University of Split

Faculty of Civil Engineering, Architecture and Geodesy

POSTGRADUATE UNIVERSITY DOCTORAL STUDY PROGRAMME

Civil Engineering

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Postgraduate University Doctoral Study
Civil Engineering

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1. Introduction

1.1. History of postgraduate university doctoral study programme

The education of higher education professionals in Split commenced in 1971 when the Department of Civil Engineering was founded in Split as part of the Faculty of Civil Engineering, University of Zagreb. Since then the institution has developed rapidly in professional and financial field. It should be noted that on 1st January 1977 the Department developed into the Faculty of Civil Engineering Sciences, University of Split, as an independent institution.

The Faculty had existed under the aforementioned name until 30th June 1991, and since then it has been known as the Faculty of Civil Engineering, University of Split. The Faculty changed its name into the Faculty of Civil Engineering and Architecture in 23rd November 2003 when the study of architecture was founded.

In the area of technical sciences, field of civil engineering, the Faculty provided its students with knowledge and skills for independent work. The students attended six-semester programme (civil engineer), eight-semester programme (civil engineer with university degree), *magistar znanosti* (equivalent to Master of Philosophy in the UK) and *doktor znanosti* (doctoral degree).

- Postgraduate study for the master`s degree has been carried out at the Faculty since 1990 and the study programme Structural Modelling and Water Resources Management for the doctoral degree since 1992. Since the academic year 1992/1993 the studies have been divided into three specialities: Structural, Hydraulics and Traffic-Geotechnical Engineering, which still exist.
- The new Scientific Research and Higher Education System Act (Official Gazette 123, 31st July 2003) achieved the necessary requirements for joining the European higher – education system, which instigated the harmonisation of the existing postgraduate studies with the principles set out in the Bologna Declaration.
- According to the aforementioned Act and the principles of the Bologna Declaration, a new 3-year programme of postgraduate study has been established (180 ECTS credits) as the third highest level of education leading to the doctoral degree in the area of technical sciences, field of civil engineering.
- The studies are based on modern scientific findings conveyed by the teachers to the students through the lectures, seminars and other forms of teaching activities (seminar papers, programmes, laboratory practice, dissertation). The teachers are involved in scientific research by working on many research projects by the Ministry of Science, Education and Sport, other ministries, professional and economy institutions, international projects funded by the European Union through international bilateral cooperation. The space and equipment of

laboratories offer the maximum of opportunities for the execution of fundamental and applied research in which experimental practice plays the most important role.

- The development of the proposed postgraduate studies in Civil Engineering was based on the experience of a great number of study programmes on European level of education. According by, ten programmes of related studies offered by various European universities were analysed, particularly during the participation in the TEMPUS Project RUCE (TEMPUS J.E.P. Project No. 17062: Restructuring and Updating of Civil Engineering Curriculum) which included the following institutions: University of Glasgow (project coordinator), University of Stuttgart, University of Trieste, University of Athens, University of Pecs, University of Ljubljana, and the Civil Engineering Faculty from Zagreb, Osijek and Rijeka.
- The proposed programme of the postgraduate study is to a great extent similar to the studies carried out at the faculties of civil engineering at Delft University of Technology (Netherlands) and ETH Zurich (Switzerland). The postgraduate studies at both universities last 3 years (180 ECTS credits), and the number of ECTS credits for each course, i.e. set of courses is similar to this proposed programme. Furthermore, experience and good collaboration of our teachers with the teachers from various universities in Europe and in the world were also implemented, for instance: University of Swansea, Wales, Colorado State University, USA, University of Reno, Nevada, USA, Universitá degli Studi di Udine, Universitá degli Studi di Urbino, Universitá degli Studi di Bari, Université libre de Bruxelles, Royal Institute of Technology in Stockholm, University of Žilina in Slovakia, Queen Mary and Westfield College in London, Vienna University of Technology in Austria and others.
- The teachers at our Faculty published a great number of scientific and professional papers and university textbooks, as well as scientifically acclaimed books. The Faculty issues the well-known and internationally acknowledged scientific and international journal "International Journal for Engineering Modelling".
- Our cooperation with the business sector of civil engineering is very dynamic, especially in solving technical problems in the coastal area, i.e. in the flysch and karst areas. In addition to that, the activity of our teachers in the realisation of numerous civil engineering projects in our country and abroad was acknowledged and awarded. Their successful educational and scientific work has been awarded as well.

1.2. Previous experience in the field

The Ordinance on Postgraduate University (Doctoral) Study of Civil Engineering was adopted in November 2014 (hereinafter: the Ordinance) which integrally sets out the rules and requirements of studying, from the basic information to enrolment, study structure, teaching, supervision, procedure of taking exams and qualification exam, proposal submission, public discussion, assessment and defence of dissertation and others.

The Ordinance represents the legal framework for the changes introduced in this new study programme. The preparatory year is introduced in which the candidate achieves the 7^{th} level learning outcomes in order to conduct his/her research (8^{th} level) in the following three years by acquiring at least 240 ECTS credits. The Ordinance has introduced the Committee of the Postgraduate University (Doctoral) Study of Civil Engineering which manages admission-related activities,

transfer, assignment of supervisors, but also handles all issues and doubts arising from the study performance and teaching quality assurance.

The study programme is based on the individual syllabus selected for each candidate based on his/her project and the goals of his/her doctoral thesis. The study is flexible and offers the possibility of acquiring and testing knowledge on other constituents of our University, but also anywhere else in the country and abroad. The cooperation within ERASMUS+ and other programmes is also possible, as well as conclusion of contracts regarding the joint doctoral degree which enables the simultaneous execution of research-related activities at out institution and some other institution.

The basis of the research plan is the minimum of three years of research which meets the requirements for thesis submission, and the publishing or acceptance for publication of at least one internationally peer-reviewed original scientific paper in a journal indexed in the databases Web of ScienceTM Core Collection (1955-danas; including Science Citation Index Expanded™) and/or Current Contents Connect® (1998-danas; including Current Contents® / Engineering, Computing & Technology). The candidate has to be listed as the main author, and the paper needs to be from the field of the research topic and published in the journal from the scientific field of doctoral research. Furthermore, the candidate is obligated to present and publish at least one paper in the proceedings from an international conference, whose subject-matter is linked to his/her doctoral research.

1.3. Openness of the study programme towards student mobility and common cooperation with national and international universities

The study is open with respect to mobility, because it is structured in a way that the students who completed the former four-year undergraduate studies or current graduate studies (300 ECTS credits) at the faculties in our country or abroad specialised in technical and natural sciences. Each candidate can take up to 18 ECTS credits from other faculties (depending on subject of the dissertation and the interest of the candidate), and the candidates from other faculties can enrol at the interesting and required courses offered by this Faculty. Considering our rich experience thus far and the experiences of numerous universities in Europe and the USA, as well as the fact that our teachers can conduct classes in English, it is not pretentious to ascertain that the proposed study programme and the entire programme ensure student mobility of foreign students to our faculties and our students to the faculties abroad. The programme encourages student mobility in line with Erasmus+ or some other form of cooperation programme, as well as the possibility of joint doctoral degrees.

1.4. Other elements

Since Croatia has been deemed as the country of knowledge, it is evident that the need for experts with high level of education will constantly grow. Interest demonstrated thus far by the economy sector, public sector and institutes (state and private) has strengthened the notion that the proposed programme and syllabus represent the basis of modern education in the field of civil engineering considering scientific research and teaching activities. The Faculty has had the highest level of cooperation with similar faculties in the country and abroad to mutual satisfaction.

2. General information

Programme title	Postgraduate University Doctoral Study of Civil Engineering	
Scientific areas, fields and branches	Area: Technical Sciences; field: Civil Engineering and Other Fundamental Technical Sciences; branches: Geotechnics, Supporting Structures, Hydrotechnical Engineering, Transport, Organisation and Technology of Construction, Materials, Mechanics of Fluids, Organisation of Work and Production, Technical Mechanics.	
Institution	**Proposed by**	University of Split, Faculty of Civil Engineering, Architecture and Geodesy
	Participating Institutions	University of Split, Faculty of Civil Engineering, Architecture and Geodesy
Duration	4 years (1 preparatory year + 3 years of research)	
ECTS	240	
Institution developmental strategy	High-quality, specific curriculum, generation of the best young researchers, scientific networking in the country and abroad, life-long learning, innovative ideas, increased cooperation with the business sector, increased development of new technologies.	
Innovations in the doctoral programme	Interdisciplinary programme, collaboration, flexibility in the selection of courses, mobility, partnership with the business sector	
Admission requirements	Completed graduate studies in civil engineering or other graduate studies from the field of technical or natural sciences in line with the Ordinance of the Study Programme.	
Learning outcomes and competences	Doctoral degree in Civil Engineering at this faculty implies a very high level of scientific education based on the most recent findings from the relevant research field with the minimum of three years of research-related activities. The candidates with this degree can work in public and private sector, with the following competences: - Devise scientific research, in cooperation with the supervisor, in order to establish new hypotheses and reach new scientific achievements within the selected research area; - Prepare and present a public communication about the research results at an international conference; - Successfully defend the hypothesis and the results of scientific research, and present substantiated arguments in the discussion at the international conference; - Provide critical analysis and reasoning of published scientific papers of other authors within the selected scientific area; - Write and successfully publish at least one scientific paper as the main author in an international peer-reviewed journal; - Write a complete doctoral dissertation, publicly present it and successfully defend it; - Implement new knowledge and scientific cognitions from the doctoral thesis in practice; - Participate in the work of scientific teams for the purpose of realising national and international scientific projects.	
Qualification awarded	Doctoral degree in the area of Technical Sciences, field of Civil Engineering and Other Fundamental Technical Sciences (Dr.Sc.)	

3. Programme description

3.1. Structure and organisation of the study programme

The study programme is organised as full-time study and lasts from three to four years (eight semesters) or as a part-time programme which lasts six years (12 semesters), during which the student collects the minimum of 240 ECTS credits. Exceptionally, according to the Ordinance, the maximum duration for the full-time study programme is six years and eight years for the part-time programme. Compulsory and elective classes are carried out during the first two semesters. Last three years are exclusively scheduled for research-related activities, i.e. writing of the dissertation. From the total of 240 ECTS credits, 60 ECTS credits are acquired by examining the 7th level learning outcomes of compulsory and elective courses in line with the Ordinance, and180 ECTS credits in the activities related to the original scientific research resulting in writing and defending of the doctoral thesis.

The student achieves the minimum of 42 ECTS upon the examination of the learning outcomes of this study programme, and the remaining credits (maximum of 18 ECTS credits) can be achieved through acquisition and examination of 7th level learning outcomes at the constituent entities of the University of Split, other universities in the Republic of Croatia and/or abroad. According to the Ordinance, upon supervisor`s request, a certain number of ECTS credits can be awarded to the student for previously acquired 7th level learning outcomes. Ideally, the candidate can be released from attending classes at the preparatory year.

The Faculty of Civil Engineering, Architecture and Geodesy provides professional scientific advancement to doctoral candidates in the area of technical sciences, filed of Civil Engineering and other fundamental technical sciences.

Upon the completed admission procedure, a supervisor is assigned to each student. Co-supervisor can be appointed in addition to the supervisor. Supervision is granted pursuant to Article 33 of the Ordinance. In order to obtain the doctoral the degree, the candidate, under the supervisor`s supervision, performs research-related activities, which are provided by the study programme through Research I, II and III. The student thus acquires knowledge and skills for independent research and successful preparation of his/her dissertation.

3.2. List of compulsory and elective courses

Except for Research I, II and III and the course Methodology and Techniques of Scientific Research, all other courses are elective. Depending on the candidate`s interest and research topic, the supervisor advises the candidates on the selection of courses, whereas the selected courses should be applicable to the research topic. Each course is represented through the immediate classes and the writing of the

seminar paper, which contains experimental work and theoretic analysis of the concerned issue. The seminar paper is composed in line with the rules set out for the writing of scientific and professional papers. The majority of exams is carried out through oral presentation of the seminar paper, unless otherwise provided by the syllabus.

Research-relate activities carried out for the purpose of obtaining the doctoral degree are provided in the study programme through the courses Research I, II and III, which prepare the student for successful participation and autonomy in research-related activities and the composition of the dissertation. Learning outcomes are examined through seminar papers presenting research methods and papers accepted for publishing in journals or papers accepted for presentation at international conferences.

The list of compulsory (research) activities and elective courses across semesters with the number of ECTS credits is presented in the following tables:

I semester		
Code	**Course name / activities**	**ECTS**
GATA01	Methodology and Techniques of Scientific Research	6
	Elective courses	24
TOTAL:		**30**

II semester		
Code	**Course name / activities**	**ECTS**
	Elective courses	30
TOTAL:		**30**

III semester		
Code	**Course name / activities**	**ECTS**
GAXA01	Research I	30
TOTAL:		**30**

IV semester		
Code	**Course name / activities**	**ECTS**
GAXA01	Research I	30
TOTAL:		**30**

V semester		
Code	**Course name / activities**	**ECTS**
GAXB01	Research II	30
TOTAL:		**30**

VI semester		
Code	**Course name / activities**	**ECTS**
GAXB01	Research II	30
TOTAL:		**30**

VII semester		
Code	**Course name / activities**	**ECTS**
GAXC01	Research III	30
TOTAL:		**30**

VIII semester		
Code	**Course name / activities**	**ECTS**
GAXC01	Research III	30
TOTAL:		**30**

The following is a list of activities and courses with ECTS credits and workload.

Table 1

CODE	COMPULSORY RESEARCH ACTIVITIES REQUIRED FOR THE DOCTORAL DEGREE IN THE FIELD OF CIVIL ENGINEERING	ECTS credits
GAXA01	Research I	60
GAXB01	Research II	60
GAXC01	Research III	60

Table 2

CODE	COMPULSORY COURSE IN THE AREA OF TECHNICAL SCIENCES	weekly workload	ECTS credits
GATA01	Methodology and Techniques of Scientific Research	30+0	6

Table 3

CODE	ELECTIVE COURSES IN THE FIELD OF CIVIL ENGINEERING, BRANCH OF BEARING STRUCTURES	weekly workload	ECTS credits
GAKA01	Meshless Numerical Methods and Corresponding Adaptive Techniques	30+0	6
GAKA02	Numerical Modelling of Shell Structures	30+0	6
GAKA03	Numerical Methods for the Mechanics of Materials	30+0	6
GAKA04	Experimental Methods	30+0	6
GAKA05	Selected chapters of Structural Dynamics and Earthquake Engineering	30+0	6
GAKA06	Selected chapters of Structural Stability	30+0	6
GAKA07	Finite Element Method	30+0	6
GAKA08	Extreme Actions and Structure Safety/Stability	30+0	6
GAKA09	Steel and Composite Structures	30+0	6
GAKA10	Numerical Modelling of Concrete Structures	30+0	6
GAKA11	Design of Supporting Systems of Bridges and Structures	30+0	6
GAKA12	Mechanics of Discontinua	30+0	6
GAKA13	Numerical Modelling of Water-Soil-Structure Dynamic Interaction	30+0	6
GAKA14	Advanced Concrete and Masonry Structures	30+0	6

Table 4

CODE	ELECTIVE COURSES IN THE FIELD OF CIVIL ENGINEERING, BRANCH OF HYDROTECHNICS	weekly workload	ECTS credits
GAHA01	Dispersion Processes in Water Resources	30+0	6
GAHA02	Theory of Risk Assessment in Environmental Engineering	30+0	6
GAHA03	Karst Water Resources	30+0	6
GAHA04	Ecohydrology	30+0	6
GAHA05	Hydrological Modelling in Karst	30+0	6
GAHA06	Marine Hydraulics, special chapters	30+0	6
GAHA07	System Engineering in Water Resources Management	30+0	6
GAHA08	Coastal Processes	30+0	6
GAHA09	Selected chapters on Karst Hydrogeology	30+0	6
GAHA10	Introduction to Engineering Numerical Modelling	30+0	6
GAHA11	Analysis of Hydrological Time Series	30+0	6

Table 5

CODE	ELECTIVE COURSES IN THE FIELD OF CIVIL ENGINEERING, BRANCH OF TRANSPORTATION	weekly workload	ECTS credits
GAPA01	Traffic Flow Theory	30+0	6
GAPA02	Highways – selected chapters	30+0	6
GAPA03	Transport Planning	30+0	6

Table 6

CODE	ELECTIVE COURSES IN THE FIELD OF CIVIL ENGINEERING, BRANCH OF GEOTECHNICS	weekly workload	ECTS credits
GAGA01	Selected chapters of Rock Mechanics	30+0	6
GAGA02	Soil Mechanics Models	30+0	6
GAGA03	Special chapters in Foundation Engineering	30+0	6

Table 7

CODE	ELECTIVE COURSES IN THE FIELD OF CIVIL ENGINEERING, BRANCH OF MATERIALS	weekly workload	ECTS credits
GAMT01	Rheology of Materials	30+0	6
GAMT02	New Materials in Civil Engineering	30+0	6

Table 8

CODE	ELECTIVE COURSES IN THE FIELD OF OTHER FUNDAMENTAL TECHNICAL SCIENCES, BRANCH OF ORGANISATION OF WORK AND PRODUCTION	weekly workload	ECTS credits
GALA01	System Engineering in Project Management	30+0	6
GALA02	Decision Support Systems	30+0	6
GALA03	System Theory	30 + 0	6

Table 9

CODE	ELECTIVE COURSE IN THE FIELD OF ARCHITECTURE AND URBAN PLANNING	weekly workload	ECTS credits
GAAA01	Highways and the Environment	30+0	6

Table 10

CODE	ELECTIVE COURSES IN THE AREA OF TECHNICAL SCIENCES	weekly workload	ECTS credits
GATA02	Information Engineering	30+0	6
GATA03	Engineering Simulations Techniques	30+0	6

Table 11

CODE	ELECTIVE COURSES IN THE FIELD OF NATURAL SCIENCES, BRANCH OF MATHEMATICS	weekly workload	ECTS credits
GAMA01	Applied Functional Analysis	30+0	6
GAMA02	Practical Methods of Optimisation	30+0	6
GAMA03	Mathematical Analysis of Boundary Value Problems	30+0	6
GAMA04	Integral Equations	30+0	6
GAMA05	Methods of Mathematical Statistics	30+0	6

3.3. Compulsory and elective activities

All candidates are obligated to participate during their doctoral study at conventions, seminars, round tables, workshops, conferences and other activities evaluated by ECTS credits through the following activities: Research I, II, III. Potential selective participation will be agreed between the candidate and his/her superior.

3.4. Course description

3.4.1. Description of compulsory research-related activities

Course title	RESEARCH I		
Code	GAXA01		
Type	Theoretical and experimental research work in the field of civil engineering and/or other relevant branches within the field of other fundamental technical sciences, as well as other scientific fields within technical, natural and other scientific fields.		
Level	8th according to CroQF		
Year	II	**Semester**	III and IV
ECTS (number of allocated credits)	60.0 Number of ECTS credits was calculated according to the assessment of the potential supervisor and the Committee for Postgraduate University Doctoral Study. • Research-related activities (1560 hours) = 52.0 ECTS; • and/or Submission of the research proposal (60 hours) = 2.0 ECTS; • and/or Participation in the organisation of a scientific conference (60 hours) = 2.0 ECTS • Writing, preparation and defence of the seminar paper (60 hours) = 2.0 ECTS; • Preparing public presentation of the research topic/doctoral thesis (60 hours) = 2.0 ECTS;		
Teachers and/or associates	Supervisor(s) proposed by the Committee for Postgraduate University Study and approved by the Faculty Council.		
Learning outcomes and competences	• Put forward a research hypothesis; • Prepare and present communication about research findings; • Successfully defend the hypothesis and research results and present substantiated arguments; • Participate with the members of the team within scientific-research activities.		
Enrolment requirements	60 ECTS from the preparatory year.		
Content	Independent research and experimental work under the supervisor`s supervision within the research project and the topic of the doctoral thesis. Individual writing of scientific papers with the supervisor. Details are defined by the supervisor depending on the topic of research/doctoral thesis.		
Recommended literature	Depending on the topic of the research/doctoral thesis in line with the supervisor`s guidelines.		
Supplementary literature	Depending on the topic of the research/doctoral thesis in line with the supervisor`s guidelines.		
Teaching methods	Consultations and monitoring of progress of writing of seminar papers and papers for publishing. Permanent consultations.		
Assessment methods	Publicly presented seminar paper which shows research results and/or overview of the selected area of research. The paper has to be in the form of a scientific paper. Additionally, research outcomes can be tested through scientific papers sent to journals or accepted for presentation at conferences.		
Language of the course	Croatian and English		

Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Postgraduate University Doctoral Study and the Committee for Teaching Quality Monitoring; (3) Supervisor. Quality and success monitoring through the presentation of the seminar paper and research topic/doctoral thesis to the academic community.

