UNIVERSITY OF SPLIT
FACULTY OF CIVIL ENGINEERING, ARCHITECTURE
AND GEODESY

SCIENTIFIC RESEARCH STRATEGY OF THE FACULTY OF CIVIL ENGINEERING, ARCHITECTURE AND GEODESY IN THE INTERDISCIPLINARY FIELD OF SCIENCE FOR THE PERIOD 2021-2025

Split, June 2021

Members of the Management Board of the Faculty of Civil Engineering, Architecture and Geodesy, current leaders of FCEAG Scientific Research and Art Projects and external stakeholders from the economy of the region and the Republic of Croatia, as well as local and regional self-government participated in this strategy.

The strategy was drafted during 2020 and 2021 and was adopted at the 9th regular session of the Faculty Council on 23 June 2021.

Contents

1. PURPOSE FOR THE ESTABLISHMENT AND ACTIVITIES OF THE INSTITUTION

History of the institution

The Faculty of Civil Engineering, Architecture and Geodesy in Split (hereinafter: FCEAG) is a higher education institution that commenced its operations in the fall of 1971 as the Department of Civil Engineering and part of the University of Zagreb. It started its autonomous work in 1977 and became an independent higher education and scientific research organization in July 1991 when it is separated from the Civil Engineering Institute.

In anticipation of the full development of the Dalmatian region, the need to establish study programmes in urban planning and architecture arose. The establishment of the study was initially made several times, but it was finally opened in 2003 on the initiative of the University of Split and the Faculty of Civil Engineering in Split. The founding cycle was completed in the academic year 2008/2009, and the first generation of enrolled students graduated.

In the academic year 2010/11, four decades after the initial idea and after several years of preparation, the Study of Geodesy and Geoinformatics was established with the assistance and support of the University of Split and the Faculty of Geodesy in Zagreb. Faculty was then renamed to its current title: Faculty of Civil Engineering, Architecture and Geodesy.

From the first day, FCEAG operated in its premises (buildings A and B) in 6,800 square meters of usable space for classrooms, cabinets, laboratories, library, council hall and computer rooms. A new building C was built and fully equipped, with a total area of 1,600 square meters.

The finalization of the capital project for the construction and equipping of new laboratory premises is underway (project “Implementation of Contemporary Scientific Research Infrastructure at FCEAG for Smart Specialization in Green and Energy Efficient Construction KK.01.1.1.02.0027'' worth HRK 84.513.801,36 – INFRA project). Generally speaking, the facilities are adequate for the Faculty operations and implementation of study programs.

The development of higher education in civil engineering in the Republic of Croatia so far shows that, along with the faculties of the University of Zagreb (Faculty of Civil Engineering, Faculty of Architecture and Faculty of Geodesy), the Faculty of Civil Engineering, Architecture and Geodesy in Split has developed strongly to its full maturity. Considering that Split is a Mediterranean and coastal city, current trends in engineering emphasize issues on the construction in karst areas and on the coastline. Great financial, organizational, and intellectual efforts are required to achieve sustainable development goals in a coastal environment. Civil engineering, architecture, urban planning, and cognate disciplines play a leading role in such endeavours and become more efficient when synthesised with other areas, skills, and fields of knowledge. This is why current scientific research topics at FCEAG are, as a rule, interdisciplinary and reflect the need to expand the activities of the institution into new research areas. The priority issues concern advancing the management of the existing built environment (specifically, infrastructure systems and built heritage), natural resources and environmental protection (specifically, water and sea management and protection), and sustainable construction in general.

FCEAG mission

FCEAG is a research and teaching constituent unit of the University of Split, with the mission of meeting society's needs in the areas of higher education, scientific, professional, and artistic activities, according to the Faculty Statute and the law. Within the scope of higher education activities, the Faculty organises and offers university-level and professional-level studies that are, in their quality, harmonised with the European higher education standards. Specifically, the learning outcomes attained after completing the study programmes reflect the societal needs and competencies required on the labour market or for the continuation of education. Learning outcomes are in harmony with the

Croatian Qualifications Framework (CROQF) and, therefore, harmonised with the European Qualifications Framework (EQF) of the Qualifications Framework for the European Higher Education Area (QF-EHEA). In defining the learning outcomes and objectives in harmony with CROQF, FCEAG always acts according to the professional requirements and internationally recognized standards within a specific profession (i.e., the qualification profile), thus ensuring the offered programs are up-to-date. For the specifically regulated profession of Architecture and Urban Planning, skills and knowledge to be attained through higher education are defined by the EU Directive on the recognition of professional qualifications. In the so-called 'notification' process carried out in 2016, the study programs in Architecture and Urban Planning were recognized to have reached a European-level quality.
The Faculty promotes scientific research in engineering sciences in fields related to civil engineering, architecture, geodesy, and geoinformatics in the broadest sense, with the aim of addressing all current issues in these fields. Contemporary societal challenges require interdisciplinarity to further develop and promote ongoing and future scientific research topics at FCEAG.
The Faculty continually strives to participate in internationally competitive European and other projects. In addition to cooperating with the largest companies in the region and the EU, FCEAG also collaborates with local authorities, thus promoting its fundamental role in society (scientific research projects in collaboration with industry stakeholders and similar). One of the general strategic objectives of the Faculty is to gain an international reputation for the quality of its work. For this reason, we encourage our students and teaching staff to become active members of the European and world scientific and teaching community. Therefore, international mobility and cooperation are among the highest priorities, as are the organization of graduate courses in English and the development of an international scientific journal published by the Faculty. Furthermore, the Faculty promotes and supports a continuous improvement of the doctoral studies to achieve greater internationalization of both studies and research (joint postgraduate study program).

Since the Faculty's primary role is to meet the current needs and goals of the society, one of the relevant strategic goals is the promotion of life-long learning in civil engineering, architecture, geodesy, and fundamental engineering sciences within the area of engineering sciences, as well as the field of project management within the interdisciplinary area of science, including all the combinations of previously mentioned civil engineering fields with other thematically cognate scientific fields and areas. Currently, the Faculty has three licensed lifelong learning programs that are subject to continuing modifications and adjustments in line with the present needs and applicable regulations. To achieve all the strategic objectives, the Faculty strives for continual and systematic advancement of all the operational areas: establishing, organization and management of study programs, increasing efficiency in the educational and scientific research process, linking educational, scientific research and professional activities, as well as capacity building and improving internal organization in accordance with ESG standards.

FCEAG vision

The Faculty will achieve recognition for its high standards in scientific, research, educational, and artistic activities and the resulting effects on society's technological and cultural development. The Faculty's status as scientific and research institution is reflected in activities focused on accomplishing mandatory, general and specific objectives of the FCEAG Science and Arts Research Projects (11 Faculty projects) that will achieve international reputation in their respective research areas.
The Faculty will become the leading promoter of collaborative research at the regional and national level, involving the industry, the academic community, and state administrative bodies and institutions. Supported by newly equipped laboratories, the Faculty's teaching staff, researchers, and students shall aim for international recognition within their specific research disciplines, collaboration with other research institutions, and publishing original research. As a result of the INFRA project that enabled modern laboratories equipped with cutting-edge technology, students will be more efficiently

included in teaching and research. Access to the European and world research area will also be facilitated for scientists and researchers. In addition, researchers will gain a competitive advantage among their international colleagues and be more easily hired on demanding projects. At the same time, industry partners, within Croatia and beyond, will be able to conduct targeted and applied research, develop new products, models and services, and test their innovative concepts and technology transfer capabilities.

Increased mobility of teachers and students will contribute to the acquisition of new experiences in education and scientific research, the creation of highly qualified staff for teaching, scientific and artistic activity, allowing adaptability to the labour market requirements within the European Union. The scientific research potential of FCEAG will be adaptable to its increasingly dynamic environment and offer the possibility of modifications and introduction of new high-quality study programs and interdisciplinary studies (and research) pertinent to regional and national development.

In the light of the contemporary, 21st-century approaches to education that interpret knowledge through the lens of the research-education-innovation triangle, FCEAG is committed to contributing to the development of all aspects of the knowledge triangle and supporting the partnership between research and business communities to meet the current societal challenges. To maintain the continuity of the abovementioned, in this preparation period, it is necessary to integrate more comprehensively into the European funding schemes (societal challenges) and the national ones (specific strategic goals and/or priority thematic areas and subareas). This implies the development of new scientific research topics at FCEAG in the interdisciplinary field of science (IFS).

The means of achieving this objective, in terms of organizational development and the selection of scientific research topics is described in Chapters 5 and 6. With such a defined vision, FCEAG has established a flexible organizational structure adapted to the needs of the European and national funding schemes, so that interdisciplinary research topics addressed so far within specific departments can be easily grouped into larger multidisciplinary research teams (also including members from outside the Faculty) that collaborate on single Science and Arts Research Project (SARP). In this way, it is possible to respond quickly to the increasingly demanding organizational challenges of the European and national research area by grouping more researchers from different fields of science into specific project teams.

FCEAG activities

Scientific and research activities have been one of the basic drivers of the Faculty's development since its inception. The current track record places FCEAG among the leading engineering sciences faculties in Croatia and the region. To maintain an already successful approach but simultaneously adapt to modern research management trends, the Faculty’s nucleus for developing contemporary, interdisciplinary research was formally established in 2011. Specifically, this was the year when the Faculty conferred the first academic title in an interdisciplinary field of science, which was a direct consequence of having recognized the need to strengthen research in engineering sciences with knowledge and skills of social sciences, to broaden the selection of research topics, and reorganize research process. Specifically, having acknowledged contemporary research trends, FCEAG formed a matrix organizational structure, i.e., a project-oriented scientific research organization within a traditionally functioning organizational system that is more suitable for other activities. Since research directly affects professional work and activities in the industry, this research-industry nexus resulted not only in the stimulation of scientific research but also in the design and construction of many significant buildings and projects, which is why FCEAG remains a foundation of professional and scientific excellence.

In addition to scientific research, higher education and lifelong learning programmes organised through professional development courses, FCEAG offers professional engineering services, such as study preparation, expert studies, design supervision studies, preliminary designs, complex structural designs, construction site and design supervision, laboratory and field structural testing, and expert consulting.

2. ANALYSIS OF THE FACULTY'S SCIENTIFIC POTENTIAL AND ITS POSITION IN THE SCIENTIFIC AND BUSINESS ENVIRONMENT

Tables 2.1 and 2.2 present an analysis of the scientific potential of FCEAG in terms of published papers in different scientific fields and completed, active and currently submitted scientific research projects related to different funding sources, such as the Croatian Science Foundation and various operational programmes for EU funding.

