Annual Report on the Activities of the

AdMaS Centre

2018

Foreword by the Dean

Dear colleagues,

You get in your hands the results of the work of the AdMaS Center in 2018. It was another year in which everything was successfully managed and when all the employees of the Center had adequate conditions for solving the given tasks. All acquired devices are fully used to fulfill the milestones set at the beginning of the project. It is very gratifying that the basic idea of building a versatile civil engineering research institution, which fully integrates knowledge from individual fields of research activities - material, construction and technology, has been fulfilled. The year 2018 was once again successfull, not only in the field of science but also in administration and in fulfilling the volume of contractual research. The NSP I AdMaS UP project from the National Sustainability Program for the period 2015–2019 is still a significant support for the operation of the center. We still have the last year of sustainability project though, which we must complete successfully as well. I am very pleased that the AdMaS Center, as co-beneficiary, acquired the National Center of Competence project from the TAČR programs, through which it will be easier to cope with the next two years. The results of 2018 show that the monitored sustainability indicators will be met without difficulty throughout the sustainability of the AdMaS project. I would like to thank for that to everyone involved.

Today, the AdMaS Center is a highly sought after and reliable partner for a number of cooperating companies and offices. Despite this, it appears that some of the assumptions on which the Center's strategy was built at the time of project creation are not being met. On the contrary, other areas are opening up for us. This is a natural phenomenon, because almost ten years have elapsed since the first project plans and significant shifts have occurred both in the market and in the research activities. The management of the AdMaS Center responds to this situation and continually updates the strategy. The Faculty of Civil Engineering has acquired in the AdMaS Center a modern workplace that is one of the best equipped scientific and technological facilities in Europe. It is up to us how we will now use the technological lead that we have over other, similarly oriented, faculties.

Once again, I thank you for the work done so far and I believe that the next period will be a continuation of the long-term successful journey of the AdMaS Center and its staff.

Prof. Ing. Miroslav Bajer, CSc., the Dean

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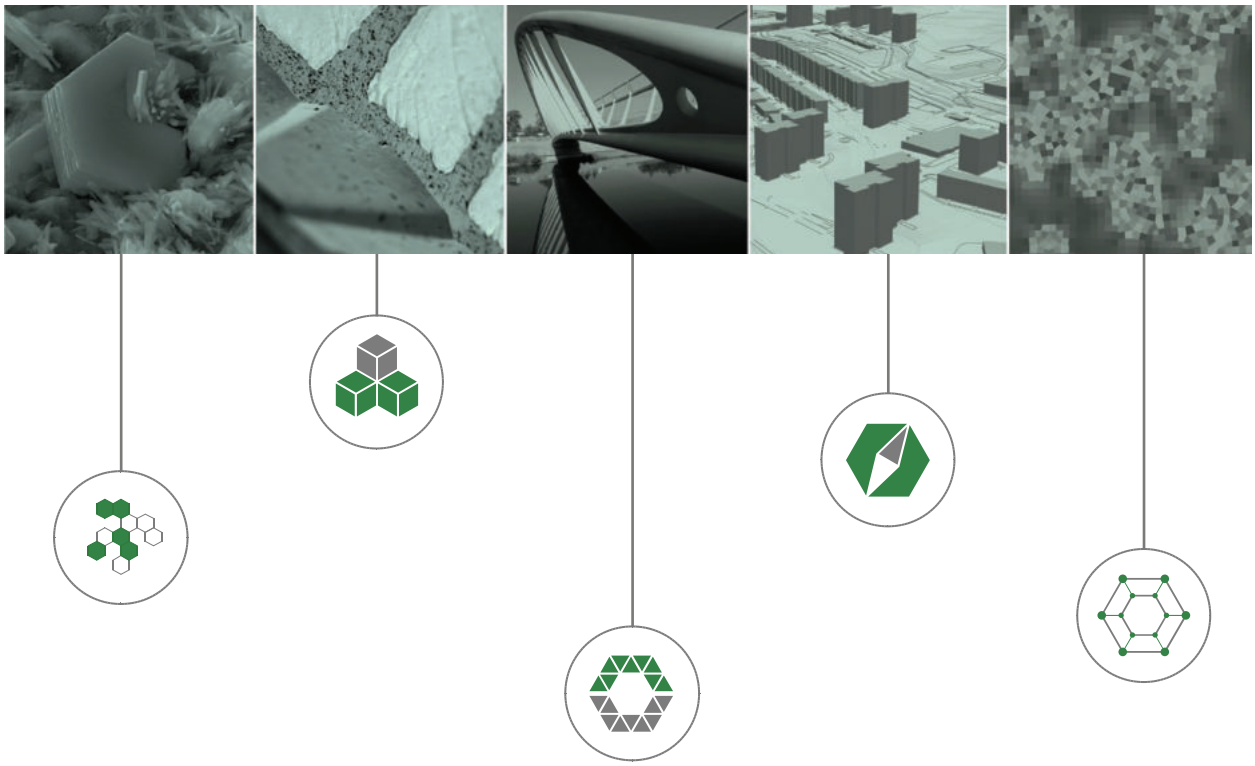


1. Organizational structure

Headquarters

Head of the Centre	Ing. JUDr. Zdeněk Dufek, Ph.D.
Scientific Director of the Centre	Prof. Ing. Drahomír Novák, DrSc.
Deputy Director, Financial Manager	Ing. Zdeněk Krejza, Ph.D.
Deputy Director of the AdMaS UP project	Assoc. Prof. Ing. Tomáš Apeltauer, Ph.D.
Administrative Manager	Assoc. Prof. Ing. Jiří Zach, Ph.D..
Lawyer	JUDr. Sylva Pochopová
Facility Manager	Ing. Michaela Ulbrychová
Economist and Coordinator of International Projects	Ing. Vilém Pařil, Ph.D.
Secretary	Zlatuše Dokoupilová

International Scientific Board

Professor Harald Garrecht (Chairman)	Universität Stuttgart, Germany
Professor Garbacz Andrzej, Ph.D. D.Sc.	Warsaw University of Technology, Poland
Professor Humberto Varum, Ph.D.	University of Aveiro, Portugal
Assoc. Prof. Dr. Andrea Giusepe Capodaglio	University of Pavia, Italy
Assoc. Prof. Dr. Alfred Strauss	University of Natural Resources nad Life Sciences, Vienna, Austria

Supervisory Board

Ing. Jaroslav Bureš, CSc.
Assoc. Prof. Ing. Ladislav Janíček, Ph.D., MBA
Ing. Pavel Krejčí
Ing. Jiří Sláma
Ing. Oldřich Šašinka, MBA

Research Programme VP1 Development of Advanced Building Materials

Head of Programme	Prof. Ing. Rostislav Drochytka CSc., MBA

Technology of Building Materials Research Group

Head of Research Group	Assoc. Prof. Ing. Jiří Zach, Ph.D.

Microstructure of Building Materials Research Group

Head of Research Group	Assoc. Prof. Ing. Jiří Bydžovský, CSc.

Research Programme VP2: Development of Advanced Structures and Technologies

Head of Programme	prof. Ing. Jan Kudrna, CSc.

Structural and Transport Engineering Research Group

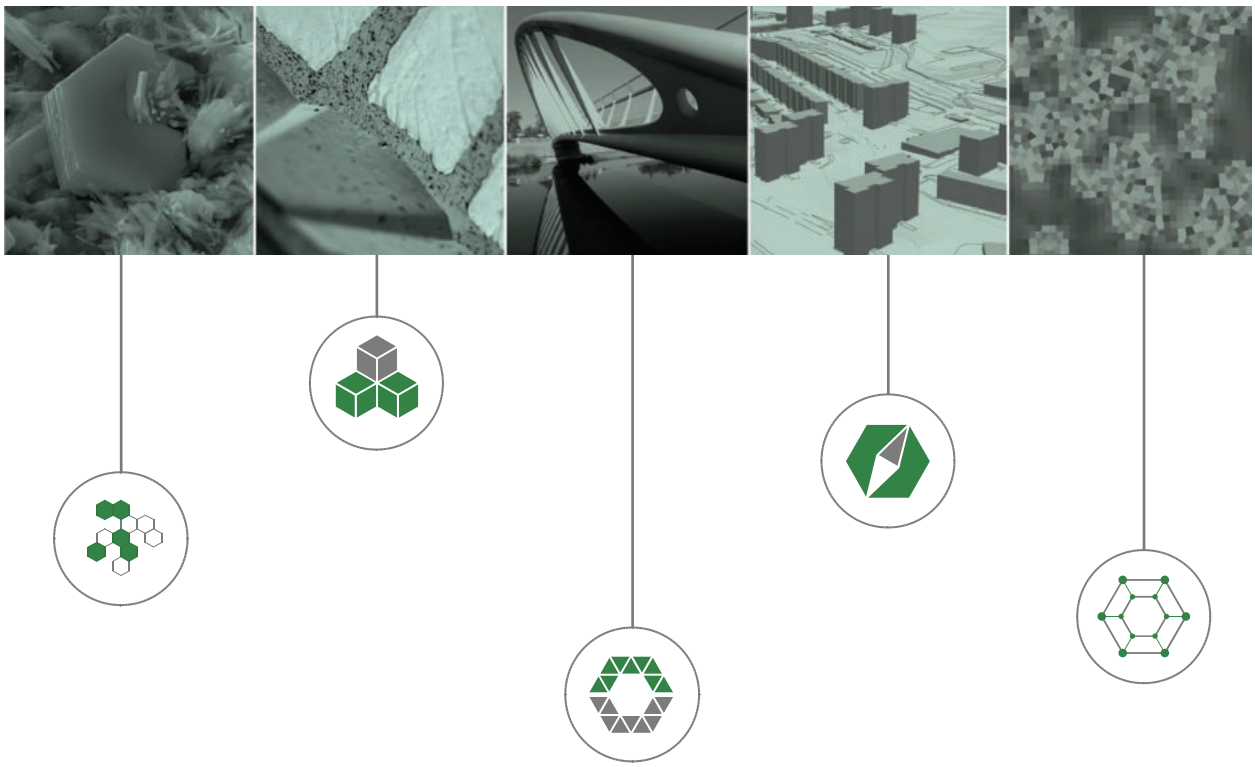
Head of Research Group	Assoc. Prof. Ing. Pavel Schmid, Ph.D..

EGAR Research Group

Head of Research Group	Prof. Ing. Petr Hlavínek, CSc., MBA

Mathematical Modelling Research Group

Head of Research Group	Prof. Ing. Drahomír Novák, DrSc.



2. Activities in the area of Centre management and organisation

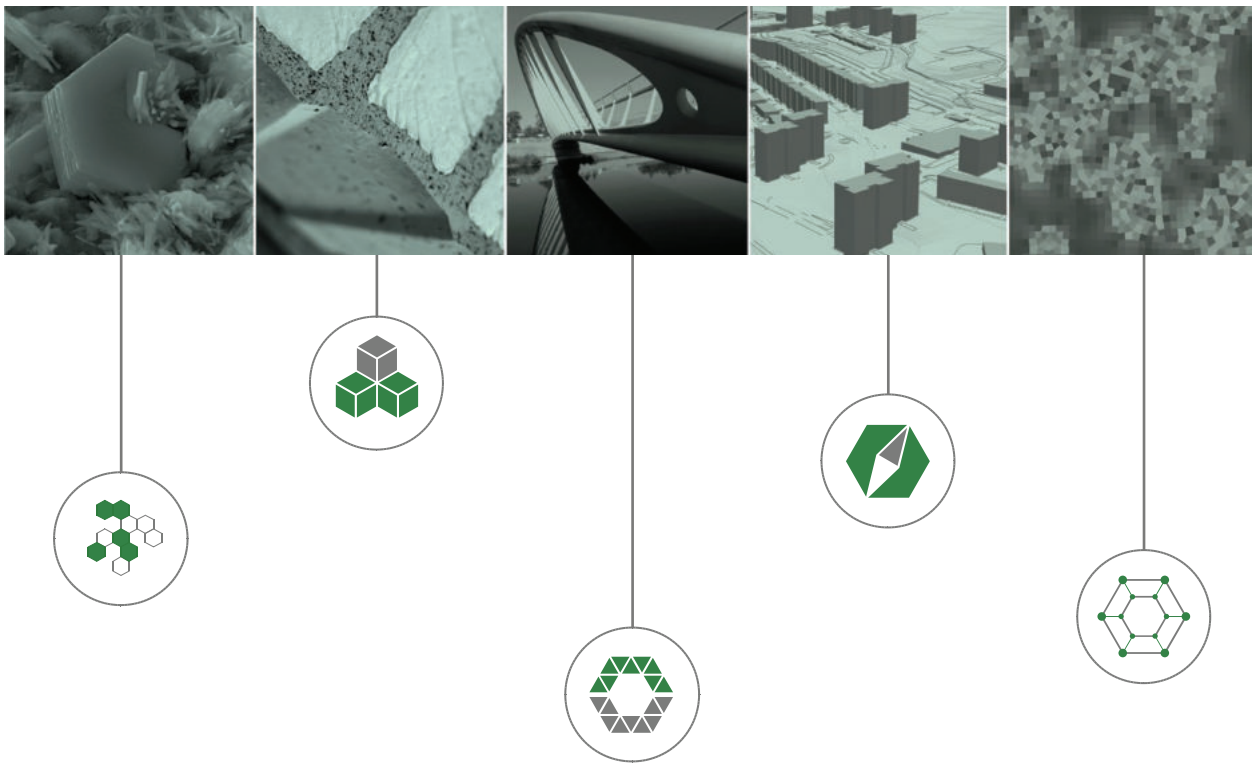
The third monitoring report from the sustainability period, which was approved by the managing authority in December 2018, was elaborated at the end of January 2018

Throughout the year, in line with the recommendations of the international evaluation, several joint horizontal integrations of research teams and meetings of R&D workers across research groups and work/scientific ranking took place. The center was involved in few promotional events such as Scientists' Night. Furthermore, elements of HR policy, introduced in previous years, such as supporting young researchers and promoting communication across AdMaS Research Groups, have been applied. As every year, in 2018, a number of domestic and foreign guests from various areas of industry and education visited the center (see Chapter 3).

