and dynamic load; long-term and short-term load; fatigue; temperature related properties; delayed stresses and brittle failure; permanent deformations; boundary states at one-way and multi-way stresses; weather related properties; theory of linear and non-linear viscoelasticity; rheology 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. Reinforced polymeric materials: types; properties; production. Foam polymeric materials: types; properties; production. Application of polymeric materials in construction of buildings: wall and roof elements; pipes and fitting elements; domes, shells and diaphragms; geosynthetic materials; sandwich elements; polymeric mortars and concretes; surface protection; waterproofing; environmental protection; supports; sealings; vibration and earthquake resistant insulation; design, production and installation. Polymeric materials in structure repair and maintenance., proizvodnja i ugradnja. Polimerni materijali u sanaciji i održavanju konstrukcija. *I Compulsory references:* Šimunić, Ž.: Polimeri u građevinarstvu, skripta, Zagreb, 2005./ Feldman, Dorel: Polymeric Building Materials, Elsevier Applied Science, London and New York 1989./ Schieβl, P. Kunststoffe, TUM, München, 2002. / *Optional references:* Ramberger, G.: Structural Bearings and Expansion Joints for Bridges, IABSE-AIPC- IVBH, Zürich, 2002./ Williams, J. G.: Stress Analyssis of Polymers, John Wiley&Sons London, 1980.

21862 Mechanics of Material (2+1) 4,5

The impact of a construction material structure on mechanical properties of a material. Probabilistic character of mechanical properties and sensitivity structure. Theory of selectivity and theory of addition. 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 materials. Brittle materials. Real material chart. Anisotropy of mechanical properties. Idealization of work material chart. Elastoplastic material with strengthening ideally elastoplastic material, solid plastic material, solid and plastic material with reinforcement. Impact of external factors 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. Strength of material in dynamic loading. Types of dynamic loading. Impact strength or material ductility. External factors affecting the impact strength of material. Testing procedures. Strength of material in cyclically changeable loading. 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. 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. 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./ *Compulsory references:* Šimić, V.: Otpornost materijala II, Školska knjiga, Zagreb, 2002. / *Optional references:* Bazjanac, D.: Nauka o čvrstoći, Tehnička knjiga, Zagreb, 1967.; Lemotive, J., Chaboche, J-L.: Mechanics of Solid Materials, Cambridge University Press, Cambridge, 1990.; Timošenko, S.: Otpornost materijala II, Građevinska knjiga, Beograd, 1965.; Timošenko, S.: Mechanics of Materials, Van Hostrand Reinhold Company, New York, 1972.

21864 Theory of Elasticity and Plasticity (3+2) 7,5

Introduction and definition of deformability continuum (History and classification of continuum mechanics) Basics of vector and tensor calculus (Euclid's E³space, Transformations of coordinates, Operations with tensors). Model of material continuum deformation (Lagrange's and Euler's principles of body deformation) Stress tensor and its properties. (Stress state surrounding the point, Equilibrium equation, Statical acceptability, Component transformations, Eigen values). Deformation tensor and its properties (Displacement and deformity gradients, Finite deformations, Infinitesimal deformations, Kinematic acceptability, Compatibility equation). State and constitutive equations (Laws on states, Material rigidity and flexibility tensor, Potential of linear-elastic body). Boundary phenomena in theory of elasticity and their solutions (Boundary phenomenon formula, solutions and their properties). Potential energy of solid deformable body and energy principles and theorems. Numerical procedures applied in solving boundary phenomena in theory of elasticity. Plane conditions in theory of elasticity (Plane stress and deformation, Airy function of stress in rectangular and polar coordinates, Solution properties of plane phenomena and some potentials of boundary phenomena). Space phenomena in theory of elasticity (Torsion, Semi-space, Thin boards). Introduction to theory of plasticity and basic criteria of plasticity (Plasticity models, Principles of plastic flow, Plasticity constant). Constitution laws in material flow theory (Misses-Levy and Prandtl-Reuss equations, Incremental procedures in flow theory). Some potentials of plasticity. / *Compulsory references:* Z. Kostrenčić,: Teorija elastičnosti, Školska knjiga, Zagreb, 1982.; J. Brnić: Elastomehanika i plastomehanika, Školska knjiga, Zagreb, 1996. / *Optional references:* S. Timošenko: Teorija elastičnosti, Građevinska knjiga, Beograd, 1962.; Y. A. Amenzade: Theory of Elasticity, MIR Publishers Moscow, 1979.; G. E. Mase: Theory and Problems of Continuum Mechanics, McGrow-Hill Company, 1970.

21810 Durability of Structural Materials (2+2) 6,0

Introduction: general facts on durability; corrosion; destructions; special durability loads. Metals: mechanisms of metal corrosion; types of metal corrosion; methods and measuring instruments applied in determining the condition of metals; Methods of metal protection. Concrete: mechanisms of concrete destruction; types of concrete destruction; methods and measuring instruments applied in determining the condition of concrete; methods of concrete protection. Wood: mechanisms of wood destruction; types of wood destruction; methods and measuring instruments applied in determining the condition of wood; methods of wood protection. Stone, glass, polymers: destruction mechanisms of stone, glass, polymers; types of stone, glass and polymeric destruction; methods and measuring instruments applied in determining the condition of stone, glass, polymer; methods of protecting stone, glass and polymers. Masonry: destruction mechanisms of masonry destruction; types of destruction; Methods and measuring instruments applied in determining the condition of stone, glass, polymers; protection methods of stone, glass and polymers. New highly resistant materials: concrete with high durability properties; high durability steel; composite polymeric materials of high durability. Durability design strategy: design with set service life; various models of designing durability; probabilistic method of service life design; the expense of total service life. Maintenance strategy: influence parameters; inspections; prevention; maintenance models. Repairs: analysis of condition; diagnosis; repair measures; strengthening; decision methods. Technical legislature within quality assurance system: standards for evaluation of construction material condition; standards for evaluation of efficacy of various protection types. Practice description. History of corrosion: metal corrosion; examples of metal protection. Visits to laboratories for corrosion and protection. Subsequent quality evaluation of concrete. Evaluation methodology of concrete condition: measurements with the purpose of damage evaluation on concrete. Corrosion of reinforcement. Laboratory work. Field work. Examples of reinforced concrete protection. Modeling the durability of reinforced concrete. Protection design. Repair design. / *Compulsory references:* Bijen, J. Durability of Engineering Structures, CRC Press, Woodhead Publishing Limited, Cambridge, England, 2003.; Mays, G. Durability of Concrete Structures, E & FN Soon, London, 1992.; Bentur, A.; Diamond, S.; Berke, N. S. Steel Corrosion in Concrete, E & FN Soon, London, 1997.; Maekawa, K.; Rajesh, P.; Chaube and Kishi, T., Coupled Mass Transport, Hydration and Structure Formation Theory for Durability Design of Concrete Structures, http://concrete.t.utokyo.ac.jp/en/demos /ducom/brieftheory/ consec1.html. / *Optional references:* Schütze, M.; Cahn, R. W.; Haasen, P.; Kramer, E. J.: Corrosion and Environmental Degradation, 2 Volume Set**,** John

Wiley &Sons, Ltd., 2000.; Roberge, P. R.: Handbook of Corrosion Engineering, McGrow – Hill, New York, 2000.

21811 Special Concrete and Technologies (3+2) 7,5

Special concretes: types, production, application, properties, composition, quality control. Types of special concrete: lightweight concrete; heavyweight concrete; fibre reinforced concrete; self-compacting concrete; hydrotechnical concrete; massive concrete; roller-compacted concrete; concrete with controlled low strength; polymer modified concrete and mortar; shaterete concrete; grouting; concrete in tunnels; concrete of high strength; high performance concrete; repair concrete and mortar. Special technologies: Introduction: types of special technologies for production of concrete; accelerated maturation; concreting in extreme weather conditions; concreting under water; prepacked concreting; industrial floors; injection technologies; production technology of shaterete concrete. Practice description. Calculation of concrete heating by hydration. Calculation and testing the crack occurrence in deformation restraint concrete. Protection of concrete in extreme conditions. Design of special concrete composition. Production and testing of special concrete: lightweight concrete, fibre reinforced concrete, self-compacting concrete, polymer modified mortar, grout. Individualized execution of all phases of concrete project. / *Compulsory references:* Neville A. M.: Properties of Concrete, Prentice Hall, 1995.; Ukrainczyk, V.: Beton – struktura, svojstva, tehnologija, Alcor, Zagreb, 1994.; ACI Manual of concrete Practice, 2004.; Spiratos, N.; Page, M.; Mailvaganam, N.; Malhotra, V. M.; Jolicoeur, C.: Superplasticizers for Concrete – Fundamentals, Technology and Practice, Supplementary Cementing Materials for Sustainable Development Inc., Ottawa, Canada, 2003.; Aitcin, P. C.: High-Performance Concrete, E&FN SPON, London, 1998. / *Optional references:* Opći tehnički uvjeti za radove na cestama, IGH Zagreb, 2001.; Ohama, Y.: Handbook of polymer-modified concrete and mortars, properties and process tecnology, Noyes Publications, 1995.; Spiratos, N.; Page, M.; Mailvaganam, N.; Malhotra, V. M.; Jolicoeur, C.: Superplasticizers for Concrete – Fundamentals, Technology and Practice, Supplementary Cementing Materials for Sustainable Development Inc., Ottawa, Canada, 2003.; Composite Materials in Concrete Construction, Proceedings of the International Seminar held at the University of Dundee, Scotland, UK, 5-6 September 2002, ed. Dhir, R. K.; Paine, K. A. and Newlands, M. D.; Concrete Floors and Slabs, Proceedings of the International Seminar held at the University of Dundee, Scotland, UK, 5-6 September 2002, ed. Dhir, R. K.; Paine, K. A. and Newlands, M. D.

21787 Concrete Structures II (2+2) 6,0

Composite slabs. Complex slabs. Flat slabs, triangular slabs, slabs supported on two adjoining borders, slabs with opening. Design, theoretical concepts, legal regulations. Torsion of reinforced concrete sections. Serviceability limit states. Creep and shrinkage of concrete. Beam deflections. Crack design according to PBAB and EC2. Minimum slab and beam reinforcement for crack limitations. Deflection design according to PBAB and EC2. Slender columns**.** Elements under longitudinal force and bending moment. Design according to 2nd order theory**.** Interaction diagrams. Jackson&Moreland's diagrams for calculation of slenderness. Biaxial bending of columns. Hollow columns. Local compressive stresses. Short cantilevers. Joints and hinges of frameworks. Bearing systems of reinforced concrete walls. Full walls and walls with openings. Mixed bearing systems of frameworks and walls. Deep beams. Frame bearing systems. Foundation and retaining concrete reinforced structures. Structural elements of masonry. Examples of design. Masonry work. Materials and their storage. Preparation of mortar and concrete for infill. Construction of masonry and concreting of infill. Protection of newly erected masonry. Masonry work categories. Masonry structures in seismic areas. Materials and masonry bond. Design models. Examples. Simple design rules for masonry buildings. Rules for seismic areas. Stability and robustness. Wall thicknesses. Strengthening of masonry structures. Structures damaged in earthquakes. Building heritage. Bonds of masonry structure elements. Research work. Examples. Practical work: during semester students will make project for design of one masonry structure. During semester there will be one mid-term exam. / *Compulsory references:* Tomičić, I. Betonske konstrukcije. Zagreb : Društvo hrvatskih građevinskih konstruktora, 1996.; Tomičić, I. Priručnik za proračun armiranobetonskih konstrukcija. Zagreb: Društvo hrvatskih građevinskih konstruktora, 1996.; Sorić, Z. Zidane konstrukcije (drugo, prošireno izdanje). Zagreb: vl. nakl., 2004. / *Optional references:* Hrvatske norme HRN ENV 1992, norme za betonske konstrukcije (Eurokod 2); Hrvatske norme HRN ENV 1996, norme za zidane konstrukcije (Eurokod 6); Hrvatske norme HRN ENV 1991, norme za opterećenja konstrukcija (Eurokod 1); Hrvatske norme HRN ENV 1998, norme za seizmička područja.

21814 Precast Systems (2+2) 6,0

General principles of production and construction with precast elements: history of precast construction. Advantages and disadvantages of precast elements: efficacy and economy of precast construction. Materials for precast construction. Types of concrete. Polymeric materials. Structural systems: skeleton systems; panel systems; spatial systems; mixed systems. Precast elements:

columns; walls; precast girders. Façade panels: thermal and acoustic properties of precast elements. Precast ceiling structures: hollow boards; ribbed boards; composite ceiling structures; massive boards. Unreinforced precast elements: concrete pipes; concrete furnishings; elements of civil engineering and hydraulic engineering; elements of building construction. Precast clay elements. Precasting plants: plant organisation; types of plants; equipment; automation in precasting plants. Storage, transport and assembly of precast elements: general rules; transient stability. Storage, transport and assembly equipment. Connections at precast structures: connections in building construction; connections in bridges; connections in tunnel construction. Connections on paneling. Sealing: types of sealing; sealing materials; durability of sealing. Robotics, economy and coordination between designer and producer: types of robots; efficacy of robots; economic aspects of industrial production; coordination among participants in precast construction. Ecolological aspects of precast construction: constructional applicability. Practice description. Types of joints. Design and production of joints in precast elements. Joints of skeleton systems in building construction. Joints in panel systems of building construction. Joints in ceiling structures. Joints in composite structures. Outline of special joints in precast elements. Examples of construction with precast elements. A visit to precast plants. Seminar papers. / *Compulsory references:* FIB Commission 6: *Planning and Design Handbook on Precast Building Structures*, 2004.; *PCI Design Handbook Precast and Prestressed Concrete*, Fifth Edition, 1999.; Elliot, K. S.: *Precast Concrete Structures*, Butterworth Heinmann, 2002.; FIB Bulletin no. 21: *Environmental issues in prefabrication*, State-of-art report, 2003. / *Optional references:* Elliot, K. S.: *Multi-storey precast concrete framed structures*, Blackwell Science, 1996.; FIB bulletin no. 19: *Precast concrete in mixed construction*, State-of-art report, 2002.