Analysis of published papers by field of science in the last five years

Basic fields of science	Number of relevant publications in the last 5 years	Relevance of FCEAG in databases (WOS/Scopus); Citation metrics (number of citations/self-citations)	Assessment of potential
Engineering sciences	A = 211 B = 6 (duplicates excluded) C = 283 Total = 500	WoS - total of 235 papers (957 citations / 213 self-citations) Scopus - total of 259 papers (1133 citations/ 361 self-citations)	The field is well represented (a large number of publications and citations) with a large number of researchers employed at the institution
Natural sciences	A = 28 B = 3 (duplicates excluded) C = 16 Total = 47	WoS - total of 28 papers (89 citations / 9 self-citations) Scopus - total of 28 papers (91 citations / 37 self-citations)	The field is well represented (medium number of publications and citations) with a smaller number of researchers employed at the institution**
Interdisciplinary field of science	A = 17 B = 0 (duplicates excluded) C = 14 Total = 31	WoS – total of 15 papers (55 citations / 25 self-citations) Scopus - total of 14 papers (55 citations / 28 self-citations)	The field is well represented (medium number of publications and citations) with a smaller number of researchers employed at the institution***
All fields of science in total	A = 254 B = 9 (duplicates excluded) C = 312 Total = 575	WoS - total of 278 papers (1101 citations)/247 self-citations) Scopus - total of 301 papers (1279 citations / 426 self-citations)	The number of papers and citations indicates the significant scientific and research potential of the institution.

* According to the Regulations on requirements for the election to scientific titles (Official Gazette, No. 28/2017):
A = scientific papers published in journals indexed in WoSCC (Web of Science Core Collection)
B = scientific papers published in journals indexed in other bibliographic databases
C = scientific papers published and presented at international conferences/posters

** There is an increase in published scientific papers in categories A, B and C compared to data from the period 2012-2017 for this field of science (A = 29, B = 3, C = 0, Total = 32)
***There is a significant increase in published scientific papers in categories A, B and C compared to data from the period 2012-2017 for this field of science (A = 4, B = 0, C = 6, Total = 10)

The analysis of published papers shows a significant increase in published scientific papers in the last five years in categories A, B and C (the field of natural sciences and interdisciplinary field of science) compared to the previous period 2012-2017, which indicates the growth of scientific and research potential of FCEAG in the specified fields and is a clear indicator of the continuous development of interdisciplinary scientific and research capacities of the institution.

Analysis of completed/active/submitted scientific research projects in the last five years

Type of project/number of projects	Project areas	The role of FCEAG	Assessment of potential and recognition
Croatian Science Foundation **8 projects**: 4 completed and 4 in progress	Roman Water Systems of City of Salona and Diocletian's Palace and Their Impact on Urban Sustainability (completed) Groundwater flow modelling in karst aquifers (completed) Influence of creep strain on the load capacity of steel and aluminium columns exposed to fire (completed) Development of numerical models for reinforced-concrete and stone masonry structures under seismic loading based on discrete cracks (completed) Seismic base isolation of a building by using natural materials - shake table testing and numerical modelling (in progress) Experimental and numerical investigations of mechanisms in unsaturated geomaterials (in progress) Parameter estimation framework for fracture propagation problems under extreme mechanical loads (approved in 2020, in progress)	FCEAG project developer	Scientific papers (**20** published papers) in the journals in the first two quartiles. International cooperation was established with universities in Sheffield, Skopje, Penn State, Lisbon, Kiel, Oak Ridge National Laboratory, and others.

	Multi-physics modelling of surface and subsurface waters (approved in 2020, in progress)		
ERDF "Competitiveness and Cohesion 2014-2020" Operational Programme projects **7 projects**: 7 projects in progress	CAAT - Development of technology for assessment of autopurification capabilities of coastal waters (in progress)	FCEAG project developer	Interdisciplinary project in the field of oceanographic and atmospheric modelling and physical process modelling related to the flow and transport of surface and groundwater runoff to Adriatic coastal waters
	STIM-REI (in progress)	FCEAG project partner	Project of the Centre of Excellence for Science and Technology Integration of Mediterranean Region (STIM), connects research (R), innovation (I) and education (E) in interdisciplinary research encompassing water and the environment
	COMMON (approved in 2020, in progress)	FCEAG project partner	Project COMON (COastal MONitoring) aims to apply innovative solutions for continuous coastal ecosystem monitoring as a foundation for their integral management. The Croatian part of the Adriatic Sea, due to its coastal length and a large number of islands, faces significant anthropogenic pressures, which are the result of economic growth and the increasingly more pronounced influence of climate change.

	Increasing the development of new products in the timber industry used in civil engineering (approved in 2020)	FCEAG project partner	The project aims to investigate the potential of hardwoods harvested in Croatian forests for the production of glued laminated timber (glulam). Although until recently the production of glulam implied the use of softwoods, the unexploited potential of increased share of hardwoods in European forests resulted in more intensive research of its use as material for the production of glulam during the last decade. The goal of the project is to provide an overview of the hardwoods currently represented in Croatia and to summarise the foreign studies published so far on the use of these types of wood in the production of glulam. An overview of the current state of knowledge will enable glulam producers in Croatia to obtain the best possible insight into the suitable types of wood, as well as the technological aspects of their application.
	Development of drainage systems on horizontal surfaces made of permeable concrete (approved in 2020, in progress)	FCEAG project partner	The planned project output is development of an innovative drainage system on horizontal surfaces made of permeable concrete, such as large parking lots. The

			research is focused on the development of a prototype drainage system under laboratory conditions using a specially designed precipitation system and measurement equipment from the INFRA project. The prototype is to be applied in a large test parking lot to demonstrate the effectiveness of the drainage system under real conditions.
	VODIME - Waters of the Imotski region Improving monitoring, forecasting and planning of climate change adaptation measures (approved in 2020, in progress)	FCEAG project developer	The VODIME project aims to strengthen the resilience to climate change of vulnerable sectors of water resource management, agriculture, energy, and tourism in a specific area of the Imotski region. Smart decision support system in the management of Imotski field in adapting to climate change will be developed based on research results, as well as Integral Study for the Management of the Imotski Field, consequently leading to strengthening resistance to climate change and greater functionality and economic progress of the Imotski Region.

	PINNA NOBILIS SSMA-19 (approved in 2020, in progress)	FCEAG project partner	The project is focused on applied industrial research of products in the nautical industry - anchors for soft seafloors and the transition zone between soft and hard seafloors.
ERDF "Competitiveness and Cohesion 2014-2020" Operational Programme projects **1 project**: 1 project in progress	INFRA – Infrastructure project for construction and equipment of 11 Faculty laboratories "Implementation of Contemporary Research Infrastructure at FCEAG for Smart Specialization in Green and Energy Efficient Construction" (in progress)	FCEAG project developer	Planned project completion by Q3 2021. Significant increase in recognition of FCEAG and improvement of research opportunities and networking at all levels.
ESF (period 2014-2020) **1 project**: 1 project completed	CPORT – Risk assessment of the pollution caused by rivers and discharges in coastal areas (completed)	FCEAG project developer	Cooperation established with MARETEC Institute, Lisbon.
ERDF INTERREG projects (period 2014-2020) **6 projects** – 6 projects in progress	AdSWiM - Managed use of treated urban wastewater for the quality of the Adriatic Sea	FCEAG project partner	The project promotes transboundary integrated management of water resources to restore nutrient balance, which influences the food chain.
	DEEP-SEA – Development of energy efficiency planning and services for the mobility of Adriatic marinas	FCEAG project partner	The goal of the project is resolving the issue of predominant single-modality land transport (cars), highly polluting maritime transport (motor boats with endothermic engines) and limited integration of mobility services offered in the mentioned sector.

	E-CITIJENS - Civil protection emergency decision support system (DSS) based on citizen journalism to enhance safety of Adriatic Basin	FCEAG project partner	The project aims to increase the safety of the Croatian and Italian Adriatic basin from natural and man-made disasters by improving emergency prevention and management measures and instruments.
	MoST - Monitoring seawater intrusion in coastal aquifers and testing pilot projects for its mitigation	FCEAG project partner	The aim of the project is to achieve a better understanding of the physical processes driving continental-marine water exchanges and to define suitable countermeasures that limit the occurrence of saltwater contamination.
	NET4mPLASTIC - New technologies for macro and microplastic detection and analysis in the Adriatic Basin	FCEAG project partner	The project involves the development of cooperation between Italian and Croatian research organizations, small and medium enterprises, and local authorities in Italy and Croatia to address the common challenge of plastics and microplastics in the Adriatic Sea.
	PMO-GATE - Preventing, managing and overcoming natural-hazards risks to mitigate economic and social impact	FCEAG project partner	The goal of the project is creating synergy between local authorities, research institutes, schools and universities, and citizens, in order to evaluate and manage multihazard risks typical of included regions.

	Plastic Busters MPA: Preserving biodiversity from plastics in Mediterranean Marine Protected Areas	FCEAG project partner	The project provides a comprehensive, multifaceted, and coordinated approach to combat marine litter in Mediterranean coastal and marine protected areas towards healthy marine ecosystems.

Based on the overview of completed/active/submitted projects, it is evident that the significant number of active interdisciplinary research projects carried out at FCEAG indicates the quality of the scientific research capacity of FCEAG in the interdisciplinary field of science, especially in combining engineering sciences (civil engineering, architecture, geodesy and fundamental engineering sciences), natural sciences (mathematics, biology and chemistry) and project management as an interdisciplinary field.

SWOT analysis of scientific research activities in the interdisciplinary field of science

Strengths

- Increase in the number of applications for and implementation of interdisciplinary-oriented scientific projects during the previous five-year period, with participation of scientific and teaching staff in the fields of civil engineering, architecture and geodesy
- Increase in the number of published papers in the interdisciplinary field of science in journals indexed in the WoS database compared to the period 2012-2017
- General increase in the number of published scientific papers in all fields of science within the scientific domain of FCEAG in the last five years
- The possibility of using new scientific equipment obtained as part of the financing of the FCEAG infrastructure project: INFRA in interdisciplinary research
- Dedication to and encouragement of interdisciplinarity at the Faculty by appointing research titles and/or initiating selection procedures, that is, by focusing doctoral research at obtaining doctoral degrees and research titles in the interdisciplinary field of science by at least 4 Faculty employees.