In accordance with the technical annex of the project, the Management of the Center has actively applied the principles of Human Resources Policy. These included regular evaluation of R&D personnel, personal and motivational interviews with the staff of the center, support for new projects and the center management mobility. In addition, regular monthly meetings of the management of the Center were organized with the participation of representatives of individual RP and RG.

Mobility of employees abroad (in all R&D categories) and internships of foreign workers in the AdMaS Center continued in year 2018 as well. The center held many seminars and training courses for application sphere workers. There was also active cooperation with the application sphere, both in the area of contractual research (the amount of contractual research for 2018 was CZK 23.7 million), and in the area of applied R&D projects (according to MI0603, the volume of funds within the R&D projects of the Center, outside the institutional support, was CZK 80.185K and CZK 4.148K within MI111300).

On February 9, 2018, was held a meeting of the employees of the Center. There the results of year 2017 and the plans for the coming years were presented. On March 26 and October 17, 2018 was meeting of the Supervisory Board of the Center and on November 29 took place a meeting of the International Scientific Council of the Center, this time in the form of a teleconference.



3. Seminars, events, presentations

From the point of view of the activities of the whole center in 2018, the following were:

- On January 8, 2018, representatives of EGAR, TBM and STC, headed by the Director, welcomed 5 new Brazilian trainees, who spent about two months in the Center practicing on various topics in their field.
- Several young researchers visited the JUNIORSTAV conference, which was held on January 25, 2018 at FCI. These were acquainted with the center's facilities and equipment and the most important research underway here.
- On January 25, 2018, the AdMaS Center lent its premises for the Healthcare Working Group within the SMART CITY CLUSTER. The programme included a lecture by Assoc. Prof. Apeltauer about evacuating patients, then introducing pilot programs and agenda for the next meeting.
- On February 15, 2018, a professional seminar organized by LABTECH s.r.o. was held at Pavilion P2 of the AdMaS Center. The focus was on analytical instruments and material testing. The seminar was divided into two sections: Analytical and Material Testing with a total of 35 students. As part of the analytical section, equipment and systems from HIDEN Analytical Company were introduced, as part of the material equipment and systems section were introduced instruments from MTS, Controls, Schleibinger, and Dantec companies. Between the individual presentations a short excursion of the premises and the equipment of the AdMaS Center took place, namely in the P1, P2 and Hall H buildings.
- At the turn of January and February, a workshop for technical supervision of the construction site on the topic "Checking and testing the properties of concrete and its components during construction" was held in the premises of the AdMaS center. The workshop dealt with the issue of concrete technology and testing of its properties. Prof. Hela and Dr. Hubáček presented to participants the knowledge of modern technology of ordinary concrete, through information concerning concrete components, up to special types of concrete applied preferably in specific conditions.
- In February, a one-day training session for Road and Motorway Directorate staff continued, organized by the AdMaS Center together with C.Q.E. The main topic was the performance of construction supervision at road constructions. General knowledge was presented by prof. Jan Kudrna for AdMaS and Ing. Květoslav Urbanec for C.Q.E. As in years 2016 and 2017, the whole event met with success and the wish of the RMD employees to participate in similar training on a regular basis.
- In March, the Public Procurement Department of the BUT Rector's Office and the Institute of Construction Economics and Management of the Faculty of Civil Engineering organized a two-day training focused on the innovative procurement method and project management in general - called Best Value Approach. Head of Public Procurement Department, Petr Jelínek, completed the BVA training last year in the Netherlands and in mid-March organized, in cooperation with the director of the AdMaS Center, Dr. Zdeněk Dufek, a similar course for BUT administrators and their colleagues from Masaryk University, the South Moravian Region, the Ministry of Agriculture and other contracting authorities.
- On Monday, April 16, 2018, a 15-member delegation from Guangdong Province, China, accompanied by three representatives of the South Moravian Region, visited the AdMaS Center. The director, Dr. Zdeněk Dufek and Scientific Director of the Center, prof. Drahomír Novák, welcomed the delegation personally and introduced them to the essence, research and goals of the center. Then the delegation moved to the Laboratory of Structures, where

Ing. Nekulová presented the work of the RG and then to RP1 laboratory.

- On April 17, 2018, students of the Křenová High School visited the P2 pavilion of the AdMaS Research Center. During the two-hour seminar focused on the basic physical phenomena, the students were introduced to the laboratories of the center and dealt with problems in the volume density of building materials and the strength of concrete.
- As part of the accompanying program of the Building Fairs Brno, held on 25 - 28 April 2018, the Czech Chamber of Authorized Engineers and Technicians Active in Construction (ČKAIT), together with the Czech Union of Civil Engineers (ČSSI), organized the Conference Engineering Day 2018 on the topic of Fast Rail Connection in Czech Republic. The AdMaS Center was represented by doc. Otta Plášek and its lecture on the Technology Platform Support Program to Accelerate the Construction of Fast Track Lines.
- On April 19, 2018, MC-Bauchemie Company, which closely cooperates with the AdMaS Center, prepared an expert seminar with a demonstration of the results of joint research tasks. The seminar was organized for students of the 1st year of the Master of Building Materials Engineering study (specialization M) and focused on a wide range of different types of grouting materials for building remediation. The specialized lecture focused mainly on materials for preventing water penetration into building structures.
- From April 25 to 26, 2018, the AdMaS Center, as part of its Smart City activities, presented itself among the exhibitors at the Urbis Smart City Fair, which was part of the traditional Brno Building Fairs. At the stand, mathematical evacuation models of places with high population density and 3D simulation flyovers of selected locations captured by the mobile mapping system were presented. Doc. Tomáš Apeltauer presented his work at the accompanying conference program.
- The AdMaS Center participated again at the conference Transport Infrastructure at the Castle Brewery in Litomyšl, this year taking place on 16 and 17 May 2018. In addition to the exhibition stand, the center was mainly presented by doc. Tomáš Apeltauer with his contribution on the Use of Simulation Tools for the Protection of Soft Objectives of Transport Infrastructure and by doc. Vít Hromádka with a contribution on Risk Analysis of Transport Infrastructure Projects. The conference proceedings were further enriched by an article on the topic of Designing Crossroads - the View Triangles by Dr. Michal Radimský and Ing. Radka Matuszková. The Director of the Center, Dr. Zdeněk Dufek, was a moderator of a lecture block on Strategy - Vision - Planning.
- As part of the Czech Development Agency's "Broadcasting of Experts" programme, which is part of a project called "Support for Building Civil Engineering Specialization at Burch International University in Sarajevo based on Building Practice Needs in Bosnia and Herzegovina", a group of FAST and AdMaS staff visited Burch International University in May 2018 (IBU). The aim of the stay was to analyze the current situation and how to help to implement the new study program. The Czech group provided practical lectures for students, discussions with the management of the university and persons responsible for the implementation of the program, as well as representatives of the construction practice in Bosnia and Herzegovina with the definition of potential for their cooperation with IBU with the support of the Czech Republic (BUT). There was also a meeting with the Consul General of the Consular Section and the Development Cooperation Section of the Embassy of the Czech Republic in Sarajevo and Coordinator of the Development Cooperation Section.
- In May 2018, a team of collaborators from the AdMaS Research Center published a publication

entitled "BIM for contracting authorities". The publication briefly introduces public procurement contracts with BIM. The content of the thesis is the legal and technical aspects of the selection of the designing contractor. The publication also includes examples and BEP and EIR , tender documentation and contract for work sample documents. These exemplars are also available in electronic form.

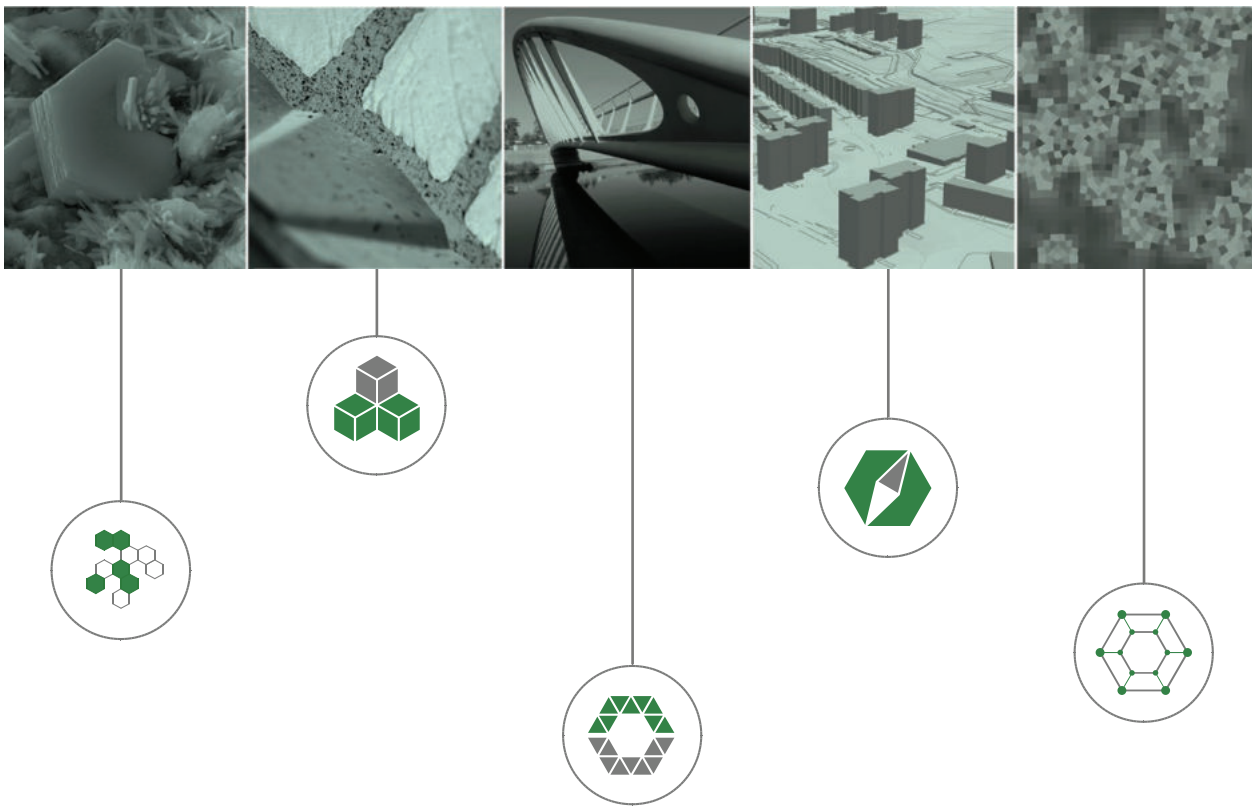
- On May 17, 2018, an international round of Student Scientific Expert Activity (SVOČ) took place at the Faculty of Civil Engineering. Bc. Radek Hermann from Building Materials Engineering (field M), who is currently working with the AdMaS Center on several research projects, has managed to attract both the expert jury and other students and so deservedly placed first in his section. Tom Kocmánek, as a future bachelor, then added a beautiful third place, which is an excellent springboard for next year.
- On June 6, 2018, the AdMaS Center participated in the Transport Engineering Day in Mikulov, organized by Česká silniční společnost z.s. in cooperation with Brněnské komunikace a.s. and Dopravní podnik města Brna a.s. At the seminar were presented the activities of the AdMaS Center and two devices. The first was the Hawkeye 1000 laser bar, the second was the Riegl VMX 450 laser device with a panoramic camera.
- On Wednesday, 6 June 2018, members of the Hong Kong Chamber of Commerce visited AdMaS. Founded in 1861, the Hong Kong Chamber of Commerce is the oldest and most dynamic trading organization in Hong Kong, representing a wide range of Chinese and international businesses. A total of 11 visitors were welcomed by the director and then introduced to the center's activities and plans through a presentation and then a practical tour of the laboratories in the P1 and P2 buildings.
- Students of the PhD study program at the Faculty of Civil Engineering, Brno University of Technology, under the guidance of a professor Rostislav Drochytka, who are actively involved in the research activities of the AdMaS Center, once again ranked first in the category 4 - Universities In the competition of the Ministry of Industry and Trade - "Transforming Waste to Resources". This year, Ing. Pavlína Šebestová won the first place with the work on the topic "Autoclaved aerated concrete based on waste ash and recycled glass" and Ing. Jakub Hodul won the second place with his work "Utilization of fly ash contaminated due to denitrification of flue gases into polymeric repair materials".
- During the seminar "Sanitising and Sludges Liquidation Complete Solution", held in June 2018 by VODA CZ in Česká Skalice, prof. Hlavínek attended a meeting with Israel's Ambassador, Mr. Daniel Martin Meron. The negotiations concerned cooperation and transfer of know-how in the field of wastewater treatment technologies and sewage sludge treatment. Prof. Hlavínek presented research topics dealt with by the EGAR Research Group and discussed with Meron the possible areas of cooperation with the Israeli Agency for International Development Cooperation (MASHAV).
- Since July 2018, BUT/AdMaS Center has been a member of the VIPA International Vacuum Insulation Panel Association. As of this year, AdMaS/RG TBM workers will be involved in the development and standardization of superinsulating building materials along with the world's best teams in the field (eg: FIW Munchen, Va-Q-Tec, Porextherm, Rockwool, Evonic, etc.).
- Thanks to IAESTE, we welcomed a new intern from Norway, Tonje Lysø, to AdMaS on 17 July 2018. Tonje is studying at the NTNU (Norwegian University of Science and Technology) in Trondheim, and at AdMaSu wanted to get to know the work in the road laboratory and to actively participate in research projects.