21815 Non-destructive Testings (2+2) 6,0

Planning of non-destructive testing: testing objective; selection of testing methods; equipment for non-destructive testing. Visual inspection: planning; methods of visual inspection; criteria of evaluation. Determination principles of material strength in construction: Schmidt hammer; penetration methods; Pull-off. Strength determination of fresh concrete. Procedures in determination of material deformability in construction: measurement procedures; advantages and disadvantages of methods; evaluation criteria. Principles applied in determining permeability properties: gas permeability; water permeability; determination of absorption. Testing diffusion. Testing with ultrasound methods: testing types ; advantages and disadvantages; application. Testing with electromagnetic methods: reinforcement detector; result processing; application. Electrochemical

testing applied in the assessment of steel reinforcement corrosion. Acoustic emission: history; measuring equipment; interpretation of results; applicability. Radar testing, thermography and radiography: testing procedures; advantages and disadvantages; application. Semi-destructive methods of testing: methods of semi-destructive testings; sample taking; laboratory testing procedures; evaluation of results. Regulations and standards regarding the application of non-destructive testings. Statistical processing and interpretation of testing results: decision criteria. Correlation of non-destructiove testing results. Application of non-destructive testings in research work. Practice description. Non-destructive testing program.Non-destructive strength determination. Non-destructive deformability testing. Measurement of the condition of steel reinforcement in AB construction. Testing concrete durability. Chemichal testing methods. Non-destructive testing of material for masonry structure, metal, wood, polymer. Combination of non-destructive and semi-destructive testing. Examples of processing and interpretation of testing results. Examples of non-destructive testing on existing structures: building construction; bridges; tunnels. Other structures. / *Compulsory references:* Malhotra, V. M.; Carino, N. J.: Handbook on Nondestructive testing of Concrete, Second Edition, CRC Press, 2004.; Proceedings from International Symposium Non-Destructive Testing in Civil Engineering, Berlin, 2003.; Bungey, J. H.; Millard, S. G.: Testing of concrete in structures, Blackie Academy & Professional, 1996. / *Optional references:* FIB bulletin no. 22, Monitoring and Safety Evaluation of Existing Concrete Structures, State-of-art report, 2003., Innovations in Non-Destructive Testing of Concrete, ACI International SP-168, ed. Pessiki S. And Olson L., 1997.

21816 Fire Protection (2+2) 6,0

Introduction: fire protection as essential requirement for structure. Definition of fire: fire expansion velocity; theories on processes of burning and fire extinction. Development of smoke: velocity of smoke expansion. Toxicity of smoke gases: reduction of visibility; human behaviour in fires. Impact of fire on properties of materials (concrete, metals, wood, brick, mortars, plastic, glass). Effects of fire on structure: calculation of structure resistance to fire. Outline of fire protection design. Passive fire protection/Active fire protection. Course description: Technical legislation on fire protection. A visit to laboratory for testing building materials' and elements' fire resistance. Execution of study on fire protection resistance of structure. Presentations of seminar papers and projects. A visit to a construction site. / *Compulsory references:* Buchanan, A. H: Structural Design for Fire Saftey, John Wiley&Sons Ltd., 2001.; NFPA: SFPE Handbook of Fire Protection Engineering, 1995.; Carević, M., Jukić, P., Kaštelanac, Z., Sertić, Z.: Tehnički

priručnik za zaštitu od požara, Zagreb, Grafo-Amadeus, 1997. / *Optional references:* prEN 1991-1-2: Eurocode 1: Basis of Design and Actions on Structures. Part 1.2: Actions on Structures Exposed to Fire; ENV 1992-1-2: Eurocode 2: Design of Concrete Structures. Part 1.2: General Rules: Structural Fire Design; ENV 1993-1-2: Eurocode 3: Design of Steel Structures. Part 1.2: General Rules: Structural Fire Design; ENV 1994-1-2: Eurocode 4: Design of Composite Steel and Concrete Structures. Part 1.2: General Rules: Structural Fire Design; ACI 216 R-89: Guide for Determining the Fire Endurance of Concrete Elements, 1994.; ACI 216.1-97/TMS 0216.1-97: Standard Method for Determining Fire Resistance of Concrete and masonry Construction Assemblies, 1997.; Council on tall Buidlings and urban Habitat: Fire Safety in tall Buildings, 1992.; Fitzgerald, R. W. : Building Fire Performance Analysis, John Wiley&Sons Ltd., 2004.; Drysdale, D.: An Introduction to Fire Dynamics, Second Edition, John Wiley&Sons Ltd., 1998.

21821 Numerical Modeling in Engineering Materials (2+2) 6,0

Continuum: continuity and preservation equation; constitutive equations of mass and energy transfer. Method of final differences: method of final elements; numerical algorithms; procedures of network generation. Procedures in solving linear and non-liner problems. Inverse methods: method of celular automats; celular. Automats and differential equations. Creation of cement and concrete virtual microstructure. Determination of mechanical and transportation properties by means of virtual microstructure. Expert systems. Neural shells. Fuzzy systems. Practice description. Numerical modeling of materials by use of computers. Problem solving by means of computer programs - Mathematica, COSMOS, NeuroShell, CIKS, VCCTL. / *Compulsory references:* Rappaz, M.; Bellet, M.; Deville, M.: Numerical Modeling in Materials Science and Engineering, Springer, 2002. / *Optional references:* http://ciks.cbt.nist.gov/monograf/; http://www. stephenwolfram.com/publication /articles/; NeuroShell2, Manual, Second Edition-November 1993.; Margolus, N.; Toffoli, T.: Cellular Automata Machines. A new environmet for modeling, MIT Press, 1987.; Raabe D.: Computational Materials: The Simulation of Materials Microstructures and Properties, John Wiley & Sons Inc 1998.

4.2.4.2. ELECTIVE SUBJECTS

21817 Technology of Repair and Strengthening (2+2) 6,0

Processes of material destruction: causes of damage ; essential properties of material durability. Diagnosis of the damaged structures' state: planning the diagnosis ; visual review ; field testing ; material sampling and laboratory testing ; analysis of test results. Non-destructive testing of damaged structures: determination of the structure strenght ; procedures in defomability testing; in situ determination of permeability; corrosion testing ; the analysis of test results. Repair or strengthening plan. Selection of repair material: criteria for selection of repair material ; testing material properties ; compatibility of repair and construction material. Methods of repair realisation: basic principles of repair realisation ; repair material preparation; repair of cracs ; surface repairs ; protective coating ; electrochemical methods ; stainless steel ; inhibitors of corrosion. Construction strengthening methods: strengthening materials. Repairs of historical structures. Special technologies of strengthening. Quality control: material control and control of systems in construction protection ; repair and strengthening realisation control ; structure repair and maintenance regulations and standards. Bacic principles of monitoring and maintenance of repaired structures. Contents of practice: Evaluation methods of the structure condition. Design of structure repair or strengthening. Testing the material for the repair. Method of selecting principles of the structure repair. Development of repair design. Testing the structure condition upon repair. Examples of various structure repair. / *Compulsory references:* Allen, R. T. L.; Edwards, S. C. *Repair of Concrete Structures*, Blackie & Son Limited, 1987., Emmons, P. H. *Concrete Repair and Maintenance Illustrated*, Construction Publishers & Consultants, 1993.; *Concrete Repair Manual*, ICRI & ACI International, 1999. / *Optional references:* Proceeding from International Conference Structural Faults and Repair 2003, London, 2003.; Mills, E.: Building maintenance & preservation, Architectural Press, Oxford, 1996.; Management, maintenance and strengthening of concrete structures, Technical report FIP Commission 10, 2002.

21818 Quality management (2+2) 6,0

Fundamental of Quality control (QC). Quality Assurance (QA) and Total Quality control (TQM): steps, principles, processes. Information systems. Organisation of laboratories and companies: by European standards and International quality standards from the series HRN (EN ISO 17250) and (HRN ISO 9000-2000). Levels of control in the following processes: planning-design, production-construction, usage-maintenance, reconstruction and re-usage-

maintenance. Analysis of parameters of Quality Assurance. Practice description. Execution of quality plan for construction materials. Plans for quality control material sampling. Execution of laboratory quality control manual. Defining processes in a company. Confomity evaluation of construction materials. Statistical methods in evaluating quality of materials. / *Compulsory references:* Skoko, H.: *Upravljanje kvalitetom*, Sinergija, Zagreb, 2000.; Kelly, J. M.: Upravljanje Totalm kvalitetom (Total Quality Management), Protecon, Zagreb, 1997.; Juran, J. M.; Gryn, F. M.: *Planiranje i analiza kvalitete*, Treće izdanje, Mate d.o.o., Zagreb, 1999.; Gitlow, H.; Gitlow, S.; Oppenheim, A.; Oppenheim, R.: *Tools and Methods for the Improvement of Quality*, Richard D. Irwin, Inc., 1989. / *Optional references:* Pauše, Ž.: Uvod u matematičku statistiku, Školska knjiga, Zagreb, 1993.; Mikulić, D.: Teorijski model osiguranja kvalitete betona, Disertacija, Građevinski fakultet Sveučilišta u Zagrebu, Zagreb, 1993.

21837 Work and Production Organization (2+0) 3,0

Organization of work. Scientific approach to the organization of work. Organization of production. Goals and scientific disciplines. Development stages of production organization. Traditional approach to organization. Functional, hierarchical and mixed organization model. Perennial values of traditional approach. Neo-classical approach to organization. Non-formal structural model of organization. System approach to organization. Structural and process approach. Diagnostic organizational model. Organization processes, levels, characteristics and measurements for the organization assessment. An application of diagnostic model in construction.Managerial approach to organization. Mintzberg, McKinsey and operational approach. Construction production. Characteristics and limitations of construction production. Structure and level of interrelatedness of building activities. Management of construction production. Goals, structure and information systems in construction production.. A worker in construction production. Psychological, physiological, sociological and ecological effects on production. Work study in construction production. Construction technological systems and processes. Basic factors and structure. Standardization of construction production. Application of work and materials standardization methods in construction. Rationalization of construction production. Types, methodology, models and algorithm for construction production rationalization./ *Compulsory references:* Marušić, J.: Organizacija građenja, FS, Zagreb, 1994. / Žugaj, M., Horvatec, Z.: Organizacija proizvodnje, Informator, Zagreb, 1985. / *Optional references:* Amstead, B.,H., Ostwald, P.,F., Bergman, M.,L.: Manufacturing Processes, John Wiley & Sons, New York, 1987.

21838 Production Technology of Materials (2+0) 3,0

Engineering and technology of production of stone chips, fresh concrete, concrete elements and systems, asphalt concrete and clay products. Quarries. Gravel pits. Excavation, transport and i processing stone materials. Blasting. Machinery and equipment used in excavation and transport of stone materials. Crushing machines. Screens. Crushing plants. Asphalt materials: organisation of asphalt works; asphalt concretes; poured asphalts; asphalt plants; plants for recycling crushed asphalt. Transported concretes: production and transport of fresh concrete; mixers; concrete plants; external transport of fresh concrete; truck mixers; truck-concrete pumps. Iron bending plants: machinery and technological equipment for production of bent concrete iron and production of bent concrete iron and reinforcing systems. Production of concrete elements: production systems and chains; production plants, machinery and other technology for production of concrete elements; technology of pressing, vibration, vacuuming, centrifuging and steaming; molds; vibrating tables; production production lines; moving tables. Clay pits: production plants, machinery and other technology for production of bricks, blocks and roofing tiles; clay crushers; mixers; presses; kilns; other producing-technological equipment for processing clay and producing ceramic products. / *Compulsory references:* www.grad.hr → djelatnici → dr. sc. Zdravko Linarić → Dokumenti raspoloživi za download: „Postrojenja za proizvodnju gradiva, I. dio, Drobilane, Tvornice betona (betonare), Asfaltne baze (asfaltna postrojenja)“ / *Optional references:* Bučar, G.: *Tesarski, armirački i betonski radovi na gradilištu,* Građevinski fakultet J. J. Strossmayera u Osijeku, 1997.; Turina, N.: *Tehnologija s poznavanjem robe,* Narodne novine, Zagreb, 1988.

21785 Metal Structures II (2+2) 6,0

Properties of steel structures. Architecture and steel. Economic parameters of construction in steel. Design procedure – higher level. Introduction to engineering reliability. Fatigure – dimensioning. Compound compressed elements. Stability of web plates due to transverse stresses. Thin walled profile structures.Design of plate elements and plate girders. Spatial structures systems. Bearing systems of multi storey buildings. Cable structures. Details of steel structures. / *Compulsory references:* Androić, B.; Dujmović, D.; Džeba, I. Metalne konstrukcije 3. Zagreb : IA Projektiranje 1998.; Androić, B.; Dujmović, D.; Džeba, I. Metalne konstrukcije 4. Zagreb : IA Projektiranje 2003.; Androić, B.; Dujmović, D.; Džeba, I. Modeliranje konstrukcija prema EC3. Zagreb : IA Projektiranje 2004. / *Optional references:* McKenzie, W. C. Design of Structural Steelwork. Macmillan 1998.

21812 Design of experiments (2+2) 6,0

Modeling of physical phenomena, numerical solutions and programming of physical models. Planning and design of experiment: selection of instruments; statistical design; construction of instruments. Electrical measuring of non-electrical values: computerised automation of measuring. Technical research literature: important journals on civil engineering, materials. Practice description: Defining experiments. Selection of instruments. Result analysis. Independent execution of tasks with description of typical examples and demonstration. / *Compulsory references:* Hicks, C. R.: Fundamental Concepts in the Design of Experiments, Holt, Reinhart and Winston, Inc., 1973.; Ashby, M. F., Joneas, D. R. H.: Engineering Materials 1, Butterworth-Heinemann, Oxford – Boston – Johannesburg – Melbourne – NewDelhi – Singapore, 1996.

21813 High Performance Concrete (2+2) 6,0

History: basic principles of HPC production. Rules on selection of integral components: cement; cement additions; aggregate ; additives; compatibility of components. Methods of composition design: basic dependences in system design; quantitative system design; quality system design. Technology: production; external and internal transport; placing; curing. Structure of HPC: relation of composition and properties; butt joint of aggregate and cement stone. Behaviour of fresh concrete: testing properties of fresh concrete; minimizing the influence of autogenous shrinkage. Methods in testing properties: strength; modulus of elasticity; working diagram; deformation characteristics. Properties of durability. Mechanical characteristics: behaviour under pressure and bending; modulus of elasticity; shrinkage; creep; fatigue. Durability of HPC: causes of damage; properties relevant to durability. Regulations and standards on testing. Special types of HPC: fibre reinforced concrete of high properties; light concretes; self-compressing; heavy concretes. Constructional application: applicability in structures; examples of use in various structures. Practice description: Determining properties of integral components of HPC. Selection of materials for HPC depending on required properties. Sequencing in concrete mixture design. Special features of PHC technology. Quality control. Testing properties in fresh and hardened state. Non-destructive testing of HPC. Long-term behaviour of HPC. Designing the composition of special types od HPC. Testing properties of special types of HPC. / *Compulsory references:* Nawy, E.: Fundamentals of high – performance concrete, Second edition, John Wiley&Sons, Inc., New York, 2001.; Aitcin, P. C.: High-Performance Concrete, E&FN SPON, London, 1998.; Proceedings from International Symposium on Utilization of High Strength /High Performance Concrete, University of Leipzig, 2002. / *Optional references:*

Naaman, A. E.; Reinhardt, H. W.: High Performance Fiber Reinforced Cement Composites 2 (HPFRCC 2), E & FN Spon, 1996.; ACI SP-189: High Performance Concrete: Research to Practice, 1989.