Weaknesses

- Lack of experience of active FCEAG research staff in finding partners to create consortia for project applications within the current EU framework programme
- A part of research active staff carries a maximum teaching workload in some undergraduate and graduate study programs
- A relatively small number of students enrolled in the Civil Engineering doctoral study program

- A relatively small number of laboratory personnel employed to conduct interdisciplinary research

Opportunities

- Utilising the full potential of the new scientific research infrastructure implemented through the FCEAG infrastructure project: INFRA in interdisciplinary research
- Use of the University's SEA-EU initiative through international cooperation and/or application of collaborative international projects
- Currently active collaborative research with other research groups in European Union countries
- Application of FCEAG interdisciplinary research to solve current economic problems in the Republic of Croatia and the Split-Dalmatia County

Threats

- Doctors of science leaving the sector, due to a lack of available jobs and relatively low salaries in the scientific research sector
- In the context of an underdeveloped Croatian economy, there is a lack of recognition and exploitation of knowledge and competencies of recent PhD graduates in the interdisciplinary field of science
- Relatively high costs of laboratory research

3. STRATEGIC GOALS OF THE FACULTY

FCEAG has adopted and is currently implementing the strategic goals defined in the Strategy of the Faculty of Civil Engineering, Architecture and Geodesy for the period 2018-2022 (hereinafter: Strategy 2018-2022), which was adopted for the purpose of planning the development of scientific research activities and the development of teaching and professional activities at the Faculty for the specified period. The strategy also refers to the promotion/development of scientific research in the interdisciplinary field of science in the following strategic goals, subgoals and activities:

Strategic goals	Subgoals	Activities
Students and teaching work: Improving the compatibility of teaching programs with European programs. Constantly improving the current programs and introducing new programs recognizable and attractive to students at the undergraduate, graduate and postgraduate levels with clearly defined learning outcomes, aligned with	Improving the compatibility of teaching programs with European programs. Constantly improving the current programs and introducing new programs recognizable and attractive to students at the undergraduate, graduate and postgraduate levels	Development of popular interdisciplinary study programs at graduate studies ***Development of a doctoral study in an interdisciplinary field of science founded on a**

the long-term demands of the community, the economy and the development of society.	***Development of postgraduate doctoral studies in Civil Engineering**	**combination of existing scientific research at FCEAG (engineering, social, natural sciences)**
Scientific research activity and international recognition: Increasing recognition in the European Research Area by conducting scientific research with the aim of contributing to the development of the region, the Republic of Croatia and the EU.	Identifying and increasing research and innovation capacities at FCEAG	Increasing research capacities of FCEAG with a special focus on interdisciplinary research, development and correlation between experimental and computational research, innovation, knowledge transfer and cooperation with the industry
Scientific research activity and international recognition: FCEAG develops and encourages interdisciplinary research	Developing interdisciplinary research at FCEAG Applying for funding of joint interdisciplinary research projects with other national and international research institutions and business enterprises	Developing interdisciplinary research by networking between departments, establishing new and creating new research groups and topics Applying for EU and national funding with competitive interdisciplinary research projects developed with current and new partners Developing new scientific findings and practical applications based on interdisciplinary research
Community engagement: Continuous development of community engagement and contribution to the advancement of the society and the economy	Developing interdisciplinary cooperation of researchers with other scientific research institutions and business enterprises with the aim of joint provision of services	Applying for interdisciplinary projects with participation of researchers from other national and international scientific research institutions and business enterprises

* Additional subgoal and activity defined within the framework of this strategy

Strategy 2018-2022 presented the need to systematically develop an interdisciplinary research framework at FCEAG, developed in the presented strategic goals, subgoals and corresponding activities. The need to develop an interdisciplinary research framework is apparent in all three areas of FCEAG activities – teaching, science and professional work.
Within the framework of this scientific research strategy in the interdisciplinary field of science, the stated strategic goals of the Faculty are therefore adopted also for the period 2021-2025, in the section referring to the development of scientific research in the interdisciplinary field.

4. REPRESENTATION OF THE INTERDISCIPLINARY FIELD OF SCIENCE AT THE INSTITUTION

Scientific Research (hereinafter: SR) topics that have been implemented at FCEAG so far are to a greater or lesser extent related to areas cognate to civil engineering in the broader field of engineering sciences, such as geodesy, architecture and urbanism, fundamental engineering sciences, mechanical engineering, and computer science. One part of SR topics also covers other areas of science (natural, social, and interdisciplinary) or their respective fields. This particularly concerns SR topics in research fields belonging to the natural sciences. The most represented field is mathematics, followed by geophysics, geology, interdisciplinary natural sciences, and chemistry. Furthermore, the field of economics represents the link with the social sciences, whereas the scientific field of history is the link with the humanities. The interdisciplinary field of science is predominantly represented by SR topics in the field of project management. The table below presents examples of previous SR topics implemented as part of the FCEAG scientific activities, that is, topics related to other fields besides civil engineering and fundamental engineering sciences.

Scientific field	Scientific research topic
Geodesy	Obstacle analysis in the surroundings of Split Airport using 3D GIS.
Architecture and Urban Planning	Analysis of historical data of the Roman water supply system for the purpose of its restoration and utilisation for the city of Split water supply.
Mechanical Engineering	Study of the impact of creep strain on the load capacity of steel and aluminium columns exposed to high temperatures.
Computer Science	Numerical simulation of reinforced concrete structures under the influence of impact load.
Mathematics	Application of mathematical modelling in the assessment of the state of historical bridges.
Geophysics	Testing of the seismic resistance of a nonlinear model of spatial structures.
Geology	Measuring the durability and shear strength of soft rocks due to weathering.
Interdisciplinary Natural Sciences	Investigating the impact of the circular economy on waste and wastewater management.
Chemistry	Measurement of pollution concentration in river estuaries.
Economics	Modeling of the project management system for the reconstruction and maintenance of urban roads.
Project Management	Modelling of decision support systems in the management of urban infrastructure systems.
Fundamental Engineering Sciences	Decision support system in the planning of the renovation of historic road bridges.
History	Research of the historical and spatial development of fortifications and the coast of the town of Kaštela.

5. SUBJECT OF ELABORATION

The commitment of FCEAG to conducting scientific research in the interdisciplinary field of science was presented in Chapter 3 Strategic goals of the Faculty. This elaboration of the existing Faculty Development Strategy for the period 2018-2022, which also represents the strategy for the development of research and scientific work in the interdisciplinary field of science for the following five-year period, forms the basis for defining scientific research work in the interdisciplinary field of science within the future FCEAG development strategy for 2023-2028. Research topics in the interdisciplinary field of science are planned to be carried out through the organisational units of FCEAG, that is, Science and Arts Research Logical Units (hereinafter: SARLU), whereas the research focus is defined by FCEAG Science and Arts Research Projects (hereinafter: SAR projects), summarised in Chapter 7. The table in Chapter 6 presents 16 research topics in the interdisciplinary field of science planned for research at FCEAG, elaborated in detail and including the following elements: summary, list of objectives, expected number of researchers, cooperation with external research institutions.
The listed research topics are of great importance for the introduction of interdisciplinarity in all institutional activities, according to the current strategic goals of FCEAG set out in Chapter 3.

6. RESEARCH TOPICS IN THE INTERDISCIPLINARY FIELD OF SCIENCE

Topic 1:
Urban renewal planning (land consolidation) – Modelling decision support systems in construction management

Interdisciplinary topic involves the following fields of science:
Interdisciplinary field of science, area of Project Management and contributory fields:

1. Engineering Sciences, areas of Civil Engineering and/or Fundamental Engineering Sciences
2. Social Sciences, area of Economics
3. Engineering Sciences, area of Geodesy

Research topic summary:
Urban renewal planning (land consolidation): The expected outcome of the research is scientific contribution in the interdisciplinary field of science, area of Project Management and a combination of contributing fields: Engineering Sciences, areas of Civil Engineering and/or Fundamental Engineering Sciences, and Geodesy; and Social Sciences, area of Economics. The research is focused on the design of a support system for urban land consolidation planning, specifically the part related to integral and inclusive planning and the design of models for establishing priorities in the process of acquiring properties and building construction. The purpose of this process is to align with the goals of large construction projects for which land consolidation is carried out, considering the limited resources available.

1.1. Planning support in the implementation of urban renewal (land consolidation) with a focus on supporting the planning of the allocation process: The research can be considered as a subtopic of the previous research topic, or as an independent topic. The expected outcome of the research is scientific contribution in the interdisciplinary field of science, with a combination of contributing fields: Engineering Sciences, areas of Civil Engineering and Geodesy; and Social Sciences, area of Economics. Within the defined broader area of scientific contribution, the research will focus on systematic decision support for strategic, tactical, and operational planning of urban renewal (land consolidation) with a special focus on the allocation process and related real property appraisal (determining real property in the context of urban renewal). The approach is based on integral and inclusive principles of planning and decision-making in management, considering all stakeholders (local authorities carrying out land consolidation, engineers, (co-)owners, property appraisers) and aspects of the issue.

Key concepts in previous research:
Decision Support System, Decision Support Concept, multi-criteria methods (PROMETHEE, AHP, SAW), Expert System, Artificial Neural Networks (ANN), Fuzzy Logic, management (planning, organisation, staffing, supervision and control), urban renewal (land consolidation), urban infrastructure, urban road infrastructure, monitoring, energy efficiency, real property appraisal, allocation

Research objectives:

General objectives:
New and original scientific contributions and advancement of existing scientific knowledge in the described research topics through interdisciplinary research combining the specific fields of science and resulting in new scientific knowledge. Establishing new (combined) areas of research within the interdisciplinary field of science.
Design useful methodologies and corresponding systems and concepts for practical application in construction industry (Civil Engineering and/or Fundamental Engineering Sciences and Geodesy) and the economy, by enhancing the quality of management and related planning, decision-making, etc.

Establishing research groups for interdisciplinary research at the Faculty, based on the described research. Establishing cooperation with other research groups with special emphasis on achieving internationalisation of scientific research work of the Faculty.

Specific objectives: Designing the architecture of DSS (Decision Support System) or DSC (Decision Support Concept for Urban Renewal Planning). Designing the structure and contents of the database relevant for use in models in the form of a GIS database. Designing the hierarchical structure of objectives as a model for ensuring consistency of decision-making. Designing data collection and monitoring models. Designing models for property appraisal and allocation in a dynamic environment. Designing models for the priority ranking of property acquisitions in accordance with the strategic objectives of the projects for which the consolidation is carried out.