Course title	RESEARCH II		
Code	GAXB01		
Type	Theoretical and experimental research work in the field of civil engineering and/or other relevant branches within the field of other fundamental technical sciences, as well as other scientific fields within technical, natural and other scientific fields.		
Level	8th according to CroQF		
Year	III	**Semester**	V and VI
ECTS (number of allocated credits)	60.0 Number of ECTS credits was calculated according to the assessment of the potential supervisor and the Committee for Postgraduate University Doctoral Study. • Research-related activities (1260 hours) = 42.0 ECTS; • and/or Submission of the research proposal (60 hours) = 2.0 ECTS; • and/or Participation in the organisation of a scientific conference (60 hours) = 2.0 ECTS • Writing, preparation and defence of the seminar paper (60 hours) = 2.0 ECTS; • Preparing public presentation of the research topic/doctoral thesis (60 hours) = 2.0 ECTS; • Preparing and writing a paper for an international scientific conference and/or international peer-reviewed journal (300 hours) = 10.0 ECTS		
Teachers and/or associates	Supervisor(s) proposed by the Committee for Postgraduate University Study and approved by the Faculty Council.		
Learning outcomes and competences	• Put forward a research hypothesis; • Prepare and present communication about research findings; • Successfully defend the hypothesis and research results and present substantiated arguments; • Participate with the members of the team within scientific-research activities.		
Enrolment requirements	Research I and 60 ECTS from the preparatory year.		
Content	Independent research and experimental work under the supervisor`s supervision within the research project and the topic of the doctoral thesis. Individual writing of scientific papers with the supervisor. Details are defined by the supervisor depending on the topic of research/doctoral thesis.		
Recommended literature	Depending on the topic of the research/doctoral thesis in line with the supervisor`s guidelines.		
Supplementary literature	Depending on the topic of the research/doctoral thesis in line with the supervisor`s guidelines.		
Teaching methods	Consultations and monitoring of progress of writing of seminar papers and papers for publishing. Permanent consultations.		

Assessment methods	Seminar paper which shows research results and/or overview of the selected area of research. The paper has to be in the form of a scientific paper. Accepted and/or published paper at an international scientific conference and/or international peer-reviewed journal.
Language of the course	Croatian and English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Postgraduate University Doctoral Study and the Committee for Teaching Quality Monitoring; (3) Supervisor. Quality and success monitoring through the presentation of the seminar paper and research topic/doctoral thesis to the academic community.

Course title	RESEARCH III		
Code	GAXC01		
Type	Theoretical and experimental research work in the field of civil engineering and/or other relevant branches within the field of other fundamental technical sciences, as well as other scientific fields within technical, natural and other scientific fields.		
Level	8th according to CroQF.		
Year	IV	**Semester**	VII and VIII
ECTS (number of allocated credits)	60.0 Number of ECTS credits was calculated according to the assessment of the potential supervisor and the Committee for Postgraduate University Doctoral Study. · Research-related activities (630 hours) = 21.0 ECTS; · and/or Submission of the research proposal (60 hours) = 2.0 ECTS; · and/or Participation in the organisation of a scientific conference (60 hours) = 2.0 ECTS · Writing, preparation and defence of the seminar paper (60 hours) = 2.0 ECTS; · Preparing public presentation of the research topic/doctoral thesis (600 hours) = 20.0 ECTS; · Preparing and/or writing a paper for an international peer-reviewed journal (450 hours) = 15.0 ECTS		
Teachers and/or associates	Supervisor(s) proposed by the Committee for Postgraduate University Study and approved by the Faculty Council.		
Learning outcomes and competences	• Write and successfully publish at least one scientific paper as the main author in an international peer-reviewed journal ; • Prepare and present a public communication about the research results at an international conference ; • Successfully defend the hypothesis and the results of scientific research, and present substantiated arguments in the discussion at the international conference; • Provide critical analysis and assessment of published scientific papers of other authors within the selected scientific area.		
Enrolment requirements	Research I and II, and 60 ECTS from the preparatory year.		
Content	Independent research and experimental work under the supervisor`s supervision within the research project and the topic of the doctoral thesis. Individual writing of scientific papers		

	with the supervisor. Details are defined by the supervisor depending on the topic of research/doctoral thesis.
Recommended literature	Depending on the topic of the research/doctoral thesis in line with the supervisor`s guidelines.
Supplementary literature	Depending on the topic of the research/doctoral thesis in line with the supervisor`s guidelines.
Teaching methods	Consultations and monitoring of progress of writing of seminar papers and papers for publishing. Permanent consultations.
Assessment methods	At least one paper accepted and/or published in an international peer-review journal cited in CC or Web of Science, and at least one paper presented at an international conference. Accepted and defended doctoral thesis.
Recommended literature	Depending on the topic of the research/doctoral thesis in line with the supervisor`s guidelines.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Postgraduate University Doctoral Study and the Committee for Teaching Quality Monitoring; (3) Supervisor. Quality and success monitoring through the presentation of the doctoral thesis to the academic community. Presentation of the results of the overall research to the international research community through paper(s) accepted for publishing in the international peer-reviewed journal cited in CC or Web of Science, and through paper(s) presented at international conferences.

3.4.2. Description of elective courses in the field of Civil Engineering, branch of Bearing Structures

Course title	MESHLESS NUMERICAL METHODS AND CORRESPONDING ADAPTIVE TECHNIQUES		
Code	GAKA01		
Type	Lecture, research seminar, independent study, work on a research project.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Blaž Gotovac, PhD / Prof. Vedrana Kozulić, PhD		
Learning outcomes and competences	Upon the completed course, the student will be able to: • Classify the types of known meshless numerical methods • Analyse geometry of the concerned area and boundary conditions by meshless method of R functions • Conduct analysis of engineering problems described by ordinary and partial differential equations by meshless methods • Analyse engineering problems by applying adaptive collocation method • Analyse stability and accuracy of adaptive meshless techniques		
Enrolment requirements	Undergraduate degree (6th level EQF or CroQF)		
Content	Review of classical numerical methods from the aspect of selection of solutions` base functions. Finite base functions from universal vector space from the aspect of practical use. Influence of the geometry of the area on the required problem solution - idea of R-functions method. Overview of adaptive techniques with the emphasis on the point collocation method and establishing numerical solutions with pre-set accuracy. Non-linear and non-stationary analysis of structures by using adaptive technique. Illustration of application of the adaptive procedure on simple examples, and the comparison of gained results with conventional solutions.		
Recommended literature	(1) Atluri, S.N., ″Methods of Computer Modeling in Engineering & the Sciences″, Volume I, Tech Science Press, University of California, Irvine, 2005. (2) Griebel, M. and Schweitzer, M.A. (Eds.), ″Meshfree Methods for Partial Differential Equations″, Springer-Verlag, Berlin, 2003. (3) Liu, G.R., ″Mesh free methods: Moving beyond the Finite Element Method″, CRC Press LLC, Boca Raton, 2003.		
Supplementary literature	(1) Gotovac B., Numeričko modeliranje inženjerskih problema pomoću glatkih finitnih funkcija, Disertacija, Fakultet građevinskih znanosti Sveučilišta u Zagrebu, Zagreb, 1986. (2) Kozulić V., Numeričko modeliranje metodom fragmenata pomoću Rbf funkcija, Disertacija, Građevinski fakultet, Sveučilište u Splitu, 1999. (3) Gotovac H., Tečenje i pronos s promjenjivom gustoćom u vodonosnicima, Magistarski rad, Građevinsko-arhitektonski fakultet, Sveučilište u Splitu, 2005. (4) Prenter P. M., Splines and Variational Methods, John Wiley & Sons, Inc., New York, 1989. (5) Rvačev V. L., Teorija R-funkcij i nekotorija jeje		

	priloženija, Naukova dumka, Kiev, 1982. (6) Čolak I., Numeričko modeliranje savijanja tankih ploča općeg oblika, Disertacija, Građevinski fakultet, Sveučilište u Mostaru, 2002. (7) Cruz, P., Mendes, A., Magalhes, F.D., Using wavelets for solving PDEs: and adaptive collocation method, Chemical Eng. Science, 56, 3305-3309, 2001.
Teaching methods	Lectures with the use of computers, consultation, seminar paper.
Assessment methods	Presentation of seminar paper results.
Language of the course	Croatian, English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	NUMERICAL MODELLING OF SHELL STRUCTURES		
Code	GAKA02		
Type	Lecture, research seminar.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Vedrana Kozulić, PhD / Prof. Blaž Gotovac, PhD		
Learning outcomes and competences	Upon the completed course, the student will be able to: • Independently create a numerical model of a building structure built of planar elements. • Properly describe arbitrary load, characteristics of material, boundary conditions at the border of a general form • Provide critical analysis of gained results in order to deliver proper engineering solutions.		
Enrolment requirements	Undergraduate degree (6th level EQF or CroQF).		
Content	Plane stress and bending of thin plates as special cases of shell structure models. Membrane and shear locking and its illustration on the line curved girder. Relationship between axe symmetric problems and special types of rotational shell structures. Examples of shell structures with geometry described by elementary functions as plane, sphere, cylinder, cone, hyper etc. Shells with regular geometry in one direction. Review of the classical theory of shells. Shell structures of general shape (analysis by 8.-node finite elements developed from 20.-node space isoparametric finite element). Computer programs: numerical simulation of mentioned phenomena and critical analysis of obtained results.		
Recommended literature	(1) Bathe, K. J., Finite Element Procedures in Engineering Analysis, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1982. (2) Zienkiewicz O.C., Taylor R.L., The Finite Element Method, Vol. 2: Solid Mechanics, Fifth edition, Butterworth-Heinemann, Oxford, 2000. (3) Irons B., Ahmad S., Techniques of Finite Elements, Ellis Horwood Limited, Chichester, 1980.		
Supplementary literature	(1) Gotovac B., Kozulić V., Čolak I.: Uvod u numeričko modeliranje prostornih konstrukcija, Sveučilište u Mostaru, Mostar, 2001. (2) Hou-Cheng Huang: Static and Dynamic Analysis of Plates and Shells: Theory, Software and Applications, Springer-Verlag, London, 1989. (3) Figueiras J.A. and Owen D.R.J.: Analysis of elasto-plastic and geometrically nonlinear anisotropic plates and shells, In: Finite element software for plates and shells, eds. E. Hinton, D. R. J. Owen, Swansea, pp. 235-322, 1984. (4) Hinton E. and Abdel Rahman H.H.: Mindlin plate finite elements, In: Finite element software for plates and shells, eds. E. Hinton, D. R. J. Owen, Swansea, pp. 157-229, 1984.		
Teaching methods	Lectures, seminar paper. Illustration of part of learnt material in practical tasks.		

Assessment methods	Oral presentation of the seminar paper. Oral exam.
Language of the course	Croatian, English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	NUMERICAL METHODS FOR THE MECHANICS OF MATERIALS		
Code	GAKA03		
Type	Lecture, research seminar, individual study with supervisor, work on a research project.		
Level	7th level EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Pavao Marović, PhD / Prof. Mirela Galić, PhD		
Learning outcomes and competences	Upon the completed course, the student will be able to: • formulate concepts and actual achievements in the area of the mechanics of materials, • select relevant numerical method at problem-solving in the area of the mechanics of materials, • create parts of computer software related to the mechanics of materials and calculations by the finite element method, • evaluate the results of numerical calculations in the area of the mechanics of materials, • suggest an appropriate numerical model depending on the type of material.		
Enrolment requirements	Graduate degree		
Content	Parameters of the solid state body: strength, elasticity, viscosity, visco-elasticity, plasticity, thermoelasticity. Load, time, temperature. Mechanical properties of materials under impact and cyclic load. Strength of materials under complex stress. Static and dynamic load. Overview and introduction into different numerical methods for numerical approximation of the description of behaviour of different materials: orthotropic and anisotropic materials, concrete (macro and micro models), stone, steel, soil, elastomers (plastics, rubber), timber. Classical elasto-plastic and elasto-visco-plastic numerical models. Geometrical non-linearity of structures – finite deformations. Geometrical non-linearity of structures – large displacements. Total and update Lagrange method. Numerical modelling of time-dependent influences: creep, cyclic actions, dynamical actions. Numerical models of composite materials. Procedures for solving systems of non-linear algebraic equations: Newton-Raphson method, Modified Newton-Raphson method, quasi-Newton method, Arc-length method.		
Recommended literature	(1) I. Alfirević: *Uvod u tenzore i mehaniku kontinuuma*, Golden marketing, Zagreb, 2003.; (2) S.P. Timoshenko: *Mechanics of Materials*, Van Nostrand Reinhold Co., New York, 1972. (3) A. Mihanović, P. Marović, J. Dvornik: *Nelinearni proračuni armirano betonskih konstrukcija*, DHGK, Zagreb, 1993.; (4) D.R.J. Owen, E. Hinton: *Finite Elements in Plasticity: Theory and Applications*, Pineridge Press, Swansea, 1980.		
Supplementary literature	(1) J. Bonet, R.D. Wood: *Nonlinear Continuum Mechanics for Finite Element Analysis*, Cambridge University Press, 1977.; (2) G.A. Holzapfel: *Nonlinear Solid Mechanics – A Continuum Approach for Engineering*, Wiley, Chichester, 2000.		
Teaching methods	Lectures with PowerPoint presentations. Composition of individual studies with the supervisor's assistance and independently during the semester where the students apply the acquired knowledge and learn basic numerical procedures in the process of numerical		

	modelling of the model in the area of the mechanics of material. Independent design of parts of computer software.
Assessment methods	Oral exam, oral presentation, seminar paper.
Language of the course	Croatian and possibly English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	EXPERIMENTAL METHODS		
Code	GAKA04		
Type	Lecture, research seminar, individual study with supervisor, independent study, work on a research project.		
Level	7th level EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Pavao Marović, PhD / Prof. Mirela Galić, PhD		
Learning outcomes and competences	Upon the completed course, the student will be able to: • devise an appropriate programme of testing structures, structural elements or structure models, • independently conduct experimental testing of the structure, structural element or structure model, • interpret testing results, • evaluate possible problem solutions, • critically analyse the rule of modelling and measurement, • discuss the selected model for experimental analysis of the structure, structural element or structure model.		
Enrolment requirements	Graduate degree		
Content	The importance of experimental analyses for the development of structures and calculation methods. Development of experimental methods assisted with micro-computers, micro-processors, automatics and telemetry – static and dynamic testing. Mechanical properties of materials. Strain and stress theory equations and the solid state body laws. Measurements, measurement techniques, metrology, measurement equipment and analysis of measurements. Model analysis of structures. Conditions of similarity. Modelling rules. Buckingham theorem. Materials for models. Procedures for determining deformation fields, strain fields, angles of rotation, deflections and curvatures. Implementation domain and accuracy of different measuring methods. Optic stress and optic strain methods for determining stress and strain fields. Plane photoelasticity. Space photoelasticity. Photo -plasticity, -viscoelasticity, -rheology. Dynamical photoelasticity. Methods of photoelastic coatings and brittle lacquers method. Moire method. Methods of analogy. Mathematical analogy. Electrical analogy (current and voltage). Implementation of mechanical waves, g- and x- rays in the stress state analysis.		
Recommended literature	(1) *Mjerenje deformacija i analiza naprezanja*, Autorizirana Lectures, Ur. A. Kiričenko, DGITZ, Zagreb, 1982.; (2) I. Alfirević, S. Jecić: *Fotoelasticimetrija*, Liber, Zagreb, 1983.		
Supplementary literature	(1) J.F. Doyle: *Modern Experimental Stress Analysis*, Wiley, Chichester, 2004.		
Teaching methods	Lectures with PowerPoint presentations. Demonstration exercises in the laboratory. Organising and conducting testing of structure, structural elements and structure models,		

	where the students implement gained knowledge.
Assessment methods	Oral exam, oral presentation, seminar paper.
Language of the course	Croatian and possibly English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	SELECTED CHAPTERS OF STRUCTURAL DYNAMICS AND EARTHQUAKE ENGINEERING		
Code	GAKA05		
Type	Research seminar.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Ante Mihanović, PhD		
Learning outcomes and competences	Upon the completed course, the student will be able to: • Create non-linear deterministic models of structures dynamic • Analyse earthquake resistance of structures by launching principle • Formulate models of direct response of structures to earthquake stimulation Formulate stochastic models of structures dynamics • Model the interaction structure-soil in dynamic tasks		
Enrolment requirements	No requirements.		
Content	Response of single-degree-of-freedom system and multiple-degree-of-freedom system by direct numerical integration. Spectral radius and numerical stability. Mixed methods. Material non-linear systems. Accuracy.. Dynamics simulation of infinite boundary. Numerical integration in structure-fluid interaction and structure-fluid-soil interaction. Numerical integration of complex civil engineering structures response. Fast Fourier transforms. Windous and wavelet procedures in structural dynamics. Structure response to random excitation by earthquake, wind, waves and sea-streams. Structure reliability in earthquake activities.		
Recommended literature	(1) Humar J.L., Dynamic of structures, Prentice Hall, New Jersey, 1990. (2) Mihanović A., Dinamika konstrukcija, Građevinski fakultet Split, Split, 1995. (3) Čaušević M, Dinamika konstrukcija, Mladost Zagreb 2005.		
Supplementary literature	(1) A.K. Chopra: Dynamic of structures – Theory and Applications to Earthquake Engineering, Prentice Hall, New Jersey, 1995. (2) Morrison F., The art of modelling dynamic system: forecasting for chaos, randomness, and determinism (Scientific and Technical Computation Series), Ronald Press, 1991.		
Teaching methods	Lecture, seminars.		
Assessment methods	Oral presentation of the seminar paper. Oral exam.		
Language of the course	Croatian, English.		
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.		