21792 Applied metallurgy (2+2) 6,0

Properties of carbon steel alloys. Production and design procedure. Introduction to engineering properties of steel. Toughness properties. Material fatigue properties. General information on types and qualities of steel. Testing methods in documenting quality. High quality steels in accordance with Eurocode 3. Weldability of construction steels. Constructional durability analysis based on fracture mechanics. Practice description. Weldability tests. Hardness testing applied in determination of mechanical characteristics of welds. properties . Selection of high-quality steel groups. Durability analysis based on fracture mechanics. / *Compulsory references:* Skripta predavača. */ Optional references:* McGannon, H. E. The Making, Shaping and Treating of Steel, 1985.; Brockenbrough, R. L. Metallurgy Chapter 1.1, Constructional Steel Design, an International Guide, 1992.: Leslie, W. L. The Physical Metallurgy of Steels. Washington, New York, London : Hemisphere Publishing Corporation, 1981.; Dahl, W.: Steel-Handbook of Materials Research and Engineering Vol. 1. Duesseldorf : Springer-Verlag, 1990.

4.2.5. CONSTRUCTION MANAGEMENT PROGRAMME

4.2.5.1. OBLIGATORY SUBJECTS

21823 Construction Management II (2+2) 6,0

Elaboration of variant solutions in organization of construction: Work rationalization measures, Procedure of variant solutions elaboration, Working processes harmonization. Analysis and grading of variant solutions, Examples. Theory of costs and time issues: Significance theory principle, Selection of significant costs issues in the list of expenses. Application of costs significance theory in variants elaboration. Methods of direct calculations of construction costs and prices: international calculation standards in construction (examples of methods from the USA, GB, G), Direct and indirect construction costs calculation, Tender calculation, Contract calculation and costs management, Computer application in price calculation). Connecting of money and construction time: Exactness of costs estimations in time, Money flow in project, Costs – time models, working capital of executor, Changes impact on costs in project, Statement of accounts in prices. Value management in construction (VM): Integrated costs management in the life span of projects, VM concept, VM uses, VM methodology, VM programme execution control, VM application problems. Development of work structure and construction management (WBS and OBS): WBS tasks and structure, WBS distribution method, WBS markings and levels, WBS elaboration in construction projects, OBS structure in construction projects, Connecting of work structure and organization. Supply and logistics organization in construction process (SL): Fragmentation of construction process, SL definition, Problem of SL complexity in construction project, SL tasks, SL cycle in construction projects, SL basic documents SL organization in construction project, SL international practice. Structures of organization in construction project: Basic structure of organization, Organization models of key participants relationships, Contract models impact on project organization, Connecting of private and public sectors. Concept of constructability: Problems of project design - construction – usage connections, Definition of constructability, Aims, Application, Uses, International practice. Construction management in multi – cultural condition and on global market: Problems of cultural differences, Development of microculture project, Communication, Regulations, (FIDIC), Project management. New trends in construction management. / *Compulsory references:* Radujković, M. – Organizacija građenja, 2004. (trenutno nerecenzirana skripta, do početka novog programa biti će knjiga) / *Optional references:* Lončarić R. – Organizacija izvedbe

graditeljskih projekata, HDGI, Zagreb, 1995.; McGeorge & Palmer. – Construction Management New Directions, Blackwell Science, Oxford, 2002.

21824 Building Maintenance Management (2+1) 4,5

Introduction to building maintenance. Maintenance management regulations. Regular maintenance, reconstructions and repairs. Life cycle costs and classification of maintenance costs.Construction process and Construction maintenance.Construction maintenance management.Maintenance management project.Planning and organization of maintenance works.Maintenance of listed buildings.Models for setting priorities in building maintenance.IT support for decision making in setting priorities in building maintenance./ *Compulsory references:* Lee, R., Building Maintenance Management, Blackwell Science Ltd, Oxford, 1987. / *Optional references:* B., Swallow, P., Building Maintenance Management, Blackwell Science Ltd, Oxford, 1996.; Mills, E. Building maintenance & preservation, Architectural Press, Oxford, 1996.

21825 Optimization Methods in Construction (2+2) 6,0

Introduction into linear programming: LP models with two variables, graphical solution, graphical analysis, sensitivity analysis. Simplex method: transition from graphical to algebraic solution, simplex method, artificial starting solution, special cases in simplex method application. Duality and sensitivity analysis: dual problem definition, primal and dual relationship, duality interpretation, dual simplex method, generalized simplex algorithm, postoptimal analysis and sensitivity analysis. Transportation models. Network models. Aimed programming. Whole-number linear programming. Deterministic dynamic programming. Deterministic inventory models. Decision analysis and games: decision making in certainty, risk decision making, decision making in uncertainty. Dynamic probability programming. Probable inventory models. Queuing systems. Simulation modelling: simulation types, Monte Carlo simulation, generators of random numbers, simulation languages. Non-linear programming. / *Compulsory references:* N. Limić: Linearno i nelinearno programiranje, Informator, Zagreb, 1978., V. Čerić: Simulacijsko modeliranje, Školska knjiga, Zagreb, 1993.; V. Žiljak: Simulacija računalom, Školska knjiga, Zagreb, 1982. / *Optional references:* H. A. Taha: Operations research, Prentice Hall, 2003.

21826 Work Study (2+1) 4,5

Organization of work. General principles and definitions. Production. Production design. Work study. Schools of work study. Analysis of construction

production. Construction production characteristics and limitations. Structure and relations among the construction activities. Production process in construction. Elements and structure of construction production process. The labor in construction process. The factors affecting the productivity of work. Production norms in construction. Preparation and design of work. Working place organization. Material consumption measurements methods. Statistic methods of work measurement. The modern tools and methods application. Construction production modeling. Construction production rationalization. Practice: Auditory practice: Graphical photo method. Continuous observation method. Activity sampling method. Daily visit method. Design practice:Individual study work based on collected data. / *Compulsory references:* Taboršak, D.: Studij rada, Orgdata-Zagreb, Zagreb, 1994. / Marušić, J.: Organizacija građenja, FS, Zagreb, 1994. / *Optional references:* Žugaj, M., Horvatec, Z.: Organizacija proizvodnje, Informator, Zagreb, 1985. / Barnes, R. M.: Motion and Time Study Design and Measurement of Work, John Wiley & Sons, New York, 1980. / Amstead, B.,H., Ostwald, P.,F., Bergman, M.,L.: Manufacturing Processes, John Wiley & Sons, New York, 1987. / Askin, R. G., Standridge, C.,R. : Modeling and Analysis of Manufacturing Systems, John Wiley & Sons, Inc., 1993. / Weihrich, H., Koontz, H.: Menedžment, MATE, Zagreb, 1994.

21827 Technology of Civil Engineering 1 (3+2) 7,5

Technique and technology of earth works in the soil and rock. Preparation of earth work. Technique and technology and logistics of construction waste removal. Technological equipment for demolishing of building structures. Technique and technology of construction waste recycling. Technique and technology of asphalt breaking recycling. Soil and rock excavation. Mining works. Mining works. Production of chippings for filling (backfilled structures). Crushers and separations. Logistics and embedding of sprinkling materials. Protection of earth works and structures. Selection and planning of earth works techniques and technology earth works in rock and soil. Earth works costs. Underground excavations. New Austrian tunnel method construction (NATM). Tunnel machine excavation (tunnel boring machines - TBM). Tunnel excavation in the ground. Technique and technology of buried pipelines (“ microtunelling”). / *Compulsory references:* www.grad.hr → djelatnici → dr. sci. Zdravko Linarić → Dokumenti raspoloživi za download „Postrojenja za proizvodnju gradiva, I. dio, Drobilane, Asfaltne baze (asfaltna postrojenja)“; „Troškovi strojnog rada u građenju“; „Izbor strojeva i planiranje strojnog rada u građenju“; Zdravko Linarić: „Prerada građevinskog otpada urbanih sredina“, Građevinar, Zagreb, 46 (1994) 6 / *Optional references:* Branko Božić: „Miniranje u rudarstvu, graditeljstvu i geotehnici“, Sveučilište u Zagrebu,

Geotehnički fakultet u Varaždinu, 1998, Dinko Mikulić: „Građevinski strojevi: konstrukcija, proračun i uporaba“, Zagreb, 1998.

21829 Management for Construction Industry (2+1) 4,5

Basic principles of management. What is management, who are managers, development of management, functions of management. Business decision making. Defining decision making, problems and mistakes in decision making, styles and modes of decision making, methods of decision making, forecasting methods. Project management**;** definitions, project leader, aims of the project, project types. Economic system and its surroundings. Basics of management organization. Aims of organization, structure of organization, technologic, economic and social aspects of organization, surroundings impact on the structure of organization, specific features of business systems in construction industry. Planning of business process**;** nature, purpose and aims of planning process. Management in business processes**; s**tyles and management modes, leadership, motivation, communication in business decision making, business behaviour. Control of business processes ; financial control of construction projects. / *Compulsory references:* Menadžment za inženjere, Mariza Katavić, Sveučilište u Zagrebu, Građevinski fakultet, Zagreb 2006 (u pripremi) i/ ili materijal složen od drugih kolegija / *Optional references:* Management for the Construction Industry, Stephen Lavender, Longman and The Chartered Institute of Building, Eseex, England 1996.

21830 Construction Project Management (4+2) 9,0

Project Management Body of knowledge. (History of project management, basic knowledge and competences in project management, according to PMI and IPMA standards). Fundamentals of construction project management (Strategies, Goals, Phases, Life cycles, Stakeholders, Constraints, Variables of success or failures, sustainability in management). Project management in project design phase (Project identification phase, Project preparation, Implementation planning), Project management in implementation phase (Project start-up, Project implementation, Project close-out). Project manager (key qualifications and competences, skills and special demands, duties and job description, responsibilities, program for management of project). Team work (Team definition, efficient team characteristics, team building, working in team, roles in team, problems in team work, examples of project teams, leader and leadership). Risk management in construction project (Risk definition, key characteristics of risk events. Risk influence to project goals. Risk identification, Risk analyze, Risk

responds). Change management (Sources of changes in construction projects, decisions system and changes, administration and documentation), Project human resource management (Organizational planning, tools and techniques, planning concepts) Project quality (cost) time management (Basic elements, Norms, Total quality management (tools and techniques); Project communication management (Information communication, IT, decision processes, information system design); Project documentation management (Tendering contractual information, Examples of documents and legislations, Types of contract, Claim processes and documentation); New trends in project management. / *Compulsory references:* Radujković, M., Pienaru, A., i skupina koautora – PM Toolkit, Hrvatska udruga za upravljanje projektima, Zagreb, 2004.; Skendrović V. – Upravljanje projektima, GF Osijek, Osijek, 2002. / *Optional references:* Skoko, H. – Upravljanje kvalitetom, Sinergija Zagreb, 2000.; Burke R. – Project Management, J. Wiley, Chicester, 2003.

21831 Construction Business Systems (2+2) 6,0

Outlines of the system general theory: system, system approach, system structure (3 hours). Business system typology in construction (2 hours). Basics of organization and organization theory (3 hours). Organization structure, review of organization structure elements (1 hour). Organization structure elements of construction business systems: human resources, equipment, material, information (3 hours). Business functions of a construction business systems: research and development, human resource management, purchase, sales, marketing, manufacturing function, finances and accountancy, planning, information management, knowledge management, organization enhancement, quality insurance, informatics (9 hours). Organization shaping factors (1 hour). Shaping of organization structure of a construction business systems (3 hours). Organization changes (1 hour). Re- engineering (1 hour). Legal forms of a company (2 hours). Cooperation and integration forms between construction business systems. / *Compulsory references:* S. Kapustić: Metodika organizacijskog projektiranja, Zagreb, Samobor, 1989.; P. Sikavica, M. Novak: Poslovna organizacija, Informator, Zagreb, 1999. / *Optional references:* J. R. Turner: The handbook of project-based management, Mc Graw Hill.; M. Goold, A. Campbell: Designing effective organization, Jossey Bass.

21832 Planning and Scheduling Methods (2+2) 6,0

Introduction. Planning elements, Various approaches and planning concepts, Place and role of planning in the building process, Aim of construction planning,

Tasks of construction planning, Differences in project planning and production planning, Planning stages of construction project, Types of plans, Requirements related to planning documents. Procedure of initial plan design. Selection of activities, Determination of relationships among activities, Estimation of activities duration, Distribution of costs to activities. Technique of linear planning (Methods: Gantogram, Ciklogram, Orthogonal plan, Hystogram, S curve, Signpost lines, Balance lines). Technique of network planning (PERT Method, PDM Method, CPM Method, Application and advantages of each method). Resources planning (Resources in construction, Significance of resources planning in construction project, Determination of number and structure resources according to activities, Adding of resources at the plan level – initial profile of resources usage, Analysis and optimization of resource profile usage in plan). Procedure of time shortening of plan duration. (Need for time shortening, Activity duration shortening, Plan duration shortening measures, Working technique in plan duration shortening, Shortening of critic and sub-critic paths in the plan). Costs planning (Cost – time relationship in activities, Cost- project duration relationship, Cash flow in the project). Monitoring and control (Process of plan execution control and monitoring, Organization for data collection, Plan updating, Data processing and report elaboration on the construction work, Distribution of reports, Communication in project, Role of plan control, Controlling system, Controlling measures). Application of computer in planning (Advantages of computer application, Role of man and computer, Estimation of computer application need, Factors for computer programme assessment, Survey of selected plan software systems). Project planning at the company level (Connecting information from various project plans, Project planning in the company information system, project management in information system). */ Compulsory references:* Radujković, M. – Researche planiranja (nerecenzirana skripta 2004., izdanje u pripremi) / *Optional references:* Osmanagić-Bedenik, N. – Operativno planiranje, Školska knjiga, Zagreb, 2002., O'Brien and Plotnick – CPM in Construction Management, McGraw-Hill, Boston, 2003.