Research is planned in the following laboratory/laboratories:

- GIS laboratory (SAR project – Geographic information systems and decision-support modelling in construction)

Human resources:
Approx. 7 teachers (4 FCEAG), 1 associate (FCEAG), 1 doctoral student (FCEAG)

External cooperation:

- Faculty of Civil Engineering in Rijeka
- Faculty of Civil Engineering in Zagreb
- Wroclaw University of Science and Technology

Topic 2:
Support to the management of energy renovation of buildings – Modelling decision support systems in construction management

Interdisciplinary topic involves the following fields of science:
Interdisciplinary field of science, area of Project Management and contributory fields:

1. Engineering Sciences, areas of Civil Engineering and/or Fundamental Engineering Sciences
2. Social Sciences, area of Economics
3. Engineering Sciences, area of Geodesy

Research topic summary:
Supporting the management of energy renovation of buildings in a sustainable manner – a concept to support the integral planning (CSIP) of energy renovation of buildings (EnRB): The expected outcome of the research is scientific contribution in the interdisciplinary field of science, area of Project Management and a combination of contributing fields: Engineering Sciences, areas of Civil Engineering and/or Fundamental Engineering Sciences, and Geodesy; and Social Sciences, area of Economics. Within the previously defined broader area of scientific contribution, the research will focus on systematic support to the energy efficiency management of multi-apartment buildings, considered collectively. The manager focuses the energy efficiency measures with the aim of attaining maximum results, both in individual buildings and the group, or subgroup of buildings managed. The approach is based on integral and inclusive principles of planning and decision-making in management, considering all the stakeholders (competent bodies, managers, (co-)owners, engineers, contractors) and all aspects of the problem (engineering: construction physics, building stability, and certification for use; economic: models and financing options; social: benefits for the co-owners and the local community; environmental: conformity with standards and improvements for future utilisation).
In more detail: CSIP design is based on defined determinants of the EnRB integral planning process, namely stakeholders, data-information and the course of the planning process. Stakeholders – project managers/decision makers, building users/owners, EnRB experts and EnRB contractors. EnRB is planned on the basis of diverse data related to EnRB (and individual buildings), including

engineering, economic, social, and environmental data, expressed in many different measurement units, measurement systems and rules.
A large number of stakeholders and the diversity of data in planning processes at different levels also influence the levels of importance of the information obtained (from these data) for different stakeholders, as well as the manner and rules of the decision-making process. Consequently, the planning problem is determined to be complex, poorly structured, and multi-criterial. The course of the planning process is dependent on and divided by levels of management decision-making, into operational, tactical, and strategic planning.
Each management level and related planning decision is specific and requires a specific way of decision support. Operational level involves the planning of data collection – monitoring. Tactical level creates input to strategic planning based on information from the operational level or is involved in the planning of energy renovation of an individual unit (one building). Strategic level plans the renovation of the entire group of buildings by defining priorities, considering the constraints – time, scope, available resources, stakeholder attitudes, etc. The planning processes should be supported by designed models using appropriate, properly organised data (database, DB). Individual models should be adaptable to changing environments, and mutually compatible and complementary. The synergistic effect of the clustered models (model base, MB) presents the expected and designed functionality of the concept to support integral planning (CSIP).
Due to the extreme complexity and unstructured nature of the respective planning processes and decisions, the concept will be designed according to the principles and logic of the MCA, DSS. The CSIP EnRB architecture will consist of three modules: database, model base, interface. Each module will contain multiple elements with an expression of functionality and inter-functional connectivity. The functional integration of the relevant elements from DB (raw and/or processed data) with the elements from MB (models for supporting planning processes) in a precisely determined order enables support to individual stages and the entire process of EnRB integral planning. The result of data processing using newly created models represents the basis for decision-making. Using this base, decision makers/project managers can increase the quality of decision making and the quality of EnRB management. It is recommended to establish a database based on GIS technology, since most of the data used are spatial data (spatial layout of buildings and layout data). Individual models need to be programmed, including user-friendly interfaces with options for model and data results visualisation. All models should be integrated into a single concept – a computer application. The specifics of the model are listed by planning levels.

<u>Planning the design of new facades or renovation of existing facades in order to achieve an energy-sustainable building at a long-term acceptable level:</u> The research can be considered as a subtopic of the previous research topic, or as an independent topic. The expected outcome of the research is scientific contribution in the interdisciplinary field of science, with a combination of contributing fields: Engineering Sciences, area of Civil Engineering, and Social Sciences, area of Economics. Research aims at establishing a methodology to support engineers in the preparation of project concept designs and/or master designs.

Key concepts in previous research:
Decision Support System, Decision Support Concept, multi-criteria methods (PROMETHEE, AHP, SAW), Expert System, Artificial Neural Networks (ANN), Fuzzy Logic, management (planning, organisation, staffing, supervision and control), monitoring, energy efficiency, energy renovation, GIS, building physics, multi-apartment buildings

Research objectives:

<u>General objectives:</u>
New and original scientific contributions and advancement of existing scientific knowledge in the described research topics through interdisciplinary research combining the specific fields of science

and resulting in new scientific knowledge. Establishing new (combined) areas of research within the interdisciplinary field of science.
Design useful methodologies and corresponding systems and concepts for practical application in construction industry (Civil Engineering and/or Fundamental Engineering Sciences and Geodesy) and the economy, by enhancing the quality of management and related planning, decision-making, etc.
Establishing research groups for interdisciplinary research at the Faculty, based on the described research. Establishing cooperation with other research groups with special emphasis on achieving internationalisation of scientific research work of the Faculty.

Specific objectives: Design CSIP EnRB and its architecture with all associated bases and models outlined above, as support of all levels of planning.
Operational planning level: Data collection model (DCM) can be developed as a mobile computer application for collecting image information and georeferencing buildings and other relevant collected data during the implementation of monitoring, and their easy transfer to the DB CSIP computer application concept. The computer application should have a functionality that allows setting up and following the implementation of the monitoring plan.
Tactical planning level: The model for determining the importance of criteria – evaluation of different aspects of energy renovation planning of individual buildings (MhscEnRU) should be an integral part of the model for determining the importance of criteria – evaluation of various aspects of integral planning EnRB (MhscEnRB), in order to ensure consistency of decision-making in planning across all levels. The MhscEnRB Model should be programmed as a functionality of the computer application, allowing relevant stakeholders to be included in the evaluation process (individually and collectively), to obtain their individual evaluation results and a collective result/ result of a compromise. The models are based on the logic of the hierarchical structure of the objectives and criteria in the form of an objective tree, considering relevant determinants/criteria of EnRB integral planning, both for clusters and individual buildings.
Approach and design/ implementation technology planning model for energy renovation of individual buildings (MEnRU) should be implemented as a functionality of the CSIP concept computer application based on the logic of multi-criteria decision support methods, functionally linked to the database BP and MhscEnRU.
Strategic planning level: Energy renovation integrated planning model (MEnRB) should be implemented as a functionality of the CSIP concept computer application based on the logic of multi-criteria decision support methods, functionally linked to the database and MhscEnRB. The MEnRB model provides ranking of the buildings in the cluster according to the energy renovation priority, based on which ranking the EnRB plan is prepared.

Research is planned in the following laboratory/laboratories:

- GIS laboratory (SAR project – Geographic information systems and decision-support modelling in construction)

Human resources:
Approx. 6 teachers (2 FCEAG), 1 associate (FCEAG), 1 doctoral student (FCEAG)

External cooperation:

- Faculty of Civil Engineering in Rijeka
- Faculty of Civil Engineering in Zagreb

Topic 3:
Management of the renovation of historical buildings – Modelling decision support systems in construction management

Interdisciplinary topic involves the following fields of science:
Interdisciplinary field of science, area of Project Management and contributory fields:

1. Engineering Sciences, areas of Civil Engineering and/or Fundamental Engineering Sciences
2. Social Sciences, area of Economics
3. Engineering Sciences, area of Architecture and Urban Planning

Research topic summary:

Management of the renovation of historical buildings: The expected outcome of the research is scientific contribution in the interdisciplinary field of science, area of Project Management and a combination of contributing fields: Engineering Sciences, areas of Civil Engineering and/or Fundamental Engineering Sciences, and Architecture and Urban Planning; and Social Sciences, area of Economics. The focus of this research is planning and related decision-making concerning the renovation of historical buildings. The research covers both individual buildings and clusters of buildings managed by one institution, by establishing a single decision support system in the management of the renovation of historical buildings. The proposed methodology for selecting renovation technology analyses the possibilities of combining modern techniques and materials with traditional ones, in different ratios, considering relevant and different aspects and stakeholders of this complex, poorly structured problem. Additionally, research investigates a specific integral method to assess the 'as is' state of structures. Methodologies with concrete comparable results and structure status index serve to determine the starting point and comparable measurability of the results. It is important to analyse expert assessments of the state of structures, as the most important integrative tool in combination with non-destructive methods of measuring individual relevant properties. For this purpose, an expert system based on multicriterial methods and “fuzzy logic” will be developed. In addition, a methodology will be developed to predict the behaviour of specific structure elements, in terms of their deterioration/decay under external influences by using an expert system based on artificial neural networks.

Key concepts in previous research:

Decision Support System, Decision Support Concept, multi-criteria methods (PROMETHEE, AHP, SAW), Expert System, Artificial Neural Networks (ANN), Fuzzy Logic, management, architectural heritage, monitoring, external influences, historical structure status index, deterioration

Research objectives:

General objectives:

New and original scientific contributions and advancement of existing scientific knowledge in the described research topics through interdisciplinary research combining the specific fields of science and resulting in new scientific knowledge. Establishing new (combined) areas of research within the interdisciplinary field of science.

Design useful methodologies and corresponding systems and concepts for practical application in construction industry (Civil Engineering and/or Fundamental Engineering Sciences and Architecture) and the economy, by enhancing the quality of management and related planning, decision-making, etc.

Establishing research groups for interdisciplinary research at the Faculty, based on the described research. Establishing cooperation with other research groups with special emphasis on achieving internationalisation of scientific research work of the Faculty.

Specific objectives: Design of the specific architecture of the decision support system for the management of the renovation of historical structures. Database design. Design of the decision support model for the renovation planning of individual structures. Creating historical structure status index. Developing a methodology for predicting the deterioration of elements of historical structures.

Research is planned in the following laboratory/laboratories:

- GIS laboratory (SAR project – Geographic information systems and decision-support modelling in construction)

Human resources:

Approx. 6 teachers (3 FCEAG), 1 associate (FCEAG), 1 doctoral student (FCEAG)
External cooperation: • Faculty of Civil Engineering in Rijeka • Faculty of Civil Engineering in Zagreb • Wroclaw University of Science and Technology • University of Florence, Department of Architecture DIDA

Topic 4: **Resilience management of clusters of architectural heritage – Modelling decision support systems in construction management**
Interdisciplinary topic involves the following fields of science: Interdisciplinary field of science, area of Project Management and contributory fields: 1. Engineering Sciences, areas of Civil Engineering and/or Fundamental Engineering Sciences 2. Social Sciences, area of Economics 3. Engineering Sciences, area of Architecture and Urban Planning
Summary of research topics: **Resilience management of clusters of architectural heritage:** The expected outcome of the research is scientific contribution in the interdisciplinary field of science, area of Project Management and a combination of contributing fields: Engineering Sciences, areas of Civil Engineering and/or Fundamental Engineering Sciences, and Architecture and Urban Planning; and Social Sciences, area of Economics. The research is focused on modelling support in the implementation of monitoring (using modern technologies), processing of data collected during monitoring, and supporting the planning of strengthening resilience of historical urban areas - clusters of architectural heritage against fires, earthquakes, and floods (FEF) in an integral and inclusive manner (considering relevant aspects and stakeholders). Narrowed down, the research specifically focuses on the methodology of planning to strengthen the resilience of the historical centres of Mediterranean cities, partially or fully protected as cultural heritage. The methodology includes the definition of evaluation criteria, allowing for consistent comparison of individual structures and clusters. Designing support in planning resilience of an individual structure of particular importance, or cultural heritage unit. Establishing methods to evaluate the status of architectural heritage clusters, using the heritage status index and analysis of the resilience status 'as is'. **Key concepts in previous research:** Decision Support System, Decision Support Concept, multi-criteria methods (PROMETHEE, AHP, SAW), Expert System, Artificial Neural Networks (ANN), Fuzzy Logic, management (planning, organisation, staffing, supervision and control), urban renewal (land consolidation), architectural heritage, monitoring, resilience, disasters, floods, earthquakes, fires
Research objectives: General objectives: New and original scientific contributions and advancement of existing scientific knowledge in the described research topics through interdisciplinary research combining the specific fields of science and resulting in new scientific knowledge. Establishing new (combined) areas of research within the interdisciplinary field of science. Design useful methodologies and corresponding systems and concepts for practical application in construction industry (Civil Engineering and/or Fundamental Engineering Sciences, and Architecture and Urban Planning) and the economy, by enhancing the quality of management and related planning, decision-making, etc.