- The AdMas Center, in cooperation with ConWe, s.r.o, participated in the implementation of the urban cell module located at Malinovske namesti in Brno. The cell is testing how to make good use of rainwater to grow the cooling green in the city. The operator of the prototype is the Veřejná zeleň města Brna and the city has paid about half a million crowns for the project.
- On 11 September, 2018, the AdMaS Center welcomed participants of the Meeting of Czech and Slovak Building Constructions Institutes and Departments (Prague - Brno - Ostrava - Bratislava - Žilina - Košice). As part of a meeting organized by the Institute of Building Construction at the Faculty of Civil Engineering, Brno University of Technology, colleagues from universities took a round in all the pavilions of the center and during the two-hour excursion they were acquainted with its equipment and currently solved projects.
- Ing. Jakub Hodul participated in the Erasmus+ program at the University of Malta, Faculty for the Built Environment. The internship was mainly focused on research and development of polymer-cement mortars with different content of crystallization additive. Sub-samples will be subject to further research at the AdMaS Center.
- Technical and Economic University of Budapest and the University of Belgrade were visited as part of the Centre's foreign business trip, where the Center's research institutes and presently solved research projects and tasks were presented. The issue of cooperation between individual workplaces, including the possibility of working stays, was discussed. A visit to the premises of the Faculty of Civil Engineering of the Brno University of Technology and the AdMaS Center was pre-arranged. In addition, the business trip focused on visits to construction material factories.
- In October 2018, the AdMaS Center succeeded in the CAMEB project, part of the National Competence Center for Applied Research, Experimental Development and Innovation, which aims to promote long-term collaboration between the research and application spheres and strengthen the institutional base of applied research. The motivation for the creation of the CAMEB center is the decline, resp. the reduction of non-renewable natural resources, both material and energy, and the impact of this phenomenon on construction. The current trend of massive energy savings in building operations brings significant improvements in operating energy, but the material and energy intensity of construction is so steep. CAMEB therefore associates partners with such competencies that will enable better use of resources in the construction industry in the spirit of circular economy principles, particularly in the areas of materials, structures, indoor environment and energy and water management. These areas will be supported by modern technologies in the field of digitization, optimization, modeling and efficient process management. The project partners are Czech Technical University in Prague, Technical University of Liberec, Mendel University in Brno and 26 companies from the private sector.
- As in previous years, this year the AdMaS Center took part in the great Scientists' Night, held on 5 October 2018. This time, two cars were in operation, which transported children and their parents from the Faculty of Civil Engineering on Veveří Street to our center in Medlánky and back. We were happy to welcome up to 250 visitors of all ages in our premises.
- Representatives of the AdMaS Center, headed by the Director, participated in the Road Conference in Ostrava from 17 to 18 October 2018, where they presented research and activities of the AdMaS Center and the FCE as a whole. During the conference, Česká silniční společnost awarded the FCE graduate, Ing. Pavel Coufalík, Ph.D., who received a diploma for the 1st place in the dissertation competition 2018 for his work Rheological properties of

asphalt binders, for which the devices and equipment of the AdMaS center were used.

- On October 26, 2018 a delegation from Slovenian Turvac visited the AdMaS Center. Turvac is one of the leading manufacturers of super-insulating materials for use in construction and industry. As part of this visit, a tour of the premises and research equipment of the AdMaS center took place and cooperation between Turvac and the AdMaS Center in 2019 was arranged.
- On 28 and 29 November 2018, the RG MBM staff, in collaboration with the scientific and technological company WTA CZ, organized the 40th annual Conference on Remediation and Reconstruction of Buildings 2018. During the conference, representatives of WTA CZ and other leading domestic experts spoke about the topics. The conference also included the awarding of major diploma and doctoral theses in the field of remediation and reconstruction of buildings and the expert section of the Quality Council of the Czech Republic "Quality in Industry and Construction" of the Ministry of Industry and Trade. The conference also hosted a conference with international participation under the title 20th CRRB - Conference on Rehabilitation and Reconstruction of Buildings.
- On Thursday, November 8, 2018, the Minister of Agriculture, Ing. Miroslav Toman, CSc., visited the Center. Visitors attended a meeting with the staff of the center, checked presentations on the structure of the center, future and current projects on the management of rain and gray waters, forest fires and peat bogs, risk analysis of drinking water supply systems, passport of building and technical condition of pumping stations and pipelines for irrigation and discussed other drought-related projects.
- On 10 and 13 November 2018 prof. Jan Kudrna and Ing. Pavel Šperka visited laboratory of CONSULTEST AG in Ohringen, Switzerland. During the visit there were discussions about research projects solved in the road laboratory of the AdMaS center. The discussion was followed by a tour of the laboratory and an excursion of the FBB mixing plant in Hinwil, which is one of the most modern in Switzerland.
- On Thursday, November 22, 2018, employees of the MBM Research Group of the AdMaS Center performed verification of developed materials for sprayed concrete directly in real conditions of construction in Prague.
- FCE student, Ing. Lukáš Novák, under the supervision of the AdMaS Center Scientific Director, prof. Ing. Drahomír Novák, DrSc., won the Ph.D. talent 2018 with work on theme "Highly Efficient Reliability Analysis (HERA)".The project is focused on the development of reliable methods applicable in practical applications.

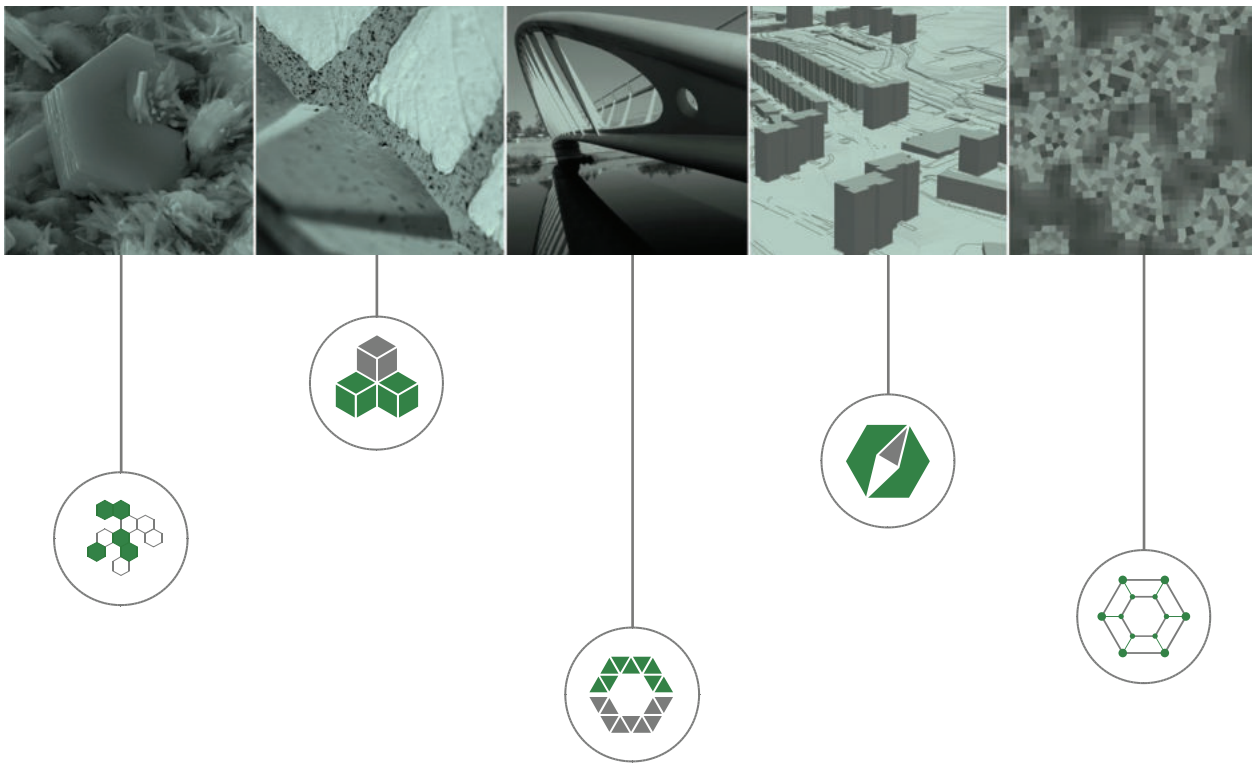
Further details of the sub-activities are given below for individual RPs.



4. Mobility of researchers and the cooperation with foreign countries

In 2018, the AdMaS Center intensified the mobility of its staff abroad under the Human Resources Policy. The aim was to further increase the number of workers from foreign universities to the AdMaS Center. This contributed to the creation of new partnerships and new areas of international cooperation (for example, TU Vienna, Vilnius Gediminas Technical University, Bauhaus University Weimar, Faculty of Civil Engineering Košice, Universität Rostock, Germany, University of Belgrade, University of Malta, PTFE Technology Platform, Cracow University of Technology, Leuven University, University of Minnesota, Hohai University, China, etc).

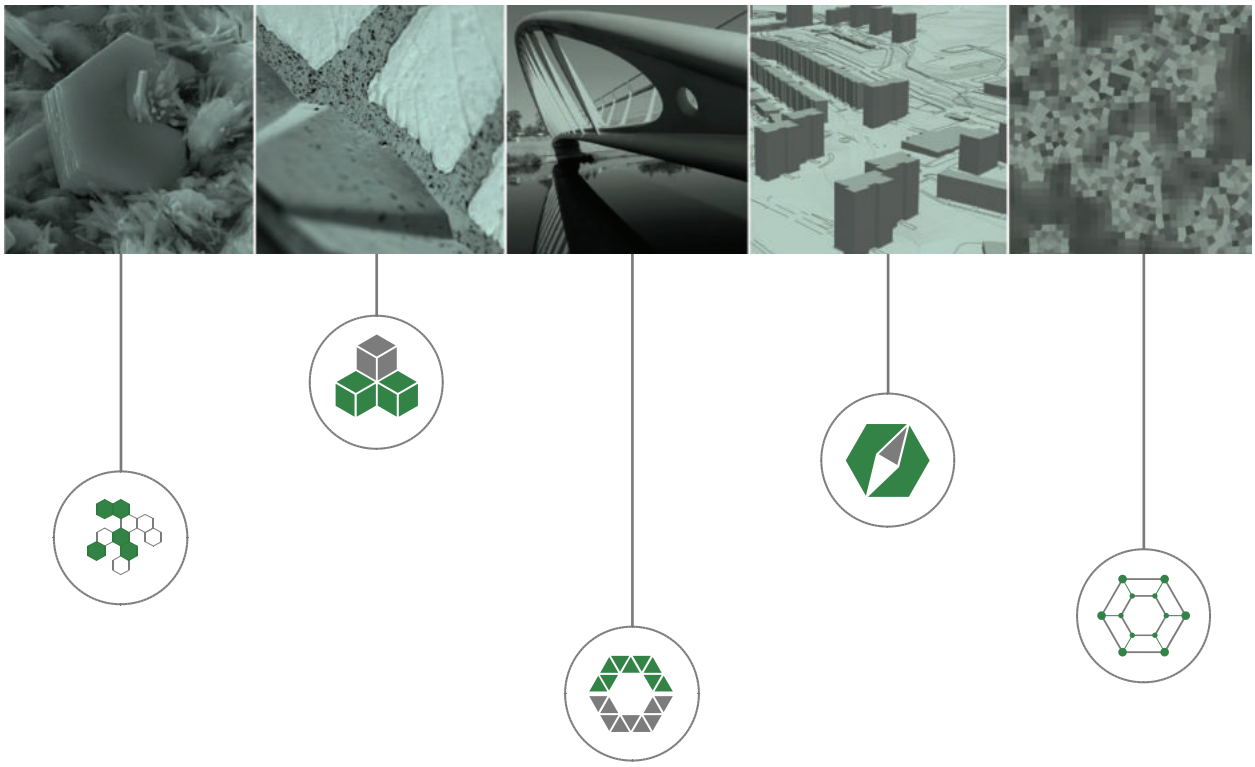
Details and examples of mobility for each RP are specified below.



5. Mobility of researches toward the application sphere

The researchers' mobility towards the application sphere continued throughout the year. In most cases, these were one-day trips to carry out partial experiments, measurements, training, consultations, etc.

Further data and examples of mobility for each RP are specified below.



6. Achievement of monitoring indicators and leading indicators for 2018

In 2018, most of the planned values of the monitoring indicators were fulfilled and in some cases the annual planned values were significantly overfulfilled.