21833 Construction Site Practice (0+4) 6,0

Auditory practice contains description and review of activities the students are due to carry out within their professional practice on the construction site. Students are assigned to follow construction works on a construction site during seven days. They will be given elements to arrange their remarks and comments into a paper which will be submitted upon completion of the practice./ References: Field practice guidelines.

21839 Business Strategies in Construction (3+0) 4,5

Business environment**;** concept of doing business, reproduction concept, economic development indicators, economic development factors, technical and economic structure of trade and industry. Basic principles of reproduction process**;** reproduction process, investment modes for reproduction, basic assets, capacity, amortization, working assets, expenses and calculations, cost- effectiveness, productivity, profitability. Market and marketing**;** concept and development of market, market trade – marketing, marketing management. Company's market policy**;** creation of company's business policy, factors of impact on construction company's businesses, participants on the construction market, supply, demand, needs, a law of supply and demand, specific features of construction industry; company's production strategy, product planning, price policy, distribution policy, promotion policy. Business strategy of construction companies**;** definition of strategy, mission statement, company's goals, marketing mix - 4P/; construction market, market segmentation, market positioning (BCG-matrix, product features), market differentiation (services, image, product positioning map, S.W.O.T. analysis ; marketing strategy for construction personnel company, the formulating strategy, strategy elements, business strategy (Mc Kinsey's 7S), market leaders strategy, market followers strategy, strategy for new markets, strategy for growing markets. International marketing. / *Compulsory references:* Menadžment za inženjere, Mariza Katavić, Sveučilište u Zagrebu, Građevinski fakultet, Zagreb 2006 (u pripremi) / *Optional references:* Management for the Construction Industry, Stephen Lavender, Longman and The Chartered Institute of Building, Eseex, England 1996.

21840 Organizational Behaviour (2+1) 4,5

Introductory lecture and definition of core terms. Organizational theories. Formal organization. Non-formal organizations. Environmental impact on organization. Cultural norm impact on organization. Culture of organization. Power and influence within organization. Leadership in organization. Decision making. Communication in organization. Organization cycles and causes of changes in organization. Technology impact on organization. Future of organization. / *Compulsory references:* Haladin, Stjepan. 1993. *Tehnologija i organizacija: uvod u sociologiju rada i organizacije*. Zagreb: Društvo za organizaciju građenja Republike Hrvatske. / *Optional references:* Vecchio, Robert P. 2003. *Organizational behavior: core concepts*. Mason, Ohio: Thomson/South-Western.

4.2.5.2. ELECTIVE SUBJECTS

21843 Supervision and Monitoring of Construction Projects (2+0) 3,0

Normative basics of construction work supervision, laws, rules. Contract basis of supervision. Supervisor and other participants in the project. Supervision team structure and mutual relationships. Role and obligations of supervision in project stages: nomination, initiating of contractor for a work, verification of technical documentation, stakeout elaboration, methods of measurement quantity control, quality control, control of construction performance dynamics, financial control, evaluation of additional work, payment certificate, final account, technical inspection, building construction. Official communication and documentation. Normative basics of technical counseling. Choice of a consultant and contract elements on o technical counseling. Consultant' s function in project stages: preparation and tender conduction, contraction of the project execution stages, monitoring of project execution related to time, quality and costs, investor' s counseling. Contract annexes and accompanying documentation. Consultant' s responsibility. Professional associations and norms. / *Compulsory references:* Skripta u izradi; http:// www.nn.hr / *Optional references:* D. Vrljić, S. Čičak, M. Mihalčić: Graditeljstvo u praksi, Vizura, Zagreb, 2002.

21834 Human Resource Management (2+2) 6,0

Introduction to human resource management. Development of human resource management theory.The concept of Human resource management. Organizational behaviour. The importance of Human resource management for business success in construction companies. Human resource management strategies in construction companies. Interaction of human resource management strategy and construction companies strategy. Human resource planning. Total quality management. Communication and negotiation. Team building. Motivation and business ethics. IT support for human resource management./ *Compulsory references:* Bahtijarević-Šiber, F. Management ljudskih potencijala. Zagreb: Golden marketing,1999. / *Optional references:* Dainty, A., Loosemore, M., Lingard, H., Human resourse management in Construction Projects. London. Spon Press, 2003.

21835 Technology of Civil Engineering 2 (2+2) 6,0

Technique and technology of concrete works. Logistics of transported concretes. Preparation of concrete works. Production, transportation and embedding of fresh concrete. Selection and planning of concrete works technique

and technology. Concrete works costs. Scaffoldings and formworks. Logistics of current formwork systems. Caculation for formwork systems and scaffoldings. Selection and planning of formwork systems and scaffoldings. Formwork setting up costs. Technique and technology of pre-cast concrete blocks and minor elements (production plants, systems, surfaces and lines). Equipment for laying of pre-cast concrete. Technique,technology and logistics of prefabricated building. Technique and technology of prefabricated elements and systems production. Tools, equipment and devices for elements and systems prefabrication. Truck cranes. Assembly technology. Prefabricating technology of buildings, halls and bridges. Selection and planning of assembly works systems. Costs of assembly works. / *Compulsory references:* Vjeran Mlinarić, Rudolf Lončarić: „Vrednovanje oplatnih sustava“, Građevinar, Zagreb, 51(1999)2, instalirane verzije programa (softwari) za korištenje u nastavi pri izradi programa, seminarskih i diplomskih radova: DOKA, The planing system for Doka formwork; PERI, „PERI ELPOS” die schnelle Schalungsplsnung / *Optional references:* Gorazd Bučar: „Tesarski, armirački i betonski radovi na gradilištu“, Građevinski fakultet J. J. Strossmayera u Osijeku, 1997.; www.grad.hr → djelatnici → dr. sci. Zdravko Linarić → Dokumenti raspoloživi za download: „Postrojenja za proizvodnju gradiva, I. dio, Tvornice betona (betonare)“, „Troškovi strojnog rada u građenju“; „Izbor strojeva i planiranje strojnog rada u građenju“; Rudolf Lončarić: „Organizacija izvedbe graditeljskih projekata“, HDGI, 1995.; Eduard Slunjski: „Strojevi u građevinarstvu“, HDGI, Zagreb, 1998.; priručnici „PERI (Schalung und Gerueste)“ i NOE kao knjige (katalozi) i CD.

21836 Investment Appraisals in Construction (2+2) 6,0

Introductory considerations : investment policy, social development cycle, national income distribution policy, investment subject, investment object, investment types. Enterprise development : enterprise development policy, enterprise development stages, development and investments, investment process in enterprise, investment decision. Investment programme ; investment programme structure, investment programme contents, investment programme impact factors, investment programme factor analysis. Investor‘s evaluation. Investor‘s evaluation procedure , investor‘s evaluation results. Market analysis. Sales market analysis, purchase market analysis, product analysis, production programme analysis, capacity analysis. Technological process analysis; technologic and technical analysis, technical aspects of investment. Location analysis; location analysis related to raw-materials basis, location analysis related to communications, location analysis related to the labor market, analysis of raw-material and energetic basis, labor tools analysis (equipment analysis).

Environment protection analysis; determined condition, consequences, measures needed to protect human environment– impact on investment programme. Economic and financial analysis; investment into basic resources, investment into working capital, investment structure into basic and working capital, financing sources and credit condition, amortization calculation, cost estimation and price calculation, projection of gain and loss account, financial course, economic course , balance projection, Investment programme evaluation. Investment programme efficiency, statistic evaluation of programme, dynamic evaluation, practical examples and application of various methods of programme evaluations, analysis and interpretation of obtained investment programme evaluation indicator. Investment programme sensitivity analysis (*«cost –benefit»* analyses); analysis of investment programme critic parameters, analysis application process of programme sensitivity, practical examples of sensitivity analysis (*«cost – benefit»* analyses), economic valorization of construction investments (*life cycle cost* analyses), application of various programmes for sensitivity analysis (e.g. COMFAR, WLC I etc.), results interpretation of sensitivity analysis. Investment programme finale evaluation; finale grade structure and contents, results interpretation of investment programme key analyses. / *Compulsory references:* HBOR, I-V. / *Optional references:* J. C. Francis, (1986) Investment Analysis and Management, McGraw Hill International, 4th edition, Singapore.

21841 Construction Equipment I (2+2) 6,0

Selection and planning of construction machines work. Logistics of construction works. Working systems of construction works and plants. Productivity of construction machines and transportation machines in the building process. Construction machines productivity factors. Machine work costs in construction. Machine amortization. Maintenance costs. Construction machines usage costs. Reliability and effectiveness. Reliability of individual machines. Construction machines reliability system. Construction machines maintenance. Construction machines in the conditions of appliance. Analyses of construction machines usage. Working time loses. Exchange of construction machines. Selection and procuration of construction machines. Leasing. / *Compulsory references:* www.grad.hr → djelatnici → dr. sci. Zdravko Linarić → Dokumenti raspoloživi za download – „Učinak građevinskih strojeva“, „Troškovi strojnog rada u građenju“, „Izbor strojeva i planiranje strojnog rada u građenju“ / *Optional references:* Marko Žaja: „Ekonomika proizvodnje“, Školska knjiga, Zagreb,1991.

21842 Facility Management (2+2) 6,0

Introductory considerations. Facilities management as a term, facility life cycle and the place of the „operation“ phase. Defining facility operation elements: elements related to physical facility elements and other elements related to operation of facilities. Organization of facility management: organization types, influential factors for the choice of an organization. Facility management costs: cost data structure, cost estimation methods in facility management, cost assessment « ownership» of facilities, cost estimation and price calculation of various facility management elements, optimization of facility management cost and income, introduction of ISO standards related to facility management. Modern methods and techniques in facility management. Reliability analysis, availability analysis, integrated logistic support analysis. Resources needed: optimization of resources needed in facility management during defined life cycle of the facility depending on designed function. Contract types suitable for facility management: contract types, advantages and limitations of possible contract types in facility management, allocation of risks in various contract types. Project documentation and facility management manuals: structure and contents of required project documentation and manuals, project documentation analysis from operational availability point of view, data updating at a operational stage. Facility management planning: content, data needed. The role of facility management. Monitoring of facility operation: defining “key operation indicators” of facilities, elements needed for “post occupancy evaluation”, POE, data collection systems needed for meaningful POE, procedures for POE. Facility management implementation systems: analysis of critical parameters in system implementation, process map of activities for the successful implementation of facility management system, practical examples of implementation system, analysis of various implementation systems and programmes for facility management. / *Compulsory references:* CIRIA, Facilities management manuals – a best practice guide, London, 2002. / *Optional references:* Spedding, A. CIOB Handbook of Facilities Management, Longman Scientific &Technical, 1994.; Williams, B., Facilities Economics, Building Economics Bureau, 2002.

4.2.6. TRANSPORTATION ENGINEERING PROGRAMME

4.2.6.1. OBLIGATORY SUBJECTS

21844 Traffic Noise (2+1) 4,5

Introduction: basic concepts. Traffic Noise: noise source, impact on working and life quality. Noise protection regulations: relevant rules and norms, European Committee recommendations, noise maps. Traffic noise measuring: equipment, carrying out of measurement and results analysis. Calculation methods: influential parameters, models, noise spreading. Noise protection measures: reduction at source, reduction of spreading, protection at the emission spot, economic measures. Monitoring: control measurements.*I Compulsory references*: Lakušić, S.; Dragčević, V.; Rukavina, T. Utjecaj buke od prometa u poslovno-stambenim zonama grada Zagreba. Zagreb : Građevinski fakultet, 2004., Opći tehnički uvjeti za radove na cestama. Zagreb : Hrvatske ceste i Hrvatske autoceste, 2001, Uputstva za korištenje softwarskog paketa LIMA™ Environmental Noise Calculation and Mapping Software,Version 4.2, Denmark, 2004., Benz Kotzen; Colin Englih. Environmental noise Barriers, London, 1999.

21845 Transportation Engineering (2+2) 6,0

Traffic engineering definitions of basic concepts. Introduction into the theory of traffic flow, motorization development and traffic flow theory. Defining and measuring of basic traffic flow variables, flow, velocity and density of traffic flow. Relationships between basic variables of the traffic flow, mutual spatial and partial variable relationships. Traffic flow models, microscopic and macroscopic models and their relationships. Flow capacity and various road services, concept development, defining of elements and their impact. Roads traffic volume, countering traffic, traffic flows in a network, elaboration and application of data, characteristics of road traffic volume. Roads and intersections traffic flow, highways, multi-lane roads, two-lane roads, various intersection types. / *Compulsory references:* Highway Capacity Manual, TRB, Washington, D.C., 2000., Gerlough, D.L. , Huber, M.J. Traffic Flow Theory, A Monograph, TRB, Special Report 165, Washington, D.C., 1975., Pignataro, L.J. Traffic Engineering, Theory and Praktice, Prentice-Hall, Inc. Englewood Cliffs, New Jersey, 1973. / *Optional references:* Transportation and Traffic Engineering Handbook, The Institute of Traffic Engineers, Washington, D.C., 1976.

21846 Highway Design (2+2) 6,0

Design rules. Modeling of solution. Spatial restriction. Digital relief models, digital solution models. Operations with models. Solution creation in plan view. Solution creation in plan. Solution creation in cross section. Computations of stopping sight distance, overtaking visibility. Computation methods of road structure volume. Complex plans of crossings and intersections. Elaboration procedures of several design phases. Cost benefit analysis and priority stating priorities. / *Compulsory references:* D. Pološki, Ž. Stepan: Ispis Lectures 2003/2004. (str. 68) B. Pribičević, D. Medak: Geodezija u građevinarstvu. Zagreb; V.B.Z., 2003. (poglavlje 13. Geodetski radovi pri projektiranju i trasiranju prometnica, poglavlje 14. Određivanje površina i zemljanih masa). Pravilnik o osnovnim uvjetima kojima javne ceste izvan naselja i njihovi elementi moraju udovoljavati sa stajališta sigurnosti prometa (NN 110, prosinac 2001). / *Optional references:* H. Lorenc: Projektovanje i trasiranje puteva i autoputeva, IRO građevinska knjiga, Beograd, 1980.