Establishing research groups for interdisciplinary research at the Faculty, based on the described research. Establishing cooperation with other research groups with special emphasis on achieving internationalisation of scientific research work of the Faculty.

Specific objectives: Design of the specific architecture of the decision support system for resilience management of clusters of architectural heritage. Database design. Designing a model to support planning resilience of an individual structure of particular importance. Creating a heritage status index for clusters of architectural heritage, based on the resilience, to be used in the analysis of the "as is" status.

Research is planned in the following laboratory/laboratories:

- GIS laboratory (SAR project – Geographic information systems and decision-support modelling in construction)
- Structures laboratory (SAR project – Research of the behaviour of different types of structures under extreme loads)
- Seismic engineering laboratory (SAR project - Experimental and Numerical Testing of Materials and Structures under Static, Dynamic, and Impact Loads)

Human resources:
Approx. 7 researchers (5 FCEAG), 1 associate (FCEAG), 1 doctoral student (FCEAG)

External cooperation:

- Faculty of Civil Engineering in Rijeka
- Faculty of Civil Engineering in Zagreb
- Wroclaw University of Science and Technology
- University of Florence, Department of Architecture DIDA

Topic 5:
Decision support in road infrastructure management – Modelling decision support systems in construction management

Interdisciplinary topic involves the following fields of science:
Interdisciplinary field of science, area of Project Management and contributory fields:

1. Engineering Sciences, areas of Civil Engineering and/or Fundamental Engineering Sciences
2. Social Sciences, area of Economics
3. Engineering Sciences, area of Geodesy

Research topic summary:
The expected outcome of the research is scientific contribution in the interdisciplinary field of science, area of Project Management and a combination of contributing fields: Engineering Sciences, areas of Civil Engineering and/or Fundamental Engineering Sciences, and Geodesy; and Social Sciences, area of Economics. Transport of people and goods is one of the key factors of industrial, economic and social development. Therefore, quality of design, construction, and maintenance of the road infrastructure plays a significant role. Road infrastructure consists of various infrastructure elements, initially classified in a manner suitable for further research (roads-road segments, intersections, public transport stops, etc.). The degradation of the pavement structure (PS), damage, and deformation occurs throughout the use period (due to continuous dynamic load of vehicles, changes in temperature and humidity conditions). To prevent further degradation and enable safe and comfortable driving, timely and efficient PS maintenance is necessary. Maintenance measures depend on the assessment of the condition of the road, with relevant data on flatness, cracks, surface damage, macrotexture, condition of road equipment, etc. and traffic load. Data should be collected (monitoring), organised (set up database structure and contents) and processed using new and existing models to determine the condition of PS and other elements of road infrastructure. In addition to these data (which are important for maintenance) the database should also contain data relevant for: tactical planning and decision-making (improvement of the functionality of existing

infrastructure elements – upgrading and additional equipment), and strategic planning and decision-making (development of the system by constructing new elements) in road infrastructure management. An integral part of monitoring research is the modelling of the process of identifying the target elements for maintenance activities, as well as properties relevant for determining maintenance priorities, taking into consideration the limited available resources. Research into strategic decision-making on the development of the system must provide specific support for planning the development of stationary traffic. For this purpose, the research is focused on modelling the decision support system in the management of road infrastructure. The system architecture is developed on the principles of an open system, and the functionalities are implemented by designing appropriate models in the model base, based on multi-criteria analysis, multi-criteria decision-making methods, artificial neural networks, new logical models, etc. Ensuring decision-making consistency in management is an important issue which can be solved by establishing a single hierarchical structure of objectives and criteria with at least three hierarchical levels analogous to the levels of decision-making and management. The methodology for establishing the hierarchical structure of objectives is an additional subject of research, since structural elements (objectives and criteria) determine the relevant aspects of the management problem and affect the level of importance of these problems for the stakeholders (managers, contractors, and users of infrastructure). The important safety aspect arising from the condition of the roads is also indirectly related to infrastructure and will be included in research in order to minimise the impact of the condition of infrastructure through maintenance, improvement, and construction activities.

Research objectives:

- Designing a decision support system in road infrastructure management;
- Database design (content and type of data) – GIS database;
- Designing a model for generating objectives and criteria and establishing a hierarchical structure of objectives – the basis for ensuring consistency in decision-making and management;
- Designing a model for the identification and prioritisation of the elements of the road infrastructure for maintenance activities;
- Designing a model for planning the development of urban road infrastructure through construction;
- Establishing a uniform classification of road infrastructure elements;
- Analysis of correlations and the impact of the condition and management of infrastructure elements on road safety.

Research is planned in the following laboratory/laboratories:

- GIS laboratory (SAR project – Geographic information systems and decision-support modelling in construction)
- Transportation laboratory (SAR project – Research in the field of road design and road infrastructure management)

Human resources:
Approx. 5 teachers, 2 associates, 1 doctoral student

External cooperation:

- Faculties of Civil Engineering in Rijeka and Mostar;
- University of Maribor, Faculty of Civil Engineering, Transportation Engineering and Architecture;
- Brno University of Technology, Faculty of Civil Engineering;
- County Road Administration;
- Units of local and regional self-government (road infrastructure management departments and municipal/county companies)

Topic 6:

Decision support in maritime domain management – Modelling decision support systems in construction management

Interdisciplinary topic involves the following fields of science:

Interdisciplinary field of science, area of Project Management and contributory fields:

1. Engineering Sciences, areas of Civil Engineering and/or Fundamental Engineering Sciences
2. Social Sciences, area of Economics
3. Engineering Sciences, area of Geodesy

Research topic summary:

Decision support in maritime domain management: The expected outcome of the research is scientific contribution in the interdisciplinary field of science, area of Project Management and a combination of contributing fields: Engineering Sciences, areas of Civil Engineering and/or Fundamental Engineering Sciences, and Geodesy; Social Sciences, area of Economics; and Natural Sciences, field of interdisciplinary natural sciences. Research is focused on the planning of projects to establish anchorages for ships (nautical tourism) and the development of concession models. The subject of research is support to the assessment of locations for specific construction projects such as anchorages, as well as support to the process of inclusive and integral design of a sustainable model of granting concessions for nautical anchoring. This approach aims to provide a platform for planning the development of anchorages in specific areas, considering all aspects relevant for assessing the sustainability of projects expressed via defined criteria. The criteria fall into several categories: engineering-construction, economic-financial, social, and cultural (i.e., employability of the local community, protection of cultural heritage, and environmental impact). The logic of multi-criteria analysis and decision support system is combined with multi-criteria methods to develop suitable DSS models for maritime domain management with a special focus on the Mediterranean coast and islands.

Key concepts in previous research: decision support system, decision support concept, multicriteria methods (PROMETHEE, AHP, SAW), expert system, management (planning, organisation, staffing, supervision and control), maritime domain, anchorage, boating, concession, sea, coast

Research objectives:

General objectives:

New and original scientific contributions and advancement of existing scientific knowledge in the described research topics through interdisciplinary research combining the specific fields of science and resulting in new scientific knowledge. Establishing new (combined) areas of research within the interdisciplinary field of science.

Design useful methodologies and corresponding systems and concepts for practical application in construction industry (Civil Engineering and/or Fundamental Engineering Sciences, and Geodesy) and the economy, by enhancing the quality of management and related planning, decision-making, etc.

Establishing research groups for interdisciplinary research at the Faculty, based on the described research. Establishing cooperation with other research groups with special emphasis on achieving internationalisation of scientific research work of the Faculty.

Specific objectives: Design of the architecture of the planning support concept for small-boat marine anchorage construction projects. Design of a decision support system for managing small-boat marine anchorage concessions. Development of a model for planning and decision-making on concession fees collected by the concession granting authority on the maritime domain.

Research is planned in the following laboratory/laboratories:

- GIS laboratory (SAR project – Geographic information systems and decision-support modelling in construction)

• Hydrotechnical laboratory (SAR project – Research of water resources and coastal areas)
Human resources: Approx. 4 teachers (2 FCEAG), 2 associate
External cooperation: • Faculty of Science, Split • Faculty of Civil Engineering, Rijeka

Topic 7: **Synergy framework for marine research**
Interdisciplinary topic involves the following fields of science: 1. Engineering Sciences, areas of Fundamental Engineering Sciences, Geodesy, Electrical Engineering, Computer Science 2. Natural Sciences, area of Geophysics
Research topic summary: The project 'Synergy Framework for Marine Research' (SfMR) will use different methods to process satellite and aerial data. One of these methods is satellite-derived bathymetry (SDB), a relatively new method using satellite or air multispectral images to determine the depth of shallow water areas, up to a depth of 20 to 30 metres (depending on the quality and transparency of seawater). The method was developed in the late 1970s but has been increasingly used in recent years. In addition to SDB, depth models can also be calculated using radar satellite altimetry data. Today, sea depth predictions produced by satellite altimetry are usually integrated into hybrid global topographic models that combine in situ measurements and predictions from satellite data. The first such models were published in the early 1980s and have been used widely since the 1990s. Other parameters and data (hydrographic-geodetic data – coastal line and coastal bathymetry; physical parameters of the sea – surface waves, sea temperature; biological parameters – chlorophyll a; environmental-ecological parameters – oil spills, plastic litter) are to be collected using optimal methods producing the best results. Project developers have experience in determining soil temperature and the same methodology will be used to determine sea temperature. The final result of this project proposal is a database of high-quality data and parameters collected for the test area of Kaštela Bay. The data related to the target parameters, collected in the proposed project, will significantly impact and contribute to different areas of scientific research, but also to the development of society and the economy in general. The expected scientific contribution of the project is the selection of the optimal method for obtaining geospatial data in the coastal part of the Adriatic Sea in Croatia, using remote sensing. There is a significant number of potential project beneficiaries, and the results of the project could be applied in many disciplines and activities related to the coastal, inshore, and offshore areas, such as: onshore and offshore area mapping, coastal area management, spatial planning, maritime transport, environmental and environmental impact assessment studies, monitoring of the quality of seawater, etc. Potential project beneficiaries include industry, research institutions, and state and local governments. The methodology of this project proposal can be presented in four phases: 1. preparatory phase, mainly involving collecting data and available satellite images suitable for processing, 2. analysis and selection of the most suitable remote data collection methods for selected parameters, 3. interdisciplinary analysis of obtained results, interpretation and validation of results using existing and available in-situ measurements, and 4. establishment of an interdisciplinary spatial-temporal database of the test coastal area.