Course title	SELECTED CHAPTERS OF STABILITY OF STRUCTURES		
Code	GAKA06		
Type	Lecture, seminar.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Ante Mihanović, PhD; Associate Prof. Boris Trogrlić, PhD		
Learning outcomes and competences	Upon the completed course, the student will be able to: • Create numerical models of material and geometrically non-linear load capacity and stability of spatial linear structures • Model the problems of bending, shear and torsion stability on spatial framework structures • Model numerically the load capacity and stability of plates and shells by the theory of small and large displacements • Analyse spectra of load capacity of pressure bending elements and apply quasi non-linear procedures		
Enrolment requirements	No requirements.		
Content	The materially and geometrically non-linear numerical model of stability and load capacity of the space line structures using small displacement theory. Implementation of bending, shear and torsion stability. Numerical modelling of stability and load-bearing capacity for plate and shell structures using small and large displacement theory. Modelling of local stability of thin-wall cross sections. Stability and load capacity of the space line structures using large displacement theory. Accuracy estimation of the solution. Modelling of gravity, polar and hydrostatic load. Particularity of non-linear structures and modelling of cable structures. Particularity of numerical modelling of arch structures stability. Determination of pressure bending elements bearing spectrum and application of quasi-nonlinear procedures. Numerical modelling of stability and load-bearing capacity for plate and shell structures using small and large displacement theory. Post-critical behaviour of plate and shell structures.		
Recommended literature	(1) Bažant Z.P. and Cedolin L., Stability of structures: Elastic, Inelastic, Fracture and Damage Theories, Dover Publications, Inc., New York, 2003. (2) Mihanović A., Stabilnost konstrukcija, DHGK, Zagreb, 1993.		
Supplementary	(1) Trogrlić B., Nelinearni numerički model stabilnosti i nosivosti prostornih		

literature	armirano-betonskih linijskih konstrukcija, doktorska disertacija, Građevinsko-arhitektonski fakultet, Sveučilište u Splitu, Split, 2003. (2) Jurić A., Nelinearni numerički model stabilnosti i nosivosti prostornih čeličnih linijskih konstrukcija, doktorska disertacija, Građevinsko-arhitektonski fakultet, Sveučilište u Splitu, Split, 2004.
Teaching methods	Lectures, seminars..
Assessment methods	Oral presentation of the seminar paper. Oral exam.
Language of the course	Croatian, English.
Quality assurance methods	P Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	FINITE ELEMENT METHOD		
Code	GAKA07		
Type	Lecture, research seminar, independent study, work on a research project.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Željana Nikolić, PhD		
Learning outcomes and competences	Upon the completed course, the student will be able to: • develop mathematical and numerical formulations for the purpose of numerical solving of different engineering tasks by finite element method; • independently create computer software using finite element method; • independently evaluate the accuracy of numerical models; • critically review the applicability of the used numerical model in the analysis of the presented task, • between several variants of solutions, select and recommend the appropriate numerical formulation and model for the solution of the given problem and provide arguments for his/her position.		
Enrolment requirements	No requirements.		
Content	System discretisation. Direct approach to solving structural mechanics problems. Generalisation of the finite element concepts. Variation formulation of finite element method. Finite elements for one-dimensional analysis. Finite elements for two-dimensional and axe symmetric analysis. Finite elements for three-dimensional analysis. Standard and hierarchical base functions. Finite element mapping and numerical integration. Pach test, reduced integration and non-conforming elements. Infinite elements. Mixed formulations. Error estimates and convergence of numerical procedures. Adaptive techniques: h, p, hp approach. Finite element method in time dependent problems. Coupled problems: fluid-structure and soil-structure interaction. Basis numerical procedures for finite element analysis. Finite element method with installed discontinuities (ED-FEM) and expanded finite element method (X-FEM) in modelling structural singularities.		
Recommended	1) O. C. Zienkiewicz, R. L. Taylor, J.Z. Zhu: The Finite Element Method, Vol. 1: Its Basis		

literature	& Fundamentals, 6th edition, Elsevier Butterworth-Heinemann, Oxford, 2006.; (2) A. Ibrahimbegovic: Nonlinear Solid Mechanics: Theoretical Formulations and Finite Element Solution Methods, Springer, 2009.; (3) V. Jović: Uvod u inženjersko numeričko modeliranje, Aquarius engineering Split, 1993.; (4) R. D. Cook, D. S. Malkus, M. E. Plesha: Concepts and Applications of Finite Element Analysis, 3th edition, John Wiley & Sons, 1989.
Supplementary literature	(1) M. A. Crisfield: Finite Elements and Solution Procedures for Structural Analysis, Vol I: Linear Analysis, Pineridge Press, Swansea, U.K., 1986.; (2) O. C. Zienkiewicz, K. Morgan: Finite Elements and Approximations, John Wiley & Sons, 1983.; (3) E. Hinton, D. R. J. Owen: An Introduction to Finite Element Computations, Pineridge Press, Swansea, U.K., 1979.; (4) J. Sorić: Metoda konačnih elemenata, Golden marketing – Tehnička knjiga Zagreb, 2004.; J. Brnić, M. Čanađija: Analiza deformabilnih tijela metodom konačnih elemenata: Fintrade & Tours d.o.o. Rijeka, 2009.
Teaching methods	Lectures with computers. Preparation of individual studies with the assistant of the supervisor and independently, where the students implement gained knowledge and learn basic numerical procedures in the finite element method analysis. Independent design of parts of computer software.
Assessment methods	Oral presentation of the seminar paper, Oral exam.
Language of the course	Croatian, English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	EXTREME ACTIONS AND STRUCTURE SAFETY/STABILITY		
Code	GAKA08		
Type	Lecture, research seminar, independent study.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Bernardin Peroš, PhD / Prof. Ivica Boko, PhD / Assistant Professor Neno Torić, PhD		
Learning outcomes and competences	Upon the completed course, the student will be able to: • anticipate the statistical model of extreme actions, • compare first and second-order reliability methods, • assess structural reliability index during extreme actions, • evaluate the probability analysis for the calibration of existing structures, • determine the level of structural safety from the aspect of durability of structures, • anticipate and self-evaluate the analysis of structure life.		
Enrolment requirements	No requirements.		
Content	Relevance of the course. Main concepts on the reliability and stability of structures. Base variables of actions on structure and structural resilience. Probability of failure of load capacity, reliability index. Analysis of extreme actions on the structures – application of modern methods for finding the optimal functions for the distribution of specific actions. Probability models for the structure response in cases of extreme actions. Reliability model for random variables, random process and random field/domain. The calibration procedure for complex structures considering reliability during the structure exploitation. Non-linear methods in the computational procedure for structure reliability – interaction between the stochastic and mechanic models. Analysis of the safety/stability degree of complex structures of the offshore type, bridges, etc. by applying the aforementioned models.		
Recommended literature	(1) Milčić V., Peroš B.: Uvod u teoriju sigurnosti nosivih konstrukcija, Građevinski fakultet Split, 2003.; (2) Peroš B., Boko I.: Sigurnost konstrukcija u požaru, Sveučilište u Splitu Fakultet građevinarstva, arhitekture i geodezije, Split, 2014.; (3) Sheldon M. Ross: Introduction to probability and statistics for engineers and scientists, University of California at Berkeley, 1997.		
Supplementary literature	(1) Schueler, Shinozuka: Structural Safety and Reliability, Proc. Icossar, Vol 1,2,3, Innsbruck, 1993.; (2) Kiureghain L.:Structural component Reliability and Finite element, Reliability Methods, Lecture Note for "Structural Reliability - Methods and Applications", University of California at Berkeley, 1989.; (3) Structural reliability analysis program system (STRUREL).		
Teaching methods	Lectures with the use of the blackboard, slides and LCD projector. Parts of lectures are		

	based on the European Steel Design Education Programme (ESDEP).
Assessment methods	Oral exam, seminar paper.
Language of the course	Croatian and possibly English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	STEEL AND COMPOSITE STRUCTURES		
Code	GAKA09		
Type	Lecture, research seminar, independent study.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Bernardin Peroš, PhD / Prof. Ivica Boko, PhD / Assistant Professor Neno Torić, PhD		
Learning outcomes and competences	Upon the completed course, the student will be able to: • determine the load capacity of steel and composite elements and systems by the first and second-order theory, • evaluate the joint calculation methods, • assess the load capacity of steel, composite elements and systems in the event of fire, • assess the load capacity of steel, composite elements and systems from the aspect of material wear.		
Enrolment requirements	No requirements.		
Content	Elastic and plastic analysis in the computation of steel and composite structures. Frame systems – classification of global imperfection, length of element torsion, joints. Application of elastic and plastic methods in the computation of frame systems. Full-side tin supporter – problem of slab/plates stability. Composite structures of the steel – concrete type, analysis of elements in supporting systems. Problem of spatial steel systems and systems with tensile supporting structures. Application of high-quality steels for supporting steel systems and extreme spans (bridges, stadiums, halls, etc.).		
Recommended literature	(1) Androić B., Dujmović D., Džeba I.: Čelične konstrukcije 1, IA projektiranje, Zagreb, 2009.; (2) Androić B., Dujmović D., Lukačević I.: Projektiranje spregnutih konstrukcija prema Eurocode 4, IA projektiranje, Zagreb, 2012.; (3) Androić B., Čaušević M., Dujmović D., Džeba I., Markulak D., Peroš B.: Čelični i spregnuti mostovi, IA projektiranje, Zagreb, 2005.; (4) R. Englekirk: Steel structures, John Wiley & Sons, Inc., New York, 1994.; (5) Peroš B., Boko I.: Sigurnost konstrukcija u požaru, Sveučilište u Splitu Fakultet građevinarstva, arhitekture i geodezije, Split, 2014.		
Supplementary literature	(1) Knowles, P.R.: Composite Steel and Concrete Construction, Butterworks, London, 1973.; (2) Johnson, R. P. and Buckly, R. P.: Composite structures of Steel and Concrete, Volume 2, Bridges, Second Edition, 1986.		
Teaching methods	Lectures with the use of the blackboard, slides and LCD projector. Parts of lectures are based on the European Steel Design Education Programme (ESDEP).		
Assessment methods	Oral exam, seminar paper.		
Language of the course	Croatian and possibly English.		
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.		

Course title	NUMERICAL MODELLING OF CONCRETE STRUCTURES		
Code	GAKA10		
Type	Lecture, seminar.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Jure Radnić, PhD / Prof. Alen Harapin, PhD / Associate Professor Domagoj Matešan, PhD		
Learning outcomes and competences	The student will be able to: • select the appropriate numerical model of behaviour of concrete and/or composite structures under static, dynamic and impact load, critical assessment of results and substantiate them with arguments; • select the appropriate numerical model for the description of geometrically and materially non-linear behaviour of concrete and/or composite structures and elaborate this selection; • create the model for dimensioning o composite cross sections, evaluation of model potentials and critical assessment of results; • select the model for the calculation of width of cracks and deflections/displacements of concrete elements, compare the results with other numerical models and experiments and perform critical selection of the most reliable model; • propose the proper model for the inclusion of rheological effects (creep/shrinkage/wear) into the numerical model for the description of behaviour of concrete elements and structures.		
Enrolment requirements	Undergraduate degree (6th level EQF or CroQF).		
Content	Behaviour and modelling of concrete under uniaxial, biaxial and triaxial states of stress and static, cyclic, dynamic and long-term loads. Behaviour and modelling of steel under static, cyclic and dynamic loads. Numerical modelling of classical reinforced and prestressed concrete structures under static, dynamic and long-term loads, taking into account the most important non-linear concrete effects (failure under compression, cracking under tension, tensile and shear rigidity of cracked concrete, opeining and closing of cracks, influence of the load velocity upon the mechanical characteristics of confrete, concrete shrinking and ageing), classical reinforcement (failure in compression and tension, influence of strain velocity upon the mechanical characteristics of steel) and cables (non-linear behavior of steel, losses of prestressing force: 2D structures, slabs/plates and shells, 3D structures konstrukcije. Numerical modelling of composite 2D structures under static, dynamic and long-term loads considering the main non-linear effects of concrete and the reinforcement. Dimensioning composite concrete cross-sections of arbitrary shape for bending taking into account the effects of concrete creeping and shrinking. Numerical modelling of cracks width in composite concrete elements of arbitrary cross-section shape, considering concrete creeping and shrinking. Modelling the dynamic interaction between concrete structures and fluids, taking into account the main non-linear effects of concrete and reinforcement and cavitation in water: 2D structures, shells, 3D structures. Some computational aspects of numerical analysis of individual and related fields/domains.		

	Some problems and dilemmas in the analysis of practical engineering structures. Unsolved research problems.
Recommended literature	(1) J. Radnić, A. Harapin,D. Matešan: „Betonske ploče i ljuske“, 2006. ; (2) J. Radnić, D. Ćubela, A. Harapin; „Modeliranje ravninskih spregnutih konstrukcija“, 2006. ; (3) J. Radnić, L. Markota, A. Harapin; „Raspucavanje betona – numeričko modeliranje“, 2005. ; (4) J.Radnić, A. Harapin, D. Brzović: „Modeliranje dinamičke interakcije tekućine i konstrukcije“ (pred dovršetkom) ; (5) J.Radnić: „Zapisi za Lectures“ (6) J. Radnić, A. Harapin: „Osnove betonskih konstrukcija“, course exam notes; (7) J. Radnić, A. Harapin: „Mostovi“, course exam notes
Supplementary literature	(1) J. Radnić, A. Harapin, D. Matešan: „Static Analysis of Concrete Shells“, Monograph, 2004. ; (2) Other literature by agreement.
Teaching methods	Lectures with the use of the blackboard, slides and LCD projector. Attending experimental testing of structures. Modelling behaviour of real structures with supervisor`s assistance and independently.
Assessment methods	Oral exam, oral presentation, seminar paper.
Language of the course	Croatian and English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	DESIGN OF SUPPORTING SYSTEMS OF BRIDGES AND STRUCTURES		
Code	GAKA11		
Type	Lecture, seminar.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher . Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Jure Radnić, PhD / Prof. Alen Harapin, PhD / Associate Professor Domagoj Matešan, PhD		
Learning outcomes and competences	The student will be able to: • critically assess and evaluate the creation of simple and complex structural supporting bridge systems, • critically assess and evaluate the creation of complex structural supporting building systems, • critically assess and evaluate the creation of earthquake-resistant structural supporting systems, • critically assess and evaluate the creation of complex cable stay supporting systems		
Enrolment requirements	Undergraduate degree (6th level EQF or CroQF).		
Content	Structural materials and supporting structures. Main supporting systems for bridges: slab bridges, girder bridges, arch bridges, suspended bridges, cable-stayed bridges, pre-stressed decks, composite bridges. Bridges with complex structures: arch with a lower deck and a hanging girder, arch with an upper deck and hanging girder, suspended and cable-stayed bridges. arch and pre-stressed deck, pre-stressed decks, etc. Beam bridges with factory precast concrete girders with extreme spans. Supporting systems of bridges for extreme spans. Immersed bridges. Design of bridge systems with seismic resistance. Beam girders externally strengthened by cables. Tensile supporting structures: cables, cables and membranes; cables and struts. Experimental testing of seismic resistance of new supporting systems. Design of structures with seismic resistance. New high-quality materials for new supporting systems and extreme spans. Unsolved research problems.		
Recommended literature	(1) Androić Boris i suradnici: „Čelični i spregnuti mostovi“, 2006.; (2) M.J.Ryall, G.A.R. Parke i J.E.Harding: „Manual of bridge engineering“, 2002.; (3) D. Horvatić,Z. Šavor: „Metalni mostovi“, 1998.; (4) Jiri Strasky: „Stress ribbon and cable-supported pedestrian bridges“, 2005.; (5) Rene Walther at all: „Cable stayed bridges“, 1988; (6) C.Melbourne; „Arch bridges“, 1995; (7) J.Radnić: Zapisi za Lectures ; (8) J. Radnić, A. Harapin: „Osnove betonskih konstrukcija“, course exam notes; (9) J. Radnić, A. Harapin: „Mostovi“, course		

	exam notes
Supplementary literature	(1) J. Radić: „Mostovi“, 2003.;(2) Other literature by agreement.
Teaching methods	Lectures with the use of the blackboard, slides and LCD projector
Assessment methods	Oral exam, oral presentation, seminar paper.
Language of the course	Croatian and English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	MECHANICS OF DISCONTINUA		
Code	GAKA12		
Type	Lecture, seminar, laboratory work.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Ante Munjiza, PhD		
Learning outcomes and competences	The student will be able to: • evaluate the effect of discontinua on a simulated problem • formulate the processes of discontinua • create problem simulations with pronounced discontinua effects • evaluate search methods and contact interactions in the processes of discontinua		
Enrolment requirements	Undergraduate degree (6th level EQF or CroQF).		
Content	Introduction to discontinua: discontinua on molecular level, nano-materials and mechanics of discontinua, granular materials as separate state of matter, concrete as discontinuum, discontinuum and military engineering, discontinuum in astrophysics. Discontinuum processes: molecular processes, mesoscale processes, contact, fluid, fraction, fragmentation, progressive demolition of high-rise structures, explosions, impacts, mining, granular flow. Discontinuum simulations: Monte Carlo, methods of molecular dynamics, methods of discreet elements, method of combined finite and discreet elements, generalization of discontinuum simulations, and APS simulations. Numerical techniques: ADT, NBS, MR spatial searches; distributed potential contacts, rock joints, fragmentation, solvers, methods of diagnostics and search of emergent properties. Applications: concrete, military engineering, engineering processes, fraction and yield of structures, progressive yield of structures.		
Recommended literature	(1)A.Munjiza, The Combined Finite-Discrete Element Method, udžbenik, Wiley&Sons, London 2004., (2) A.Munjiza, Earl E. Knight, Esteban Rougier, Computational Mechanics of Discontinua , udžbenik, Wiley&Sons London 2011.,		
Supplementary literature	Many papers in international journals at student`s selection.		
Teaching methods	Lectures with the use of developmental programmes. Composition of independent seminar paper related to published scientific paper at student`s selection.		
Assessment methods	Seminar paper and defence of seminar paper. Oral exam.		
Language of the course	Croatian and English.		
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.		

Course title	NUMERICAL MODELLING OF WATER-SOIL-STRUCTURE DYNAMIC INTERACTION		
Code	GAKA13		
Type	Lecture, seminar.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Jure Radnić, PhD / Prof. Alen Harapin, PhD / Associate Professor Domagoj Matešan, PhD		
Learning outcomes and competences	The student will be able to: • assess the need to use the model for modelling dynamic interaction between concrete structures and fluid in real structures; • proper/critical section of the numerical model for modelling dynamic interaction between concrete structures and fluids; • assess and evaluate gained results with several models, and the assessment of relevance of specific data; • prepare, conduct critical discussion and evaluation of the model of real structure by using the existing numerical model for the simulation of dynamic water-soil-structure interaction.		
Enrolment requirements	Undergraduate degree (6th level EQF or CroQF).		
Content	Methods for solving of coupled fields dynamic problem. Fluid modelling. Structure modelling. Numerical modelling of fluid-soil-structure dynamic interaction using linear and non-linear models for fluid and structure. Simulation models of dynamic interaction between fluid and concrete structures (2D problems, shells, spatial problems), with a particular model for reinforced concrete modelling. Some mathematical aspects of numerical analyses of single and coupled fields: spatial and time discretization, eigenvalue problem, non-linear problem solution, mass modelling, stiffness and dumping modelling, numerical integration, boundary problems, non-linear behaviour of materials etc. Experimental research of some coupled water-soil-structure dynamic problems. Open research problems.		
Recommended literature	(1) J. Radnić, A. Harapin, D. Brzović: knjiga „Modeliranje dinamičke interakcije tekućine i konstrukcije (pred dovršetkom). Odabrani članci iz područja numeričkog modeliranja dinamičkog međudjelovanja tekućina - tlo - konstrukcija.		
Supplementary literature	(1) J. Radnić: „Modeliranje interakcije fluida i konstrukcije“, doktorska disertacija, 1987. ; (2) A. Harapin: „Numerička simulacija dinamičkog međudjelovanja tekućine i konstrukcije“, doktorska disertacija, 2000.		
Teaching methods	Lectures with the use of blackboard, slides and LCD projector. Attending experimental dynamic testing of problems of single and coupled fields. Modelling of real problems of dynamic water-soil-structure interaction with the supervisor`s assistance and independently.		
Assessment methods	Oral exam, oral presentation, seminar paper.		
Language of the course	Croatian and English.		
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.		