21847 Railway Design and Construction (2+2) 6,0

Generally of trackways. Train traction basics of design: resistances of trains, locomotive traction force, train mass, braking forces. Traffic and transportation track indicators: traffic railway line zone, cargo and passenger traffic volume. Design track elements: elements of plan view and longitudinal track section, number of tracks. Route design: route alignment modes, railway engineering software‘s. Design stages: feasibility studies, preliminary design, main and working design. Variant solutions evaluation: methods for variantevaluation, exploitation costs. Track capacity calculation: capacity of the line, carrying capacity of the line. Reconstruction of single trackrailway lines: baselines of reconstruction, route parameters selection. Second track design: second track construction modes, location related to other objects. High speed tracks: specific features, plan view elements, elements of longitudinal section of track. / *Compulsory references:* Marušić, D. Projektiranje i građenje željezničkih pruga. Split : Građevinski fakultet, 1994.

21829 Management in Civil Engineering (2+0) 3,0

Basic principles of management. What is management, who are managers, development of management, functions of management. Business decision making. Defining decision making, problems and mistakes in decision making, styles and modes of decision making, methods of decision making, forecasting methods. Project management**;** definitions, project leader, aims of the project,

project types. Economic system and its surroundings. Basics of management organization. Aims of organization, structure of organization, technologic, economic and social aspects of organization, surroundings impact on the structure of organization, specific features of business systems in construction industry. Planning of business process**;** nature, purpose and aims of planning process. Management in business processes**; s**tyles and management modes, leadership, motivation, communication in business decision making, business behaviour. Control of business processes ; financial control of construction projects. / *Compulsory references*: Menadžment za inženjere, Mariza Katavić, Sveučilište u Zagrebu, Građevinski fakultet, Zagreb 2006 (u pripremi) i/ ili materijal složen od drugih kolegija / *Optional references*: Management for the Construction Industry, Stephen Lavender, Longman and The Chartered Institute of Building, Eseex, England 1996.

21848 Pavements Structures (2+2) 6,0

Introduction and basic concepts. Historical survey of transportation facilities with emphasis on pavement development. Current pavement systems (asphalt pavements, concrete pavements). Pavement performance factors in design, construction and maintenance of pavement structures. Subgrade (subgrade made of natural materials, subgrade made of stabilized materials). Sub-base layers (mechanically compacted granular stone materials layer, cement stabilized layer, bituminous layer). Wearing course (bituminous layer, wearing course made of asphaltic concrete, wearing course made of splitmastics asphalt, microasphalt wearing course, surfacing and dressing, drainage asphalt). Design of new pavementsv(design of asphalt and concrete pavements). Design applied to existing pavements. / *Compulsory references*: Babić, B. Projektiranje kolničkih konstrukcija. 1997. Babić, B.; Horvat, Z. Građenje i održavanje kolničkih konstrukcija. 1985. Roberts, F., i drugi. Vruće asfaltne mješavine. 1996. (prijevod na hrvatski) / *Optional litaratura*: Opći tehnički uvjeti za radove na cestama, 2001. Babić, B.; Prager, A. Građevni godišnjak // Projektiranje kolničkih konstrukcija cesta. Zagreb : HSGI, 1997.

21849 Permanent Way (3+1) 6,0

Basic concepts on permanent way elements: rails, fastenings, slippers, ballast. Rails: shape, strength, testing and inspection, deterioration, lubrication. Fastenings: tasks and fastening testing, rigid and elastic fastenings. Slippers: timber slippers, reinforced-concrete slippers. Ballast: tasks, shapes and dimensions of ballast prism, bearing increase of ballast prism. Track arrangement:

track gauge, superelevation of track, transition curve, transition gradient. Permanent way design: static track design, dynamic track design. Special permanent way structures: structure requirements, applications. Continuous welded rails (CWR): temperatures and stresses in CWR, freeing of CWR from stresses. Rail welding procedures: Thermic (aluminothermic) welding, electrical resistance welding, testing of welds. Turnout: parts of a turnout and their function, switch types, crossings (frogs) and guide rails. / *Compulsory references:* Prister, G.; Pollak, B. Željeznice – gornji stroj i specijalne željeznice. Zagreb: Građevinski Institut, 1988. Lakušić, S. Gornji ustroj željeznica, interna skripta / *Optional references*: Pravilnik o održavanju gornjeg ustroja željezničkih pruga HŽ (Službeni vjesnik, br. 20/91). Eld, C. Modern Railway Track, *Second Edition*. MRT Productions, Zaltbommel, 2001.

21850 Earthworks (2+2) 6,0

Introduction: definitions, elements and cross-sections types. Previous works: data collection on terrain and soil, earth works material classification. Cross-section elements: characteristics cross-sections types and design. Embankment and excavation: design and conducting of cut and fill, slope treatment and protection. Ancillary construction work: retaining walls, drainage equipment, culverts. Calculation, distribution and balancing of masses. Cut and fill construction in inconvenient soil conditions: landslides, low bearing capacity of soil. Works in rock. / *Compulsory litaratura:* Dragčević, V.; Korlaet, Ž. Osnove projektiranja cesta. Zagreb : Građevinski fakultet Sveučilišta u Zagrebu, 2003. Opći tehnički uvjeti za radove na cestama. Zagreb: Hrvatske ceste i Hrvatske autoceste, 2001.; Dragčević, V., Rukavina T. Donji ustroj prometnica. Zagreb: Građevinski fakultet Sveučilišta u Zagrebu, 2006.

21851 Road Intersections (2+2) 6,0

Traffic at intersections, traffic flow, variety of movements, channelling. Criteria for the selection of intersection kinds and types, traffic considerations, geometry design. Intersections classification. Vehicle movement geometry, vehicle types, trajectories, methods. Intersection lanes, lane design for turning, slowing down and acceleration. Traffic islands, division, function, design. Interchanges ramps, categorization, connection. Horizontal and vertical alignment, longitudinal and transversal slopes, pavement screwing, sight distance. Intersections at the grade, categorization, design. Interchanges, categorization, design. / *Compulsory references*: Klemenčić, A. Oblikovanje cestovnih čvorišta izvan razine, monografija. Zagreb : Građevinski institut, 1982. str. 109. Korlaet, Ž. Čvorišta,

skripta. Zagreb : Građevinski fakultet, 2004., str. 69. Richtlinien für die Anlage von Straβen, Plangleiche Knotenpunkte, RAS-K-1, FGSV, Bonn, 1988., str. 120.

21852 Traffic Tunnels (2+2) 6,0

Tunnel entities. Significance of tunnel construction exemplified with international and local tunnels. Parameters and parameter values for tunnel design, roads, railway, metro. Distribution method of rocky mass, RMR, Q system, NATM. Excavation method of rocky mass and support systems, traditional way, current methods. ADECCO-RS methods, excavation, deformations, excavation safety measures. Portal structures. Safety in tunnels, infrastructure measures, safety equipment, users measures. / *Compulsory references*: Mikulić, J; Stipetić, A; Željezničke pružne građevine, IGH, Zagreb. 1999. (Tuneli str. 150.-197. posebno str. 174.-187.); Banjad, I; Tuneli, GF, Zagreb, 1986; (Researche izvedbe tunela, str. 163-194); Marušić, D.: Projektiranje i građenje željezničkih pruga, GF Sveučilišta u Splitu,1994. (posebno- Usponi u tunelu str. 135.-137.) http://www.rocksoil.com/ingindex3.html; Lunardi P., 2000. Design & constructing tunnels – ADECO-RS approach, T&T International special supplement, May 2000. Poloski, D.: Ispis Lectures. / *Optional references*: http://home.no.net/lotsberg/; http://www.metropla.net/index2.htm; http://www. alptransit.ch/

21853 Airport (2+1) 4,5

Introduction. History of aeronautics. Civil air traffic, organization and regulations. Basics of meteorology for airport study, location and exploitation. Air traffic systems, airport and its elements, divisions, classifications and airport definitions. Airport surfaces – definitions and characteristics. Airport manoeuvre zones. Airport and airport area marking. Obstacles and obstacles marking. Passenger building. Cargo traffic building Pavement surface classification for airplane traffic (volume, classification according to various methods) Flexible pavement design. Rigid pavement design./ *Compulsory litaratura*: Horvat Z. Aerodromi I. 1982.; Prager A. Aerodromi I – izmjene i dopune. 1990.; Rukavina T. Bilješke za Lectures. 2004. / *Optional references:* Pavlin S. Aerodromi I. Aerodromes, Annex 14 to the Convention on International Civil Aviation, ICAO, 1999.; Airport Pavement Design and Evaluation, Federal Aviation Administration, 1995.

21854 Equipment of traffic routes (3+0) 4,5

General terms and definitions. Traffic route equipment and traffic safety:traffic signs, warning signs, information signs, positive instruction signs, changeable

traffic signs. Road markings: along the carriageway, across the carriageway and other markings on carriageway. Roadworks signs. Pavement edge markings: direction pillars, other. Protective railings: steel, concrete and wire railings. Noise protection facilities: walls, fills. Dazzle prevention railings. Other traffic facilities: automatic traffic Hoursila, road weather stations, telecommunication call systems, snowbreaks, windbreaks. / *Compulsory references:* Opći tehnički uvjeti za radove na cestama. Zagreb: Hrvatske ceste i Hrvatske autoceste, 2001. Benz Kotzen, Colin Englih, Environmental noise Barriers, London, 1999. god.

21855 Traffic Systems (3+0) 4,5

Traffic, historical development, definitions and divisions. Vehicles, roads and journeys, main features. Drivers and passengers, physical and psychological characteristics. General traffic characteristics, speed, divisions, traffic volume. Urban traveling, city features, traveling generators. Public urban and regional traffic, role in city development, types, capacities, productivity, performance, economic and environmental aspects. Paratransfer, definitions and main characteristics, integration of paratransfer and conventional transfer, role in different spatial surroundings, economic aspects. Passenger traffic, general, passenger flow, planning and passenger facilities design. Bicycle traffic, general, bicycle flow, planning and design of bicycle tracks. Traffic safety, elaboration of accidents, analysis of accidents and safety studies, evaluation system, improvement activities. Traffic studies, data types, elements of study, traffic volume, speed, journey time and losses, traffic flow, crossings, parking. Traffic planning, general methodological approach, problem defining, elaboration of statistics and documentation, forecasting social and economic development and traffic needs, creation and evaluation of plan. / *Compulsory references:* McShane, W. R. i Roess, R. P.: Traffic Engineering, Prentice-Hall, Inc. Englewood Cliffs, New Jersey, 1990.; Pađen, J.: Researche prostorno-prometnog planiranja, Informator, Zagreb, 1978.; Korte, J. V.: Osnove projektiranja gradskog i međugradskog putnog saobraćaja, Građevinska knjiga, Beograd, 1968.; Pignataro, L. J.: Traffic Engineering, Theory and Praktice, Prentice-Hall, Inc. Englewood Cliffs, New Jersey, 1973. / *Optional references:* Transportation and Traffic Engineering Handbook, The Institute of Traffic Engineers, Washington, D. C., 1976.

21858 Pavement Management (2+0) 3,0

Introduction. Fundamentals on pavement management systems. Road maintenance (definitions, goals, economic aspects). Pavement condition features (damages types, ways of collecting data on pavements, pavement condition

evaluation on the basis of collected data). Asphalt pavement maintenance. Concrete pavements maintenance. Asphalt pavement roads reconstruction (by reinforcement, total replacement of an existing one by another, combination of reinforcement and total replacement). Concrete pavement road reconstruction. Cuts and other damages /repairs caused by works on municipal infrastructure. Management systems structure and elements. Pavement management models (HDM III, system dTIMS/VIAPMS). / *Compulsory references:* Sršen, M.: Održavanje cesta, Građevni godišnjak, HSGI, Zagreb, 2000.; Dragčević V., Korlaet Ž., Rukavina T., Katalog oštećenja asfaltnih kolnika, GF, Zagreb, 2004.; Rukavina T.: Bilješke za Lectures. / *Optional references*: OECD (Scientific Expert Group): Road maintance management Systems in developing Countries, Organization for Economic Co-operation and Development, Paris, 1995.

4.2.6.2. ELECTIVE SUBJECTS

21856 Drainage of Transportation Facilities (2+1) 4,5

Hydrologic foundations, hydrologic concepts and data, hydraulic conditions. Protection from surface, underground and seepage waters. Pavement surface drainage. Devices for surface drainage. Devices for drainage of ballast. Devices for drainage of city streets. Culverts. Determination of volume for a drainage facility. Environmental parameters of water protection. / *Compulsory references*: RAS, Entwässerung, FGSV, Boon, 1987. g.; RAS, Tabellen für Bemessung von Entwässerungsrinnrn und mulden in befestigen Verkehrsflächen, FGSV, Bonn, 1987. g; Richard, K. Untermann, Principles and practices of grading, drainage and road aligenment: An ecologic approach, Prentice-Hall, Inc, 1978. g.

21881 Traffic Buildings (2+1) 4,5

City and traffic. Basic characteristics of the architecture of traffic buildings. Pedestrian overpasses and underpasses. Parking lots and multi-storey parking lots. Garage buildings. Urban gas stations. Service stations. Motels. Bus stations in city and inter city traffic. Motels. Typology of passenger railway buildings. Typology of airport buildings. Roadside ancillaries. Ancillary facilities in ports and marinas.

21857 Soil – improvement Methods (2+1) 4,5

Introduction Purpose. Definition, application areas, stabilization, application for transportation facilities. Concept of unstable soil and unstable soil types.

Selection of procedures (influential parameters in decision making on soil-improvement methods). Mechanically stabilized soil. Stabilization with lime. Stabilization with cement . Soil stabilization with a mixture of fly ash with lime or cement. Soil stabilization with bitumen. Soil stabilization with cement-lime and lime–bitumen mixtures. Thermal soil stabilization procedures. Low bearing capacity soil stabilization with geosynthetics. Other ways of low bearing capacity soil stabilization. / *Compulsory references*: Babić, B.; Horvat, Z. Građenje i održavanje kolničkih konstrukcija. 1985.; Babić, B. Geosintetici u prometnicama, Građevni godišnjak, HSGI, Zagreb, 1995.; Rukavina T.: Bilješke za Lectures. / *Optional references*: Opći tehnički uvjeti za radove na cestama, IGH, 2001.