The research is carried out by an interdisciplinary team with the purpose of analysing and visualising the remote sensing data (satellite and unmanned aerial vehicle (UAV) data for the broader coastal and offshore area of Kaštela Bay, which will serve as a test area. The sources of data are:

1. Satellite data (commercial and free of charge data);
2. Drone data (UAV data);
3. In situ measurements.

Research objectives:

The collected data can be divided into the following groups:

1. Hydrographic-geodetic data: coastal, onshore and offshore bathymetry;
2. Physical parameters of the sea: surface waves, sea temperature;
3. Biological parameters: chlorophyll a;
4. Environmental-ecological parameters: oil spills, plastic litter.

The basic dataset is hydrographic-geographic data of the coastline and bathymetry (sea depth) which represent the basis for the development of a digital terrain model – high-resolution DTM in the test area. DTM is the basis for the presentation of other selected physical, biological and environmental-ecological data obtained by remote sensing methods, and the foundation for spatial modelling and analysis.

The expected outcome related to the first objective is obtaining all the listed data for the area of Kaštela Bay from available scientific papers, studies, published official maritime and topographic maps and publications, orthophoto images, etc. The planned outcome of the second objective is collecting free satellite imagery and corresponding commercial satellite imagery of the broader area of Kaštela Bay, to compare the quality of these two data sources. The outcome of the third objective is an interdisciplinary comparison of standard measurement data (objective 1) and satellite detection (objective 2). Based on the outcome of the third objective, pilot areas are selected for parameter detection using drones with suitable sensors, which is the fourth objective of this project. In this stage, it is necessary to test the hypothesis that the use of drones significantly improves the spatial resolution achieved by satellite imagery. The outcome of the fifth objective is a high-quality database of selected hydrographic-geodetic, physical, biological and environmental-ecological data and parameters for future scientific research in the selected test area. The database will be available to users via the web browser.
The web browser of the selected data is created in the initial phase of the project, once the first objective is achieved, followed by successive complementary fulfilment of the remaining objectives.

Research is planned in the following laboratory/laboratories:

- Geodetic laboratory (SAR project - Geodetic research in the environment)

Human resources:
The research group is highly interdisciplinary and consists of several researchers and several PhD students.

External cooperation:

- Institute of Oceanography and Fisheries, Split
- Faculty of Maritime Studies, Split
- Faculty of Geodesy, Zagreb
- Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture, Split
- Faculty of Electrical Engineering and Computing, Zagreb
- Croatian Hydrographic Institute, Split

Topic 8:
Synergy framework for environmental research

Interdisciplinary topic involves the following fields of science:

1. Engineering Sciences, areas of Fundamental Engineering Sciences, Geodesy, Hydrology
2. Biotechnical Sciences, area of Agriculture
3. Natural Sciences, area of Geophysics

Research topic summary:
The use of remote sensing methods has been on the rise recently, as they achieve very good results in the collection of environmental data. Remote detection has become a valuable tool, used in many segments of interdisciplinary research, while it has been applied for the longest time in the fields of forestry and agronomy. Data obtained with such tools and currently available free satellite missions (Landsat, MODIS, Sentinel) allow for simpler and faster modelling and interpretation of various natural and environmental processes.

Research objectives:
Obtaining spatial data as well as additional data (vegetation indices, water indices, soil and moisture indices, etc.) pertaining to vegetation and different environmental parameters which would otherwise require a large number of expensive, comprehensive and long-lasting in-situ measurements.

Research is planned in the following laboratory/laboratories:

- Geodetic laboratory (SAR project - Geodetic research in the environment)

Human resources:
The research group is highly interdisciplinary and consists of several researchers and several PhD students.

External cooperation:

- Faculty of Geodesy, Zagreb
- Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture, Split
- Faculty of Electrical Engineering and Computing, Zagreb
- Institute for Adriatic Crops and Karst Reclamation, Split
- Faculty of Agriculture, Zagreb
- Croatian Forest Research Institute, Zagreb

Topic 9:
Exploration of soil/soft rock and other unsaturated geomaterials

Interdisciplinary topic involves the following fields of science:

1. Engineering Sciences, area of Fundamental Engineering Sciences
2. Natural Sciences, areas of Geophysics and Chemistry

Research topic summary:
Unsaturated or partially saturated conditions are actual situations of terrain and buildings, studied and investigated especially in cases of porous fine-grain structures where matrix suction occurs in the material as the difference between air pressure and water pressure in pores. Taking into consideration the unsaturated environment, corresponding research is planned to expand and advance the field of geotechnical research and investigation of soft rocks (marl, siltite) of the flysch sequence typical for the Dalmatian area and other rocks prone to degradation and weathering. The behaviour of these materials is dependent on complex hydromechanical (including thermal and electro-chemical) interaction and unsaturated soil mechanics (behaviour controlled by suction and specific phenomena such as subsidence induced by moisture, irreversible deformations due to suction cycles, swelling and collapse of structure, degradation of properties over time, loss of strength and durability). In a broader sense, the effects of structural changes in the hydromechanical behaviour of porous (geo)materials are studied, where the process of differential suction and the

resulting differential swelling significantly contribute to the development of weathering, which occurs in unsaturated conditions and in interaction with the environment.
The results of the research will be used not only for the purposes of geotechnical research of the terrain and in project design, but also to provide general support for the protection and sustainability of the environment and economy in the coastal area of Croatia. The research will encourage the study of issues related to environment/soil/terrain protection, climate change mitigation, reduction of resource consumption, and sustainable coastal zone management, all of which are closely connected to the geotechnical profession (shore erosion, flood/drought protection, landslides, rockfalls – problems of stability, safety, durability, etc.). Additional studies involve mechanisms in unsaturated geomaterials and modelling of the consequences of properties associated with suction, in terms of building construction and maintenance, as well as in terms of durability of the cuts/slopes and environmental sustainability.
The research topic is related to the soil properties necessary for further analysis of stability and bearing capacity, as well as project design and construction of all earthfill structures, since compacted soil materials are unsaturated (e.g. construction of railway and other environmentally sound embankments, dams, plateaus, and controlled surfaces). The soil materials to be investigated are soft rock and mixtures of soft rock and clay soil as intergranular fillings, i.e., mixed or improved materials.
Unsaturated environment research is linked to other areas of science, e.g. Geology and Chemical Engineering (thermodynamics, matter and energy transfer) and plays an important role in agriculture.
Experimental research consists of measuring or controlling suction under different stress and deformation conditions, that is, testing SWCC – Soil Water Characteristic Curve and SDSWCC – Stress Dependent SWCC in previously untested soft rock materials and other materials, as well as properties related to suction, pore pressure testing using the axis translation technique, and other techniques/methods in the laboratory and in the field.
Laboratory and field research and observations are complemented by related research in the field of numerical modelling, i.e. application of experimental analysis results in existing models and the development of new models for unsaturated conditions. Systems or methods for new types of measurements and tests may be developed or upgraded.
Further development of funding resources is planned through project applications and corresponding dissemination through publication of scientific papers and writing of graduate/doctoral thesis.

Research objectives:

Continued research of data from scholarly resources and expanding the knowledge base. Developing and advancing the research group and laboratory for unsaturated soils. Conducting experimental and numerical research of mechanisms in unsaturated geomaterials, using the example of soil/soft rock or other geomaterials and fine-grained porous materials. Connecting the issue of unsaturated environment mechanics with the demands and challenges related to sustainable and environmentally sound construction of embankments, plateaus, dams and other earthfill structures using non-traditional materials (soft rock and mixtures, mixed and/or improved materials). Analysing the problems of erosion and weathering on slopes, considering the unsaturated environment, i.e. behaviour controlled by occurrence and development of suction. Investigating the connection suction and weathering and modelling the consequences of suction on the construction and maintenance of buildings, stability and durability of cuts/slopes, environmental sustainability, and time-related properties of geomaterials and porous environments. Achieving appropriate dissemination through scientific papers. Providing students with opportunity to conduct independent research and produce final, graduate, and doctoral thesis.

Research is planned in the following laboratory/laboratories:

- Geotechnical laboratory (SAR Project – Geotechnics and environmentally sustainable construction approach)

Human resources:
Three teachers (geotechnics), two associates (doctoral or postdoctoral students, associate for numerical modeling) and one laboratory assistant

External cooperation:
- FGG Ljubljana (University of Ljubljana, Faculty of Civil and Geodetic Engineering, Slovenia)
- IST DECivil Lisbon (University of Lisbon, Department of Civil Engineering, Architecture and Georesources, Portugal)
- Faculty of Civil Engineering, Rijeka
- Faculty of Mining, Geology and Petroleum Engineering, Zagreb
- Faculty of Chemistry and Technology, Split

Topic 10:
Investigating the quality impact of Spanish broom (Spartium junceum L.) fibres on the cement composite

Interdisciplinary topic involves the following fields of science:
1. Engineering Sciences, area of Civil Engineering
2. Natural Sciences, area of Chemistry
3. Biotechnical Sciences, area of Agriculture (Agronomy)

Research topic summary:
Spanish broom (Spartium junceum L.) is a typical wild plant of the Mediterranean area. It grows as a shrub, with usual height of approx. 1.5 m, although it can reach over 3 m. It is a perennial plant with a maximum of 20 growing seasons. The most important part of the plant are its sturdy branches, consisting of two layers (external and internal) and containing a high cellulose content. The recommended harvest period is August, when the pod on top of the branches is already brown. Fibres obtained from shoots (branches) can be used to strengthen composites. The Spanish broom fibre has the lowest specific weight compared to other fibres, and the tensile strength value is close to most natural fibres. By adding fibres to the matrix of cement, mortar, or concrete, the spreading of microcracks is delayed by transfer of stress from the crack position to adjacent sections. However, there is an issue of durability of cellulose fibres in cement composites, due to their degradation under the influence of alkalis, which dissolve lignin and hemicellulose. To increase the durability of fibres, they are processed before they are added to the composites, to remove parts of the fibres sensitive to alkali. Hydroxide is most often used to improve the chemical quality of fibres. The processed fibres are analysed using different methods such as FTIR, TD/DTG-DTA, XRD, etc. Mechanical and physical characteristics are determined on composite samples. On the basis of the obtained results, the correlation between composite testing and fibre testing will be determined in order to provide guidance for further investigations.