The fulfillment of the monitoring indicators was as follows:

Tab. 1: Personal MI

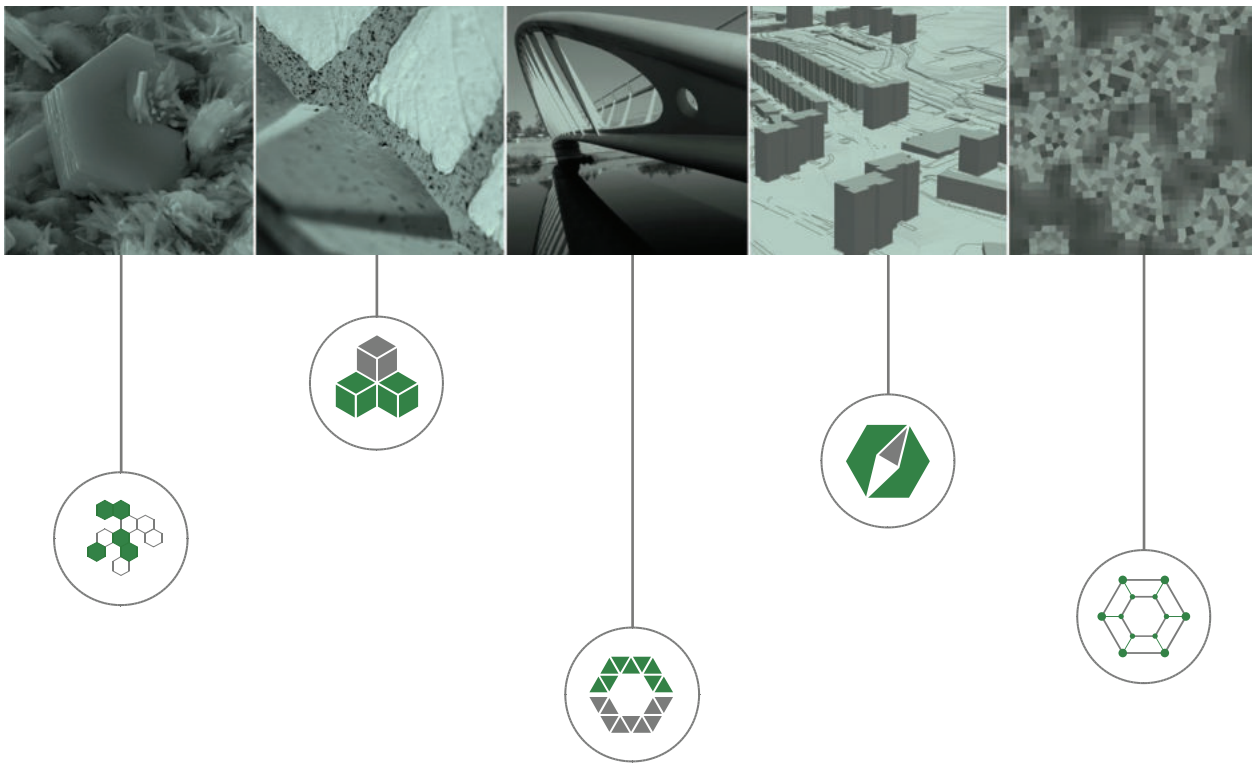
Indicator code	Indicator	2017	
		plan	reality
110815	Number of students of all grades who use the built infrastructure / involved in the Centre activities	91	311
110300	Number of newly created working places, R & D employees	95.9	120.5
110302	Number of newly created working places, R & D employees - women	28.8	30.9
071700	Number of newly created working places, researchers total	71.8	93.5
071800	Number of newly created working places, researchers - women	21.5	20.5
071900	Number of newly created working places, researchers under 35 years old	34.3	55.1
072000	Number of newly created working places, researchers under 35 years old - women	10.3	9.68
074901	Number of successful graduates of master's degree programs	63	169
074902	Number of successful graduates of doctoral study programs	12	16

Tab. 2: R&D outputs

Indicator code	Indicator	2017	
		plan	reality
110502	Publications (impacted journals) (Jimp)	4	29
	Publications (other)	43	64
	Scientific publications total	47	93
110503	Patents (national)	1	0
	Patents (international, triadic (EU, US, Japan))	0	0
	Results of research protected under a special legal regulation 1	1	0
110504	Pilot, certified technology, variety ... (Z, T)	10	0
	Prototype, methodology, useful and average pattern .... (S)	27	9
	Applied research results 1	37	9

Tab. 3: Financial MI

Indicator code	Indicator	2017	
		plan	reality
111200	Contract research volume	21000	23683
111300	Volume of R & D funds obtained from foreign sources	10700	4148
110720	Number of cooperation projects of application sphere with regional R & D centres	18	24
0603	Amount of funds received in the public tender for targeted support for R & D of national sources	43763	80186



7. Research activities at the Centre

7.1. Research programme RP1: Development of advanced building

7.1.1. Activities of Research Groups in the area of management

The achievement of the aims of Research Programme RP1: Development of Advanced Building Materials took place completely in accordance with the specialized focus and expected goals described in the TA for the year 2018.

As part of the planning and coordination of research activities in 2018, quarterly meetings took place with the participation of the Head of RP1 and the Heads (or their representatives) of the Research Group Microstructure of Building Materials (RG MBM) and the Research Group Technology of Building Materials (RG TBM). The meetings featured a concise presentation of current activities from the perspective of the acquisition of financial means from public funds (coordination of the preparation of projects in response to calls currently announced by the Czech Science Foundation, the TACR, the Ministry of Industry and Trade, etc.), as well as with regard to contract research projects with industrial partners, and other information connected with present needs.

7.1.2. Trainings and seminars

- On 9 and 10 January 2018 and 14 and 15 March 2018, ČEZ a.s. staff underwent laboratory training via a basic preparatory course which entailed 14 hours of tuition, most of which took place in laboratories. During the course, issues related to the design, preparation and quality control of fresh and hardened concrete were presented. Destructive and non-destructive tests for use with fresh and hardened concrete were presented and then tried out in practice. Attention was paid to the inspection and remediation of concrete structures at nuclear power stations, the surface finishes of materials, and the pore structure and inner structure of materials. Another part of the course involved an introduction to the latest laboratory methods for the evaluation of construction materials. Time was also spent on the theoretical background to X-ray diffraction analysis, scanning electron microscopy and computed tomography.
- On 31 January and 1. February 2018 SŽDC staff underwent training concerning the checking and testing of the properties of concrete. The participants witnessed presentations of the latest knowledge regarding modern technologies used with ordinary concrete, and were provided with information concerning concrete components and special kinds of concrete whose application brings advantages under specific conditions. The programme also included an evaluation of the parameters of concrete in accordance with the requirements of pertinent standards and government regulations. Issues concerned with the testing of the properties of fresh and hardened concretes were analysed in detail, which included detailed practical demonstrations of individual tests.
- On 27 February 2018 was held training of employees from the company BEST a.s. concerning the inspection and testing of concrete products. Requirements were presented concerning the parameters of concrete products such as concrete paving slabs, kerbstones, masonry elements, and the sewerage programme. A description of the test procedures for individual products was included, together with the required evaluation. The majority of the test procedures were also demonstrated in the laboratory.
- On 19 June 2018 the AdMaS Centre staff, led by Prof. Ing. Rostislav Drochytka CSc., MBA, held the 5th WTA Colloquium - Remediation of Concrete Structures. The colloquium was organized

by BUT, together with WTA International and SSBK (the Concrete Structures Repair Association). The colloquium acquainted the participants with the latest findings in the area of the remediation of concrete structures, while simultaneously providing the opportunity to make new contacts among renowned specialists both from the Czech Republic and abroad.

7.1.3. Research staff mobility and cooperation with institutions abroad

- In 2018, three employees from the CTU in Prague took part in activities performed within the context of RP1 at the AdMaS Centre. Specifically, these were Ing. Pavel Reiterman, Ph.D. (Experimental Centre, in the period from 1.6. - 30.6.2018), Assoc. Prof. Ing. Tomáš Klečka, CSc. (Klokner Institute, from 1.6. - 31.8.2018) and Ing. Radka Pernicová, Ph.D. (Klokner Institute, from 1.6. - 31.8.2018). The employees investigated subsidiary research tasks in the area of high-strength silicate composites, the resistance of silicate composites to the effect of high temperatures and, last but not least, issues connected with the verification of various types of admixtures in lime-metakaolin mortars.
- In 2018, RP1 further intensified its activities with regard to staff mobility abroad, while visits by staff from foreign universities to the AdMaS Centre also increased. This fact contributed to the creation of new partnerships and new areas of international cooperation (for example with TU Wien, Bauhaus University Weimar, the Faculty of Civil Engineering in Košice, Universität Rostock, Germany, the University of Belgrade, the University of Malta, and others.) Specifically, framework agreements were signed concerning cooperation with the University of Malta and Hochschule Wismar.
- In the period from 1.2. till 30.6.2018, a Master´s student from University KU Leuven (Belgium), Damien Guldentops, also took part in the research activities of the AdMaS Centre. The results of his stay included a Diploma thesis with the title "Development of cement composite mixture for improved earthing". At the end of his stay, he presented his work successfully before a committee of experts and in the presence of an external opponent.

7.1.4. Research staff mobility: collaboration with industry partners

In 2018, close cooperation took place with many companies from the construction industry, including manufacturers of building materials and construction firms.

- One of main mobility projects in the industrial sphere saw the engagement of Prof. Ing. Rostislav Drochytka CSc., MBA at the company Hradecký písek a.s. from 1 June till 30 September 2018. He was involved in particular in the preparation and testing of mechanically and chemically resistant composites based on cement and non-cement binders and secondary raw materials. He took part in the optimization of recipes as well as test procedures related to the use of composites in real conditions. He also verified subsidiary research results on real structures.
- Ing. Jakub Hodul also underwent an internship in Hradecký písek a.s. in the period from 23 April till 20 July 2018, when he was involved in the preparation and testing of high-resistance cement-free composites utilizing secondary raw materials. He took part in the optimization of recipes, test procedures related to the use of composites in real conditions, and the verification of subsidiary results on real structures.
- Last but not least, Ing. Jindřich Melichar´s internship at KOMFORT, a.s. from 16 March till 15

June 2018 should be mentioned. He participated in the preparation of high-resistance silicate composites for floor structures utilizing secondary raw materials. He was involved in the adaptation of raw material compositions, the optimization of the technical process and the testing of final structures.

As regards other mobility, visits by RP1 researchers to companies active in the construction industry took place throughout the year. In the majority of cases, these were one- to three-day trips for the purpose of carrying out experiments or measurements, training, consultation, etc.

7.1.5. Research activities of the RG 1

The achievement of the aims of Research Programme RP1: Development of Advanced Building Materials took place completely in accordance with the specialized focus and expected goals described in the TA for the year 2018:

- Researchers dealt with such issues as the influence of the maturing time of Portland cement on its properties, the hydration of ternesite clinker, proving the effect of adding plaster on selected properties of lime-metakaolin mortars, the effect of the firing process on lime crystallinity, the influence of milling intensifiers on the pozzolanic activity of glass, the effect of the milling process on the granulometric properties of triclinic alite, and e.g. the evaluation of the effect of crystallization admixtures on the long-term durability of cement composites.
- In the area of mortars and plasters, researchers were involved in for instance the development of advanced plasters for the insulation and reconstruction of buildings with regard to their hygrothermal behaviour, along with light mortars containing a high quantity of alternative raw materials with increased thermal resistance, the monitoring of the long-term durability and microstructure of polymer-based reprofiling materials with a high content of secondary raw materials using advanced methods, the investigation of patching composites utilizing hazardous waste containing heavy metals, etc.
- As far as concrete technology issues are concerned, one of the key activities of the TBM Group in particular was the performance of research into the use of non-traditional fibres for the production of light concretes, the effect of alkalinity and the temperature of the environment on the long-term properties of GFRP reinforcement, the influence of CNT on the frost resistance of concrete, and the properties of light concretes with recycled glass-based aggregate. They also gave attention to the development of light concrete utilizing foam glass-based aggregate.
- Other interesting topics which were investigated as part of the research and development activities conducted for RP 1 included the re-use of soil from excavation work in a stabilized and liquefied form, the use of undersize fractions of claystone for refractory grog manufacturing in shaft kilns, the development of special grouting material with a high content of fly ash contaminated by the effects of flue gas denitrification for the anchoring of steel elements, the influence of raw material mixture composition on the properties of forsterite ceramics, the synthesis of the structure of tobermorite with non-traditional composites of silicon dioxide, the study of the hydrophobization treatment of ceramic elements, the influence of raw material composition on the synthesis of forsterite, and e.g. the deposition of hydroxyapatite and tricalcium phosphate coatings by suspension plasma spraying.

In 2018, several specific research projects were implemented in which Ph.D. and Master´s students were heavily involved. As regards areas concerning the use of secondary raw materials,

these include A study of the structure of advanced silicate composites, which is being investigated in cooperation with the Faculty of Chemistry at BUT. Furthermore, projects are under way that focus on the impact of SNCR on the quality of high-temperature fly ash, and their use as admixtures for cement composites, the study of the structure of advanced silicate composites with an emphasis on the characteristics of the effect of secondary raw materials, the study of the effect of the application of graphenoids and carbon nanotubes in cement composites, the use of soils from excavation work and the possibility of their treatment via liquefaction, the verification of various types of silicate raw materials for the synthesis of tobermorite in calcium silicate composites, and for instance the development of a high-resistance patching composite made from melted basalt utilizing secondary raw materials for use in structural reconstruction work.

Staff in the physical part of the programme investigated the application of acoustic emission methods and methods of influencing structural rehabilitation, along with conducting the evaluation of the mechanical properties of thermally loaded composite materials utilizing a high-frequency electric field, the analysis of concrete thermally degraded at high temperatures using nonlinear characteristics and e.g. the classification of cracks recorded using the acoustic emission method during the cyclic loading of a concrete beam.

Examples of significant R & D outputs:

RP1 staff members constantly and actively publish the programme's achieved results at significant scientific conferences and in prestigious international journals, by which they present not only the latest findings from the area of research and development but also the AdMaS Centre itself. Their activity in this area also includes the gaining of new contacts for future cooperation in the area of R&D, as well as individual contracts. The achieved results are also registered in the form of functional samples, verified technologies, etc., and may be legally protected via utility models and patents. It is not only important research workers in senior researcher positions that are significantly involved in the activities of the research groups, but also (and indeed mainly) young people in junior researcher positions who additionally cooperate closely with Bachelor´s, Master´s and Ph.D. students and pass on their experience to them.