21859 Urban Transportation Facilities (2+1) 4,5

Urban traffic systems. Road facilities and their attributes. Route alignment of transportation routes, basic network, residential streets, access roads. Connections of urban and external system. Road intersections. Traffic demand planning. Journey matrix determination. Modal split. Traffic joining modes to the network. Plan evaluation, driving velocities, network saturation, harmful matters emission, noise. Cost benefit analysis, plans. / *Compulsory references*: D. Pološki, Ispis Lectures (handouts) VISUM manual.

21860 Parking Lots (2+1) 4,5

Urban and traffic baselines. Parking lots capacity. Parking systems, organization, management. Parking types and parking facilities types. Design elements of parking places, parking by driving ahead and back, dimensions of parking places, widths of driving lanes, exploitability of surface. Construction performance and equipment, pavement, drainage, signalization, lightning, safety equipment. Parking places for special purposes, bus and lorry stations, shopping centres, sports facilities, airports, P+R systems, bicycles and motorcars. Parking objects-garages, systems of internal organization, road network connections, design elements, ramps, control systems, control and charging systems, safety measures. / *Compulsory references*: Empfelungen für Anlagen des ruhenden Verkehrs, EAR 91, FGSV, Bonn, 1995., str. 99.

21861 Track Maintenance (3+0) 4,5

Basic concepts on track maintenance. Track condition inspection: geometry of tracks, tracks, structure gauge and ballast prism. Track maintenance work types: current track maintenance (routine maintenance, investment maintenance), track reconstruction. Permanent way maintenance: manual maintenance and

mechanical maintenance. Current methods of track maintenance: works in the course of traffic flow, works with no train traffic. Track maintenance for high speeds. Turnout maintenance: set of switches maintenance, common crossing maintenance. Track material regeneration:rails, turnouts, fastenings, slippers, ballast; Substructure of the track maintenance: track formation level, subbase, drainage ditches. Railway facility inspection: inspection of bridges, culverts, tunnels, level crossings. Maintenance and reconstruction of railway facilities. / *Compulsory references*: Eld, C.: ''Modern Railway Track'', *Second Edition*, MRT Productions, Zaltbommel, 2001.; Mikulić, J., Stipetić, A.: „Željezničke pružne građevine“, Institut građevinarstva hrvatske, Zagreb, 1999./ *Optional references:* Pravilnik o održavanju gornjeg ustroja željezničkih pruga HŽ (Pravilnik 314); Pravilnik o održavanju donjeg ustroja željezničkih pruga HŽ (Pravilnik 315).

4.2.7. THEORY AND MODELLING OF STRUCTURES PROGRAMME

4.2.7.1. OBLIGATORY SUBJECTS

21862 Mechanics of Material (2+1) 4,5

The impact of a construction material structure on mechanical properties of a material. Probabilistic character of mechanical properties and sensitivity structure. Theory of selectivity and theory of addition. 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 materials. Brittle materials. Real material chart. Anisotropy of mechanical properties. Idealization of work material chart. Elastoplastic material with strengthening ideally elastoplastic material, solid plastic material, solid and plastic material with reinforcement. Impact of external factors 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. Strength of material in dynamic loading. Types of dynamic loading. Impact strength or material ductility. External factors affecting the impact strength of material. Testing procedures. Strength of material in cyclically changeable loading. 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. 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. 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. / *Compulsory references*: Šimić, V.: Otpornost materijala II, Školska knjiga, Zagreb, 2002. / *Optional references*: Bazjanac, D.: Nauka o čvrstoći, Tehnička knjiga, Zagreb, 1967.; Lemotive, J., Chaboche, J-L.: Mechanics of Solid Materials, Cambridge University Press, Cambridge, 1990.; Timošenko, S.: Otpornost materijala II, Građevinska knjiga, Beograd, 1965.; Timošenko, S.: Mechanics of Materials, Van Hostrand Reinhold Company, New York, 1972.

21863 Nonlinear Statics of Rod Structures (2+1) 4,5

Idealization in linear statics of bar structures, exact theory of geometry displacement and equilibrium on a deformed rod. Relationships between linear and nonlinear theory. Differential relations of forces and loadings in geometric nonlinearity. Relations between forces and displacements of bar ends in geometric nonlinearity. Equations of equilibrium knots. The concept of imperfection, derivations and solutions of differential equations of bars. Linearization of computation, P-delta analysis. Physical nonlinearity, basic concepts. Idealization in material nonlinearity. Approximation of physically nonlinear tasks. General bilinear approximation. Interaction of internal forces in physical nonlinearity. Simultaneous geometric and physical nonlinearity. Iterative computation of bearing capacity by differential equations method. The general equation of a moment in plastic hinges. / *Compulsory references*: V. Jović: Uvod u inženjersko numeričko modeliranje, Aquarius Engineering, Split, 1993.; E. Rahm: Stabtragwerke, Teil V, Nichtlineare Verfaren, Universitaet Stuttgart, 1995. / *Optional references*: W. Wunderlich & W. D. Pilkey: Mechanics of Structures. Variational and Computational Methods, CRC Press, Boca Raton, 2003.

21785 Metarl Structures II (2+2) 6,0

Properties of steel structures. Architecture and steel. Economic parameters of construction in steel. Design procedure – higher level. Introduction to engineering reliability. Fatigure – dimensioning. Compound compressed elements. Stability of web plates due to transverse stresses. Thin walled profile structures.Design of plate elements and plate girders. Spatial structures systems. Bearing systems of multi storey buildings. Cable structures. Details of steel structures. / *Compulsory litartura*: Androić, B.; Dujmović, D.; Džeba, I. Metalne konstrukcije 3. Zagreb : IA Projektiranje 1998.; Androić, B.; Dujmović, D.; Džeba, I. Metalne konstrukcije 4. Zagreb: IA Projektiranje 2003.; Androić, B.; Dujmović, D.; Džeba, I. Modeliranje konstrukcija prema EC3. Zagreb: IA Projektiranje 2004. / *Optional references*: McKenzie, W. C. Design of Structural Steelwork. Macmillan 1998.

21864 Theory of Elasticity and Plasticity (3+2) 7,5

Introduction and definition of deformability continuum (History and classification of continuum mechanics). Basics of vector and tensor calculus (Euclid's E³space, Transformations of coordinates, Operations with tensors). Model of material continuum deformation (Lagrange's and Euler's principles of body deformation). Stress tensor and its properties. (Stress state surrounding the point, Equilibrium equation, Statical acceptability, Component transformations,

Eigen values). Deformation tensor and its properties (Displacement and deformity gradients, Finite deformations, Infinitesimal deformations, Kinematic acceptability, Compatibility equation). State and constitutive equations (Laws on states, Material rigidity and flexibility tensor, Potential of linear-elastic body). Boundary phenomena in theory of elasticity and their solutions (Boundary phenomenon formula, solutions and their properties). Potential energy of solid deformable body and energy principles and theorems. Numerical procedures applied in solving boundary phenomena in theory of elasticity. Plane conditions in theory of elasticity (Plane stress and deformation, Airy function of stress in rectangular and polar coordinates, Solution properties of plane phenomena and some potentials of boundary phenomena). Space phenomena in theory of elasticity (Torsion, Semi-space, Thin boards). Introduction to theory of plasticity and basic criteria of plasticity (Plasticity models, Principles of plastic flow, Plasticity constant). Constitution laws in material flow theory (Misses-Levy and Prandtl-Reuss equations, Incremental procedures in flow theory). Some potentials of plasticity. / *Compulsory references:* Z. Kostrenčić: Teorija elastičnosti, Školska knjiga, Zagreb, 1982.; J. Brnić: Elastomehanika i plastomehanika, Školska knjiga, Zagreb, 1996. / *Optional references*: S. Timošenko: Teorija elastičnosti, Građevinska knjiga, Beograd, 1962.; Y. A. Amenzade,: Theory of Elasticity, MIR Publishers Moscow, 1979.; G. E. Mase: Theory and Problems of Continuum Mechanics, McGrow-Hill Company, 1970.

21865 Dynamics of Structures and Earthquake Engineering (3+2) 7,5

Linear oscillator, a theory survey of free and forced vibrations with and without damping. Types of dynamic load. (earthquake, wind, sea waves, explosions, machine work). Spectrum concept. Duhamel's integral. Phenomenon and resonance impact. Generalized systems with one-degree systems. Energy approach. System Vibrations with more degrees of freedom. Coordinates selection (discrete, generalized), static condensation, matrix structure formulation, longitudinal forces impact (computer application). Generalized coordinates, Hamilton principle, Lagrange motion equations. Clear vibrations, eigenvalues and eigenvectors, orthogonality conditions, normal coordinates. Matrix iteration methods. Dynamic response by use of modal superposition method (superposition of influences of individual eigenvectors. Symmetric and asymmetric buildings in a plan view. Dynamic response of a structure by integration "step by step" method. Accelogrammes (computer application). Spectral computation of buildings. Dynamics of engineering facilities. Finite element method application. Systems vibration with continually distributed mass (bending and longitudinal strain of a beam). Thin plate clear vibrations, beams,

cantilevers, frames. Nonlinear vibrations. Causes of nonlinearity. Mathematical models, solutions, Runge-Kutt ‘s methods (pendulum, Duffing’s equation). Parametric vibrations. (computer application). Earthquake phenomenon, seismic zones, basics of earthquake loading, design spectra, equivalent static load. Basic rules and principles in designing buildings in seismic areas. Wind and earthquake: corresponding regulations and application. / *Compulsory references*: A. Mihanović, Dinamika konstrukcija, Građevinski fakultet Sveučilišta u Splitu 1995.; J. Dvornik, V. Raduka, Bilješke uz Lectures. / *Optional references*: R. W. Clough, J. Penzien, Dynamics of Structures, McGraw-Hill 1993. A. K. Chopra, Dynamics of Structures: Theory and application to earthquake Engineering, Prentice Hall, inc. 1995.

21866 Experimental Methods I (2+2) 6,0

Instruments and measuring methods on the prototype and models. Modeling theory and technique. Dimensional analysis. Theory of similarity. Dimensional formulations. Buckingham’s theorem. Differential equations of law on similarity. Model elaboration materials. Materials for model creation. Model testing. Investigation of isotropic and anisotropic materials. Mechanical characteristics of material. Parameter identification of fracture mechanics and theory of plasticity. Parameters of creeping, shrinking and relaxation. Inherent stress and strain identification methods. Deterministic and stohastic excitations. Response in a time, frequency and amplitude. Simultaneous registration of excitation and response.FFT analysis. Functions of correlation, spectral density power, coherence and frequency system response. / *Compulsory references*: Papoulis, A.: Probability, random variables and stohastic processes, McGraw-Hill, Singapore, 1987.; Rohrbach, C.: Handbuch für experimentelle Spanungsanalyse, VDI, Düsseldorf, 1989. / *Optional references:* Helstrom, C. W.: Probability and stohastic processes for engineers, Macmilan, New York, 1984.

21867 Theory of Composites (2+1) 4,5

Introduction into Composite theory**:** classification of composites, compatible composite element of structures; composite systems, layered composites; special composites; design. Properties: mechanical properties of reinforcement, matrix and composites; strain analysis, stress and boundary conditions; short-term and long-term loads; dynamic loads; analysis of homogeneity and anisotropy; behavior in constant and dynamic mechanical loads; non-mechanic actions: moisture, temperature, radiation; testing procedures. Theoretical and experimental basis for dimensioning: multi-layered composites; procedures for setting of characteristic values; composite systems; rheologic properties and models of

composite elements and systems. Loads and calculation of systems and structures. Numerical fundamentals: static loads, dynamic loads, examples of application, construction of new buildings, repair of buildings; plates; retaining structures, pipes; sandwich-elements, tension members, bearings, transitional device, anti-vibration and anti- earthquake systems; models for design and repair. Safety and reliability testings; monitoring, quality control in production and on construction site; laboratory and field tests; state of the art development and application recommendation./ *Compulsory references*: Moser Kurt: Faser-Kunststoff-Verbund, VDI-Verlag GmbH. Düsseldorf, 1992.; Advanced Composite Materials in Bridges and Structures ACMBS-IV. Calgary, Alberta, Canada, 2004.; Eggert, H., Kauschke, W.: Structural Bearings, Ernst&Sohn, Berlin, Germany, 2002.; Ramberger G.: Structural Bearings and Expansion Joints for Bridges, IABSE-AIPC- IVBH, Zürich, 2002. / *Optional references*: Laszlo, P. Kollar: Mechanics of Composite Structures, Cambridge University Press 2003.

21787 Concrete and Masonry Structures II (2+1) 4,5

Composite slabs. Complex slabs. Flat slabs, triangular slabs, slabs supported on two adjoining borders, slabs with opening. Design, theoretical concepts, legal regulations. Torsion of reinforced concrete sections. Serviceability limit states. Creep and shrinkage of concrete. Beam deflections. Crack design according to PBAB and EC2. Minimum slab and beam reinforcement for crack limitations. Deflection design according to PBAB and EC2. Slender columns**.** Elements under longitudinal force and bending moment. Design according to 2nd order theory**.** Interaction diagrams. Jackson&Moreland's diagrams for calculation of slenderness. Biaxial bending of columns. Hollow columns. Local compressive stresses. Short cantilevers. Joints and hinges of frameworks. Bearing systems of reinforced concrete walls. Full walls and walls with openings. Mixed bearing systems of frameworks and walls. Deep beams. Frame bearing systems. Foundation and retaining concrete reinforced structures. Structural elements of masonry. Examples of design. Masonry work. Materials and their storage. Preparation of mortar and concrete for infill. Construction of masonry and concreting of infill. Protection of newly erected masonry. Masonry work categories. Masonry structures in seismic areas. Materials and masonry bond. Design models. Examples. Simple design rules for masonry buildings. Rules for seismic areas. Stability and robustness. Wall thicknesses. Strengthening of masonry structures. Structures damaged in earthquakes. Building heritage. Bonds of masonry structure elements. Research work. Examples. / *Compulsory references*: Tomičić, I. Betonske konstrukcije. Zagreb: Društvo hrvatskih građevinskih konstruktora, 1996.; Tomičić, I. Priručnik za proračun armiranobetonskih konstrukcija. Zagreb:

Društvo hrvatskih građevinskih konstruktora, 1996.; Sorić, Z. Zidane konstrukcije (drugo, prošireno izdanje). Zagreb : vl. nakl., 2004. / *Optional references*: Hrvatske norme HRN ENV 1992, norme za betonske konstrukcije (Eurokod 2), Hrvatske norme HRN ENV 1996, norme za zidane konstrukcije (Eurokod 6), Hrvatske norme HRN ENV 1991, norme za opterećenja konstrukcija (Eurokod 1), Hrvatske norme HRN ENV 1998, norme za seizmička područja.