Research objectives:
- Testing of physical-mechanical properties of fibres
- Design and testing of physical-mechanical properties of composites
- Publication of scientific papers
- Producing a doctoral thesis

Research is planned in the following laboratory/laboratories:
- Building materials laboratory (SAR project – Research in improving the properties of concrete and other basic building materials)

Human resources:
2 teachers, 1 doctoral student, 1 laboratory assistant

External cooperation:
- Faculty of Chemistry and Technology in Split
- University of Applied Sciences Marko Marulić Knin – Karst agriculture department

- Faculty of Civil Engineering and Architecture in Osijek
- Faculty of Civil Engineering in Rijeka

Topic 11:
Monitoring of ancient structures – MANGRA

Interdisciplinary topic involves the following fields of science:
1. Engineering Sciences, area of Civil Engineering
2. Humanities, area of Archaeology

Research topic summary:
Ancient structures are exposed to a variety of increasing static and dynamic loads during their lifespan. Many of these structures suffered significant damage (settlement, cracks, partial damage, etc.). In the first phase of the research, investigations of the current condition and determination of the mechanical properties of building materials are conducted on several selected significant historical structures. In the second phase, monitoring of the behaviour of the historical structure over a period of time, under static and dynamic ambient loads, would be carried out, observing the effects of temperature, humidity, settlement, and load on changes in stress and deformation of the structure, as well as existing cracks.
Based on the collected data, and considering archaeological and architectural recommendations, restoration / maintenance methods would be proposed.

Research objectives:
- Collecting basic data on the structure
- Comprehensive general visual inspection of the structure
- Monitoring the behaviour of the structure over time
- Investigating the mechanical properties of building materials used

Research is planned in the following laboratory/laboratories:
- Structures laboratory (SAR project – Research of the behaviour of different types of structures under extreme loads)
- Building materials laboratory (SAR project – Research in improving the properties of concrete and other basic building materials)

Human resources:
6 teachers, 2 doctoral students

External cooperation:
- Mediterranean Centre for Built Heritage
- Institute of Art History – Centre Cvito Fisković, Split
- Archaeological Museum Split

Topic 12:
Integrated approach to safety analysis in the event of fire in enclosed spaces

Interdisciplinary topic involves the following fields of science:
1. Engineering Sciences, areas of Civil Engineering and Mechanical Engineering
2. Natural Sciences, area of Chemistry

Research topic summary:
Fire safety can generally be defined by analysing the issue in three domains: analysis of the safety of load-bearing structures in the event of fire, analysis of the development of the actual fire in terms of temperature and smoke, and analysis of the evacuation of people present in the facility or enclosed space. The nature of safety analysis is interdisciplinary, and conducting a quality analysis requires knowledge/expertise from different branches and fields of science. The research topic will focus on the behaviour of bearing structures in the event of fire, studying the properties of building

materials and proposing new types of fire-resistant structure to increase the safety of the load-bearing structure. In this context, traditional building materials are studied: steel, concrete, and wood, as well as contemporary materials such as aluminium, stainless steel, and glass. Experimental research and numerical modelling are carried out to investigate the behaviour of these materials, using suitable research software. In terms of the analysis of the development of actual fires, the focus of research is the application of existing numerical models in the analysis of the spread of fires in enclosed spaces. As part of the research topic, the analysis of evacuation of people is based on the application of existing numerical models and the optional development of new numerical models. The expected result of the research is the development of an optimal integrated approach to increasing fire safety in enclosed spaces.

Research objectives:

- Investigating the behaviour of modern building materials in the event of fire and fire ratings of building materials used in different types of load-bearing structures
- Developing numerical models for modelling different aspects of fire safety
- Developing a more reliable approach to safety analysis in the event of fire in enclosed spaces

Research is planned in the following laboratory/laboratories:

- Structures laboratory (SAR project – Research of the behaviour of different types of structures under extreme loads)
- Building materials laboratory (SAR project – Research in improving the properties of concrete and other basic building materials)

Human resources:
4 teachers, 3 associates, 2 laboratory assistants

External cooperation:

- University of Zagreb, Faculty of Civil Engineering
- University of Split, Faculty of Chemistry and Technology
- University of Sheffield, Department of Civil and Structural Engineering
- University of Prague, Faculty of Civil Engineering

Topic 13:
Application of hardwood in the production of glued laminated beams (GLULAM)

Interdisciplinary topic involves the following fields of science:

1. Engineering Sciences, area of Civil Engineering
2. Biotechnical Sciences, area of Wood Technology
3. Natural Sciences, area of Chemistry

Research topic summary:
Sustainable construction implies the use of sustainable materials and the introduction of safe construction practices in accordance with new building technologies in the construction of homes, offices and industrial facilities. Wood is considered a sustainable building material and is widely used in construction. Although conifers have been used primarily in glulam production for a long time, the unexploited potential of the increased share of hardwoods in European forests resulted in more intensive research on its use as a material to produce glulam during the last decade. The hardwood species used in the production of glulam beams that are widespread in the territory of the Republic of Croatia include oak, beech, ash, and poplar. From a strategic perspective, it is necessary to invest in research of these resources to achieve the highest level of utilisation and optimise long-term management.
Current European standards for design of timber structures HRN EN 1995 (Eurocode 5) cover the requirements and properties of glulam made of coniferous woods (HRN EN 14080:2013 Timber structures -- Glued laminated timber and glued solid timber -- Requirements). Within the framework of the ETA (European Technical Assessment), individual glulam beams made of hardwood, as well

as joints between the flanges, were adopted. Some countries have also granted national authorisations for hardwood glulam products, while more research is still necessary to develop comprehensive European standards. To take full advantage of the existing hardwood and ensure a quality construction product, the only way to introduce the products into construction practice is by determining the product properties based on experiments.
In addition to material, processing technology also largely affects the level of compliance of the construction product with applicable standards. In the case of glulam, the focus is primarily on surface processing of flanges and gluing technology. Due to its microstructure, hardwood requires careful processing to achieve satisfactory strength of glued compounds. In addition to the problem of structural penetration of glue, hardwood also has a greater tendency for moisture absorption, swelling, and shrinkage.
Since there is no database of standardised glulam beams made of hardwood, or calculation models describing their properties, so far, the main focus of the research is conducting experiments. The development of numerical models should facilitate this path. Glulam flexural strength is obtained by numerical calculation of the mechanical properties of individual hardwood flanges. The models proposed to describe softwood glulam cannot be successfully applied to hardwood beams due to the significant difference in their microstructures. In addition to the statistical parameters that describe the mechanical properties of flanges, special attention should be paid to modelling of joints. Softwood research has shown stable crack expansion, while in hardwood there is unstable propagation before the crack stops.

Research objectives:

- Investigating the behaviour of hardwood in glulam beams
- Developing the numerical model of hardwood behaviour
- Application of glulam beams in construction

Research is planned in the following laboratory/laboratories:

- Structures laboratory (SAR project – Research of the behaviour of different types of structures under extreme loads)
- Building materials laboratory (SAR project – Research in improving the properties of concrete and other basic building materials)
- Numerical modelling laboratory (SAR project – Numerical modelling in civil engineering)

Human resources:
4 teachers, 3 associates, 2 laboratory technicians

External cooperation:

- University of Zagreb, Faculty of Forestry and Wood Technology
- University of Split, Faculty of Chemistry and Technology
- Pannonian Wood Competence Centre, Virovitica
- Drvene konstrukcije d.o.o., Voćin

Topic 14:
Impact of wind energy and climate conditions in construction

Interdisciplinary topic involves the following fields of science:

1. Engineering Sciences, areas of Civil Engineering, Architecture and Urban Planning
2. Natural Sciences, area of Geophysics

Research topic summary:
The research topic investigates the complex interaction of structures and extreme climatic events such as wind storms, extreme temperatures, and the effects of ultraviolet (UV) radiation on structures. All aspects of climate variability, both natural and human-driven causes of climate change, are taken into account. The research connects different topics in the field of civil engineering, including lightweight structures, reliability of structures, durability of structures, and fatigue of materials in structures, with meteorological and climatological research. The final

objective of the research is to provide guidelines for strengthening existing structures and designing new structures in areas particularly vulnerable to climate change. In vulnerable areas, special attention will be paid to urban environments that are affected by extreme wind speeds due to the formation of urban canyons. Additionally, dark glass facades and the lack of green areas contribute to the formation of extremely high-temperature zones, or 'urban heat islands'.

Research objectives:

- Defining probabilistic models of effects of extreme climatic conditions on usability, bearing capacity and durability of structures
- Developing experimental procedures for collecting data on the effects of extreme climatic events on structures
- Adapting the existing and developing new numerical models for analysis of fluid dynamics, heat transfer and degradation of structures

Research is planned in the following laboratory/laboratories:

- Structures laboratory (SAR project – Research of the behaviour of different types of structures under extreme loads)
- Wind energy measurement station (SAR project – Effect of wind energy and climate change in civil engineering)
- Hydrotechnical laboratory Žrnovnica (SAR project – Research of water resources and coastal areas)

Human resources:
3 teachers

External cooperation:

- Croatian Meteorological and Hydrological Service
- Faculty of Science Split

Topic 15:
Development of technology for permanent monitoring of structures

Interdisciplinary topic involves the following fields of science:

1. Engineering Sciences, areas of Civil Engineering, Electrical Engineering, Computer Engineering

Research topic summary:
All structures are exposed to different loads during their lifetime. The variability of loads is described on different time scales and degrees. As a result of overloading of structures, permanent deformation or damage to the structure occurs, further reducing the load capacity. Renovation activities can recover one part of the initial load capacity. It is difficult to fully quantify the effects of renovation activities without a structural monitoring system. Currently, structural monitoring in construction is carried out on a very limited number of structures, due to the high cost of such systems. On the other hand, because of the mass production of personal electronic devices, the cost of producing MEMS sensors suitable for monitoring structures has decreased. The purpose of this research is to provide guidelines for the integration of MEMS sensors into existing structures and new construction projects, the development of new sensors, and the development and optimisation of systems for collecting, storing, and processing long-term data on the structure. The benefits of this research for the beneficiaries, that is, the users of the buildings, include an optimal choice of time and scope of the renovation, an overview of the effect of the renovation on the resilience of the structure, and the actual condition of the structure as one of value parameters. The benefit of this research topic for the society is the large amount of data which presents a solid foundation for standardisation.