Course title	ADVANCED CONCRETE AND MASONRY STRUCTURES, SELECTED CHAPTERS		
Code	GAKA14		
Type	Lecture, seminar.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Jure Radnić, PhD / Prof. Alen Harapin, PhD / Associate Professor Domagoj Matešan, PhD		
Learning outcomes and competences	The student will be able to: • select the model for calculation and evaluation of results for complex strain states in simple and complex concrete elements/cross sections; • select the model for the analysis of cracks and deflections/displacements, and the calculation of width of cracks and deflections for simple and complex concrete elements, • create, critically discuss and evaluate the manner of installing reinforced concrete in complex concrete structures, • create, critically discuss and evaluate the selected solution of the complex rc/pre-stressed concrete element/structure; • create, critically discuss and evaluate the manner of installing reinforced concrete in complex concrete structures, • create, critically discuss and evaluate the manner of installing cables in complex pre-stressed structures, • select the constructive solution and selection/composition of the model and calculation of tall building, • select the constructive solution and selection/composition of the model and calculation of complex masonry structure.		
Enrolment requirements	Undergraduate degree (6th level EQF or CroQF).		
Content	CONCRETE STRUCTURES (1) General information about materials: conventional concrete, high-strength concrete and special concrete. Influence and calculation of rheological effects in concrete: yielding, creeping and ageing. Calculation of crack width for complex sections and elements. Deflection calculation of concrete elements. Calculation of slender compression elements. Calculation of combined action of bending, shear force and torsion. (2) Design and calculation of complex reinforced concrete structures: frame structures, structures with concrete walls, mixed structures of frames and walls, truss structures, high corbel girders, arc girders, slabs, shells, foundation structures, prefabricated structures, composite structures. Design of reinforcement (conventional and pre-stressed). (3) Design and calculation of complex pre-stressed concrete structures (4) Specific concrete structures: large concrete bridges, high buildings, silo, bunkers, cable-stayed structures, concrete dams. (5) Design of seismic resistant structures. (6)Systems for construction and maintenance of concrete structures. (7) Overview of relevant standards for concrete structures. MASONRY STRUCTURES (1) General information about materials: bricks, mortar, additives. (2) Design of masonry structures: unreinforced, reinforced and confined. (3) Specificity of stone masonry structures. (4) Influence of inter-storey structures on bearing		

	capacity and security of masonry buildings. (5) Calculation of masonry structures: simple and advanced calculation models. (6) Design and calculation of seismic resistant masonry structures. (7) Recovery (reparation and strengthening) of masonry structures. (8) Masonry bridges. (9) Systems for construction and maintenance of masonry structures. (10) Overview of relevant standards for masonry structures.
Recommended literature	(1) I. Tomičić: „Betonske konstrukcije“, (2) J. Radić i suradnici: „ Betonske konstrukcije“, knjige 1,2,3; (3) J. Radnić, A. Harapin, D. Matešan: „Betonske ploče i ljuske“, (4) J. Radić i suradnici: „Zidane konstrukcije I“, (5) Z. Sorić: „Zidane konstrukcije 1“ ; (6) J. Radnić, A. Harapin: „Osnove betonskih konstrukcija“, course exam notes; (7) J. Radnić, A. Harapin: „Mostovi“, course exam notes
Supplementary literature	(1) J. Radnić, D. Ćubela, A. Harapin: „Modeliranje ravninskih spregnutih konstrukcija“, 2006.; (2) J. Radnić, L. Markota, A. Harapin: „ Raspucavanje betona – numeričko modeliranje“ 2005. ; (3) J. Radnić: „ Zapisi za Lectures“; (4) Other literature by agreement.
Teaching methods	Lectures with the use of blackboard, slides and LCD projector.
Assessment methods	Oral exam, oral presentation, seminar paper.
Language of the course	Croatian and English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

3.4.3. Description of elective courses in the field of Civil Engineering, branch of Hydrotechnics

Course title	DISPERSION PROCESSES IN WATER RESOURCES		
Code	GAHA01		
Type	Lecture and seminar paper.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Roko Andričević, PhD / Associate Professor Hrvoje Gotovac, PhD		
Learning outcomes and competences	The student will be able to: • create a conceptual dispersion model in surface and underground waters considering the type of flow and transport • make and /or select the mathematical dispersion model in surface and underground waters considering the type of flow and transport • analyse practical dispersion problems, i.e. calculate and/or assess the field of concentration and time of travel using Eulerian method of finite volumes and elements • analyse practical dispersion problems, calculate and/or assess the field of concentration and time of travel using Lagrangian methods		
Enrolment requirements	Graduate degree.		
Content	Part one: review of main elements of stochastic processes, random domains and mathematical transformations in the Laplace and Fourier domains. Part two: Fundamental flow and dispersion equations. Transfer of the process to the local scale (scale of *in-situ* measurements). Heterogeneity of hydraulic conductivity and other parameters of the model. Part three: Eulerian and Lagrangian approaches to the solution of the dispersion equation. The concept of absolute and relative dispersion, the concept of mass discharge and dispersion of reactive substances. Flow and dispersion processes on the regional scale. The problem of averaging, effective parameter value, the concept of macro dispersion. Transport problems from point sources and non-point sources.		
Recommended literature	(1) Dagan. G, Flow and transport in porous formation, Springer-Verlag, 1989. (2) Andričević, R. Effects of local dispersion and sampling volume on the evolution of concentration fluctuations in aquifers, Water Resources Research,Water Resources Research, 34(5), pp. 1115-1129, 1998. (3) Andričević, R. and V. Cvetković, Relative dispersion for solute flux in aquifers, Journal of Fluid Mechanics, Vol. 361, pp. 145-174,1998. (4) Hassan, A.E., R. Andričević and V. Cvetković, Computational issues in the determination of solute discharge moments and implications for comparison to analytical solutions, Advances in Water Resources Journal, Vol. 24, pp. 607-619, 2001.		
Supplementary	(1) Zhang, D., R. Andričević, A.Y. Sun, X. Hu and G. He, Solute flux approch to transport		

literature	through spatially nonstationary flow in porous media, Water Resources Research, 36(8), pp. 2107-2120, 2000. (2) Purvance, D.T. and R Andričević, Geoelectric characterization of the hydraulic conductivity field and its spatial structure at variable scales**,** Water Resources Research, 36(10), pp. 2915-2924, 2000.
Teaching methods	Lectures with the use of developmental programmes. Composition of individual seminar paper as a reproduction of a published scientific paper.
Assessment methods	Seminar paper as a reproduction of the selected paper and final exam-written (done at home for 3-4 days).
Language of the course	Croatian; English for supplementary literature.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	THEORY OF RISK ASSESSMENT IN ENVIRONMENTAL ENGINEERING		
Code	GAHA02		
Type	Lecture and seminar paper.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Roko Andričević, PhD		
Learning outcomes and competences	The student will be able to: • implement and/or select the risk concept in water resources • define and assess the risk of exposing people to cancerogenic and non-cancerogenic factors; • define and assess the risk of eco-system pollution • assess the risk of exposure within the risk analysis concept • apply the concept of risk analysis in managerial activities		
Enrolment requirements	Graduate degree		
Content	Main principles and methodology applied in the approach to environmental risk analysis. Hydrological risk analysis: stochastic approach to risk balancing, benefit; avoiding and recognition of risk; recognition of threats; physical/chemical characteristics and trends and methods of exposure, structure-activity dependence; exposure assessment: estimation of human and animal epidemiological data, exposure directions; exposure assessments: identification of the pollution source, paths and analysis of consequences (transport of pollutants), evaluation of concentrations in the environment, analysis of the population, modelling of the exposure level and estimation of non-reliability, characteristic features of risk; risk management: regulatory actions and options, social and economic influence on risk management.		
Recommended literature	(1) Andričević, R. and V. Cvetković, Evaluation of risk from contaminants migrating by groundwater,Water Resources Research, 32 (3), 611-621, 1996. (2) Andričević, R., J. Daniels, and R. Jacobson, Radionuclide migration using travel time transport approach and its application in risk analysis, Journal of Hydrology, 163, 125-145, 1994. (3) Hamilton, L.D, R. Andričević, and R.L. Jacobson, Pilot study risk assessment for selected problems at three U.S. Department of Energy facilities, Environmental International, 20, 585-604, 1994. (4) U.S. EPA, 1988, Methods used in United States for the Assessment and Management of Health Risk Due to Chemicals, Federal Register PB89-222707, National Research Council, 1983, (5) Risk Assessment: Managing the process, National Academy Press, Washington, D.C.		
Supplementary literature	(1) Fischoff, B., Lichtenstein, V., Slovic, V., Derby, S.L., Keeney, R.L.: Acceptable Risk, Cambridge University Press, New York, 1981. (2) Coastal and Estuarine Risk Assessment, edited by M. Newman, Lewis Publisher, 2002.		
Teaching methods	Lectures with the use of developmental programmes. Composition of individual seminar paper as a reproduction of a published scientific paper.		
Assessment methods	Seminar paper as a reproduction of the selected paper and final exam-written (done at home for 3-4 days).		

Language of the course	Croatian; English for supplementary literature.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	KARST WATER RESOURCES		
Code	GAHA03		
Type	Lecture		
Level	7th level CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Ognjen Bonacci, PhD		
Learning outcomes and competences	The student will be able to: • synthetise the specificity of kart area for the purpose of proposing and creating protection measures of water resources, • Formulate models for assessment of the state of karts water resources, • predict the effects of pressures on karts water resources, • connect and improve various offered solutions to numerous practical and theoretical problems related to karts water management.		
Enrolment requirements	No requirements.		
Content	Definition of karst. Soluble karts-forming rocks, closed protrusions on the surface of the rocks, water circulation in karst, karst springs, rifts, open water streams in karst, water in karst coastal areas, karst fields and their water balance, karst aquifer.		
Recommended literature	(1) O. Bonacci, Karst hydrology, Springer Verlag, Berlin 1987. (2) O. Bonacci, Posebnosti krških vodonosnika, Građevinski godišnjak ¾, Zagreb, 2004: 91-187.		
Supplementary literature	(1) D. Ford, P. Williams, Karst geomorphology and hydrology, Unwin Hyman, London, 1989. (2) J. Gunn (urednik), Encyclopedia of caves and karst science, Fitzroy Dearborn, New York		
Teaching methods	Oral lectures, PowerPoint presentations.		
Assessment methods	Oral exam, seminar paper, thesis.		
Language of the course	Croatian.		
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.		

Course title	ECOHYDROLOGY		
Code	GAHA04		
Type	Lecture, seminar.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Ognjen Bonacci, PhD		
Learning outcomes and competences	The student will be able to: • connect the basic principles of ecology and hydrology for the solution of various engineering problems in ecohydrology, • formulate the main interaction relationship between the eco-system and hydrological cycle and anticipate their strength with respect to anthropogenic influences and other pressures on both systems, • organise regulatory relationship between hydrological and ecological processes based on the integral systematic approach (integral basin management). • anticipate water availability in the future and the level of generated stress on the living environment in water shortage..		
Enrolment requirements	Hydrology.		
Content	Relationship between hydrology and ecology Concept of sustainable development. Definition of ecohydrology. Elements of hydrology and water resources essential for ecology. Hydrological systems and processes. Influence of global climate change on hydrological cycle. Floods, flooded and damp areas. Dryness, drought, scant rainfall areas. Open water streams as part of eco-system. Open water stream management. Environmental needs for open water streams water. Environmental needs for open water streams water. Principles and methods for ecologically acceptable flow definition. Methods of determining ecologically-friendly water flow.		
Recommended literature	O. Bonacci: Ekohidrologija, Građevinski fakultet Split, 2003.		
Supplementary literature	O. Bonacci: Oborine-glavna ulazna veličina u hidrološki ciklus, Geing, Split, 1994.		
Teaching methods	Lectures and seminars with the use of state-of-the-art devices (computer work).		
Assessment methods	Oral exam, orally presented seminar.		
Language of the course	Croatian and possibly English.		
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.		

Course title	HYDROLOGICAL MODELLING IN KARST		
Code	GAHA05		
Type	Lecture, seminar, research seminar.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Vesna Denić-Jukić, PhD		
Learning outcomes and competences	Upon completing the exam, the student will be able to: • set and create hydrological models in karst • synthetise developed models on the new research area, • connect the concepts of water balance from the aspect of karts basins, • formulate and implement the verification and model calibration procedures.		
Enrolment requirements	Graduate degree		
Content	System approach: definitions and concepts. Problems and models in hydrology. Linear, time-variant and nonlinear models. Black box and conceptual models. Catchment runoff modelling. System unit response characteristics. Models for ungauged catchments. Analysis of the recession part of the hydrograph. Modelling parameters. Balance of groundwater in the ground. Conceptual models of karst water balance. Characteristics of recharge-discharge relations in karst aquifers. Determination of catchment areas and runoff coefficients. Model calibration and verification. Efficiency coefficient.		
Recommended literature	(1) O. Bonacci, Karst Hydrology, Springer Verlag, Heidelberg, 1987.; (2) V.P. Singh, Hydrologic Systems, Rainfall-Runoff Modeling, Prentice Hall, 1988.; (3) Metka Petrič: Characteristics of recharge–discharge relations in karst aquifer, Inštitut za raziskovanje krasa ZRC SAZU, Založba ZRC, Postojna-Ljubljana, 2002.		
Supplementary literature	(1) Mc Cuen: Hydrologic analysis and design, Prentice Hall, 1989.; (2) M.P. Wanielista, Hydrology and water quantity control, John Wiley & Sons, 1990.		
Teaching methods	Lectures and seminars with the use of state-of-the-art devices (computer work).		
Assessment methods	Oral presentation of the seminar paper. Oral exam.		
Language of the course	Croatian, English.		
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.		

Course title	MARINE HYDRAULICS, SPECIAL CHAPTERS		
Code	GAHA06		
Type	Lecture, seminar, exercises, practical work, field work.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Assistant Professor Nenad Leder, PhD		
Learning outcomes and competences	The student will be able to: • determine the influence of surface waves cause by wind in the littoral area, • determine the influence of sea currents in the littoral area, • assess the influence of pollution in the littoral area • assess the influence of modelling and dimensioning of coastal buildings on environment protection, • by critical reasoning select the concept of numerical and physical modelling of littoral processes.		
Enrolment requirements	Knowledge of hydromechanics, hydraulics and coastal engineering.		
Content	Special topics in physical oceanography: theory of waves, currents and mixing processes (transport of matter), coastal oceanography. Wind-generated surface waves, log sea-level oscillations and currents in the Adriatic Sea. Resonant oscillations in the Adriatic Sea. Tsunami. Spectral analysis. Theory of extremes. Numerical and physical modelling. Physical oceanography in relation to hydraulics projects in the sea and coast. Field measurements.		
Recommended literature	(1) R.G. Dean, R.A. Dalrymple: Water Wave Mechanics for Engineers and Scientists, Prentice-Hall, Inc., 1984.; (2) B. LeMehaute, D.M. Hanes: The Sea, Ocean Engineering Science, Vol. 9, John Wiley&Sons Inc., 1990.; (3) J.W. Kamphuis: Physical Modelling of Coastal Processes, Advances in Coastaland Ocean Engineering (Ed. P.L.-F. Liu), Vol. 2, Word Scientific, 1996; (4) B. Cushman-Roisin et al. (Eds): Physical Oceanography of the Adriatic Sea, Kluwer, Dordrecht, 2001.; (5) B. Johns: Physical Oceanography of Coastal and Shelf Seas, Elsevier OceanographySeries, Vol. 35, 1983.; (6) W.J. Emery, R.E. Thomson: Data Analysis Methods in PhysicalOceanography, Pergamon, 1998.; (7) D.T. Pugh: Changing Sea Levels. Effect of Tides, Weather and Climate, Cambridge University Press, 2004.; (8) A.B. Rabinovich: Long Ocean Gravity Waves: Trapping, Resonance and Leaking (inRussian), Gidrometeoizdat, St. Petesburg, 1993.		
Supplementary literature	(1) N. Leder, A. Smirčić, I. Vilibić: Extreme values of surface wave heights in the northern Adriatic, Geofizika, 15, 1-13, 1998.; (2) I. Vilibić, N. Leder, A. Smirčić: Storm surges in the Adriatic Sea: An impact on the coastal infrastructure, Periodicum Biologorum, 102, Suppl. 1, 483-487, 2000.; (3) N. Leder, M. Orlić: Fundamental Adriatic seiche recorded by currentmeters, AnnalesGeophysicae, 22, 1449-1464, 2004.; (4) N. Leder: Primjena spektralne analize, analize sistema i rotacione spektralne analize u oceanologiji i meteorologiji, Hidrografski godišnjak 1990 1991, Split, 19 36, 1992.; (5) I. Vilibić, N. Leder, A. Smirčić, Z. Gržetić: Dugoročne promjene razine mora na hrvatskoj obali Jadrana, Tisuću godina prvoga spomena ribarstva u Hrvata, Hrvatska akademija znanosti i umjetnosti, (urednik B. Finka), Zagreb, 437-445, 1997.; (6) I. Vilibić, N. Domijan, M. Orlić, N. Leder, M. Pasarić: Resonant coupling of a travelingair-pressure wave with the east Adriatic coastal waters, Journal of		

	Geophysical Research – Oceans, 109, C100001, doi:10.1029/2004JC002279, 2004.
Teaching methods	Lectures and seminars and experimental field work.
Assessment methods	Assessment of practical seminars and oral exam.
Language of the course	Main language is Croatian. English is also possible.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	SYSTEM ENGINEERING IN WATER RESOURCES MANAGEMENT		
Code	GAHA07		
Type	Lecture, exercises, individual study with supervisor.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher . Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Assistant Professor Jure Margeta, PhD		
Learning outcomes and competences	The student will be able to: • apply the systematic approach and systematic analysis to solving engineering problems related to design and operation of water tanks • plan and design water tanks in solving water use problems, protection from harmful effect of waters and protection of waters • formulate mathematical stochastic and deterministic models of water tanks and apply the tools of systemic analysis in design and water tank management problem solving • set forth a model for simulation of water tank operation with the aim of solving various water-related problems • formulate optimisation models for solving engineering problems in planning, design and water tank management • prepare data necessary for planning and design of water tanks • anticipate the influence of water tanks on environment and define protection measures		
Enrolment requirements	Basic knowledge of hydrology.		
Content	Water tanks and their role in water management and maintenance of sustainable water supply, food and energy production, protection from floods and droughts and water environment. The main principles water tanks design theory: planning of water resources and water tanks, main characteristics of tanks considering their capacity, volume equations. System approach to planning and design of the tank volume. Methods for determining the tank capacity; computation by applying the balance equation, methods of the critical period, methods of low water levels, methods of the probability matrix, methods based on generated data, simulation and optimisation methods. System engineering - main definitions. Formulation of optimisation problems. Introduction to linear programming. Main principles of linear programming. Application of linear programming to the tank design and management and to other water resources problems. The concept of dynamic programming. One-dimensional dynamic programming. Multi-dimensional dynamic programming. Special types of dynamic programming. Application of dynamic programming to the tank design and accumulation management and to the solution of other problems related to water resources.		

Recommended literature	(1) Margeta, J.: Osnove sistemskog inženjerstva vodnih resursa, Građevinski fakultet, Split, 1993; (2) Margeta, J., Uvod u sistemsko inženjerstvo u projektiranju i upravljanju akumulacijama, Split, 1988.; (3) Margeta, J.: Osnove gospodarenja vodama, G.F. Split, 1992.; (4) Margeta J.:Smjernice za integralni pristup razvoju, gospodarenju i korištenju vodnih resursa, 1999.
Supplementary literature	(1) Smith A.A., E. Hinton, R.W. Lewis: Civil Engineering Systems Analysis and Design, John Willey amd Sons, New York, 1983.; (2) Gillet, B.E.: Introduction to Operation Research, McGraw Hill, New York, 1976.; (3) J. Margeta: Projektiranje i upravljanje volumenima vodospremišta, Građevinski fakultet, Split, 1994.; (4) McMahan, T.A.: Reseroir Capacity and Yield. Elsevier Scientific Publishing Company, Amsterdam, 1978. (5) Moran, P.A.P.: The Theory of Storage, Methuen, London, 1959.
Teaching methods	Lectures with the use of state-of-the art devices. Practical work in problem solving and independent design of programme and homework.
Assessment methods	Oral and written exam, continuous evaluation.
Language of the course	Croatian with possibility of English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	SUSTAINABLE URBAN WATER SYSTEMS		
Code	GAHA08		
Type	Lecture, exercises, individual study with supervisor.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Jure Margeta, PhD		
Learning outcomes and competences	The student will be able to: • formulate the assessment of sustainability of urban water system • apply system approach and system analysis in problem solving of sustainable urban water system • synthetise interpolation measures into existing urban water systems in line with the principles of sustainable development and sustainable living in urban environments • anticipate the influence of climatic changes on the work of urban water systems including the work of waste water purification device, influence on the environment and formulate measures for the increase of the level of sustainability and its adjustment in the future • anticipate the influence of climatic changes on the work of littoral urban water systems and formulate the measures for the increase of the level of sustainability and its adjustment to the expected increase of median water level • combine existing and develop new social and technological measures for increasing the level of sustainability of urban water systems		
Enrolment requirements	Basic knowledge of water supply and sewage system in settlements and purification of rainfall and waste waters.		
Content	Sustainable development and climatic changes. Urban environments, sustainability of living in urban environments, sustainable urban water system. Integral urban water system. Urban water system water balance, vertical water balance in rainfall water eco-drainage system; Renewable energy sources and urban water system; Tasks related to management of sustainable urban water systems; Integration with other management processes; Planning of integral urban water system in line with the concept of sustainable development; Techniques and tools for decision-making support; Managing requirements; Techniques of urban water cycle; Design of water-sensitive urban environments; Risk management.		
Recommended literature	(1) Margeta, J.: Osnove sistemskog inženjerstva vodnih resursa, Građevinski fakultet, Split, 1993.; (2) UNEP: Integrated Coastal Urban water System Planning in Coastal Areas of the Mediterranean, 2007. ; (3) Margeta J.:Smjernice za integralni pristup razvoju, gospodarenju i korištenju vodnih resursa, 1999.		
Supplementary literature	(1) CIRIA; C523 Sustainable Urban Drainage Systems – Best Practice Manua, 2001; Haugton, G. and Hunter, C. Sustainable Cities, Jassica Kingsley, London, 2001.		
Teaching methods	Lectures with the use of state-of-the art devices. Practical work in problem solving and independent design of programme and homework.		
Assessment methods	Oral and written exam, paper, continuous evaluation.		
Language of the course	Croatian with possibility of English.		
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.		