21868 Shell Structures (2+2) 6,0

Structural achievements and design principles throughout history. Basic principles of solving. Boundary problems: force method and displacement method. Strong and weak formulation. Discretization concept and a survey of numerical calculation method. Ritz method. Idea of finite element method. Grids and plates. Wall girders. Folded-plate structures. Shells. Static and kinematic constraints in engineering structures. Auditory practice: general guidelines for solving each unit of programming tasks. Design practice: auditory practices on computer. Construction practice: each student will be taught individually in design work. Seminar: final assignment presentation./ *Compulsory litearatura*: S. Timošenko, S. Woinowsky – Krieger: Teorija ploča i ljuski, Građevinska knjiga, Beograd, 1962.; K. Girkman: Površinski sistemi nosača, Građevinska knjiga, Beograd, 1965.; I. Senjanović : Teorija ploča i ljuski, učilišna naklada Liber, Zagreb, 1973. / *Optional references*: J. Sorić: Metoda konačnih elemenata, Golden Marketing, Tehnička knjiga, Zageb, 2004.; I. E. Gordon: Structures, or why things don't fall down, Da Capo Press, Inc, New York 1978.

21869 Stability Theory (2+1) 6,0

Basics on a stability phenomenon. Possible ways of stability losses. Basic approach to stability analysis. Examples of stability on mechanical models (including the theory of small and large displacements. Problem of elastic columns stability, differential equations of buckling of 2^{nd} and 4^{th} order for different supporting conditions (equilibrium approach).Imperfection impact on stability of compressively loaded columns. Stability of columns and beams simultaneously loaded by compressive forces and in bending. Frame stability (equilibrium approach). Arch stability. Energy-based methods of application in stability analysis. Rayleigh' s and i Timošenko 's quotient, Rayleigh-Ritz method, Galerkin's method. Plate stability. Basics on a plate bending theory. Stability of thin elastic plates by means of a small displacement theory. Stability of thin elastic plates applied by means of a theory of moderately large displacements. Postcritical behaviour of plates. Stability of shells. Stability of thin-walled transverse girders.

Stability in plastic space. Engesser 's and Shanley' s theory. / *Compulsory references*: Pisani materijali s Lectures (Dvornik, Bjelajac), Timošenko; Teorija elastične stabilnosti; A. Mihanović: Stabilnost konstrukcija. DHGK,1993.

21870 Structural Testings (2+2) 6,0

Introduction. Purpose of testing of structures. Classification of tests. Research and investigation. Inspection. Mechanical and geometric sizes measured at testing of structures**.** Absolute displacement of structural point. Change in the distance of structural points (strain). Rounding angle. Bent. Relative strains. Measuring tools for mechanical and geometric values. Tools elements. Augmentation. Precision.Reliability. Hysteresis. Sensitivity. Guaging area. Measuring tools for displacement, changes in length (strain gauges), angle alteration, change of bent. Guaging of tools. Tensometry. Tensometry types: mechanical, optical and mechanical, optical, acoustic, electrical. Electroresistive strain gauges (EOT). Types. Ways of installation and connection. Measuring instruments systems. Creation of supporting devices for gauging displacement, acceleration, thrust force etc. Analysis of plane state stress by strain gauging**.** Uniaxial stress state. Biaxial stress state. Biaxial stress state with known major directions of stress. General biaxial stress state. Rosette. Mohr s strain circle. Triaxial strain state and stress state. Relevant methods of strain state and strain of structures analysis and their members. Photoelasticimetry. Moire method. Procedure with brittle waves. Hollographic methods. Geodesic surveys. Modeling. Procedures of material checks and characteristics of tested structure. Hollowing out of cores. Utrasound. Sclerometry. Radiographic recording. Static testing of structures. Design. Performance. Modes of loading. Results evaluation. Norms and conditions of structure validity. Dynamic testing. Design. Performance. Modes of measured loading and values. Dynamic parameters of structures. Measuring outcome assessment. Norms. / *Compulsory references*: Kiričenko, A. i sur.: Mjerenje deformacija i analiza naprezanja konstrukcija, DIT-Zagreb, Zagreb, 1982.; Alfirević, I., Jecić, S.: Fotoelasticimetrija, Liber, Zagreb, 1983./ *Optional references*: Brčić, V., Čukić, R.: Eksperimentalne Researche u projektiranju konstrukcija, Građevinska knjiga, Beograd, 1988.; Aničić, D.: Examivanje konstrukcija, Građevinski fakultet Sveučilišta u Osijeku, Osijek, 2002.

4.2.7.2. ELECTIVE SUBJECTS

21783 Prestressed Concrete (2+2) 6,0

General information on presstressed concrete: types of prestressing, types of prestressed concrete structures, systems of lifter anchoring, introducing prestressing force into structure, basic calculations of prestressed concrete structures, computer application, materials properties of prestressed concrete structures, dimensioning of sections - meeting the basic criteria, serviceability limits, stability of prestressed concrete elements, fatigue of prestressed concrete structures, behaviour of prestressed concrete structures under fire, production and assembly of prestressed concrete structures, prestressing in bridge construction, prestressing in industrial facilities, prestressing in building construction (frames, floor slabs, cupolas, shells), prestressing in geotechnics, maintenance and repair of prestressed concrete structures, application of new materials. / *Compulsory references:* Pičulin, S.; Dekanović, Đ.; Kindij, A. *Prednapete betonske konstrukcije*, CD s predavanjima 2001-2005., Zagreb. / *Optional references:* Leonhardt, V. Vorlesungen űber Massivbau, Fűnfter Teil. Berlin, Heidelberg, New York : Springer-Verlag, 1979.

21784 Bridges 2 (2+2) 6,0

Elements of structural planning. Structural planning of bridges. Bridge design – conceptual design. Optimization of alternative solutions. Combinations of bridge actions. Basic bridge statical analysis. Stability problem in bridges. Seismic analysis. Beam bridges (analysis and detailing). Plate main girders of metal bridges. Truss main girders. Beam bridges (construction). Slab bridges (statical analysis, design, construction). Decks of railway bridges. Bracings. Orthotropic steel decks. / *Compulsory references:* Radić, J. Mostovi. Zagreb: Dom i svijet, 2002.; Tonković, K. Masivni mostovi (Opća poglavlja). Zagreb : Školska knjiga 1977.; Tonković, K. Mostovi (Građenje). Zagreb : Školska knjiga 1979. / *Optional references:* Taly, N. Design of Modern Highway Bridges. New York : McGraw-Hill, 1992.; Bennett, D. The Creation of Bridges. New Jersey : Chartwell Books, 1999.

21871 Numerical Methods in Structural Analysis (2+1) 4,5

Equation system solving and stiffness matrix representations. Approximations of functions. Numerical integration. Finite difference method. Boundary element method. Discrete element method. Partition of unity methods. Finite volume method. Differential quadrature method. Application of splines.Equation systems solving and numerical integration. Numerical example of finite differences. Numerical example of boundary elements. Elaboration of students' papers.

Presentation of students' papers. / *Compulsory references*: E. Stein, R. de Borst, T. J. R. Hughes: Encyclopedia of Computational Mechanics, Vol. 1. Skripta (u pripremi). / *Optional references*: Z. Bittnar, J. Šejnoha: Numerical Methods in Structural Mechanics.

21872 Selected Topics on Strength of Material (2+1) 4,5

Rod bending of gradually alternating cross section. A girder of equal strength. Transversal normal stresses in rod bending under transversal stresses. (2) Concentration of stresses. Axial load, torsion, bending. Modeling of structures made of nonlinear elastic material. Axial load of rod structure. Straight rod bending of bilinear elastic material. Torsion. Contact tasks. General assumptions. Herz' s formulas for contact stresses and strains. Two spheres under pressure. Two rollers under pressure. General case of two bodies touching point under pressure. Thick-walled tubes. General definitions and assumptions. Differential equations and boundary conditions for axially symmetric body. Stresses and strains in thick-walled tubes under the action of internal and external pressures. Stresses and strains in composed thick-walled tubes. Heat strains in thick-walled tubes. Dynamic tasks. Strains in structural members at motion with an acceleration. Inertia forces, internal forces. Bending. Theory of impact. General assumptions. Stresses calculation and rod strain at impact load. Axial impact load. Impact load at bending. Torsion impact load. Stresses in longitudinal rod impact against a hard base. Stresses in transversal girder impact against stiff bearings. Calculation of strength in alternating stresses. Multiaxially alternating stresses. Application of strength theory. / *Compulsory references*: Šimić, V.: Otpornost materijala I, Školska knjiga, Zagreb, 2002.; Šimić, V.: Otpornost materijala II, Školska knjiga, Zagreb, 2002. / *Optional references*: Case, J., Chilver, A.: Strength of Materials and Structures, Edward Arnold, 1985.

21873 Finite Element Method (2+1) 4,5

Motivation and basic formulas in the analysis of structures. Derivation of variational formulation of fundamental problems. Linear and cubic finite elements. Application of FEM to beam girders. Application of FEM to frame plane girders. Derivation of elementary stiffness matrix for wall girders. Solution of equation of plate by the finite element method (derivation of bicubic finite element, derivation of elementary stiffness matrix, application to the variational formulation of the problem). Derivation of elementary stiffness matrix for shells. Application of FEM to stationary conduction equation. Concept of numerical calculation. Error estimation of numerical calculation. Auditory practice: Illustration of solving of

equation system and numerical integration. Numerical analysis of a beam girder. The concept of numerical computation of a plate bending problem. Design practice: Demonstration of programming packages. Preparation of input data for correct calculation by programming packages. Construction practice: Preparation of input data for standard problems of structural analysis. Presentations of final works – seminar. / *Compulsory references*: 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.; G. R. Buchanan: Finite Element Analysis, McGraw-Hill, 1994.; Skripta (u pripremi). / *Optional references*: T. J. R. Hughes: The Finite Element Method: linear Static and Dynamic Analysis, Dover, 2000.; W. B. Kraetzig, Y. Basar: Tragwerke 3, Theorie und Anwendung der methode der Finiten Elemente, Springer, 1997.; H. Werkle: Finite elemente in der Baustatik, Vieweg, 1995.; J. Sorić: Metoda konačnih elemenata, Golden Marketing-Tehnička knjiga, 2004.

21874 Programming of Structure Analysis Procedures (2+1) 4,5

Programming paradigms and programming languages; syntax and semantics; Turing' s machine. Basic data types and basic operations. Representation of real numbers (IEEE norm); algebraic operations; rounding off and precision. Control structures: loops and branching. Mathematical and programming functions. Classes. Object-oriented and functional programming. Concept based programming. Vectors and matrixes (full and sparce). Data structures (arrays, lists, trees, dictionaries). Programming of linear algebra operation. Structure of finite element programmes: Topological relations in finite element mesh; refinement and hierarchy of meshes. Element and structure stiffness matrixes; load vector. Coordinate systems and transformation of coordinates. Equilibrium equations and assembly of structure stiffness matrix. Solutions of equation system; utilization of programming libraries (Lapack, Umfpack, SuperLU). Relaxation, gradient and multilevel procedures. Programming elements for stability calculation and dynamic calculation. / *Compulsory references*: I. M. Smith & D. V. Griffiths: *Programming the Finite Element Method*, Wiley, New York, 1999. / *Optional references*: R. Sethi: *Programming Languages. Concepts and Constructs*, Addison-Wesley, Reading, 1989.; M. L. Overton: *Numerical Computing with IEEE Floating Point Arithmetic*, SIAM, Philadelphia, 2001.; M. A. Weiss: *Data Structures and Algorithm Analysis*, Addison-Wesley, Reading, 1998.; J. J. Barton & L. R. Nackman: *Scientific and Engineering C++*, Addison-Wesley, Reading, 1994.; D. R. Brooks: *Problem Solving with Fortran 90 for Scientists and Engineers*, Springer, New York, 1997.

21875 Polymers (2+1) 4,5

General information on polymers: history; polymeric materials in construction; composition; procedures of creation: polymerisation, polycondensation, polyaddition, combined procedures; classification of polymeric materials on the basis of physical properties, conditions of processing, application. Major types of polymeric materials in construction of buildings. Processing: vulcanisation; extrusion; rolling; pouring; pressing; coalescence; blowing; laminating; coiling; sprinkling. Properties. Mechanical properties: static and dynamic load; long-term and short-term load; fatigue; temperature related properties; delayed stresses and brittle failure; permanent deformations; boundary states at one-way and multi-way stresses; weather related properties; theory of linear and non-linear viscoelasticity; rheology 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. Reinforced polymeric materials: types; properties; production. Foam polymeric materials: types; properties; production. Application of polymeric materials in construction of buildings: wall and roof elements; pipes and fitting elements; domes, shells and diaphragms; geosynthetic materials; sandwich elements; polymeric mortars and concretes; surface protection; waterproofing; environmental protection; supports; sealings; vibration and earthquake resistant insulation; design, production and installation. Polymeric materials in structure repair and maintenance. / *Compulsory references:* Šimunić Ž.: Polimeri u građevinarstvu, skripta, Zagreb, 2005.; Feldman, Dorel: Polymeric Building Materials, Elsevier Applied Science, London and New York 1989.; Schießl, P. Kunststoffe, TUM, München, 2002. / *Optional references*: Ramberger, G.: Structural Bearings and Expansion Joints for Bridges, IABSE-AIPC- IVBH, Zürich, 2002.; Williams, J. G.: Stress Analyssis of Polymers, John Wiley&Sons London, 1980.

21876 Methods of Theory of Elasticity and Plasticity (2+1) 4,5

Vector and tensor analysis. (Coordinate transformations, Operations with tensors, eigen values and vectors.) Methods of stress and deformity analysis. (Basic equations in theory of stress and defomities. Acceptable static and kinematic levels, boundary conditions in theory of elasticity and plasticity). Formulation of boundary phenomena in theory of elasticity and plasticity, Solution on the basis of various parameters, Procedure in solving boundary phenomena of theory of elasticity and plasticity. Numerical and analytic methods in solving boundary phenomena in theory of elasticity and plasticity. (Differential procedure, Residual procedures (Galerkin method, Least squares method ....), Airy function of

stress, Analytic functions and functions of complex variable). Methods in solving boundary phenomena based on functional enegry. (Energy principles and theorems, Variational principles, Principle on minimum total and complementary potential energy, Application of variational methods in mechanics of continuum, Rayligh-Ritz method, Method of final elements, Method of boundary elements, Incremental procedures in theory of elasticity and plasticity). Procedures in solving some partial differential equations of theory of elasticity and plasticity). / *Compulsory references:* Z. Kostrenčić: Teorija elastičnosti, Školska knjiga, Zagreb, 1982.; J. Brnić: Elastomehanika i plastomehanika, Školska knjiga, Zagreb, 1996. / *Optional references*: I. Aganović; K. Veselić: Jednadžbe matematičke fizike, Školska knjiga Zagreb, 1985.; C. A. Brebbia and A. J. Ferrante: Computational Methods for the Solution of Engineering Problems, Pentech Press, London, 3rd revised edition, 1986.; N. S. Bakhvalov: Numerical Methods, MIR Publishers – Moscow, 1977.; W. F. Ames: Nonlinear Partial Differential Equations in Engineering, Volume II, Academic Press,New York – London, 1972.