As far as significant RP1 outputs are concerned, a patent was granted - CZ307408B6 "Cement composite with a polymer additive".

Basic research primarily entailed the investigation of Czech Science Foundation projects such as:

- **GA16-25472S** - Dynamics of the degradation of cement composites modified by secondary crystallization
- **GA17-00243S** – A study of the behaviour of insulation materials under extremely lowered pressure
- **GA17-14198S** – Kinetics of silicate microstructure formation in relation to hydrothermal conditions and type of input raw materials
- **GA17-24954S** – Conditions for the thermodynamic stability and transformation of AFt phases
- **GA18-25035S** – A study of the effects of flowing fluids on the erosive wear of cement composites, and the subsequent modelling of mechanical corrosion
- **GA18-02815S** - Elimination of sulphur dioxide emissions during the firing of ceramic body manufactured using power plant fly ash

Information on the use of purchased equipment:

Within the project, effective use was made of key laboratory instrumentation such as an X-ray CT scanner, an XRD system with Rietveld refinement, high-temperature chambers and SAXS, an REM with an environmental probe and 3D imaging, and QSUN and QUV chambers with simulated aggressive gases or salt mist.

SEM was used for the analysis of:

- the structure of materials based on hydrothermal CSH phases (Ministry of Industry and Trade, FV10284),
- phase transformations of CaSO4 during the production of alpha plaster in acid solutions,
- the influence of the genesis and type of limestone on the size and shape of lime and hydrate crystals, and the production process,
- the effect of the synthesis of pure silicate phases on their properties,
- the thermodynamic stability of ettringite and thaumasite,
- the burning and kinetics of the creation of ternesite,
- hydration processes in ternesite clinkers,
- the development of historical binders for historical mortar and plaster,
- anhydrite binders,
- the ratio of tridymite to cristobalite in silica refractories monitored during burning
- the effect of crystallization admixtures on the structure of cement composite (GA16-25472S),
- corrosion products which appeared within the body of the Libeň bridge (SR12745016L),
- Various research endeavours executed for the preparation of Bachelor´s and Master's theses in the area of high-performance cement composites, the use of secondary raw materials in building materials, the development of polymer materials, porous concrete products, etc.

XRD was used not only for the above-mentioned Czech Science Foundation projects but also for research in areas such as:

- the thermodynamic stability of ettringite-based AFT phases (dissertation – Jana Moura),
- the thermodynamic stability of thaumasite-based AFT phases (Master's thesis – Aneta Ďurtová),
- research into the reactivity of lime produced via desulphation (dissertation - Dolák, Sklenářová),
- research into the development of CaO crystallites during limestone burning,
- the influence of the genesis and type of limestone on the properties of lime and hydrates, and the production process,
- the development of new methods to improve the grindability of samples,
- the effect of the synthesis of pure silicate phases on their properties,
- study of the formation of polymorphs of alite (dissertation thesis - Ravaszová),
- research into alpha plaster using the pressureless method (Bachelor´s thesis - Zájeda),
- the thermodynamic stability of ettringite and thaumasite (GA 17-24954S),
- hydration processes in ternesite clinkers (GA 17-24954S),

- study of refactories, Mulitu (TH02020321),
- the development of historical binders for historical mortar and plaster,
- anhydrite binders,
- study of the effect of raw materials on the contents of tobermorite (Ministry of Industry and Trade, FV10284),
- analysis of the level of crystallization of added crystallization admixture for concrete (GA16-25472S),
- observation of burning in order to monitor the ratio of tridymite to cristobalite in silica refractories,
- study of clay materials (dissertation thesis - Nguyen),
- mineralogical analysis of a set of fly ashes (dissertation thesis - Ťažký),
- measurements conducted during Bachelor's and Master's thesis research concerning the use of fly ashes and epoxides, the preparation of agloporites, etc.,
- study and characterization of corrosion products which appeared within the body of the Libeň bridge (SR12745016L),
- analysis of by-products from the production of cement-bonded particleboards and other potentially suitable alternative sources for the substitution of composite binder with cement matrix and organic filler (Diploma thesis - Dobrovolná, Urbánek, Ministry of Industry and Trade, TRIO, FV30072).

X-ray CT scanner was used in 2018 for sample analysis in connection with:

- the layers of a silicate-based floor system,
- the fracture failure of cement bonded particleboards,
- concrete samples treated with a water beam,
- anchoring materials in a concrete base,
- surface characteristics of reinforcement in concrete,
- the direct connection of original and new concrete without the use of an adhesive bridge,
- technology for the cold rolling of anchors for the construction industry,
- in cooperation with VSB, research was performed into the effects of wolfram sub-calibre ammunition during the penetration of steel armour plating,
- in cooperation with CEITEC, components such as rangefinders, turbine blades, filters and retaining systems for cars, connectors, electric coils, etc.

WUV and QSUN devices were used in the following way:

- the QUV was used to simulate the accelerated degradation of newly developed surface finishes on segments of garage doors manufactured by KRUŽÍK, s.r.o. during the implementation of project CZ.01.1.02/0.0/0.0/17_205/0014381. As part of this project, a unique method of achieving accelerated degradation was designed. It utilises (among other things) a QUV chamber when it is necessary to verify the real durability of surface finishes applied by digital printing over a period of about 10-12 years during laboratory exposure lasting approximately 1 year. The QUV chamber enabled the simulation and monitoring of the influence of a combination of increased temperatures, UV radiation (specifically the UVA-340 type, i.e. with a wavelength of 340 nm; exposure at a temperature of 60 °C) and condensed moisture (at a temperature of 50 °C) on changes in the properties of surface

finishes applied directly to galvanized steel sheets which see real world use in the production of garage door segments connected with a joint). The listed conditions were alternated cyclically. Furthermore, polyvinyl chloride and thermoplastic olefin-based polymer foils used as the final layer of roof coverings for flat roofs were also exposed to the same conditions,

- additionally, test specimens fabricated from vibropressed concrete and treated with surface finishes (varnishes based on polyurethane dispersion and acrylates) were also subjected to UV radiation. Among other things, the effect of QUV exposure on changes in the properties of vibropressed paving slabs was monitored - resistance to chemical de-icing agents, absorption, the occurrence of efflorescence, etc. In the Q-SUN chamber, exposure to radiation from TUV-type xenon lamps (i.e. with a wavelength of 300-400 nm) took place. This chamber also enables exposure to adverse light conditions on almost all surfaces (e.g. with a focus on edges, which can be a more problematic part),
- in the Q-SUN chamber, polyvinyl chloride and thermoplastic polyolefin-based polymer foils used as a final layer of roof covering for flat roofs underwent exposure,
- samples representing a plastic tank (for windscreen washer fluid) used in buses were also exposed to conditions in the Q-SUN chamber. As part of contract research with the company SYNPO a.s., the irradiation of samples of the plastic tank was tested under defined conditions (according to the IVECO 16-0180 Standard), which involved continuous irradiation over a period of 2500 hours with a radiation intensity of 0.35 W/m2 and an insulated black body temperature of 65 °C (chamber temperature 40 °C). Before the start and also during adverse exposure (both in the AUV and Q-SUN chambers), differences in colour parameters (CIELAB colour space) were monitored and evaluated using a CMD-600D spectrophotometer; the parameter ΔCMCwas used for the monitoring of changes.

HK 800/M/WTG corrosion chambers were used mainly for the following activities:

- an HD 800/M/WTG corrosion chamber enabling the simulation of an environment containing aggressive gases was used for e.g. investigations connected with project GA16-25472S - Dynamics of the degradation of cement composites modified with secondary crystallization. Emphasis was specifically placed on the achievement of an environment in accordance with the provisions defined in the ČSN EN ISO 3231 technical standard, which describes a procedure for the verification of resistance to exposure in humid atmospheres containing sulphur dioxide. This is a relatively aggressive gas whose effects are potentiated by higher temperature and humidity, resulting in very hostile conditions that will significantly speed up the degradation of tested specimens,
- newly developed surface finishes applied to segments of garage doors by digital printing were also tested in the way described above (CZ.01.1.02/0.0/0.0/17_205/0014381, KRUŽÍK, s.r.o.) at the highest concentration stated in the quoted standard, i.e. 2.7 l of gas (within a space with a volume of approx. 0.8 m3). The flat segments subjected to this exposure were evaluated continuously during the test (via the observation of changes in hue using a spectrophotometer, and the taking of photographs in the "macro" mode), and also after the end of the required number of cycles (testing of adhesion to the base, thickness, resistance to the separation of the surface finish from the base, etc.),
- the chambers were also used to conduct the Kesternich test of corrosion resistance on anchoring elements suitable for use in concrete and TR sheet metal according to the working procedure laid down in ČSN EN ISO 6988,
- one of the HK 800/M/WTG corrosion chambers was also used for the simulation of salt fog

in accordance with ČSN EN ISO 11997-1, 2. Digital print-based surface finishes (CZ.01.1.02/0.0/0.0/17_205/0014381, KRUŽÍK, s.r.o.) were exposed to this adverse environment. Cyclic exposure to a sprayed solution (salt fog) containing an increased concentration of NaCl and (NH4)2SO4 ions took place with simultaneous exposure to increased temperature (35 °C) and an accumulation speed of 2 ml/h. The following phase involved an environment with a relative humidity of 100% and a temperature of 40 °C, and a subsequent drying stage at a relative humidity of 50% and a temperature of 23°C. The samples subjected to this exposure were evaluated both continuously (via the observation of hue changes using a spectrophotometer and the taking of photographs in the "macro" mode) and after the end of the required number of cycles (testing of adhesion to the base, thickness, resistance against separation of the surface finish from the base, etc.).

RP1's mobile laboratory was used for trips to perform measurements and take samples. These were mainly visits to production plants and specific sites where project-related activities were being carried out. Specifically, these trips involved the following types of work:

- the taking of samples from boreholes with diameters of 75, 100 and 150 mm drilled into vibropressed and cast products for street drain inlets, sumps, water shafts, shaft bases, gullies, manhole covers, cones and grade rings with inner diameters of 250, 500 and 1000 mm, etc. Laboratory tests were performed on the borehole cores: compressive strength, bulk density and resistance to type C chemical de-icing agents were determined. The whole products were subsequently subjected to subsidiary tests such as the determination of reinforcement cover layer thickness, absorptivity, the vertical and horizontal load-bearing capacity of steps, peak load-bearing capacity, and so on, which then resulted in the optimization of recipes,
- the taking of aggregate samples (mined, crushed) for which grain size was determined using sieve analysis, as well as grain bulk density, absorptivity after 24 hours, shape index determination, sand equivalent value determination, bulk weight, void content, resistance against freezing and thawing, compressive strength, the bulk weight of loosely poured and shaken aggregate, and the quantity of washoff particles. In the case of limestone samples: evaluation of fine particles via the methylene blue test, determination of the bulk weight of loosely poured and shaken aggregate, of the quantity of washoff particles, of lightweight polluting substances, the potential presence of humus, and of granulometry,
- in-situ testing of fresh concrete, including air content, consistency (by slump test), the density of fresh concrete, shrinkage of fresh concrete, and the preparation of laboratory samples on which physicomechanical tests were subsequently performed to determine the following: compressive strength, flexural tensile strength, the depth of penetration of water under pressure, resistance to chemical de-icing agents, absorptivity, the characteristics of air pores,
- the production of test specimens (cylinders, prisms, cubes): the specimens were subsequently subjected to frost resistance tests and the density of hardened concrete was determined, as well as the tensile and flexural strength, compressive strength, resistance to chemical de-icing agents, the depth of penetration of water under pressure, absorptivity, humidity, static modulus of elasticity, watertightness, spacing factor, and shrinkage,
- the taking of samples for the testing of small concrete products such as: flat paving slabs, interlocking pavement, road and pavement curbs, slope blocks, lost formwork, coping stones and grassing blocks. Subsequently, flexural, transverse tensile and compressive strength were determined for them, along with abrasion resistance (Böhme), resistance

against type A and C chemical de-icing agents, and absorptivity. The slip resistance properties of the surface were measured via the pendulum test, and adhesion tests, tear tests, and qualitative tests of dimensional tolerance and flatness were performed, alongside the determination of the slip resistance of slabs made from natural stone, and also densities, the strength of sidewalls in flexure,

- the taking of aggregate samples manufactured by the company Tech Trading with the brand name Liapor, and the determination of their basic parameters, followed by further testing of their suitability for use in light concretes, focusing on factors such as absorptivity, bulk density and compressive strength,
- the execution of preliminary, main and supplementary engineering surveys in the field: tearing tests, semi-destructive strength testing, the durability analysis of structures, crack widths, the evaluation of surface hardness using a Schmidt hardness tester, the detection of the occurrence of reinforcement corrosion, and its analysis, the design of remedial measures, and the testing of the adhesion of the surface finishes of built structures to the base,
- inspection testing of fresh concrete during the concreting of a motorway: determination of consistency via slump test, air content and the density of fresh concrete, the taking of samples for further laboratory testing of physicomechanical properties such as compressive, tensile and flexural strength, the depth of penetration of water under pressure, resistance against chemical de-icing agents,
- investigation of anhydrite floor durability, testing of relative deformation and the slip resistance of the surface, measurement of humidity.