Course title	SELECTED CHAPTERS OF KARST HYDROGEOLOGY		
Code	GAHA09		
Type	Lecture (2 hours), research seminar (2 hours).		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher in terms with their long experience in postgraduate study teaching: Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Ognjen Bonacci, PhD		
Learning outcomes and competences	The student will be able to: • organise the characteristics of karst morphological phenomena and connect them with underground water flow. Organise various terrains in relation to water permeability. • combine findings from karst morphology and terrain water permeability for proposing the zones of sanitary protection. • present hydrodynamic karst zones. • implement the procedures of calculating water loss from karst accumulations.		
Enrolment requirements	Geology and petrography basics and applied geology in technical sciences.		
Content	Geotectonics and karst. Development of the relief and groundwater flow in karst. Phases of karstification and morphological phenomena in karst. Positive and negative effects upon karst development; formation and development of karst fields and hydrogeological phenomena in the underground areas. Water losses from karst accumulations.		
Recommended literature	(1) P. A. Domenico & F. W. Schwartz (1997): Physical and Chemical Hydrogeology. J. Wiley & Sons, Inc.p 506, New York. (2) M. Herak (1957): Geološka osnova nekih hidroloških pojava u dinarskom kršu. Zbornik II. kongr. geol. Jug., 523-535, Sarajevo. (3) M. Herak (1986): Geotektonski okvir zaravni u kršu. Acta Carsologica XIV/XV, 13-18, Ljubljana. (4) M. Herak (1990): Geologija. V. izdanje. Šk. knjiga, p. XV+433, Zagreb. (5) M. Herak, S. Bahun & A. Magdalenić (1969): Pozitivni i negativni utjecaji na razvoj krša u Hrvatskoj. Krš Jug. 6, 45-78, Zagreb. (6) S. Bahun (1978): Model razvoja hidrogeologije nekih polja u dinarskom kršu. Zbornik IX. kongr. geol. Jug., 855-861, Sarajevo. (7) A. Stepinac (1969): Otjecanje u dinarskom kršu. Krš Jug. 6, 207-235, Zagreb. (8) S. Šestanović (1979): Mogućnost kvantitativnog definiranja vodopropusnosti akumulacije Buško Blato. Zbornik RGN fakulteta, 363-377, Zagreb. (9) S. Šestanović (1985): Graditeljski zahvati i zaštita voda u kršu. Naš krš XI/18-19, 33-38, Sarajevo. (10) S. Šestanović (1986): Utjecaj građevinskih objekata izvan urbaniziranih područja na vodne resurse u kršu. Acta Carsologica XIV/XV, 241-244, Ljubljana.		
Supplementary literature	(1) D. Mayer (1993): Kvaliteta i zaštita podzemnih voda. Hrvatsko društvo za zaštitu voda i mora, p 146, Zagreb. (2) K. Urumović (2003): Fizikalne osnove dinamike podzemnih voda. RGN Fakultet Zagreb, 318 str., Zagreb. (3) M. E. Aljtovski (1973): Hidrogeološki priručnik. Građevinska knjiga, 616 str., Beograd. (4) Pollak, Z. (1995): Hidrogeologija za građevinare. Poslovna knjiga, 206 str., Zagreb		
Teaching methods	Lectures with videos and PowerPoint presentations. Supervision of the research seminar in the field, consultations.		
Assessment methods	Oral exam with analysis and defence of research seminar report.		

Language of the course	Croatian with possibility of English and Italian.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	INTRODUCTION TO ENGINEERING NUMERICAL MODELLING		
Code	GAHA10		
Type	Lecture, seminar, computer work.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Associate Professor Hrvoje Gotovac, PhD		
Learning outcomes and competences	The student will be able to: • make a mathematical model of engineering problems • formulate and make a numerical model of engineering problems by finite differences method • formulate and make a numerical model of engineering problems by using finite elements technique • formulate and make a numerical model of engineering problems by using point and sub-area collocation method • analyse stationary and non-stationary engineering problems by using the aforementioned numerical methods • analyse engineering problems by using the Lagrangian ("Random walk") and Euler-Lagrangian methods • analyse engineering problems by using the Monte-Carlo method • analyse the accuracy and stability of numerical solutions		
Enrolment requirements	Graduate degree. Programming basics in Fortran.		
Content	Introduction. Functional approximations. Approximate solutions of differential equations; procedures of strong and non-strong formulation. Method of finite differences (MODFLOW formulation in underground water flow). Galjerkin`s formulation and method of the conservation law. Method of point collocation. Method of sub-area collocation. Finite elements technique. Modelling of the stationary heat conductivity by using the method of finite elements (Konelib library), Modelling of planar state of strain and deformation and modelling of prismatic bar torsion (Konelib). Explicit, mixed and implicit procedures of numerical time integration. Modelling of non-stationary product conductivity by using the method of finite elements (Konelib), Solving large linear and non-linear equation systems (frontal procedure, conjugate gradients method, GMRES, Newton` method). Adaptive procedures. Stability and accuracy of the numerical solution. Modelling of non-stationary transport of the mass by using Lagrangian ("Random Walk Particle Tracking") and Euler-Lagrangian methods. Monte-Carlo method.		
Recommended literature	(1) Jović V. (1993.), *Uvod u inženjersko numeričko modeliranje, Aquarius Engineering,* (2) Zheng C., Bennet G. D. (2002), *Applied Contaminant Transport Modelling*, John Wiley and Sons, (3) Saad Y. (2003), *Iterative methods for sparse linear systems*, SIAM. (4) Ascher U.M., Petzold L.R. (1998), *Computer methods for ordinary differential equations and differential-algebraic equations.* SIAM.		

Supplementary literature	(1) Kaliakin V. N. (2002), *Introduction to approximate numerical solution techniques, numerical modeling and finite element methods, Marcel Dekker.* (2) Gotovac H.,, Andričević R., Gotovac B. (2007) Multi-resolution adaptive modeling of groundwater flow and transport problems, Advances in Water Resources (30), 1105-1126.
Teaching methods	Lectures with the use of a projector and computer, writing of the seminar paper with the supervisor's assistance on the computer and cluster.
Assessment methods	Oral exam. Oral presentation and defence of the seminar paper.
Language of the course	Croatian and English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	ANALYSIS OF HYDROLOGICAL TIME SERIES		
Code	GAHA11		
Type	Lecture, research seminar.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study = 3.2 ECTS; Composition of research seminar paper = 2.0 ECTS.		
Teachers and/or associates	Prof. Damir Jukić, PhD		
Learning outcomes and competences	Upon the completed exam, the student will be able to: • write an analysis of time series by descriptive techniques • propose adequate models of time series • propose prognostic models • propose time series in frequency domain		
Enrolment requirements	Enrolment at Methods of Mathematical Statistics.		
Content	Introduction: hydrological and climatic time series and their characteristics, basic terminology goals and approaches to the analysis of hydrological time series. Unilateral descriptive techniques: types of time series, analysis of trending series, graphical illustration and comparison of time series, analysis of series with seasonal variations, auto-correlation and correlogram, cross-correlation, partial correlation, regression, graduation of series. Models of hydrological time series: stochastic processes and their characteristics, stationary processes, "white noise", characteristics and assessment of auto-correlation function, AR, MA, ARMA and ARIMA models, Box-Jenkins seasonal ARIMA model, adjustment and assessment of model parameters, analysis of residual values. Prognostic models, overview of prognostic procedures and their comparison. Analysis of hydrological time series in frequency domain: spectral analysis, periodogram, spectral density function, cross-spectral density function, transfer function.		
Recommended literature	(1) Chris Chatfield: The Analysis of Time Series: An Introduction, Sixth Edition, Texts in Statistical Science, 2003.		
Supplementary literature	(1) George E. P. Box, Gwilym M. Jenkins, and Gregory C. Reinsel: Time Series Analysis: Forecasting and Control, Wiley Series in Probability and Statistics, 2008. (2) A.R. Rao and E.-C. Hsu: Hilbert-Huang Transform Analysis of Hydrological and Environmental Time Series, Water Science and Technology Library, 2008. (3) Shumway R.D., Stoffer D.S.: Time Series Analysis and Its Applications, Springer Verlag, 2000. (4) Napler Addison: The Illustrated Wavelet Transform Handbook, 2002.		
Teaching methods	Seminar paper presentation with state-of-the-art devices and discussions with students; individual work with students.		
Assessment methods	Oral exam, oral presentation.		
Language of the course	Croatian, English		

Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

3.4.4. Description of elective courses in the field of Civil Engineering, branch of Transport

Course title	TRAFFIC FLOW THEORY		
Code	GAPA01		
Type	Lecture, research seminar.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Dražen Cvitanić, PhD		
Learning outcomes and competences	The student will be able to: • select traffic flow parameters required for analysis (time of sequence, critical time gap, free flow speed…) • assess and develop analytical models of traffic flow at intersections without signalling lights • assess and develop analytical models of traffic flow at intersections with signalling lights • assess and develop analytical models of traffic flow at roundabout intersections • assess and develop analytical models of traffic flow of extra-urban roads • assess and develop simulation models of traffic flow		
Enrolment requirements	Undergraduate degree (6th level EQF or CroQF).		
Content	Traffic flow characteristics. Traffic flow, density, speed, spatial and temporal gaps. Measurement at a point; measurement over a short section. Two and three-dimensional speed-flow-density models. Human factors (perception-response time, braking inputs, acceleration, deceleration..). Influence of gender, age and trip purpose on the flow. Car sequence models. Lane changing models. Macroscopic traffic flow models. Analytical models and application of queuing theory. Theory of recognising time gaps. Critical time gaps. Saturated flow. Analysis models of functioning of non-signalised and signalised intersections. Simulation traffic flow models.		
Recommended literature	(1) D.R. Drew: *Traffic Flow Theory and Control*, McGraw-Hill, New York 1968. (2) *Traffic flow theory*, Transportation Research Bord 1998. (3) F.A. Haight: *Mathematical Theories of Traffic Flow*, Academic press, London 1963 (4) Cvitanić, D:Teorija prometnog toka, Split 2008, course exam notes na web stranama fakulteta, (5) Roger P. Roess, Elena S. Prassas, William R. McShane: Traffic Engineering (2004.).		
Supplementary literature	(1) Cvitanić, D.: *Modeliranje kapaciteta i razine usluge nesemaforiziranih raskrižja*, Građevinski fakultet Sveučilišta u Splitu, Magistarski rad, Split 2000. (2) Breški, D.: *Usporedba analitičkih i simulacijskih modela za analizu funkcioniranja semaforiziranih*		

	raskrižja, Magistarski rad, Split 2000.
Teaching methods	Lectures with the use of state-of-the-art devices. Work with software for the analysis of traffic flow on the elements of the traffic network, supervised writing of the seminar paper.
Assessment methods	Oral exam with the presentation of the seminar paper.
Language of the course	Croatian and English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	HIGHWAYS – SELECTED CHAPTERS		
Code	GAPA02		
Type	Lecture and seminar paper.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Associate Professor Deana Breški, PhD		
Learning outcomes and competences	The student will be able to: • present basic theories of vehicle circulation and forces affecting the vehicle • determine optimal route elements with regard to the category of the highway, filed conditions, lateral impact, visibility, etc. • select and design the optimal type of intersections with all pertaining elements • justify the selection of the model and procedure of traffic analysis • determine the maximum capacity of road network elements by using different models • select the model of road management		
Enrolment requirements	Graduate degree (7the level EQF or CroQF).		
Content	The role of traffic in planning. Main theories on vehicles circulation. Management and maintenance of roads. Environmental protection. Assessment of potential pollution. Protective measures. General considerations in planning and design. Cross-road types. Design elements. Routing of traffic flows. Traffic islands. Traffic control. Flow capacity. Level cross-roads. Cross-roads beyond the level. Classification of the sources of conflict points. Theoretical form of the function for inflow-outflow levels/ramps. Traffic consideration. Geometrical formation of descending-ascending level crossings. Flow capacity of the intersections. Classification of intersections. Criteria for the selection of intersections.		
Recommended literature	(1) *A Policy on geometric design of Highways and streets*, AASHTO 2001. (2) McShane,W.R. Roess, R.P., Prassas,E.S.: *Traffic engineering*, Prentice Hall, 2004. (3) Maletin, M.: *Planiranje i projektovanje saobraćajnica u gradovima*a, Orion art, 2009.		
Supplementary literature	(1)*Transportation Impact Analyses for Site Development*, Institute of Transportation Engineers (ITE), 2005. (2) Pađen, J.: *Osnove prometnog planiranja*, Informator, Zagreb, 1986.		
Teaching methods	Lectures with the use of state-of-the-art devices.		
Assessment methods	Seminar paper, oral presentation, oral exam.		
Language of the course	Croatian with possibility of English.		
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.		

Course title	TRANSPORT PLANNING		
Code	GAPA03		
Type	Lecture, research seminar.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Dražen Cvitanić, PhD / Associate Professor Deana Breški, PhD		
Learning outcomes and competences	The student will be able to: • select parameters of the traffic model required for analysis • assess and develop the models of travel generation • assess and develop models travel split • assess and develop models of travel assignment		
Enrolment requirements	Undergraduate degree (6th level EQF or CroQF).		
Content	Transport planning history. Interaction between transport and other activities. Travel demand forecast. Modelling of road network with intersections. Zoning, placing centroids, zone properties. Trip generation models; application of multi-dimensional regression analysis, category analyses, logistic analyses. Models of selection of transport means. Utility models. Models of travel split between the zones; Fratar`s method, gravity model, opportunities model. Route assignment models: capacity restrain models; multi-route assignment models. Model calibration.		
Recommended literature	(1) B.Y. Hutchinson: Principles of Urban Transport Systems Planning, Book Company, 1974. (2) J. Pađen: Osnove prometnog planiranja, Informator, Zagreb, 1986. Transportation planning handbook, ITE 2005.		
Supplementary literature	R. Lane, Powel, T.J.: *Analytical transport planning,* Redword Burn Limited 1974.		
Teaching methods	Lectures with the use of state-of-the-art devices. Work with software for transport planning, supervised writing of the seminar paper.		
Assessment methods	Oral exam with the presentation of the seminar paper.		
Language of the course	Croatian and English.		
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.		

3.4.5. Description of elective courses in the field of Civil Engineering, branch of Geotechnics

Course title	SELECTED CHAPTERS OF ROCK MECHANICS		
Code	GAGA01		
Type	Lecture, seminar, laboratory work.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Predrag Miščević, PhD		
Learning outcomes and competences	The student will be able to: • critically assess and improve the measurement methods of crack, rock and rock mass parameters required for solving engineering problems in rock masses • independently re-evaluate the classifications of rock mass • develop rock mass models • devise rock mass improvement methods • select and plan complex foundations on rock mass • create new methods of analysis of high rock mass slopes • develop rock mass design based on observation methods		
Enrolment requirements	Graduate degree (7^{th} level EQF or CroQF).		
Content	Content of investigative works for design and construction of structures in rock mass. Correlation between engineering geological characteristics (cracks, percentage of core, RQD) and geotechnical characteristics of the rock mass. Rock and rock mass models. Improvement (reinforcement) of rock masses (drainage, bolting, grouting). Guidelines for design and measurement of foundations, high rock slopes, retaining constructions and underground excavations (geological engineering model – geotechnical model – numerical model). Use of numerical methods at foundation, securing high rock slopes, retaining structures with bolts and underground excavations. Observations of structures in rock mass and interpretation of the measured results.		
Recommended literature	(1) Hudson J.A. & Harrison J.P. (1997.), *Engineering rock mechanics, an introduction to the principles*, Pergamon. (2) Duncan C. W. (1999.), *Foundation on Rock*, E & FN Spon, second edition. (3) Hoek E. & Brown E.T. (1980.), *Underground Excavations in Rock*, Institute of Mining and Metallurgy, London.		
Supplementary literature	(1) Hanna T.H. (1982.), *Foundations in tension, ground anchors*, Trans Tech Publications. (2) Hoek E. & Bray J.W. (1974.), *Rock slope engineering*, The Institution of Mining and Metallurgy, E & FN Spon. (3) Goodman R.E. (1989.), *Introduction to Rock Mechanics*		

	(second edition), John Wiley & Sons.
Teaching methods	Lectures with the sue of a video projector with a computer, supervised writing of the seminar paper, and performance of laboratory testing.
Assessment methods	Oral presentation of the seminar paper. Oral exam.
Language of the course	Croatian and English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	SOIL MECHANICS MODELS		
Code	GAGA02		
Type	Lecture, research seminar, laboratory study, individual study with supervisor.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Tanja Roje-Bonacci, PhD		
Learning outcomes and competences	The student will be able to: • critically assess the most recent findings available in the existing literature with special emphasis on the area of small deformities; • comment on mutual relations, implementation advantages and disadvantages of known and acknowledged soil models; • independently determine, on the existing equipment in the laboratory, the input parameters for some of the known soil models; • assess and apply gained laboratory data on idealised numerical soil model; • assess gained solutions by comparing several variants; • express substantiated opinion on the possibility of adjusting theoretical solutions for solving natural phenomena in geotechnics, which are appropriate for subject research.		
Enrolment requirements	Graduate degree (7^{th} level EQF or CroQF). Fluency in English..		
Content	Main principles of the mechanics of the continuum. Soil as a two-phase continuum. Differential equation of balance and motion. Simple constitution equations for the soil. Influence of non-linearity on the soil behaviour. Drainage and non-drainage conditions; water flow in soil and consolidation. Boundary and initial conditions. Main rules in numerical modelling for geotechnical operations. Constraints and criteria. Non-linear soil models and finite element method. Computer programmes: requirements and possibilities. Selection of input data. Critical approach to problem simplification. Acceptability of the results of numerical analysis. Numerical modelling of complex geotechnical operations: embankments, anchoring supporting structures etc.		
Recommended literature	(1) Mechanics of Geomaterials: Rocks, Concrete, Soils, Z.P. Balant ed., John Wiley & Sons, Inc., New York, 1985. (2) Naylor, D.J., Pande, G.N., Simpson, B., Tabb, R.: Finite Elements in Geotechnical Engineering, Pineridge Press Ltd., Swansea (UK), 1981.		
Supplementary literature	(1) Roscoe, K.H., Burland, J.B.:. *On the generalised stress-strain behaviour of an idealised wet clay*. U: Heineman i Leckie (ur.), Engineering plasticity, (1968), Cambrige University Press, 535-609. (2) Chen, W.F.,: *Limit analysis and soil plasticity*. Elsevier, New York, 1975. (3) Chen, W.F., Saleeb, A.F., *Constitutive Equations for Engineering Materials*. *Vol 1- Elasticity and Modeling*, Wiley, New York, 1982. (4) GeoSlope, *Manual Sigma/W define*, version 5.01. (5) ABAQUS, *Theory Manual version 6.3*. (6) Mihanović, A:, Marović, P., Dvornik, J.: *Nelinearni proračuni armirano betonskih konstrukcija.* Društvo hrvatskih građevinskih konstruktora, Stručna biblioteka, Serija priručnici, knjiga 7, Zagreb, 1993. (7) P.I.S.A. *Program for incremental stress analysis*; Elastic models, Plastic models, Critical state models. (8) Atkinson, J.H.; Bransby, P.L.: 1978. *The mechanics of soils, An introduction to critical state soil mechanics*, McGrow-Hill, London. (9) Britto, A.M., Gunn, M.J., 1987. *Critical State Soil Mechanics via Finite Elements*, John Wiley and Sons.		