Research objectives:

- Analysis of existing measurement systems and optimisation of measurement parameters for structures

- Development of new measurement systems and integration of existing measuring systems into structures
- Optimisation of the collection, storage, and processing of the resulting long-term data on the condition of structures

Research is planned in the following laboratory/laboratories:

- Structures laboratory (SAR project – Research of the behaviour of different types of structures under extreme loads)
- Wind energy measurement station (SAR project – Effect of wind energy and climate change in civil engineering)
- Seismic engineering laboratory (SAR project - Experimental and Numerical Testing of Materials and Structures under Static, Dynamic, and Impact Loads)

Human resources:
3 teachers, 3 associates, 2 laboratory assistants

External cooperation:

- Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture Split

Topic 16:
Determining properties of biocomposites and their application in construction

Interdisciplinary topic involves the following fields of science:

1. Engineering Sciences, area of Architecture and Urban Planning
2. Engineering Sciences, area of Fundamental Engineering Sciences

Research topic summary:
Composites are a combination of two different materials combined into a new material with significantly improved physical or chemical properties compared to the individual materials of which the composite is made of. The properties of fibre-reinforced composite materials are higher ductility, bending strength, tensile strength, fatigue, dynamic strength, and shock resistance. Fibres are short elements with high tensile strength. The properties of the fibres are determined by the relationship between length and diameter. By adding fibres to the matrix of a brittle material such as concrete, the propagation of cracks is lessened due to the transfer of stress to the adjacent sections. Fibres are classified as steel fibres, synthetic fibres, and natural fibres (biofibres). Synthetic fibres are classified as organic and inorganic, while natural fibres are classified into vegetable fibres, animal fibres, and mineral fibres.
The use of non-renewable sources of raw materials and the evident negative impact of human activity on the environment encouraged the investigation of sustainable development practices and the use of environmentally friendly materials. Synthetic fibre production, which involves the use of expensive equipment and significant investments, is mainly located in developed countries. On the other hand, natural fibres can be produced by human labour using traditional knowledge and practices. Steel and synthetic fibres are increasingly being replaced by natural cellulose fibres obtained from various plant sources.
Compared to other types of fibres, natural (cellulose) fibres derived from plants have a number of advantages. They are locally sourced, economical, biodegradable, renewable, have low density, are safer for handling and production, and are nonabrasive and therefore cause less wear of equipment. Cellulose fibres are not conductive and can be by-products of textile and agricultural production.
Furthermore, one additional advantage of cellulose fibres is that they are a product of the photosynthesis process, in which the plant takes carbon dioxide and releases oxygen. Therefore, natural fibres are a carbon-negative material. The application of cellulose fibres in composites results in reduced plastic waste, improved sound and thermal insulation, and vibration attentuation in cement composites. Cellulose fibres also have disadvantages: a relatively short lifecycle, difficulties in dosing, and unpredictable variations of properties.

Although the use of cellulose fibres in construction is limited, it has become a standard practice in other areas of human activity (textile industry, auto industry, aviation industry, and widely used packaging material). Therefore, the purpose of this scientific research is to explore the properties and possible applications of biocomposites in construction and to open new directions of research and application in construction.
Research objectives: Investigate the properties, potentials and areas of application of cellulose fibres in construction.
Research is planned in the following laboratory/laboratories: • Contemporary architectural technologies laboratory (SAR project: Research on the implementation of modern materials and technologies in architecture) • Building materials laboratory (SAR project – Research in improving the properties of concrete and other basic building materials)
Human resources: 3 (doctoral student, laboratory assistant, occasional assistance by external associates)
External cooperation: TPA Društvo za održavanje kvalitete i inovacije d.o.o.

7. SCIENTIFIC ORGANISATION ORGANIZATIONAL DEVELOPMENT PLAN

Organizational development with regard to creating interdisciplinary organisational units of FCEAG takes place through 11 SARLU (Science and Arts Research Logical Unit), i.e. 11 FCEAG Science and Arts Research Projects (currently 11 projects, with the development of scientific research activities in the future, several projects are planned in each SARLU). The purpose of organisational SARLU and corresponding SAR projects defining scientific research activities, is focused and continuous improvement of the development of scientific research and artistic work of FCEAG employees and institution as a whole, in a manner adapted to contemporary needs within the Croatian and European research area. Each of the 11 SAR projects includes multiple project activities and several research topics, with at least one interdisciplinary topic. The prevailing topics belong to the field of engineering sciences, while the interdisciplinary topics developed within SAR projects are mainly determined by engineering sciences, as the dominant research area at the Faculty. Research topics are usually presented as a combination of research problems, the solution of which requires scientific contributions in the field of engineering sciences and one or more other fields of science. SAR projects and associated activities are suitable organisational elements to conduct competitive research in the described topics.

The basic features of SAR projects are: stated objectives, project activities (also developed as projects – subprojects), financial, human, and material resources and a temporal/dynamic implementation plan. Interdisciplinarity is achieved through the participation of employees with research areas/fields of specialisation (in one or several SARLUs or on one or several SAR projects). Some members of project teams are employed exclusively on projects, i.e., SAR project activities or other projects carried out by the Faculty, and their salaries are financed from other funding sources, as they are not registered in the central employee register of the Republic of Croatia. In addition, project team members also include employees of cooperating institutions, companies and individuals conducting scientific research (based on research cooperation agreements with the Faculty) in several common research areas and/or fields, within the framework of specific research topics of any particular SAR project.

Research topics in all areas and fields of science that had been traditionally implemented at Faculty departments are now being continuously carried out within specific SARLU and through defined SAR projects. Faculty staff employed in scientific and associate research positions at several Faculty departments, recently employed researchers on scientific projects and researchers from collaborating institutions and companies constitute effective interdisciplinary teams, based on joint SAR project activities and knowledge synergy. The project-based approach to organising research work enables the formation of interdisciplinary project teams and facilitates the adaptation to different research topics and interdisciplinary topics, as well as reaching well-founded scientific results. All of the above contributes to the development of scientific and research activities within the interdisciplinary field of science. The organisational structure established in this way provides continuous support, conformity, and direction to SAR projects research topics, in accordance with societal needs, national priorities, and the EU thematic areas within particular projects/calls and programmes.

8. CONCLUSION

Interdisciplinarity developed in an integrated environment and conducted by 11 existing organisational units (SARLUs and 11 SAR projects), engaged on 16 corresponding interdisciplinary research topics, that can also be considered as project activities, as well as networking with economic operators, forms an important determinant of conducting research and overall development of FCEAG.

The individual research topics objectives defined in Chapter 6 of this Strategy are aligned with the general strategic objectives defined in the current FCEAG Development Strategy 2018-2022: Improving existing and developing new interdisciplinary study programmes and increasing scientific excellence and international recognition in the European Research Area.
The programme of scientific research, i.e. the associated research topics in the interdisciplinary field of science, is also focused on the development of the Dalmatian region and the development of related innovations.

9. EXPECTED OUTCOMES OF SCIENTIFIC RESEARCH PROGRAMME IN THE INTERDISCIPLINARY FIELD OF SCIENCE

The scientific and research strategy of the FCEAG in the interdisciplinary field of science describes the expected outcomes of achieving proposed research objectives and activities within the framework of specific research topics. The expected outcomes in relation to the proposed research topics in the interdisciplinary field of science can be presented as follows:

- Increase in scientific research activities at FCEAG in a general sense (increase of the number of competitive research projects applications focused on applied research and experimental development, with at least one application for scientific research project planned each year);
- Increase in the number of published scientific papers in the interdisciplinary field of science in reputable international journals (at least 2 papers per year);
- Stronger links with the community and the industry through better cooperation and concluding new collaborative research agreements (signing at least one new collaborative research agreement with partners from the industry and/or local community each year);
- Improving the research quality (reaching an annual average of one published paper per each FCEAG employee, including researchers active in the interdisciplinary field of science);
- Employee career development in the interdisciplinary field of science (at least two employees appointed to scientific titles in the interdisciplinary field of science in the upcoming period)
- Preparation and proposal of the postgraduate doctoral study programme in the interdisciplinary field of science (application for initial accreditation).

10. PERFORMANCE INDICATORS OF STRATEGIC PROGRAMME IMPLEMENTATION

Successful implementation of the proposed FCEAG Scientific Research Strategy in the interdisciplinary field of science is assessed using performance indicators related to the activities in applied research and experimental development, namely:

- Performance indicators for scientific activity (number of published papers, number of citations, journal quartiles);
- Performance indicators for scientific research projects (number of submitted/approved scientific research projects);
- Performance indicators for cooperation projects with industry and local community (number of projects realised and signed cooperation agreements);
- Performance indicators for the completed international mobility of researchers (number of research and professional trainings of doctoral students, postdoctoral students, and scientific and teaching staff);
- Performance indicators for dissemination of scientific research (number of scientific panels, congresses, conferences, round tables, etc. organised by FCEAG);
- Number of employees appointed to scientific titles in the interdisciplinary field of science.

11. QUALITY ASSURANCE

Strategic goals	Subgoals	Activities
The quality assurance system is an integral part of all Faculty activities and involves all Faculty stakeholders	Implementing and supporting all the activities constituting parts of the quality assurance system in accordance with national and ESG standards	Adopting and monitoring of the implementation of strategic documents based on established indicators (in accordance with ESG standards and higher-level strategic documents) and their publication Harmonization of legal acts with legal regulations and university documents Regular quality evaluation through cyclical external quality evaluation and self-evaluation

Measurable indicators for achieving quality assurance goals are defined as follows:

- Adopting and publishing strategic documents of the Faculty and corresponding operational (action) plans and reports at the annual level;
- Adopting and publishing legal acts of the Faculty;
- Adopting reports on the conducted evaluations and procedures/ reports based on the received recommendations.

12. REFERENCE DOCUMENTS

Strategic Plan of the Ministry of Science and Education of the Republic of Croatia for the period 2020-2022
(MSE Strategy 2020-2022)

Scientific Strategy of the University of Split 2021-2025, March 2021

Strategy of the Faculty of Civil Engineering, Architecture and Geodesy for the period 2018-2022
(FCEAG Strategy 2018-2022)

Strategic programme of scientific research of the Faculty of Civil Engineering, Architecture and Geodesy for the period 2015-2020
(FCEAG Strategy 2015-2020)

Smart Specialisation Strategy of the Republic of Croatia for the period 2016-2020
(S3 Strategy)

European Commission Strategic plan 2020-2024 – Research and innovation
(EU 2020-2024)

Report on the implementation of the Action Plan to Improve the Quality of Postgraduate University Studies in Civil Engineering for 2018, Split, 28 February 2018

Action Plan to Improve the Quality of Postgraduate (Doctoral) University Studies in Civil Engineering in the follow-up monitoring phase for 2019 and 2020, Split, 26 November 2020

Implementation of Contemporary Research Infrastructure at FCEAG for Smart Specialization in Green and Energy Efficient Construction - feasibility study with cost-benefit analysis, UHY Consulting

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Split, 23 June 2021

Dean:

Associate Professor Nikša Jajac, Ph.D.

I, Jelena Madunić, court interpreter of English language, as appointed by the Republic of Croatia Ministry of Justice and Public Administration, Ref.No.: 514-03-03-03/01-23-06 of 26 May 2023, do hereby certify that the above translation is a faithful and complete translation of the original document written in Croatian language.

Date: 7 May 2024, cert.no. 22/2024