Major R & D projects with application sphere and other activities:

Cooperation with partners in projects supported by the Ministry of Industry and Trade (MPO), the Technology Agency of the Czech Republic (TAČR) and the Czech Science Foundation (GAČR), as well as with partners in the execution of contract research, was excellent, with the activities of the individual cooperating organizations complementing one another effectively. This involved collaboration with producers of raw materials, manufacturers of materials and parts, organizations planning to apply for research funding in the future, and other research organizations.

The following specific cases can be named as examples:

- cooperation with BETOSAN s.r.o. during the investigation of project MPO FV20149 - A comprehensive system for the remediation of chemically attacked and stressed structures. Within this cooperation, the development activities of BUT are synergically connected with the production/development potential of BETOSAN,
- cooperation with PORFIX CZ a.s. on a Ministry of Industry and Trade project, TRIO FV10284 - Advanced technology for the production of sand-based porous concrete with added secondary raw materials and more efficient utilisation of natural resources. The many years of practical experience of the porous concrete manufacturer PORFIX, CZ a.s. provide ideal support for the development of materials using new sources of raw materials at BUT,
- cooperation with the company KOMFORT, a.s. on Ministry of Industry and Trade project MPO TRIO FV10118 – Progressive waste-free technology for the re-usability of soil in the form of self-compacting grouts; the project combines research findings from BUT and industry partners, here represented by KOMFORT a.s.,
- cooperation with the company Redrock Construction s.r.o. on the project MPO TRIO FV20303 - Progressive polymer materials utilizing secondary raw materials and dangerous

waste for use in chemically highly aggressive environments. Again, it involves the optimum connection of the high research potential of BUT with the production/development activities of a company with broad experience in the application of its own product under real conditions,

- cooperation with the company Prefa Brno a.s. on the project MPO FV10680 - Development of prefabricated components made from HWC and HPC for special applications in precision engineering and radiation protection. Prefa Brno a.s. has been a BUT partner for many years, both in the area of research and development and in the testing of its own products,
- cooperation with REFAGLASS s.r.o. on the project MPO FV20086 - Development of lightweight modern building materials utilizing light glass powder-based aggregate,
- cooperation with Retex a.s. in the development of new thermal and acoustic insulation materials based on waste textile fibres as part of the project MPO FVFV10078 - Research and development of advanced thermal and acoustic insulation materials based on waste textiles and natural fibres.

In 2018, new cooperation began not only in the execution of basic and applied research, but also within the framework of contract research. The newly-started projects include:

- **MPO TRIO FV30325** - Application of laser and radar road measurements in the diagnostic analysis of the cement-concrete covers of motorways, with the implementation of physical and chemical analyses of concretes in order to limit the degradation processes of concretes which lower the lifespan of highway pavements. The project was conducted with the company CONSULTEST s.r.o.,
- **MPO TRIO FV30072** - Effective optimization of the use of waste from the production of cement-bonded particleboards in the production of competitive building materials; project investigated in collaboration with CIDEM Hranice, a.s.,
- **MPO TRIO FV30327** - Progressive waste-free technology for high performance porous concrete utilizing renewable resources; project conducted in collaboration with PORFIX, CZ a.s.,
- **TACR EPSILO TH03020072** - Development of high-performance porous concrete resistant to the chemically aggressive environments of special agricultural structures. The project was investigated in collaboration with ZAPA beton a.s.,
- **Czech Science Foundation GA18-25035S** – A study of the effects of flowing fluids on the erosive wear of cement composites, and the subsequent modelling of mechanical corrosion,
- **Czech Science Foundation GA18-02815S** - Elimination of sulphur dioxide emissions during the firing of ceramic body manufactured using power plant fly ash,

Fig. 1 Test of the corrosion resistance of anchoring elements

Fig. 2 Photo of a polystyrene concrete sample after the bearing strength of the filling of the reinforced concrete panel was tested (in cooperation with the company 3isolet)

Fig. 3 Photo of samples of textile insulation with hydrophobization in a chamber providing a controlled atmosphere (development of new materials with the company Retex)

Activities of the Center in Sustainability - Examples of R&D Activities CZ.1.05 / 2.1.00 / 19.0406 for 2018

Fig. 4: Testing the fire resistance of a wall element structure of wooden construction with an integrated thermal insulating layer inside the element.

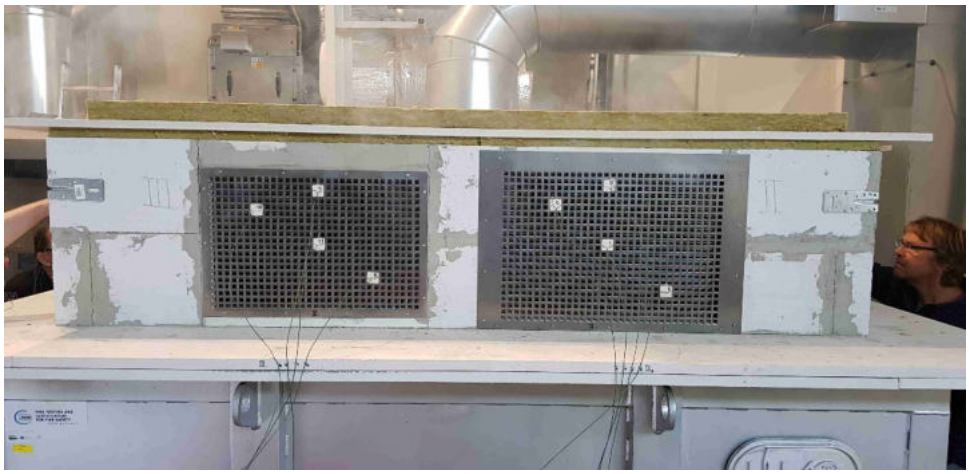


Fig. 5: Testing the fire resistance of fire ventilation grilles in which segments that expand during the increase of the temperature and prevent further spread of the flame through the ventilation grilles, are integrated.

Fig. 6: View of a wooden acoustic panel sample after the test, with an expanded fire coating on the surface

Fig. 7: Wooden acoustic panels prior to the test and during the test of determination of the reaction to fire, specifically with the action of a single burning object. Both pictures show test specimen mounted on a test rig truck that is loaded into a test chamber.

Fig. 8: A detailed view of specimens of cement-bonded chipboard after the test (left) and before the test (right) for determining the heat of combustion which is part of the fire performance classification tests.

Fig. 9: Samples of heat insulating material after testing the reaction to fire - flammability of construction products exposed to direct flame - small flame source.

Fig. 10: Testing of the fire resistance of the thermal insulator in a reinforced concrete slab and monitoring the temperature development inside the element for 120 minutes at high temperatures (up to 1100 ° C) - view of the stored sample during the test

Fig. 11: Test chamber for single burning item testing (SBI test)

7.2. Research programme RP2: Development of advanced structures and technologies

7.2.1. Activities of Research Groups in the area of management

Research Group STC (Structures and Traffic Constructions)

The members of Research Group RP2-RG1 Structures and Traffic Constructions act as the guarantors for individual areas of R&D. The individual research areas, divisions and guarantors are as follows in 2018:

Construction division
Diagnostic Analysis of Structures and Building Testing (SZK) - Věra Heřmánková, Ph.D.;
Concrete and Masonry Structures (BZK) - Ing. Ivana Laníková, Ph.D.;
Metal and Timber Structures (KDK) - Ing. Michal Štrba, Ph.D.;
Mathematical Modelling (MAT) - Prof. RNDr. Josef Diblík, DrSc.

Transport Structures division
Roads, Highway Engineering (PKO) - Ing. Pavla Nekulová;
Railway Engineering (ZEL) - Ing. Jaroslav Bílek.

Building Structures division
Building Construction (PST) - Ing. David Bečkovský, Ph.D.;
Technology, Mechanization and Construction Management (TST) - Ing. et Ing. Barbora Nečasová.

Operations and coordination meetings are led by the Head of the Research Group, Assoc. Prof. Ing. Pavel Schmid, Ph.D., with his deputies Ing. David Bečkovský, Ph.D. and Ing. Pavla Nekulová. This direct leadership variant with the aforementioned selected staff optimally covers the needs of all three of the above-mentioned divisions. The management of the group communicates with the teams of the listed guarantors, and wider management meetings also take place with the members of those teams. The guarantors and Deputy Heads are drawn from the RG's team of young researchers. They coordinate research activities for the Head of the RG within the context of their specialized and mainly interdisciplinary activities in the areas of basic, applied and contract research. The main aim of this leadership system is to make maximum use of the time and skills of younger employees with the goal of eliminating the need for colleagues in senior researcher positions to spend time doing paperwork.

Social events: Sports Day (May), Kite Flying (November)

Research Group EGAR

The previously created management structure of the EGAR Research Group did not change in 2018:

Head of RG - Prof. Ing. Petr Hlavínek, CSc. MBA

Deputy Heads of the RG - Assoc. Prof. Ing. Jaroslav Raclavský, Ph.D., Ing. Tomáš Chorazy, Ph.D.

The Heads of the individual sub-groups and scientific research areas which make up the EGAR Research Group are as follows:

Urban Engineering – Assoc. Prof. Ing. Jaroslav Raclavský, Ph.D.

Geoinformatics – Ing. Zdeněk Krejza, Ph.D.

Geotechnics – Assoc. Prof. Ing. Lumír Miča, Ph.D.
Energy Diagnostics of Buildings and Regions – Prof. Ing. Jiří Hirš, CSc.

A coordination meeting is organised once a month for all the heads of the applied scientific areas. At such meetings, the working activities of the EGAR research group and its individual sub-groups are discussed. The heads of the sub-groups organize working meetings as needed, but at least once a month.

Also in 2018, exceptional emphasis was placed on applications for national and international grant programmes. Apart from specific topics concerning individual applied areas, cross-disciplinary themes and comprehensive topics are sought.

As regards the promotion of the AdMaS Centre and the EGAR group, presentations are organised for selected partners from the construction industry, the operators of water management systems, waste handling companies, etc.

RG EGAR participates significantly in the holding of public events. In 2018, these included:

- An excursion for participants in a life-long learning course focusing on the "circular economy". The organizers of the course (the Faculty of Environmental Technology at UCT Prague, and its partners, INCIEN, z.ú, SUEZ Využití zdrojů, a.s. and the Czech Circular Economy Association) chose the AdMaS Centre with regard to its current activities in the investigated area and also to the technical and technological facilities of the centre.
- A workshop concerning mathematical modelling of the structure of the primary utility corridor at the Leitnerova - Hybešova site in Brno. This took place as part of the Knowledge Transfer Partnership project. The participants also made an excursion to the AdMaS Centre's geotechnical laboratory.
- Lectures for the public, e.g.
    - The quality of the interior environments of buildings in Ostrava and Brno at the beginning of the new millennium.
    - A presentation at the construction trade fair as part of the accompanying programme on Ventilation and Smart Regions (https://www.tzb-info.cz/stavebni-veletrhy-brno/17209-inspekce-nemovitosti-a-gdpr-pro-remeslniky-to-je-doprovodny-program-tzb-info-v-brne).
    - An exhibition stand at the Urbis trade fair.
- Urban Ecosystem Brno – workshop with a Dutch specialist in multi-criteria solutions for urban activities – presentation of smart regions as part of a pilot task.
- Training of energy specialists under the auspices of the Ministry of Industry and Trade of the Czech Republic.

Night of the Scientists. The 2018 Night of the Scientists offered demonstrations of, for example, unmanned vehicles, popular devices for the inspection of utilities, and a mobile mapping system.

The EGAR group uses shared data storage to archive documents related to its activities. Business strategy is created at the level of the individual sub-groups due to the diversity of their interests. The aim is to seek cross-disciplinary themes, which reappear again and again in (for example) the case of the Smart City topic when creating smart city concepts. The creation of business strategy is based on current market requirements, which are constantly monitored. This partly takes place in the form of papers and outputs from specialized conferences, which are

presented during the abovementioned meetings. Business strategy is adapted according to this up-to-date information. Business strategy information is submitted to the management of RG EGAR.

Research Group MM (Mathematical Modelling)

In 2018 the MM Research Group primarily concentrated on basic research, which is due to the large amount of projects from the Czech Science Foundation being conducted by the group. The management of the MM group remained the same in 2018, i.e. Prof. Ing. Drahomír Novák, DrSc., Prof. Ing. Zbyněk Keršner, CSc., Assoc. Prof. Ing. David Lehký, Ph.D., and Assoc. Prof. Ing. Jan Eliáš, Ph.D. The management of RG MM holds team coordination meetings which serve as a coordination platform both for the RG MM and for the MM division of the AdMaS UP project.

7.2.2. Training and seminars

Research Group STC (Structures and Traffic Constructions)

The RG's important activities in the area of training and the organization of seminars mainly include the following:

- The workshop "Evaluation of dynamic effects in railway points", on 12 July 2018, Brno. The event focused on "in-situ" measurements of dynamic effects, and their evaluation.
- The organization of specialized section No. 76 "Dynamical systems and their applications to advanced materials, structures and technologies" at the ICNAAM conference (International Conference on Numerical Analysis and Applied Mathematics), 14 contributions, Sheraton Hotel, Ixia, Rhodos, Greece, from 13 till 18 September 2018. The proceedings have been prepared for publishing in the AIP (American Institute of Physics) Conference Proceedings 2019.

Research Group EGAR

- Workshop: Mathematical modelling of the structure of the primary utility corridor at the Leitnerova - Hybešova site in Brno, on 30 May 2018

  The workshop presented the most recent results of the research project "Creation of a cooperative partnership between the company GEOtest and the regional AdMaS Centre" with the participation of the team of investigators, Technical Networks Brno and specialised professionals. The following topics were presented:
  - The design of a computational model for the investigated site
  - The definition of values for material parameters based on laboratory tests
  - Analysis of a tunnel lining weakened by the possible degradation of materials
- Workshop for the Intelligent Regions working group with representatives of the Austrian research organization FH Burgenland – Pinkafeld, on 18 July 2018.