	(10) Časopisi: Geotechnique; Engineering Modelling; Soils and Foundations; Journal of Solis Mech. And Fuond. Engineering, ASCE.
Teaching methods	Lectures, seminar paper, laboratory testing of sample properties. Solving of a practical problem by numerical methods.
Assessment methods	Oral presentation of laboratory work, seminar paper, presentation of numerical calculations. Oral exam.
Language of the course	Croatian, English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	SPECIAL CHAPTERS IN FOUNDATION ENGINEERING		
Code	GAGA03		
Type	Lecture, seminar, individual study with supervisor.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Tanja Roje-Bonacci, PhD		
Learning outcomes and competences	The student will be able to: • assess the condition of technology of performance of unusual foundation methods form the available literature; • assess the most recent improvement possibilities of sub-foundation soil and critically review them; • model unusual foundation and improvement of sub-foundation soil for the same geotechnical conditions and set parameters; • compare and assess on a specific example all aspects of quality and effect of unusual foundation and improvement of sub-foundation soil; • test the effects of change of value and specific input data in a certain model of unusual foundation and/or improvement of foundation soil • select the most favourable solutions in complex conditions of foundation.		
Enrolment requirements	Graduate degree (7^{th} level EQF or CroQF). Fluency in English.		
Content	Foundations of silos and reservoirs; towers, chimneys, transmission lines and antenna columns, foundations of arch bridges, suspended and other types of bridges (cofferdams and abutments/piles); deep massive foundations, foundations in deep water (docks, platforms; coastal structures, foundations and transfer of horizontal forces; overcoming buoyancy for immersed structures (dry docks, rafts, dam superelevation). Correction of sloped/inclined structures. Change of stress in the structure due to the development of settlement with time. (The course contents will be adapted to the candidates' requirements since it is too complex for the proposed timetable).		
Recommended literature	(1) Fang, H.-Y.: Foundation Engineering Handbook, Chapman & Hall, London, 1991. (2) Zeevaert. L.: Foundation Engineering for Difficult Subsoil Conditions, Van Nostrand Reinhold Company, New York, 1973. (3) Agatz, A.; Lackner, E.: Erfarungen mit Grundbauwerken, Springer – Verlag, Berlin, 1977.		
Supplementary literature	(1) Desai, C.S.. Christian, J.T.: Numerical Methods in Geotechnical Engineering, McGraw-Hill Book Company, New York, 1977. (2) Bowles, J.E.: Foundation Analysis and Design, McGraw-Hill Book Company, New York, 1988. (3) Kany, M.: *Berechnung von Flächengründungen,* Wilhelm Ernst&Sohn, 1974, Berlin. (4) Prudon, L. *Traveau maritime, Bibliothèque de l'ingénieur de travaux publics,* Dunod, 1936. Paris.		
Teaching methods	Lectures, composition of the seminar paper with target subject-matter, composition of a design at the level of study from the target area.		
Assessment methods	Written seminar paper, written-graphic study and its oral presentation. Oral exam.		
Language of the course	Croatian, English.		
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.		

3.4.5. Description of elective courses in the field of Civil Engineering, branch of Materials

Course title	RHEOLOGY OF MATERIALS		
Code	GAMT01		
Type	Lecture, seminar, laboratory work.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Associate Professor Sandra Juradin, PhD		
Learning outcomes and competences	The student will be able to: • develop and select options of rheological concrete models • develop and select options of rheological special concrete models • assess functional ties between spatial and rheological properties of concrete • select the composition of concrete based on required spatial model of normal and special concrete • recommend the type rheometer for certain tests • assess gained results		
Enrolment requirements	Graduate degree (7^{th} level EQF or CroQF).		
Content	Rheological models Applied concrete rheology Viscosity and boundaries of flow: determination methods Concrete, suspension and coat rheology. Design of rheometer for liquid concretes. Rheology of fresh shotcrete. Rheology of self-compacting concrete Sample. System of particles. Skeletal structure. Dilatation. Spatial sample model. Stability of sample. Functional tie between spatial and rheological properties of concrete.		
Recommended literature	(1) Powers, T.C.: The Properties of Fresh Concrete, J.Willey and Sons, 1968., (2) Krstulović, P.; Juradin, S.; Reologija materijala, skripta (3) Bartos, P. J. M.: Special Concretes, workability and mixing, proceedings of the international RILEM workshop, Paisley, Scotland, 1993		
Supplementary literature	(1) Banfill, P. F.G.: Rheology of Fresh Cement and Concrete, Proceedings of the International Conference organized by the British Society of Rheology, Licerpool, UK 1990. (2) Krstulović, P: Svojstva i tehnologija betona, Građevinski fakultet Sveučilišta u Splitu i Institut građevinarstva Hrvatske, Split, 2000. (3) Tattersall, G.H.: The Workability of Concrete, Cement and Concrete Association, Wexham Springs, Slough, 1976. (4) Reiner, M.: Deformation, Strain and Flow, H. K. Lewis & Co., London, 1969 (5) Ferraris, C.F.; de Larrard F.; Martys, N.: Fresh Concrete Rheology – Recent Developments, to be published in Materials Science of Concrete, Volume VI (6) Hackley A.V.; Ferraris, C.F.: Guide to Rheological Nomenclature: Measurement in Ceramic Particular Systems,		

	NIST Special Publication 946, National Institute of Standards and Technology, Gaithersburg, 2001 (7) Whorlow, R.W.: Rheological Techniques, John Willey & Sons – Ellis Horwood Ltd, Chichester, England, 1980.
Teaching methods	Lectures and seminars with the use of state-of-the-art devices (computer work), laboratory.
Assessment methods	Oral exam, Oral presentation of the seminar paper.
Language of the course	Croatian, English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	NEW MATERIALS IN CIVIL ENGINEERING		
Code	GAMT02		
Type	Lecture, seminar, laboratory work.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Associate Professor Sandra Juradin, PhD		
Learning outcomes and competences	The student will be able: • select and recommend the composition of self-compacting concrete • select and recommend the composition of light concrete (regular and self-compacting) • select and recommend the composition of recycled material concrete • select and recommend the composition of concrete with high usability properties • select and recommend the composition materials • test properties, compare and recommend types of insulation materials		
Enrolment requirements	Graduate degree (7th level EQF or CroQF).		
Content	Technology, structure and properties of cement composites Special concrete (micro-reinforced concrete with high usability properties, self-compacting, light concrete with high usability properties, recycled material concrete, eco-concrete) Special concrete (smart concrete, shotcrete with high usability properties, injection mixtures, mortar, decorative concrete) Composite polymer-based materials. New types of reinforcement materials (micro fibres of different kind and origin, bearing reinforcement of different types and origin) New types of glass as building material Modern insulation materials (hydro-insulation, thermos-insulation) Modern insulation materials (noise insulation).		
Recommended literature	(1) Ukrainczyk, V.: Beton: struktura, svojstva, tehnologija, ALCOR, Zagreb, 1994. (2) Bartos, P. J. M.: Special Concretes, workability and mixing, proceedings of the international RILEM workshop, Paisley, Scotland, 1993, (3) Balaguru, P.; Nanni, A.; Giancaspro, J.: FRP Composites for Reinforced and Pre-stressed Concrete Structures, Taylor & Francis, New York and London (4) MacElroy D.,L.; Kimpflen J.L.: Insulation, materials, testing and applications, ASTM Symposium on Insulation materials, Baltimore 1990.		
Supplementary literature	(1) Maso, J.C.: Interfaces ina Cementitous Composites, LMDC, INA-UPS, Touluse, France 1992, (2) Feldman, D.: Polymeric building materials, (3) Clarke, J.L.: Structural Design of Polymer Composites, The European structural polymeric composites group (4) Gjørv E., Sakai, K.: Concrete Technology for a Sustainable Development in the 21st Century, E&FN Spon		
Teaching methods	Lectures and seminars with the use of state-of-the-art devices (computer work), laboratory.		

Assessment methods	Oral exam, oral presentation of the seminar paper.
Language of the course	Croatian, English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

3.4.7. Description of elective courses in the field of Other Fundamental Technical Sciences, branch of Organisation of Work and Production

Course title	SYSTEM ENGINEERING IN PROJECT MANAGEMENT		
Code	GALA01		
Type	Lecture, research seminar, exercises.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Snježana Knezić, PhD		
Learning outcomes and competences	The student will be able to: • apply system analysis to system modelling, i.e. project management; • plan and manage projects by using models and techniques of system engineering; • optimise project processes, especially in conditions of limited resources; • apply models of operational research and expert systems in project management; • select and rank projects; • implement TQM in project management.		
Enrolment requirements	Graduate degree (7th level EQF or CroQF)		
Content	Basics of system theory. System approach. Structured system analysis. Natural and managed (cybernetic) systems. Civil engineering project as system. Planning and management of civil engineering projects. System elements modelling. Models and techniques of system engineering. Operational research methods and their application in civil engineering project management. Project planning in conditions of limited resources. Selected models of linear programming, dynamic programming, game theory, and expert systems in project management. Mono-criteria and multi-criteria methods of project selection and ranking. Simulation systems in civil engineering project management. TQM project management. Software and systems for large-scale civil engineering projects management – integrated computer systems. New methods and trends in the project management. Examples from the civil engineering practice.		
Recommended literature	(1) H. Kerzner: Project Management, a System Approach to Planning, scheduling and, VNR New York. (2) B.S. Blanchard: System Engineering Management, John Wiley & Sons. (3) S. Knezić: Autorizirani materijali s Lectures.		
Supplementary literature	(1) L. Troncale: The system sciences: What are they? Are they one or many?, Invited Review, EJOR Vol. 31, No. 1. (2) S.E. Elmaghraby: Activity nets: A guided tour through some recent developments, Invited Review, EJOR Vol. 82, No. 3. (3) P. Brucker et al: Resource-constrained project scheduling: Notation, classification, models and methods, Invited Review, EJOR Vol. 112, No. 1		
Teaching methods	Lectures. Problem-solving exercises with available software support. Independent composition of the seminar paper.		

Assessment methods	Oral exam and oral presentation of the seminar paper.
Language of the course	Croatian and English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	DECISION SUPPORT SYSTEMS		
Code	GALA02		
Type	Lecture, exercises.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Nenad Mladineo, PhD / Assistant Professor Nikša Jajac, PhD		
Learning outcomes and competences	The student will be able to: • connect the basic principles of decision-making theory with specific problem • select the most appropriate method of multi-criteria analysis • integrate certain system constituents for decision-making support • evaluate the efficiency of certain systems in civil engineering practice		
Enrolment requirements	No requirements.		
Content	Introduction to decision-making theory. Decision models. Decision support systems. Decision support systems concept. Structured, semi-structured and ill-structured problems. Group decision support systems. Data base management. Model management. User interface management. Information systems as parts of decision support systems. Multi-criteria decision making. Multi-criteria analysis methods (AHP, PROMETHEE, ELECTRE, etc.). Expert systems. Conceptual basis of expert systems. Knowledge base models (predicate calculus, frames, semantic networks, production systems, scripts, neural networks). Knowledge acquisition. Expert systems as parts of decision support systems. Strategy of decision support systems development. Software and application in the civil engineering practice.		
Recommended literature	(1) P.G.W. Keen, M.S.C. Morton: Decison Support System: an Organisational Perspective, Addison-Wesley Publishing Company, 1978. (2) T.L. Saaty: The Analytic Hierarchy Process, McGraw Hill, New York, 1980. (3) J.P. Brans, B. Mareschal: The PROMCALC & GAIA Decision Suport System for Multicriteria Decision Aid, Vrije Universiteit Brussel, 1991. (4) G. DeSanctis, R.B. Gallupe:Foundation for Study of Group Support Systems, Management Science, Vol. 33, No. 5, 589-609. (5) E. Turban: Decision Support and Expert Systems (Management Support Systems), Macmillan Publishing Company New York, 1993. (6) S. Knezić: Autorizirani materijali s Lectures.		
Supplementary literature	(1) T.L. Saaty: Group Decision Making and the AHP, 59-67, 1987. (2) J.P. Brans, C. Macharis, B. Mareschal: The GDSS PROMETHEE Procedure, Vrije universitet Brussel, 1997. (3) L.M. Jessup, J.S. Valacich: Group Support Systems: New Perspectives, Macmillan, 1992. (4) L. Troncale: The system sciences: What are they? Are they one or many?, Invited Review, EJOR Vol. 31, No. 1.		
Teaching methods	Lectures. Problem-solving exercises with available software support. Independent composition of the paper.		
Assessment methods	Oral exam, oral presentation of the paper.		

Language of the course	Croatian, English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	SYSTEM THEORY		
Code	GALA03		
Type	Lecture, research seminar, exercises.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	**ECTS (number of allocated credits)**		
Teachers and/or associates	**Teachers and/or associates**		
Learning outcomes and competences	**Learning outcomes and competences**		
Enrolment requirements	Undergraduate degree (6th level EQF or CroQF)		
Content	General system theory. Basic structure and characteristics of systems. System entropy. Models of open systems. System analysis. Lifecycle of systems. Linear and dynamic processes. Cybernetic systems. Basics of cybernetics. Regulation of systems' functioning. System management. Automated management.		
Recommended literature	**(**1) L. von Bertalanffy, General System TheoryGeorge Braziller, bilo koje izdanje (2) General Systems Theory and Cybernetics, Springer Berlin / Heidelberg, Volume 216/2007 (3) Žugaj, M., J. Šehanović, M. Cingula: Organizacija, TIVA, Varaždin, 2004. (4) S. Knezić: Autorizirani materijali s Lectures.		
Supplementary literature	(1) L. Troncale: The system sciences: What are they? Are they one or many?, Invited Review, EJOR Vol. 31, No. 1.		
Teaching methods	Lectures. Problem-solving exercises with available software support. Independent composition of the paper.		
Assessment methods	Oral exam and oral presentation of the seminar paper.		
Language of the course	Croatian and English.		
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.		

3.4.8. Description of elective courses in Architecture and Urban Planning

Course title	HIGHWAYS AND THE ENVIRONMENT		
Code	GAAA01		
Type	Lecture.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher . Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Darovan Tušek, PhD		
Learning outcomes and competences	The student will be able to: • analyse factors affecting the selected traffic solution, • assess the influences of the traffic intervention on the environment, • support conclusions on the assessment of environmental impact with appropriate regulations, • propose alternative traffic solution		
Enrolment requirements	No requirements.		
Content	Integral concept of environmental protection. Main principles, documents and implementation of environmental protection. Environmental impact assessment; content of the environmental impact study. Analysis of potential environmental effects, measures for reducing the environmental threats and the programme for monitoring the state of the environment. Final evaluation of the study. Analysis of factors influencing the selection of the highway route: climate, geology, terrain, hydrology, archaeology, ecosystems and all other natural and man-made values: developmental, social, political and economic factors. Change of land use. Highway, railroad, airport and river structures. Emissions of harmful substances, noise, visual degradation of the environment. Presentation and analysis of already developed environmental impact studies for traffic - infrastructure interventions into the environment.		
Recommended literature	(1) Izbor iz zakonske regulative: Zakon o prostornom uređenju (NN 153/2013); Zakon o gradnji (NN 153/2013), Zakon o zaštiti okoliša (NN 80/2013, 153/2013)); Uredba o procjeni utjecaja zahvata na okoliš (NN 61/2014); (2) I.Lozić: Planning and Design of Roads in Protected Areas. 12th World Congress International Road Federation, Madrid, 1993. (3) S.Jurković: Promjene vizuelnih vrijednosti krajolika gradnjom infrastrukturnih trasa. Prostor, 1,1993.		
Supplementary literature			
Teaching methods	Lectures; seminar paper.		
Assessment methods	Defence of the seminar paper. Oral exam.		
Language of the course	Croatian.		
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.		

3.4.9. Description of elective courses in the field of Technical Sciences

Course title	METHODOLOGY AND TECHNIQUES OF SCIENTIFIC RESEARCH		
Code	GATA01		
Type	Lecture, research seminar.		
Level	7th level EQF or CroQF		
Year	I	**Semester**	I
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher and the Committee for Postgraduate University Doctoral Study. Teaching (30 hours) = 1.6 ECTS Independent work and studying (36 hours) = 2.4 ECTS Writing of research seminar paper (20 hours) = 2.0 ECTS;		
Teachers and/or associates	Prof. Pavao Marović, PhD / Prof. Mirela Galić, PhD		
Learning outcomes and competences	Upon the completed course, the student will be able to: • differentiate between written papers and their categorisation, • classify scientific and artistic papers by scientific fields and branches, • differentiate between scientific and scientific-research titles, • learn the signs for correcting text errors, • write and format the scientific and professional paper, • properly cite the used literature, • correct the text of the scientific and professional paper, • decide on the categorisation of certain scientific or professional paper, • self-evaluate and review scientific and professional paper.		
Enrolment requirements	No requirements.		
Content	Basic terminology regarding scientific and professional papers; classification of science (areas, fields, branches); research and scientific-teaching titles; writing and correcting of text; citing literature within the text and in bibliography; peer-review process. Application to competitive research projects. Patent and intellectual property protection.		
Recommended literature	(1) Zelenika, R.: *Metodologija i tehnologija izrade znanstvenog i stručnog djela*. Ekonomski fakultet, 781 str., Rijeka, 2000. (2) Simonić, A.: *Znanost: najveća avantura i izazov ljudskog roda*. Sveučilište u Rijeci, 483 str., Rijeka, 1999.		
Supplementary literature	(1) Zelenika, R.: *Znanost o znanosti*. 5. izmij. i dop. izd., Ekonomski fakultet, XXIII + 422 str., Rijeka, 2004. (2) Silobrčić, V.: *Kako sastaviti, objaviti i ocijeniti znanstveno djelo*. 5. dop. izd., Medicinska knjiga, VIII + 220 str, Zagreb, 2003. (3) Tkalec Verčić, A.; Sinčić Ćorić, D.; Pološki Vokić, N.: *Priručnik za metodologiju istraživačkog rada: Kako osmisliti, provesti i opisati znanstveno i stručno istraživanje*. M.E.P. d.o.o., Zagreb, 2010. (4) Tuđman, M.: *Obavijest i znanje*. Radovi Zavoda za informacijske studije, knjiga 2, 264 str., Zagreb, 1990.		
Teaching methods	Lectures with PowerPoint presentations, Monitoring progress of writing of the seminar paper. Consultations.		
Assessment methods	Oral presentation of the seminar paper. Oral exam.		
Language of the	Croatian, possibly English.		

course	
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	INFORMATION ENGINEERING		
Code	GATA02		
Type	Lecture, seminar, laboratory work.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Ante Munjiza, PhD		
Learning outcomes and competences	The student will be able to: • differentiate between computer languages • develop a computer application describing an engineering process • assess the advantages of structured and object-oriented approach • design the graphic interface for the application • integrate the methods of team development, spatially distributed development, parallel and distributed computer science and intelligent engineering		
Enrolment requirements	Graduate degree (7th level EQF or CroQF).		
Content	Introduction to computer languages: C, C++, Java, C#. Design of conventional engineering software systems and platforms, Software structures in architecture and civil engineering, Software structures for engineering systems applications. Design of object-oriented engineering software systems and platforms, object-oriented approach to development of engineering simulations, architectural applications and applications of systems engineering. Development of engineering software: top-bottom approach, team work, distributed developments, automated developments, grid computing, parallel computing, distributed computing, intelligent engineering, virtual reality, GUI. Application: Students will apply gained knowledge on their research through the seminar paper.		
Recommended literature	1) S. Robinson et al.: Professional C#. ISBN 1 86100704-3. 2) R. Winder: Developing Java Software, ISBN 13: 9780470090251. 3) T. Grandon: Introduction to Programming Using Visual C++.NET. ISBN 13: 9780471487241. 4) E. Koffman, P. Wolfgang: Objects,Abstraction, Data Structures and Design. ISBN 13: 97804171467557. 5) H Van Vliet: Software Engineering. ISBN 13: 9780471975083. 6) C. Horstmann: Object-Oriented Design and Pettern, ISBN 13: 9780471744870. 7) W. Emmerich: Engineering Distributed Objects, ISBN 13: 9780471986577. 8) A. Munjiza: The Combined Finite-Discrete Element Method, udžbenik, Wiley&Sons, London 2004.		