21877 Stohastic Analysis of Structures (2+1) 4,5

Basic concepts of probability theory. Random variables. Functions of random variables. Random functions. The concept of uncertainty of input parameters in structure analysis. Structures described by a single random variable. Stohastic method of finite elements. Application of results in commutation of structure reliability. Practice: Operations with random variables. Application of uncertainty to beam girders (3 hours for one random variable, 2 hours for more random variables.) Application of stochastic method of finite elements to a beam girder. Numerical example of stochastic method of finite elements (4 hours – design practice. Students' works presentation / *Compulsory references*: I. Elishakoff: Probabilistic Theory of StructuresSkripta (u pripremi) / *Optional references*: A. Haldar, A. Guran, B. M. Ayyub: Uncertainty Modelling in Finite Element, Fatigue and Stability of Systems; A. Haldar, S. Mahadevan: Reliability Assessment Using Stochastic Finite Element Analysis.

21878 Selected Topics on Theory of Stability (2+1) 4,5

Static, energy and dynamic approach to the problem of stability. Survey of energy principles and their application. Stability in post-critical area. "Snap-through". Frameworks. Plates. Cylindrical shells. Local buckling. Problems of multiple eigenvalues. Basics of bifurcation theory and theory of catastrophe. Koiter' s theory. Dynamic stability and stability of nonconservative systems. Problems of aerodynamic stability (divergence, flutter, Karman' s effect. Beck' s

problem ("Follower forces"). Parametric vibrations, parametric resonance. Phasic system. Poincare' s maps. Chaos in deterministic systems. / *Compulsory references:* J. Dvornik, V. Raduka, Bilješke iz Lectures; S. Timošenko, Teorija elastične stabilnosti, Naučna knjiga, 1952. / *Optional references*: Z. P. Bažant, L. Cedolin, Stability of structures, Oxford University Press, 1991.; J. M. T. Thompson, G. W. Hunt, A general theory of Elastic Stability, John Willey & Sons, 1973.

21879 Basics of Fracture Mechanics (2+1) 4,5

Introduction and historical development of fracture mechanics. Physics of fracture. Ideal strength of material. Ductility and brittleness. Modes of cracks propagation. Basic definitions. Linear and elastic fracture mechanics (LEFM): Basic equations. Impact of cracks on stress concentration. Grifftih's condition for crack development (energy approach) and Irwin' s modification. The speed of energy release (G). Instability of crack and «R» curve. Basic shapes of crack development. The field of stress and displacement in the surroundings of crack peak. Stress intensity factor (K) d its significance. Functions of geometry (shape factors). Fracture criteria. Fracture toughness. Material toughness. Relation between stress intensity factor and released fracture energy. Experimental methods of parameter determination LEFM. Elastic-plastic fracture mechanics (EPFM): plasticity area at the peak crack. Dugdale's model for elastic-plastic materials. Opening of a crack in peak (CTOD). Rice's contour integral. Connection between CTOD and Rice's contour integral. Stable and unstable crack development. Fracture criteria. Experimental determination of EPFM parameters. Fracture mechanics of metals, ductile fracture. Fracture mechanics of nonmetals. Fracture mechanics of nonmetals (plastic materials, ceramics, concrete and stone) Quasi-brittle fracture. / *Compulsory references*: Anderson, T. L.: Fracture mechanics: Fundamentals and Applications, CRC Press LLC, 2000 N. W. Corporate Blvd., Boca Raton, Florida, 1995.; Šumarac, D., Krajčinović, D.: Osnovi mehanike loma, Naučna knjiga, Beograd, 1990.; Šimić, V.: Otpornost materijala II, Školska knjiga, Zagreb, 2002./ *Optional references*: Knott, J. F.: Fundamentals of Fracture Mechanics, Butterworths, Printed in Great Britain by Page Bros., Norwich, 1973. (Reprinted 1981.); Parton, V. Z. & Morozov, E. M.: Elastic-Plastic Fracture Mechanics, „Nauka", Moscow, 1974., Prijevod na engleski „Mir Publishers", Moscow, 1978.; Karihaloo, B. L.: Fracture mechanics & Structural Concrete, Concrete Design & Construction Series, Sidney, 1995.

THE BOLOGNA PROCESS

The Bologna Process is a European higher education reform. It is named after the Bologna Declaration signed by ministers of education from 29 European countries in the Italian city of Bologna, on 19 June 1999, with the view of establishing a European Higher Education Area by 2010. Up to date The Bologna Declaration has been signed by 40 European states. The Republic of Croatia joined the Declaration in May 2001.

Its goals are as follows:

- Accepting the system of easily recognizable and comparable academic and professional degrees and the introduction of additions to diplomas for the purpose of quicker and easier employment and international competitiveness.

  Diploma Supplement is issued upon graduation. It outlines the curriculum of all the courses taken and their ECTS credit value. It officialy states the level of education reached.

- Accepting the unique system of three cycles of studying: undergraduate, graduate and postgraduate (professional or doctoral).

  The first cycle (BA, undergraduate, bachelor's degree) - is a three-year programme with a qualification for the European labour marker and preparation for further education.

  The second cycle (MA, graduate, master's degree) – offers students further specialization in the fields of the same or other sciences. Degree in graduate studies enables students to join European labour market or enrol in postgraduate studies.

  The third cycle (Phd, postgraduate, doctor's/professional degree).

- Introduction of a credit system (ECTS). Credits can also be accumulated outside the system of higher education through lifelong learning programmes. European Credit Transfer System are credits. Their value represents the course load of students compulsory for finalizing a course. They are distributed within the required total course load in an academic year. According to the ECTS system one academic year accounts for 60 credits (one semester is 30 credits). The credits are earned if students' performance has been evaluated either through examinations or other evaluation method.

Student course load during one academic year is from 1500 to 1800 working hours, namely 60 ECTS credits for one academic year. One ECTS credit is worth 25-30 working hours.

- Promoting mobility and overcoming obstacles to free movement of students and instructors. Student mobility means the return of students' to their domicile university after education finalised at some other home or European universty.

  There are two types of mobility:

  - Horisontal mobility – students spend time studying at some other university in country or abroad.
  - Vertical mobility – students graduate from a European university.

- Promoting European cooperation in securing quality.

  The system of quality assurance ensures permanent quality control and development of study programmes during academic year (the quality and implementation of the curriculum, assessment of lecturers' work, technical equipment, information access etc.)

  The condition for introducing the quality assurance system is the introduction of comparative methods and criteria for assessing quality of research and higher education instruction. In 1998 the European Commission recommended closer cooperation in this field and established the European Association for Quality Assurance in Higher Education (ENQA).

- Promoting a European dimension in higher education.

  The European area of higher education is promoted by developing study programmes, inter-institutional cooperation, mobility programmes, integrated study programmes, specialization and research.

  The goal is to make European Union most competitive and most dynamic learning society in the world, capable of sustainable economic development with higher quality jobs and higher social cohesion. The goal will be realized by extensive investment into education and advancement of educational systems. For this purpose European Commission has started various programs and funds for the promotion of student, instructor and administrative staff mobility. They are opened to citizens of EU member states, and some to the citizens of candidate states for membership in EU (The Republic of Croatia).

COURSE LIST The Bologna Process is a European higher education reform. It is named after the Bologna Declaration signed by ministers of education from 29 European countries in the Italian city of Bologna, on 19 June 1999, with the view of establishing a European Higher Education Area by 2010. Up to date The Bologna Declaration has been signed by 40 European states. The Republic of Croatia joined the Declaration in May 2001.

COURSE LIST

UNDERGRADUATE UNIVERSITY STUDY

Course code	Course title
21675	English in Civil Engineering
21677	Introduction to Civil Engineering
21678	Mathematics 1
21679	Descriptive geometry
21680	Basics of Engineering Informatics 1
21681	Physics
21682	Mathematics 2
21683	Sociology of Work and Professional Ethics
21684	Business Economics
21685	Mechanics 1
21687	Hystory of Building Constructions
21688	Building Construction
21690	Probability and Statistics
21692	Materials Science
21693	Basic of Engineering Informatisc 2
21716	Geodesy
21717	Applied Geology
21718	Soil and Rock Mechanics
21719	Geotechnical Engineering
21720	Fluid Mechanisc
21721	Hydrology
21722	Environmental Protection

Course code	Course title
21723	Water Supply and Sewerage 1
21724	Water Protection
21725	Hydraulic Engineering Structures
21726	Concrete and Masonry Structures
21727	Metal Structures
21728	Bridges
21729	Timber Structures
21730	Leightweight Structures
21731	Construction of Materials
21732	Basics of Concrete Technology
21733	Law in Construction
21734	Building Technology
21735	Technology of Heavy Construction
21736	Construction Management
21737	Education on Construction Site
21738	Roads
21739	Railways
21740	Strenght of Materials 1
21741	Mechanics 2
21742	Strenght of Materials 2
21743	Structural Analysis 1
21744	Structural Analysis 2
21745	Numerical Modelling of Structures
21764	Outline of Civil Engineering Legislation
21894	Physical Education
21910	German Language in Civil Engineering

GRADUATE UNIVERSITY STUDY

Course code	Course title
21675	English in Civil Engineering
21722	Environmental Protection
21746	Geotechnical laboratory
21747	Flow processes in soil and rock
21748	Soil mechanics
21749	Rock Mechanics
21750	Foundation engineering
21751	Numerical modeling in geotechnics
21752	Applied geology
21753	Field Investigations and Monitoring
21754	Earthfill and Retaining Structures
21755	Hydrogeology and engineering geology
21756	Underground structures
21757	Geotechnics and Environmental Protection
21758	Dynamics of Soil
21759	Geotechnical design
21760	Improvement of Soil and Rock
21761	Hydraulics
21762	Hydrology 2
21763	River Training
21764	Water Supply and Sewerage 1
22765	Water Protection
21766	Ports and Waterways
21767	Drainage and Irrigation 1
21768	Water Power Development

Course code	Course title
21770	Water Resources Engineering
21771	Water Supply and Sewerage 2
21772	Urban Hydrology
21773	Potable and Water Treatment
21774	Modeling in Hydraulic Engineering
21775	Drainage and Irrigation 2
21776	Flood Protection
21777	Design in Hydraulic Engineering
21778	Vegetative Water Facilities
21779	Road Runoff Treatment and Disposal
21780	Experimentaql Hydraulics
21781	Special Water Power Projects
21782	Maritime Structures
21783	Prestressed Concrete
21784	Bridges II
21785	Metal Structures II
21786	Reliability of Structures
21787	Concrete and Masonry Structures II
21788	Metal Structures III
21789	Timber Structures II
21790	Durability of Structures I
21791	Precast Reinforced Concrete Structures
21792	Applied metallurgy
21793	Concrete Structures III
21794	Bridges III
21795	Stability of Structures
21796	Durability of Structures II

Course code	Course title
21797	High - rise Buildings
21798	Special Engineering Structures
21799	Composite Structures
21800	Earthquake Engineering
21801	Structures
21802	Mathematics 3
21803	Stochastic Processes
21804	Basics of Differential Geometry
21805	Numerical mathematics
21806	Perspective
21807	Vibrations and Waves
21808	Theory and technology of concrete
21809	Building Physics
21810	Durability of Structural Materials
21811	Special Concrete and Technologies
21812	Design of experiments
21813	High Performance Concrete
21814	Precast Systems
21815	Non-destructive Testings
21816	Fire Protection
21817	Technology of Repair and Strengthening
21818	Quality management
21819	Transportation Facility Concrete
21820	Hydraulic concretes
21821	Numerical Modeling in Engineering Materials
21822	Research Methods
21823	Construction Management II

Course code	Course title
21824	Building Maintenance Management
21825	Optimization Methods in Construction
21826	Work Study
21827	Technology of Civil Engineering
21828	Management for Construction Industry
21829	Management in Civil Engineering
21830	Construction Project Management
21831	Construction Business Systems
21832	Planning and Scheduling Methods
21833	Construction Site Practice
21834	Human Resource Management
21835	Technology of Civil Engineering 2
21836	Investment Appraisals in Construction
21837	Work and Production Organization
21838	Production Technology of Materials
21839	Business Strategies in Construction
21840	Organizational Behaviour
21841	Construction Equipment I
21842	Facility Management
21843	Supervision and Monitoring of Construction Projects
21844	Traffic Noise
21845	Transportation Engineering
21846	Highway Design
21847	Railway Design and Construction
21848	Pavements Structures
21849	Permanent Way
21850	Earthworks

Course code	Course title
21851	Road Intersections
21852	Traffic Tunnels
21853	Airport
21854	Equipment of traffic routes
21855	Traffic Systems
21856	Drainage of Transportation Facilities
21857	Soil – improvement Methods
21858	Pavement Management
21859	Urban Transportation Facilities
21860	Parking Lots
21861	Track Maintenance
21862	Mechanics of Material
21863	Nonlinear Statics of Rod Structures
21864	Theory of Elasticity and Plasticity
21865	Dynamics of Structures and Earthquake Engineering
21866	Experimental Methods I
21867	Theory of Composites
21868	Shell Structures
21869	Stability Theory
21870	Structural Testings
21871	Numerical Methods in Structural Analysis
21872	Selected Topics on Strength of Material
21873	Finite Element Method
21874	Programming of Structure Analysis Procedures
21875	Polymers
21876	Methods of theory of elasticity and plasticity
21877	Stohastic Analysis of Structures

Course code	Course title
21878	Selected Topics on Theory of Stability
21879	Basics of Fracture Mechanics
21880	Dynamic of Structures
21881	Traffic Buildings
21910	German Language in Civil Engineering