Research Group MM (Mathematical Modelling)

In 2018 the RG MM didn't hold any training sessions or seminars. Even though several lectures were given by speakers from abroad, we didn't report them as seminars.

7.2.3. Research staff mobility and cooperation with institutions abroad

Research Group STC (Structures and Traffic Constructions)

Visits to institutions abroad:

- Assoc. Prof. Ing. Otto Plášek, Ph.D., educational visit through the ERASMUS+ programme, University of the Basque Country, Bilbao, Spain, 19. – 24. 3. 2018,
- Ing. Richard Svoboda, Ph.D., educational visit through the ERASMUS+ programme, Universidad Politécnica de Madrid, Madrid, Spain, 19. – 24. 3. 2018,
- Prof. RNDr. Josef Diblík, Dr.Sc.: 7.10.-10.10.2018, educational visit through the ERASMUS+ programme, University of Žilina, Faculty of Civil Engineering,
- Prof. RNDr. Josef Diblík, Dr.Sc.: 26.9.2018, educational visit through the ERASMUS+ programme, Slovak University of Technology, Bratislava, Faculty of Civil Engineering,
- Ing. David Bečkovský, Ph.D.: educational visit, Reykjavik University, Iceland, 22.4 – 28.4. 2018,
- Ing. Radim Kučera: educational visit, Reykjavik University, Iceland, 22.4 – 28.4. 2018,
- Ing. Petr Selnik: educational visit, Reykjavik University, Iceland, 22.4 – 28.4. 2018,
- Ing. David Bečkovský, Ph.D.: educational visit, Univerzita Ciudad Real, Spain, 26.11. - 29.11. 2018,
- Assoc. Prof. Ing. Jan Pěnčík, Ph.D.: educational visit, Univerzita Ciudad Real, Spain, 26.11. - 29.11. 2018,
- Oulu University of Applied Sciences Ltd - PaiBiRa - testing and analysis - Testing, analysis and structural/physical evaluation of local building materials of biological origin from the area of Oulu – Finland,
- Ing. Pavel Liška, Ph.D.: 2. - 8. 9. 2018, Technical University of Lisbon, Portugal
- Ing. Ondřej Anton, Ph.D.: University of Žilina, Faculty of Civil Engineering, 14. - 17. 5. 2018,
- Ing. Věra Heřmánková, Ph.D.: University of Žilina, Faculty of Civil Engineering, 14. - 17. 5. 2018.

Visits by foreign students to the AdMaS Centre:

- Tonje Lysø, Norwegian University of Science and Technology, 07 – 08/2018

Examples of cooperation with foreign research institutions and companies in 2018:

- Within the framework of the national technological platform "Interoperability of Railway Infrastructure", cooperation took place with our Spanish partners - The Spanish technological platform PTFE (the Spanish Railway Foundation, the Technical Secretariat of the Spanish Railways Technological Platform).
- Membership in the EURNEX network - preparation of projects within the Horizon2020 and Shift2Rail programmes.
- Open Calls (Open calls for non-members of Shift2Rail) 2018: two participations in the BUT Consortium with the projects S2R-OC-IPX-01-2018 "Vehicle Based Switching", coordinator University of Loughborough (not accepted for financing), and S2R-OC-IP3-01-2018 "InMODE4Rail", coordinator UNIFE (not accepted for financing, replacement project).

Research Group EGAR

- Visits to institutions abroad:

- Assoc. prof. RNDr. Mgr. Lukáš Krmíček, Ph.D.: University Centre in Svalbard (UNIS), Spitsbergen,
- Assoc. prof. RNDr. Mgr. Lukáš Krmíček, Ph.D.: University of the Faroe Islands,
- Assoc. prof. RNDr. Mgr. Lukáš Krmíček, Ph.D.: Universität Potsdam, Germany,
- Ing. Martin Závacký: Institute of Rock Mechanics and Tunnelling – Graz University of Technology, Austria,
- Ing. Miroslav Čekon, Ph.D.: University of Oulu, Faculty of Technology, Finland,
- Ing. Miroslav Čekon, Ph.D.: Žilinská univerzita v Žiline, Stavebná fakulta, Slovakia,
- Ing. Miroslav Čekon, Ph.D.: University of Coimbra, ITeCons, Portugal,
- Ing. Miroslav Čekon, Ph.D.: KU Leuven, Faculty of Architecture, Belgium,
- Ing. Karel Struhala: Uniwersytet Warmińsko-Mazurski w Olsztynie, Poland,
- Ing. Jakub Čurpek: KU Leuven, Faculty of Architecture, Belgium,
- Ing. Richard Slávik: TU Košice, Stavebná Fakulta, Slovakia,
- Ing. Richard Slávik: TU Dresden, Instituts für Bauklimatik, Germany,
- Ing. Richard Slávik: KU Leuven, KU Leuven, Faculty of Architecture, Belgium,
- Ing. Tomáš Fečer: NTNU Trondheim, Norwegian University of Science and technology, Norway,
- Assoc. prof. Ing. Tomáš Hanák, Ph.D.: University of Ljubljana, Slovenia,
- Assoc. prof. Tomáš Hanák, Ph.D.: Sopot University of Applied Sciences, Poland,
- Assoc. prof. Ing. Tomáš Hanák, Ph.D.: University of Split, Croatia,
- Assoc. prof. Ing. Tomáš Hanák, Ph.D.: University of Science and Technology, China,
- Assoc. prof. Jana Korytárová, Ph.D.: University of Science and Technology, China,
- Assoc. prof. Ing. Vít Hromádka: University of the West of Scotland, UK,
- Assoc. prof. Ing. Vít Hromádka: University of Rijeka, Croatia.

Mobility of staff from foreign partner institutions to the AdMaS Centre

- Mihaela Pericleanu: Ovidius University in Constanta, Romania,
- Dan Pericleanu: Ovidius University in Constanta, Romania,
- Carles Serrat: UPC Barcelona TECH, Spain

Examples of cooperation with foreign research institutions and companies:

University of Žilina – basic research in the area of thermal phenomena in building physics, and specifically in advanced building structures, based on the joint results of cooperation in the field of the thermal efficiency of transparent insulation facades (TIF) using experimental and theoretical methods. Additionally, electronic and measuring devices were produced for a partner institution to use in the measurement of wind-driven rain.

Slovak University of Technology in Bratislava – experimental BIPV (Building Integrated Photovoltaics) research, facade concepts offering the option of storing thermal energy while using latent warmth.

KU Leuven, Laboratory of Acoustics – cooperation was launched concerning the evaluation of the use of drones to take acoustic measurements.

Collaboration with Cracow University of Technology, Poland, in the release of a monograph (2 chapters in total) in a foreign publication - expected date of issue: 2018.

Research group MM (Mathematical Modelling)

Visits to institutions abroad:

- Ing. Miarka Petr: research visit, Gent University, Belgium, 29.1.2018 - 8.2.2018,
- Ing. Šimonová Hana, Ph.D.: research visit, Belgrade, Serbia, 25.08.2018 - 31.08.2018,
- Prof. Ing. Keršner Zbyněk, CSc.: research visit, TU Belgrade, Serbia, 25.08.2018 31.08.2018,
- Assoc. prof. Ing. Seitl Stanislav, Ph.D.: research visit, Budapest University Of Technology and Economics, Hungary, 16.07.2018 - 20.07.2018,
- Ing. Lipowczan Martin: research visit, BOKU University, Vienna, Austria, 11.06.2018 - 15.06.2018,
- Ing. Šimonová Hana, Ph.D.: research visit, Koszalin, Poland, 03.06.2018 - 15.06.2018,
- Prof. Ing. Keršner Zbyněk, CSc: research visit, Koszalin, Poland, 03.06.2018 - 15.06.2018,
- Ing. Novák Lukáš: research visit, Stellenbosh Univ. SAR, 02.04.2018 - 15.04.2018,
- Ing. Květoň Josef: research visit, Delft University of Technology, Holland, 15.01.2018 - 13.07.2018,
- Assoc. prof. Ing. Lehký David, Ph.D.: research visit, Hohai University, Nanjing, China, 30.04.2018 - 12.05.2018,
- prof. Novák Drahomír, DrSc.: research visit, Hohai University, Nanjing, China, 30.04.2018 - 12.05.2018,
- Ing. Šimonová Hana, Ph.D.: research visit, Wroclaw, Poland, 07.05.2018 - 11.05.2018,
- Prof. Ing. Keršner Zbyněk, CSc.: research visit, Wroclaw, Poland, 07.05.2018 - 11.05.2018,
- Prof. Ing. Vořechovský Miroslav, Ph.D.: research visit, RWTH Aachen, Germany, 7.3.2018 - 10.3.2018,
- Ing. Malíková Lucie, Ph.D.: research visit, Koszalin, Poland, 03.06.2018 - 09.06.2018,
- Prof. Ing. Keršner Zbyněk, CSc. research visit, Lublin University of Technology, Poland, 03.09.2018 - 07.09.2018.

Mobility of staff from foreign partner institutions to the AdMaS Centre:

- prof. Katzer Jacek: research visit, Koszalin University of Technology, Poland, 18.06.2018 - 22.06.2018,
- Assoc. prof. Ing. Domski Jacek Ph.D.: research visit, Koszalin University of Technology, Poland, 18.06.2018 - 22.06.2018,
- Metra Ildiko, Senior Scientist Dipl.-Ing. Dr. techn.: research visit, TU Vienna, Austria, 21.1.2018 - 23.1.2018,
- Metra Ildiko, Senior Scientist Dipl.-Ing. Dr. techn.: research visit, TU Vienna, Austria, 31.1.2018 - 2.2.2018,
- Metra Ildiko, Senior Scientist Dipl.-Ing. Dr. techn.: research visit, TU Vienna, Austria, 7.3.2018 - 9.3.2018,
- Metra Ildiko, Senior Scientist Dipl.-Ing. Dr. techn.: research visit, TU Vienna, Austria, 25.06.2018 - 29.06.2018,
- Metra Ildiko, Senior Scientist Dipl.-Ing. Dr. techn.: research visit, TU Vienna, Austria, 18.06.2018 - 22.06.2018,

- prof. Dr. Eng. Mitashev Dimitar: research visit, University of Architecture, Civil Engineering and Geodesy, Sofia, Bulgaria, 1.4.2018 - 15.4.2018,
- prof. Canteli Alfonso Fernandez: research visit, University of Oviedo, Spain, 21.05.2018 - 25.5.2018,
- Gonzalez Alvaro Martin: research visit, University of Oviedo, Spain , 11.09.2017 - 22.06.2018,
- Alonso Alejandro Parcero: research visit, University of Oviedo, Spain, 11.09.2017 - 22.06.2018.

Other examples of cooperation with foreign research institutions are articles in high-impact journals:

- Cooperation with BOKU, Vienna - Monitoring and the mechanics of bridges,
- Cooperation with RWTH Aachen, Germany - Fibre composites,
- Cooperation with University of Minnesota, USA - Probabilistic models of concrete failure,
- Cooperation with BOKU, Vienna - Simulation of steel-concrete anchors,
- Cooperation with Hohai University, China - Sensitivity analysis of prestressed structures.

7.2.4. Research staff mobility: collaboration with industry partners

Research Group STC (Structures and Traffic Constructions)

- Knowledge Transfer Partnership OP PIK, The repair and reconstruction of roof decks without needing to completely dismantle them, ROMEX s.r.o, Adamov,
- Ing. Lukáš Janda - 1FTE from 1/2018 to 12/2018 within the programme Knowledge Transfer Partnership OP PIK, Reducing the costs of repairs and reconstructions of flat roofs and eliminating the effects of roofs on the environment during their operation, ROMEX s.r.o, Adamov,
- Ing. David Bečkovský, Ph.D. – 0.3 FTE from 01/2018 to 9/2018 within the programme Knowledge Transfer Partnership OP PIK, The repair and reconstruction of roof decks without needing to completely dismantle them, ROMEX s.r.o,
- Ing. David Bečkovský, Ph.D. - 0.3 FTE from 1/2018 to 12/2018 with the programme Knowledge Transfer Partnership OP PIK, Reducing the costs of repairs and reconstructions of flat roofs and eliminating the effects of roofs on the environment during their operation, ROMEX s.r.o, Adamov.

Research Group EGAR

In 2018, investigations continued in the project "Creation of a cooperative partnership between the company GEOtest and the regional AdMaS Centre": Reg. No. CZ.01.1.02/0.0/0.0/15_013/0004874. The aim of this project is to transfer theoretical knowledge concerning geotechnical monitoring to the commercial sphere. The eventual output will be a methodological procedure for designing an underground structure utilizing a combination of mathematical modelling approaches – an advanced material model. The main know-how transfer will take place via the placement of a second-year Ph.D. student, Ing. Martin Závacký, at GEOtest, a.s. in a knowledge transfer assistant position.