Supplementary literature	Many papers in international journals at student`s selection.
Teaching methods	Lectures with the use of developmental programmes. Composition of independent seminar paper related to published scientific paper at student`s selection.
Assessment methods	Seminar paper and defence of seminar paper. Oral exam.
Language of the course	Croatian and English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	ENGINEERING SIMULATIONS TECHNIQUES		
Code	GATA03		
Type	Lecture, seminar, laboratory work.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher . Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Ante Munjiza, PhD		
Learning outcomes and competences	The student will be able to: • integrate the formulation of finite rotations and deformities into the finite element method • formulate modern methods in engineering simulations • present scientific papers by the use of contemporary engineering notation • formulate processes of contact interaction and fragmentation in discreet systems		
Enrolment requirements	Graduate degree (7th level EQF or CroQF).		
Content	Modern approach to engineering applications of tensor calculus and its demonstration through finite rotations, finite strain, balance and residual formulations, contact formulations, fragmentation and fraction formulations. Presenting scientific papers through the use of contemporary engineering notation. Basic techniques of engineering simulations: Gaussian integration, basal functions, method of conjugate gradients, skyline method. Direct integration, Runge-Kutta method, relaxation, optimisation techniques. Implementation of said techniques within contemporary computer languages. This part includes a seminar paper and “hands-on experience”. Generalisation of techniques within contemporary methods for engineering simulations including structures, geotechnics, mechanics of fluids, engineering systems and generalisation into complex systems like biological, financial, economic, climatic etc.		
Recommended literature	(1) A.Munjiza, The Combined Finite-Discrete Element Method, udžbenik, Wiley&Sons, London 2004.; (2) A.Munjiza, Tensor Algebra in Science and Engineering, udžbenik, Ventus Publishing, 2010.; (3) A.Munjiza, Mechanics of Discontinua, udžbenik, Wiley&Sons, London 2010.; (4) A.Munjiza, Tailor made .pdf and .ppt notes.		
Supplementary literature	Many papers in international journals at student`s selection.		
Teaching methods	Lectures with the use of developmental programmes. Composition of independent seminar paper related to published scientific paper at student`s selection.		
Assessment methods	Seminar paper and defence of seminar paper. Oral exam.		

Language of the course	Croatian and English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

3.4.10. Description of elective course in the field Natural Sciences, branch of Mathematics

Course title	APPLIED FUNCTIONAL ANALYSIS		
Code	GAMA01		
Type	Lecture, seminar.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher . Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Assistant Professor Slavica Ivelić Bradanović, PhD		
Learning outcomes and competences	The student will, through basic concepts and functional analysis theorems, be able to: • formulate some boundary-value problems in the form of variation equations; • determine the existence and uniqueness of weak solutions of given boundary-value problems • test the conditions of solving potential of linear algebraic and operation equations; • by applying the adequate algorithm, solve the task with limitations in the form of equality		
Enrolment requirements	Basic knowledge of Mathematical Analysis and Linear Algebra. Probability and Mathematical Methods in Statics. Knowledge of basic terminology in ordinary and partial differential equations and their application.		
Content	Convex set. Divergence theorem. Gradient theorem. Continuity equation. Deformity and stress tensor. Newton`s fluid. Boundary-value problems with limitations in the form of equality and inequality. Theory of normed and inner product spaces (Banach and Hilbert spaces). Linear transformations and functionals. Linear transformations on finite-dimensional spaces. Linear, bilinear and quadratic forms. Linear functionals and operators on Hilbert spaces. Symmetric, positive and positive-definite operator. Sobolev functional space and the functional trace from that space. Inequalities (Friedrichs, Poincare). Variation (weak) boundary-value formulation. Weak solutions. Minimum of quadratic functional. Linear algebraic equations and solvability conditions. Linear operator equations and solvability conditions and Banach`s fixed point theorem. Regularity of solution for the variation boundary-value problem and Lax-Milgram theorem. Method of Lagrangian multipliers. Penalty method. Introduction. Existence and uniqueness.		
Recommended literature	(1) J.N. Reddy, Applied Functional Analysis and Variational Methods in Engineering, McGraw-Hill Book Company, 1987; (2) I. Aganović, Uvod u rubne zadaće mehanike kontinuuma, Zagreb, 2003.		
Supplementary literature	S. Kurepa, Funkcionalna analiza- elementi teorije operatora, Školska knjiga, Zagreb, 1980.		
Teaching methods	Lectures and composition of the seminar paper.		
Assessment methods	Oral exam, oral presentation of the seminar paper.		
Language of the	Croatian and English.		

course	
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	PRACTICAL METHODS OF OPTIMISATION		
Code	GAMA02		
Type	Lecture, seminar.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Assistant Professor Jelena Sedlar, PhD		
Learning outcomes and competences	The student will be able to: • assess if a practical problem can be formulated as mathematical optimisation problem, • establish if the formulated problem of mathematical optimisation belongs to the type of problem which can be reliably and efficiently solved by optimisation methods (least squares method, linear programming, convex optimisation) and provide substantiated arguments for his/her position, • select optimisation method for solving the formulated problem, • develop algorithms for solving moderate size problems by the selected optimisation method, • define the optimal solution, • assess performance constraints and elaborate his/her position.		
Enrolment requirements	Basic knowledge of Mathematical Analysis and Linear Algebra. Probability and Mathematical Methods in Statics. Knowledge of basic terminology in ordinary and partial differential equations and their application.		
Content	Problem classification. Convex set, convex conus. Representation of the convex set. Convex function. Convex programming. Examples. Linear programming. Minimum requirements for unconstrained problems. Numerical methods: gradient method, Newton`s method, quasi-Newton method, conjugate gradient method etc. Convex programming with constraints. Duality in convex optimisation. Kuhn- Tucker`s conditions. Optimisation methods: Lagrangian method of multipliers, penalty method etc. Other optimisation methods: dynamic programming, 0-1 search method, stochastic programming.		
Recommended literature	(1) S. Boyd, L. Vandenberghe, Convex Optimization, Cambridge University Press New York, New York, 2004; (2) M. Bazara, J. Jarvis, H. Sherali, Linear Programing and Network Flows, John Wiley & Sons, Inc., Hoboken, New Jersey, 2010; (3) S. Zlobec, J. Perić, Nelinearno programiranje, Naučna knjiga, Beograd, 1987.		
Supplementary literature	F. L. Vasiljev, Čislenije metodi ekstremalnyh zadač, Nauka Moskva, 1988.		
Teaching methods	Lectures, research seminar, consultations.		
Assessment methods	Oral exam, oral presentation, rad.		
Language of the course	Croatian and English.		
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.		

Course title	MATHEMATICAL ANALYSIS OF BOUNDARY-VALUE PROBLEMS		
Code	GAMA03		
Type	Lecture, research seminar.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher . Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Božo Vrdoljak, PhD		
Learning outcomes and competences	The student will be able to: • formulate partial differential equations for given physical problems • classified partial differential equations into linear, quasi-linear and non-linear, • assess if the formulated partial differential equation can be solved by analytical methods or select the appropriate method • assess if the formulated partial differential equation can be solved by numerical methods or select the appropriate method		
Enrolment requirements	Knowledge of undergraduate courses in mathematics..		
Content	Equilibrium of stretched string and membrane, oscillation and diffusion problems, equilibrium and constitutive laws. Modelling for wave, diffusion and potential equations. Types of conditions and problems, initial and boundary-value problem, Dirichlet and Neumann problem, classification of second-order partial differential equations. Method of characteristics for first and second-order equations, transformation of equations to normal form. Equilibrium of stretched string, Green function. Contact field and equilibrium of stretched membrane, Laplace equation, Green formula. Fundamental solutions, Green function, harmonic functions. Dirichlet and Neumann problem for circle and ball, spherical and cylindrical functions. Diffusion equation in thermodynamics, maximum principle, Poisson formula. Wave equation, Kirchoff and Poison formula. Method of separation of variables, Green method. Calculus of variations, variation problems for functions of one or several variables, variation problems with higher derivatives and with several unknown functions, Euler differential equation in calculus of variations. Variation formulation of boundary-value problems. Numerical solution of boundary-value problems, method of finite differences, method of collocation and least square method, variation methods, Galjerkin method, Rayleigh-Ritz method, finite element method.		
Recommended literature	[1] I. Aganović i K. Veselić, Linearne diferencijalne jednadžbe, PMF, Zagreb, 1997. [2] T.A. Bick, Elementary Boundary-value Problems, Marcel Dekker, New York, 1993. [3] P.K. Kythe, P. Puri and M.R. Schaferkotter, Partial Diferential Equations and Boundary-value Problems with Mathematica, Chapman & Hall/CRC, Boca Raton, 2003.		
Supplementary literature	[1] M.A. Pinsky, Partial Differential Equations and Boundary-Value Problems with Applications, McGraw-Hill, Boston, 1998. [2] K. Yosida, Lectures on Differential and Integral Equations, Dover Publications, New York, 1991.		

Teaching methods	Lectures, research seminar, consultations.
Assessment methods	Oral exam, oral presentation of the seminar paper.
Language of the course	Croatian, English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	INTEGRAL EQUATIONS		
Code	GAMA04		
Type	Lecture, research seminar.		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	**Semester**	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Božo Vrdoljak, PhD		
Learning outcomes and competences	The student will be able to: • formulate integral equations for solving initial and boundary problems of regular and partial equations • classify integral equation and select appropriate solving method • determine if integral transformations are applicable • determine if numerical methods are applicable		
Enrolment requirements	Knowledge of undergraduate courses in mathematics..		
Content	Definition and classification, Fredholm and Volterra integral equations, relation to differential equations. Fredholm integral equations, equations with degenerate kernels, discussion on solutions, eigenvalues and eigenfunctions, transposed integral equation, method of successive approximations, Neumann series. Fredholm method, Fretholm theorems. Solution of homogeneous integral equation, orthonormal systems for given kernel, iterative procedure. Volterra integral equations, solution by differentiating, method of successive approximations, Neumann series, Volterra integral equations of convolution type. Singular integral equations, Abel equation, equation with Cauchy kernel. Hilbert-Schmidt theory of integral equations with symmetric kernels, eigenvalues and eigenfunctions, Hilbert-Schmidt theorem. Integral equations which transform to equations with Hermite kernel. Banach fixed point theorem and existence of solution of integral equations Integral transformations: Laplace, Fourier and Hankel, inverse transformations, properties, applications in solving initial and boundary value problems for ordinary and partial differential equations. Numerical solution of integral equations, approximation of integral, approximation of kernel, collocation method, quadrature formula, variation methods, collocation method, least square method and Galjerkin method.		
Recommended literature	[1] H. Hochstadt, Integral Equations, J, Wiley, 1994. [2] K. Yosida, Lectures on Differential and Integral Equations, Dover Publications, New York, 1991.		
Supplementary literature	[1] I. Aganović i K. veselić, Linearne diferencijalne jednadžbe, PMF, Zagreb, 1997. [2] T.A. Bick, Elementary Boundary-value Problems, Marcel Dekker, New York, 1993.		
Teaching methods	Lectures, research seminar, consultations.		

Assessment methods	Oral exam, oral presentation of the seminar paper.
Language of the course	Croatian, English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

Course title	METHODS OF MATHEMATICAL STATISTICS		
Code	GAMA05		
Type	Lecture, research seminar		
Level	7th according to EQF or CroQF		
Year	Candidate`s choice	Semester	Candidate`s choice
ECTS (number of allocated credits)	6.0 Number of ECTS credits was calculated according to the assessment of the course teacher. Lectures (30 hours) = 0.8 ECTS; Independent work and study (97 hours) = 3.2 ECTS; Composition of research seminar paper (60 hours) = 2.0 ECTS		
Teachers and/or associates	Prof. Božo Vrdoljak, PhD		
Learning outcomes and competences	The student will be able to: • formulate stochastic model of practical problems with emphasis on water management • select statistical method or test for model evaluation • assess gained results of the formed stochastic model • assess constraints of the selected model		
Enrolment requirements	Completed all undergraduate courses in mathematics.		
Content	Random events, random variables. Distributions of random variables: Normal or Gauss, lognormal, gamma, log-Pirson 3, chi-square, Gumbel, student t-distribution, Fisher F-distribution. Distribution function. Random vectors, independence of random variables, moments, correlation coefficient, regression. Statistical decision, estimation of parameters, sample mean, sample variance, sample range, sample correlation coefficient. Method of maximum likelihood, method of moments, distribution of parameter estimators. Some statistical distributions, confidence intervals for unknown parameters of distribution, confidence intervals for distribution function. Hypothesis testing, hypothesis tests for distribution. Example of applications of statistics in hydrology: Coincidence tests of empirical and theoretic distributions in hydrology, chi-square test, Kolmogorov-Smirnov test. Analysis of homogeneity of hydrological series. Testing of mean, student t-test. Testing of variance of two samples. Independence analysis of hydrological series, test for squares of differences. Sample regression and correlation, least square method, Gauss-Markov theorem, analysis of data dispersion, testing of hypothesis on regression coefficient, generating series by linear regression model, auto-correlation. Independence analysis of time series components, linearly dependent stationary processes. Nonlinear regression. Multiple correlation and regression.		
Recommended literature	[1] B. Vrdoljak, Vjerojatnost i statistika, Građevinsko-arhitektonski fakultet, Split, 2006. [2] Ž. Pauše, Uvod u matematičku statistiku, Školska knjiga, Zagreb, 1993. [3] J.D. Salas, J.W. Delleur, V. Yevjevich and W.L. Lane, Applied Modeling of Hidrologic Time Series, Water Resources Publications, Michigan, 1980.		
Supplementary literature	[1] I. Pavlić, Statistička teorija i primjena, Tehnička knjiga, Zagreb, 1977. [2] M. Ilijašević i Ž. Pauše, Riješeni primjeri i zadaci iz vjerojatnosti i statistike, "Zagreb", Zagreb, 1990.		
Teaching methods	Lectures, research seminar, consultations.		
Assessment methods	Oral exam, oral presentation of the seminar paper.		

Language of the course	Croatian, English.
Quality assurance methods	Quality and success monitoring shall be executed on three levels: (1) University; (2) Faculty through the Committee for Teaching Quality Monitoring; (3) Course teacher.

3.5. Conditions of studying

The studies are very flexible with the maximum possible mobility within Croatia and abroad which can be confirmed by a great number of elective courses. Thus a candidate can, in agreement with the supervisor, attend courses at any doctoral study in the field of civil engineering in Croatia and abroad and collect a required number of ECTS credits and he/she can also research and write his thesis at another university and/or other universities during two terms and collect 60 ECTS credits.

Each candidate, after the agreement with the supervisor and depending on the topic of the research, selects a suitable module, which means that each thesis in fact represents a specific specialisation, i.e. module. Enrolment requirements for a course or research-related activities are presented in the description of the courses and syllabus.

The terms for the exams will not be determined in advance, but they will be subsequently established depending on the completed obligations and the ability of the candidate to take the exam.

3.6. Selection of students, the system of consultation and supervision

General admission requirements for the doctoral studies are defined by the ordinance in Section 6-7. Student admission is based on individual evaluation approach for each student. The right of enrolment is granted to every candidate who completed the graduate study in the area of Technical and Natural Sciences. The candidate submits the following: letter of intent, certification of graduate degree, diploma supplement, and three recommendations of scientists who are familiar with the candidate's research. The assessment approach to each candidate is individual.

The candidate specifies his/her field of research interest in the letter of intent. The candidate has to be assessed by minimal mark "good" (C) for subjects that the Committee for Postgraduate University Doctoral Study finds to be relevant for candidate's research. The Committee for Postgraduate University Doctoral Study decides about the candidate no later than fifteenth day from the beginning of the study programme.

If there are more students than the supervisory capacity of the study, the advantage is given to the students who graduated from the undergraduate and graduate civil engineering studies, and further classification of the candidates is performed according to their success (GPA) at the 4-year undergraduate, graduate and undergraduate level.

For candidates who graduated from the field of natural or technical sciences that do not belong to the field of civil engineering, the Committee for Postgraduate University Doctoral Study

evaluates the competences (skills and knowledge) from both undergraduate and graduate studies of civil engineering the candidate has to achieve so as to be eligible for postgraduate doctorate studies in civil engineering.

For the candidates who passed all exams of former scientific postgraduate master studies, but have not defended their master`s thesis, as well as those who have a scientific degree of Master of Philosophy, the Committee for Postgraduate University Doctoral Study appoints a subcommittee composed of teachers from the relevant field of research which then conducts an interview with the candidate and evaluates their knowledge, interests and results from previous activities. The subcommittee assesses the number of recognised ECTS credits based on the master`s study, whether it is courses or research work since the defended master`s thesis is not necessarily from the desired filed of doctoral research the candidates proposes on application. Depending on the decision, the candidate enrols at required courses and at least "Research III".

The candidate who obtained the 4-year undergraduate study pre-Bologna, is granted by law the same admission right as the candidate with graduate degree.

In agreement with the candidate, a supervisor, and co-supervisor if necessary, is appointed to each candidate and this supervisor shall monitor his/her research work and thesis writing. Their responsibility is to guide the candidate in all segments from the date of his/her enrolment to the date of his/her oral presentation of the thesis, to consult him/her on the possible courses to attend in Croatia and/or abroad and to ensure all necessary conditions for his/her continuous progress during the studies (literature, consultations, suggestions for conferences to attend, co-authorship in writing papers, selection of basis for experimental work within the University in Split and other universities in Croatia and abroad, introducing the candidate to professors in other faculties and ensuring cooperation with them).

Teacher, i.e. supervisor, at the postgraduate doctoral study has to be either a leading researcher or associate in a research project which will serve as a research platform for student's research. The teacher at the postgraduate doctoral study, as well as the supervisor has to meet the criteria of at least scientific associate in the field of technical sciences in accordance with the operative Ordinance on the Election into Scientific Titles.

List of supervisors:

1. Prof. Roko Andričević, PhD
2. Prof. Ivica Boko, PhD
3. Professor Emeritus Ognjen Bonacci, PhD
4. Associate Professor Deana Breški, PhD
5. Assistant Professor Dražen Cvitanić, PhD
6. Assistant Professor Vesna Denić-Jukić, PhD
7. Prof. Mirela Galić, PhD
8. Prof. Blaž Gotovac, PhD
9. Prof. Hrvoje Gotovac, PhD
10. Prof. Alen Harapin, PhD
11. Assistant Professor Nikša Jajac, PhD
12. Prof. Damir Jukić, PhD
13. Prof. Sandra Juradin, PhD

14. Prof. Snježana Knezić, PhD
15. Prof. Vedrana Kozulić, PhD
16. Prof. Pavao Marović, PhD
17. Prof. Domagoj Matešan, PhD
18. Prof. Predrag Miščević, PhD
19. Prof. Ante Munjiza, PhD
20. Prof. Željana Nikolić, PhD
21. Prof. Bernardin Peroš, PhD
22. Prof. Jure Radnić, PhD
23. Prof. Tanja Roje-Bonacci, PhD
24. Assistant Professor Neno Torić, PhD
25. Prof. Boris Trogrlić, PhD
26. Assistant Professor Veljko Srzić, PhD

According to the Ordinance, the constituents can prescribe their own bylaws for the students of postgraduate studies in terms of different admission deadlines, i.e. right and obligations related to the admission deadline. Admission of the students of the Postgraduate Doctoral Study of Civil Engineering is defined by the Syllabus. The student who earns at least 60 ECTS credits in one academic year can apply for courses that total 75 ECTS credits and all others 60 ECTS credits in general. Courses that the student selects in one academic year depend on the enrolment requirements. A full-time student who has not passed the exam in a certain course in one academic year should select this course in the next academic year. A part-time student who has not passed the exam in a certain course in two academic years should select this course again.

The obligations of the doctoral candidate include his/her permanent professional improvement, collection of data on all past and most recent scientific achievements in the field of his/her specialisation, completing all exams, demonstration of autonomous initiative and competences in reasoning, research and cooperation.

3.7. List of all courses or modules available to the students from other studies

Considering the conception of this this study, it is impossible to list all elective courses the student can attend at other faculties. Since the students have a wide possibility of attending elective courses of doctoral studies depending on the their research topic at this Faculty and at other faculties of the University of Split and/or any other university in Croatia and abroad, the candidate will select a group of courses, in agreement with the supervisor, which will lead him/her to the final objective - successful presentation of his/her doctoral thesis.

3.8. List of all courses or modules available in a foreign language

All the offered courses at this doctoral study can be lectured in English; the same applies to the consultations and exams as stated in the description of each course. In addition, part of the recommended and supplementary literature is either in English or in another major world language. Even for the students of the Croatian speaking area, the courses may be organised in English if the

candidates insist on it. Nowadays, students and teachers find data very fast through Internet search engines and most data and relevant literature titles are in English and some papers are published in English, therefore it is implied that both the students and teachers have to have a good command of English.

3.9. Criteria and terms of transfer of ECTS credits

The Bologna Process, through the transfer of ECTS credits, enables the mobility of students worldwide. If the student adheres to the mobility procedure prescribed by the Ordinance on Studies and Rules of Studying at the university of Split, and previously agrees with his/her supervisor about the courses which he/she will study at another University, and subsequently submits the certificate of ECTS credits (ECTS Transcript of Records) from the higher education institution he/she attended, his/her credits will be acknowledged at this study.

3.10. Manner of study completion and conditions of thesis proposal submission

The student completes his/her doctoral study after collecting 240 ECTS credits.

All requirements for thesis proposal submission, public discussion, assessment and defence of the doctoral thesis are defined by the Ordinance.

3.11. Requirements for continuation of studies

Candidates who have interrupted the studies or have lost the right to study at one programme of studies, can continue their doctoral studies at this faculty if no more than two years have passed from the date of interruption or loss of their right to study. The transfer of ECTS credits and the recognition of the passed exams shall be decided by the committee from the branch of the candidate's field of specialisation. The committee is appointed by the Faculty Council according to the proposal of the Committee for Postgraduate Doctoral Studies.

3.12. Requirements for obtaining certificate on completed part of the programme

The candidate enrolled in doctoral studies is entitled to the certificate on the completed part of the study programme as part of life-long education after he/she has collected a total of 120 ECTS credits, of which at least 90 at this faculty.

3.13. Conditions and terms of acquiring a doctoral degree by enrolling at a doctoral study and composing a thesis without attending classes and taking exams

A doctoral degree can be obtained by candidates enrolled in doctoral studies without attending the courses and without passing exams if they have published papers that qualify them for a position of

Senior Scientific Associate in the field of technical sciences according to the relevant bylaws. The final decision is made by the Committee for Postgraduate University Doctoral Study.

3.14. Maximum duration of studies

The maximum duration of studies according to the Ordinance for full-time students is six year, and for part-time students eight years.

4. Conditions for realisation of study

4.1. Study programme locations

Postgraduate Doctoral Study of Civil Engineering for obtaining the doctoral degree in Civil Engineering is carried out for the most part at the Faculty of Civil Engineering, Architecture and Geodesy, University of Split, Matice hrvatske 15, 21000 Slit, and partly at other universities in the Republic of Croatia and in the world.

Regarding signed agreements of scientific and professional collaboration with other institutions, City of Split, County Split-Dalmatia, as well as regulated mobility of both students and teachers with other civil engineering faculties in Croatia, research and study programme can be performed at the venues defined in abovementioned agreement.

4.2. Data on space and equipment

The Faculty has 8615m^2 of useful space for lecture rooms, computer rooms, laboratories, library, conference room, teachers` offices and other auxiliary rooms. The mentioned place is located in Ulica Matice hrvatske 15 and in the building in Žrnovnica.

Available space covers: 1820m^2 of lecture rooms and computer rooms including two lecture theatres, one of 268m^2, the other 111m^2, laboratories of overall surface area 605m^2, phonetic laboratory of 73m^2, library of 248m^2, teachers` offices 1585m$^2$, students` rooms of 37m^2, computer centre 117m^2, buffet 56m^2, wardrobe, sanitary facilities, corridors and staircases, workshop and other rooms.

The Faculty has the following equipment at its disposal:

(1) Computer equipment:

- three computer rooms (C1, C2, C3)
- cluster (12 nodes, each node has 8-16 BG RAM, total of 100 processor cores, 4TB hard disk; we are currently obtaining a new part of the cluster with over 100 processor nodes: Head – Associate Professor Hrvoje Gotovac, PhD)
- Bonney Lab (numerical laboratory composed of several connected computers; Head - Prof. Ante Munjiza, PhD)

(2) Laboratory equipment:

- equipment for testing materials: vibro-table, laboratory mixer, hydraulic press, concrete mixer, multiple-purpose press, VB apparatus, quartering equipment, sieve shaker, aggregate mill;
- equipment for testing structures; convergence gauge, measuring equipment for velocity and direction of wind, platform for dynamic test, equipment for static test, gauges for measuring deformations, equipment for dynamic testing, chamber for testing fire conditions, equipment for testing fire conditions;
- geodesic equipment: geodesic instruments and tools (theodolite, levelling instruments, distance gauges, and others);
- equipment for geotechnical testing; gauge for testing uniaxial strength, triaxial device for testing strength, direct shearing device, device for testing rock wearing (ageing), device which determines spot strength of rock, electromechanically precise weighing machine (2 pieces), dryer (2 pieces), saw for stone and rocks, still, Casagrande's shakers, sieve vibrator, calcimetre, mixer for aerometering, vacuum pump, entire GPS system, geological hammers, geological compasses, Schmidts hammer;
- water and waste waters equipment; automatic meteorological station, devices measuring flow, water sampling devices, water temperature gauge, water quality gauge;
- devices used in environmental research, equipment for measuring the strength of sound and vibrations;
- equipment received from Croatian-Japanese project: LIDAR and spectrometer;
- .dynamic platform for testing structures under seismic load in Žrnovnica

The library at the Faculty is intended for students, teachers and associates for the execution of their educational research and professional tasks. The library contains available literature from many scientific fields on which this doctoral study is based and is also able to procure all new materials required for the doctoral candidate’s research.

4.3. Institutional management of the doctoral programme

In order to achieve better results, the postgraduate doctorate studies have been carried out in the scientific domains of civil engineering. These are: (1) Geotechnics, (2) Bearing Structures, (3) Hydrotechnics and (4) Transport. There is an open possibility to enrol into an interdisciplinary doctoral study at this Faculty by combining the courses from the field of civil engineering and the field of other fundamental technical sciences. Depending on the topic of dissertation, the candidates are grouped under the competence of one of the four mentioned branches of civil engineering.

Postgraduate doctorate studies are managed by the Committee for Postgraduate University Doctoral Study composed of five members. Its head is the vice-dean for science. The committee is appointed for the term of two years.

4.4. Contractual relations between students and the institution of the doctoral study

ECTS credits are obtained by regularly attending classes, fulfilling obligations required by the programme and by passing the exam in each particular course.

Research work is credited by ETSC credits during activities Research I, II and III. These activities include experimental research work in the laboratory and other teaching bases, and writing of seminar papers, papers, participating in conventions, workshops, round tables and conferences.

The requirements a candidate must meet in order to complete the doctoral study are defined by the Ordinance.

All compulsory and elective activities are regulated in the programmes of the courses. The candidate and the teacher mutually agree on the time and manner of their realisation.

4.5. Teachers

Courses/ activities	**Teachers:**
COMPULSORY RESEARCH ACTIVITIES FOR OBTAINING A DOCTORAL DEGREE IN CIVIL ENGINEERING	
Research I	Supervisor(s)
Research II	Supervisor(s)
Research III	Supervisor(s)
ELECTIVE COURSES IN THE FIELD OF CIVIL ENGINEERING, BRANCH OF BEARING STRUCTURES	
Meshless Numerical Methods and Corresponding Adaptive Techniques	Prof. Blaž Gotovac, PhD / Prof. Vedrana Kozulić, PhD
Numerical Modelling of Shell Structures	Prof. Vedrana Kozulić, PhD / Prof. Blaž Gotovac, PhD
Numerical Methods for the Mechanics of Materials	Prof. Pavao Marović, PhD / Prof. Mirela Galić, PhD
Experimental Methods	Prof. Pavao Marović, PhD / Prof. Mirela Galić, PhD
Selected chapters of Structural Dynamics and Earthquake Engineering	Prof. Ante Mihanović, PhD / Prof. Boris Trogrlić, PhD
Selected chapters of Structural Stability	Prof. Ante Mihanović, PhD / Prof. Boris Trogrlić, PhD
Finite Element Method	Prof. Željana Nikolić, PhD
Extreme Actions and Structure Safety/Stability	Prof. Bernardin Peroš, PhD / Prof. Ivica Boko, PhD / Assistant Prof. Neno Torić, PhD
Steel and Composite Structures	Prof. Bernardin Peroš, PhD / Prof. Ivica Boko, PhD / Assistant Prof. Neno Torić,

	PhD
Numerical Modelling of Concrete Structures	Prof. Jure Radnić, PhD
Design of Supporting Systems of Bridges and Structures	Prof. Jure Radnić, PhD
Mechanics of Discontinua	Prof. Ante Munjiza, PhD
Numerical Modelling of Water-Soil-Structure Dynamic Interaction	Prof. Jure Radnić, PhD
Selected chapters of Concrete and Masonry Structures	Prof. Alen Harapin, PhD / Prof.Jure Radnić, PhD
ELECTIVE COURSES IN THE FIELD OF CIVIL ENGINEERING, BRANCH OF HYDROTECHNICS	
Dispersion Processes in Water Resources	Prof. Roko Andričević, PhD / Prof. Hrvoje Gotovac, PhD
Theory of Risk Assessment in Environmental Engineering	Prof. Roko Andričević, PhD
Karst Water Resources	Prof. Ognjen Bonacci, PhD
Ecohydrology	Prof. Ognjen Bonacci, PhD
Hydrological Modelling in Karst	Assistant Prof. Vesna Denić-Jukić, PhD
Marine Hydraulics, special chapters	Assistant Prof. Nenad Leder, PhD
System Engineering in Water Resources Management	Prof. Jure Margeta, PhD
Coastal Processes	Prof. Jure Margeta, PhD
Selected chapters of Karst Hydrogeology	Prof. Ognjen Bonacci, PhD
Introduction to Engineering Numerical Modelling	Associate Prof. Hrvoje Gotovac, PhD
Analysis of Hydrological Time Series	Prof. Damir Jukić, PhD
ELECTIVE COURSES IN THE FIELD OF CIVIL ENGINEERING, BRANCH OF TRANSPORTATION	
Traffic Flow Theory	Prof. Dražen Cvitanić, PhD
Highways – selected chapters	Associate Prof. Deana Breški, PhD
Transport Planning	Prof. Dražen Cvitanić, PhD / Associate Prof. Deana Breški, PhD
ELECTIVE COURSES IN THE FIELD OF CIVIL ENGINEERING, BRANCH OF GEOTECHNICS	
Selected chapters of Rock Mechanics	Prof. Predrag Miščević, PhD
Soil Mechanics Models	Prof. Tanja Roje-Bonacci, PhD
Special chapters in Foundation Engineering	Prof. Tanja Roje-Bonacci, PhD
ELECTIVE COURSES IN THE FIELD OF OTHER FUNDAMENTAL TECHNICAL SCIENCES, BRANCH OF ORGANISATION OF WORK AND PRODUCTION	
System Engineering in Project Management	Prof. Snježana Knezić, PhD
Decision Support Systems	Prof. Nenad Mladineo, PhD / Assistant Prof. Nikša Jajac, PhD
System Theory	Prof. Snježana Knezić, PhD / Prof. Nenad Mladineo, PhD

ELECTIVE COURSE IN THE FIELD OF ARCHITECTURE AND URBAN PLANNING	
Highways and the Environment	Prof. Darovan Tušek, PhD
ELECTIVE COURSES IN THE AREA OF TECHNICAL SCIENCES	
Methodology and Techniques of Scientific Research	Prof. Pavao Marović, PhD / Prof. Mirela Galić, PhD
Information Engineering	Prof. Ante Munjiza, PhD
Engineering Simulations Techniques	Prof. Ante Munjiza, PhD
ELECTIVE COURSES IN THE FIELD OF NATURAL SCIENCES, BRANCH OF MATHEMATICS	
Applied Functional Analysis	Assistant Prof. Slavica Ivelić Bradanović, PhD
Practical Methods of Optimisation	Assistant Prof. Jelena Sedlar, PhD
Mathematical Analysis of Boundary Value Problems	Prof. Božo Vrdoljak, PhD
Integral Equations	Prof. Božo Vrdoljak, PhD
Methods of Mathematical Statistics	Prof. Božo Vrdoljak, PhD

4.6. List of sites (teaching, research and professional bases)

Teaching, research and professional bases depend on the dissertation topic, it is impossible to list them individually. Central basis is undoubtedly our Faculty and the University of Split with all its contents, the auxiliary bases are other faculties, universities, complex construction sites, institutes and laboratories in the country and abroad. The candidate will select the bases upon agreement with his/her supervisor which best suit his/her topic. Part of practical teaching will be performed by our teachers and associates in laboratories at the Faculty, and by qualified experts and professionals at dislocated bases and construction sites.

4.7. Optimum number of students

The optimum number of students is determined by the Committee for the Postgraduate University Doctoral Study based on the number of applications and available capacity.

4.8. Study programme cost estimate per student

The analysis of annual revenue received from the Ministry of Science, Education and Sport and our own funds gained by enrolment fees and other realised activities and by direct and indirect studying costs of the candidates at the doctoral study (teachers` and service personnel salaries, external associates` remuneration, purchase costs of laboratory and computer equipment needed for unobstructed teaching course, maintenance costs of accommodation spaces and equipment material costs, organisation costs of training in laboratories and field classes, costs of buying necessary literature and publishing) estimates that studying costs of one candidate are 40,000.00 HRK per year.

4.9. Funding of the doctoral programme

According to the Ordinance, the university postgraduate doctoral programme will be funded from several sources: (1) financial resources of MSES for junior researchers and scholarship holders in accordance with the rules and conditions of the contract; (1a) resources from CSF for funding doctoral students, which prescribes that the supervisors shall be appointed to said students with respect to the criteria of excellence and their projects (2) resources from our scientific and international projects, planned in advance; (3) own resources of the candidate; (4) resources of donations given by our and international associations and organisations; (5) resources of companies and institutions which send their employees to the study programme.

All candidates will have social and health care benefits and occupational safety will be provided to them in accordance with statutory regulations and the Ordinance on Occupational Safety. In the event of required education abroad, the candidates will be provided life insurance, and other kinds of insurance will be regulated by a contract with the respective institution.

4.10. Quality of the doctoral programme

Monitoring of quality and successful performance of the doctoral programme will be carried out at three levels: (1) University; (2) Faculty through the Committee on Teaching Quality Monitoring; (3) supervisor.

(1) The University will regulate performance monitoring at the doctoral study by a special ordinance.

(2) The Faculty will organise and carry out teaching quality monitoring through a Committee for Teaching Quality Monitoring composed of five members in three ways:
   (a) Students will put their written remarks and observations regarding the lecturing process and the problems referring to the programme realisation in a specially designated mailbox. These remarks will be collected and analysed by the Committee for Teaching Quality Monitoring, of which they will inform the Committee for Postgraduate University Doctoral Study and the Faculty Council;
   (b) The record will be made of performed lectures signed by course teacher and attending students;
   (c) Each academic year a survey will be carried out at the doctoral study in which the students will assess the manner of teaching performance for each course, compliance of literature with the course and literature availability, teachers` and associates` performance in each course and the time required for each student to fulfil his/her obligations (presence at lectures and exams, experimental work, seminars, learning for an exam) in order to control whether the expected number of ECTS credits for each subject corresponds with the time the student actually spends in that respect;
   d) Once a year the supervisor is obligated to write a report on the candidate`s progress and submit it for inspection to the Committee for Postgraduate Doctoral Study and the Faculty Council;
   e) Once a year the Committee for Postgraduate Doctoral Study organises a congress for doctoral candidates where they present their research work from the course Research I and II. The progress of each candidate is monitored at that congress.

(3) Each course teacher will independently organise and analyse successful performance of studying in his/her course.

Realisation of doctoral programme objectives in view of competences is analysed at the council meetings of each respective branch, then at the meeting of the Committee for Postgraduate Doctoral Study and finally at the Faculty Council. Supervisors play an extremely important role in all that, because they are every day in a direct contact with candidates and therefore they can best evaluate the development of each of them in achieving the competence.

Institutional mechanisms for the development of the doctoral programme are based on: (a) self-evaluation method which has been carried out by each teacher for his/her course during teaching and, especially, after its completion; (b) evaluation method carried out within a particular branch at the end of each semester, which is notified to the Committee for Postgraduate Doctoral Study as well as the Faculty Council. The mentioned evaluation methods analyse the results of surveys between the students of doctoral studies and their successful performance that gives the basis for the improvement of the programme quality. Besides, the obligation of the relevant managing officials of the postgraduate doctorate studies and the Faculty executives is to evaluate, at the end of each cycle of teaching (every four years), the successfulness of the doctoral programme and to update the programme if deemed necessary, taking into account all indicators of successfulness gained by monitoring the progress of the candidates.

5. Other notes

University programme of postgraduate doctoral study has been devised and described so as to enable **mobility** to each candidate in terms of collecting ECTS credits at other faculties in the country and abroad, and **flexibility** in forming the module, which will, by choosing the courses recommended by his/her supervisor, ensure the composition of high quality dissertation in one of scientific branches of civil engineering or interdisciplinary. Moreover, the candidate can transfer ECTS credits from this Faculty (minimum 90) and thus continue and complete his/her study, write and defend the dissertation at another faculty in the country and abroad. It should be pointed out that the programme is based on **collaboration** and inevitable **partnership with the business sector**.

The **goal** of this doctoral study is to train successful doctoral candidates who will be highly ranked at the market of labour and knowledge, as the fundamental prerogative for renewing existing resources, which implies their recognition in our country, the European Union and other parts of the world. To achieve this aim, the **institutional development strategy** of this Faculty is as follows:

- to create and realise the curriculum which will be recognised by its quality and yield professionally trained experts ready to actively participate in the development of the society of knowledge;
- to select the best young engineers as the renewable source of the domain of science, education and economy;
- to provide scientific networking within and outside of Croatia, especially in international scientific projects;
- to ensure prerequisites for long-life education, which implies mobility and innovation for organisation of work in applied and development projects in the economy.