Research group MM (Mathematical Modelling)

- Stavitelství Klon, spol. s.r.o. - Klon Radomír Ing. - 2.1.2018 - 2.3.2018 - research visit

7.2.5. Research activities of the RG2

Researche Group STC (Structures and Traffic Constructions)

Examples of important R&D outputs:

- DIBLÍK, J. Positive solutions to generalized Dickman equation. Applied Mathematics Letters, vol. 82, 2018, s. 111-117. ISSN: 0893-9659,
- DIBLÍK, J. Long-time behaviour of solutions of delayed-type linear differential equations. Electronic Journal of Qualitative Theory of Differential Equations, vol. 2018, no. 47, 2018, s. 1-23. ISSN: 1417-3875,
- DIBLÍK, J.; MEDINA, R. Exact asymptotics of positive solutions to Dickman equation. Discrete and continuous dynamical systems, Series B, vol. 72, no. 10, 2018, s. 101-121. ISSN: 1553-524X,
- RŮŽIČKOVÁ, M.; DZHALLADOVA, I.; LAITOCHOVÁ, J.; DIBLÍK, J. Solution to a stochastic pursuit model using moment equations. Discrete and continuous dynamical systems, Series B, vol. 72, no. 10, 2018, s. 473-485. ISSN: 1553-524X,
- HOLEŠOVSKÝ, J.; ČAMPULOVÁ, M.; MICHÁLEK, J. Semiparametric outlier detection. In: Nonstationary Times Series: Case Study for Atmospheric Pollution in Brno, Czech Republic. Atmospheric Pollution Research, vol. 9, no. 1, 2018, s. 27-36. ISSN: 1309-1042,
- RUČKA, J.; HOLEŠOVSKÝ, J.; SUCHÁČEK, T.; TUHOVČÁK, L. An experimental water consumption regression model for typical administrative buildings in the Czech Republic. Water, vol. 10, no. 424, 2018, s. 1-20. ISSN: 2073-4441,
- VALA, J.; JAROŠOVÁ, P. Optimization approaches to some problems of building design. Applications of Mathematics, vol. 63, no. 3, 2018, s. 305-331. ISSN: 0862-7940,
- KOMÁRKOVÁ, T.; LÁNÍK, J.; ANTON, O. Evaluation of Selected Physicomechanical Properties of SFRC according to Different Standards. Advances in Materials Science and Engineering, 2018, vol. 2018, no. 1, p. 1-9. ISSN: 1687-8434.

Important outputs of contract research:

- **SR12857002** - Diagnostic research and evaluation of a suspension bridge in Kroměříž; Investigator: Assoc. Prof. Ing. Ladislav Klusáček, CSc.; Client: the city of Kroměříž
- **SR12857112** - Measurement of deformations for the 1st Stage - additionally pinned monolithic bracket; Investigator: Assoc. Prof. Ing. Ladislav Klusáček, CSc. Client: PEEM, spol. s r. o.
- **SR12857092** – Diagnostic analysis of a stone bridge in Dolnoveská Street; Investigator: Assoc. Prof. Ing. Ladislav Klusáček, CSc.; Client: the town of Fryšták
- **SR12857093** – Structural alterations to a footbridge (Reg. No. L07) across the Morava River in Kroměříž; Investigator: Assoc. Prof. Ing. Ladislav Klusáček, CSc.; Client: the city of Kroměříž
- **SR12857157** - Production of a tool for the evaluation of the severity of defects/failures of prestressed bridges for use during selection for diagnostic analysis - catalogue of defects; Investigator: Assoc. Prof. Ing. Ladislav Klusáček, CSc.; Client: Directorate of Roads and Motorways of the Czech Republic
- **HS12854189L** - Design of the configuration and measurement of samples for long-term static tests of an i-Korb beam; Investigator: Prof. RNDr. Ing. Petr Štěpánek, CSc., Dr.h.c; Client: PREFA KOMPOZITY,a.s.
- **HS12854184L** - Fire tests for the pressure bearings of an i-Korb thermal insulation beam, incl.

evaluation; Investigator: Prof. RNDr. Ing. Petr Štěpánek, CSc. Dr.h.c; Client: PREFA KOMPOZITY,a.s.

- **HS12854183L** - Consultation regarding the technical execution of a fire test for samples of i-Korb beams; Investigator: Prof. RNDr. Ing. Petr Štěpánek, CSc. Dr.h.c; Client: PREFA KOMPOZITY,a.s.
- **HS12854178L** - Monitoring and evaluation of witness samples for the long-term diagnostic analysis of reinforced concrete supporting structures in the area of shaft 1.RB: supervision by the author; Investigator: Prof. RNDr. Ing. Petr Štěpánek, CSc. Dr.h.c; Client: ČEZ, a. s.
- **HS12854045L** - Static evaluation of a reinforced concrete slab in structure SO20, Litvínov – Záluží; Investigator: RNDr. Ing. Petr Štěpánek, CSc., Dr.h.c; Client: STRABAG a.s., PIS Direkce TR, Vrbenská 31, 370 06 České Budějovice
- **HS12854020L** - Analysis of allowable pressure differences between shaft spaces of the localization of an accident at Dukovany NPP; Investigator: Prof. RNDr. Ing. Petr Štěpánek, CSc. Dr.h.c; Client: ČEZ, a. s.
- **SR12857003** - Static and dynamic calculation of collector head beam No. – 242320; Investigator: Prof. Karmazínová; Contractual partner: TRIBOTEC, spol. s r.o.
- **SR12857094** - Graphic and computational prediction of glass behaviour on facades under wind load; Investigator: Ing. Pilgr; Contractual partner: Mendel University in Brno
- **SR12857111** - Numerical prediction of the behaviour of glass fastened on facades under wind load; Investigator: Ing. Pilgr; Contractual partner: Mendel University in Brno
- **SR12857114** - Execution of tensile strength tests on supplied samples of steel wire; Investigator: Prof. Bajer; Contractual partner: EGÚ Brno, a.s.
- **SR12857131** - Processing of load tables and load patterns for CEMVIN boards; Investigator: Prof. Melcher; Contractual partner: TOPWET s.r.o.
- **SR12857141** - Tests comparing an improved beam with beams available from standard suppliers; Investigator: Prof. Melcher; Contractual partner: KARPEN PLUS s.r.o.
- **SR12857142** - Static and dynamic calculation of collector head beam No. - 24262 (edited drawing); Investigator: Ing. Balázs; Contractual partner: TRIBOTEC, spol. s r.o.
- **SR12757220L** - Assessment and qualification of the defects of four steel hanging balconies forming part of the outer sheath of the building at Bieblova 28,30,32; Investigator: Prof. Karmazínová; Contractual partner: Association of Owners of the Units Bieblova 28,30,32
- **SR12757234L** - Preparation of a detailed inspection and assessment of the current state of the roof structure of the Winter Stadium in Uherské Hradiště; Investigator: Prof. Bajer; Contractual partner: GG ARCHICO a.s.
- **SR12757235L** - Evaluation of documentation for the execution of structures SO 800/1-01, SO 805/1-01, SO 806/1-01, SO 806/1-02 HVB I based on outputs from the definitive computational model HVB I after the exclusion of anchor No. 128 due to the complete loss of load bearing capacity, after the realization of reinforcement, including the final evaluation report.; Investigator: Prof. Karmazínová; Contractual partner: EGP INVEST, spol. s r.o. Uherský Brod
- **HS12854000L** - Execution of long-term monitoring of the behaviour of the supporting steel structure of the roofing of the Winter Stadium in Uherské Hradiště; Investigator: Prof. Bajer; Contractual partner: GG ARCHICO a.s.
- **SR12857149** - SUJB (State Office for Nuclear Safety) determination of mechanical properties; Expert assessment and determination of mechanical properties at 20 °C and 350 °C (Rm; Re or Rp0.2; A; Z) of selected materials which are supplied to Czech nuclear power stations, and

a comparison of the established properties with the data required by standards documents and in technical conditions defining supply requirements for nuclear power stations.; Investigator: Assoc. Prof. Ing. Pavel Schmid, Ph.D.; Contractual partner: State Office for Nuclear Safety

Important R&D projects with industry partners, and other activities:

Transport Structures division - Railway Engineering (ZEL)

- **TE01020168** - The Technology Agency of the Czech Republic's Competence Centre, the Centre for Effective and Sustainable Transport Infrastructure (CESTI), the recipient CTU in Prague, and BUT as a member of the consortium, see www.cesti.cz
- **Projekt S-CODE**, (optimal design and development of switches and crossings)

  Type of project: Horizon2020, Shift2Rail-RIA (H2020-S2RJU-OC-2016-01-2)

  Implementation period: 36 months

  Start of implementation: 1. 11. 2016

  Funds: 4 999 771.25 EUR

  From which BUT was awarded: 318 235.00 EUR, i.e. 8 813 030 CZK

  Recipient: University of Birmingham

  Consortium: DT - Výhybkárna a strojírna, a.s., Ferrovial, Rhomberg-Sersa Rail Group, Rail Safety and Standards Board, COMSA, Loughborough University, Brno University of Technology, University of Pardubice.

  The project focuses on the radical improvement of the construction of switches and crossings in accordance with TD3.2 (Technology Demonstrator) – A new generation of switches and crossings. The basic aim of the S-CODE is to perform research & development, validation and the initial integration of a radically new conception in switch & crossing construction with the potential to increase capacity, reliability and safety while simultaneously lowering investment and operating costs. The project will focus on the use of advanced diagnostic and monitoring systems, the construction of rail track superstructure and substructure, and the development of new switch control systems.

  The project is being conducted as part of the Shift2Rail Joint Undertaking, open call S2R-OC-IP3-01-2016 – Research into new radical ways of changing trains between tracks, and will be coordinated together with the open call for members S2R-CFM-IP3-01-2016 – Research into an enhanced track and switch and crossing system, project IN2TRACK.

Construction division - Concrete and Masonry Structures (BZK)

TH02020548 - Advanced assembled composite structures fabricated from pultruded profiles,

Provider: TA0 - Technology Agency of the Czech Republic,

Recipient: PREFA KOMPOZITY, a.s., Investigator: Ing. Jan Prokeš, Ph.D.

Co-recipient: BUT, Prof. RNDr. Ing. Petr Štěpánek, CSc. D.h.c

Project implementation period: 2017 - 2020

The project focuses on the development and improvement of the utility properties of advanced assembled structures fabricated from composite pultruded profiles and semi-finished products (mainly glass fibre-based, i.e. GFRP). The purpose of the project is to develop new and improve current structural connections for composite pultruded profiles,

and to verify them experimentally. The aim is to increase the stiffness and bearing capacity of the connections, and thus the whole structure. These are connections between individual composite rod elements, and also between (interlocked) composite rod cross-sections and planar elements (reinforced concrete or hybrid slabs).

It is currently the second year of project implementation (project duration is 4 years). This year, shear tests were conducted on pultruded profile cut-outs. Based on the findings, samples of the connections were designed; these are currently being manufactured. These are combined bolted and glued connections featuring the interlocking of the pultruded profile with the reinforced concrete segment of the slab. Experimental verification is planned for the 3rd quarter of this year.

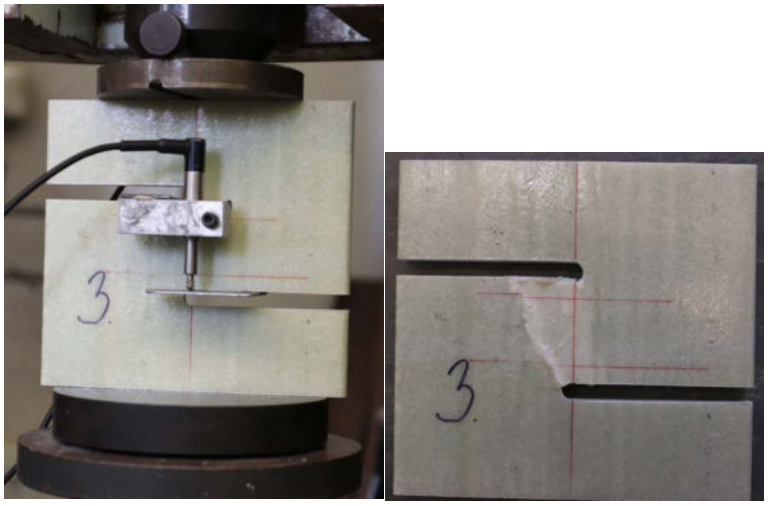


Fig. 12: Configuration of the longitudinal shear strength test; manner of sample failure.

- **FV10588** - A new generation of spatial prefabricated components made from high-performance concretes with increased mechanical resistance and durability,

  Provider: MIT - Ministry of Industry and Trade

  Recipient: Prefa Brno a.s., Investigator: Ing. Michal Holák

  Co-recipient: BUT, Co-investigator: Prof. RNDr. Ing. Petr Štěpánek, CSc. D.h.c

  Project implementation period: 2016 - 2019,

  Degradation tests were performed on GFRP materials to ascertain the dependence of the ultimate tensile strength of GFRP reinforcement on the logarithm of time under load only, under the influence of the surrounding environment only, or under a combination of both. Alkaline solution with high pH is considered to be an aggressive environment (with regard to the use of glass fibres in the composite).

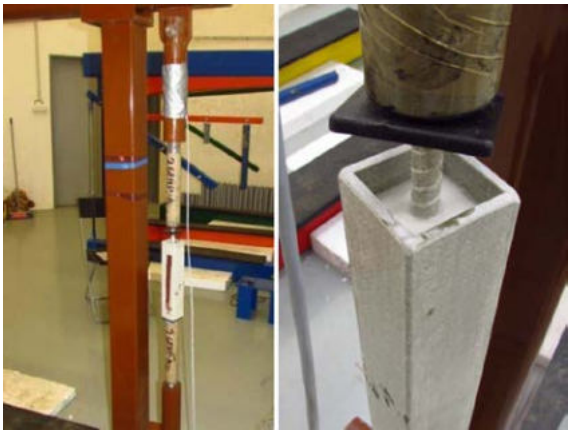


Fig. 13: Test configuration, container with alkaline solution

Another sub-objective of the project focused on the comparison of the resistance of three variants of mainly high-performance concretes in a hungry water environment with aggressive carbon dioxide. In order to optimize the length of the laboratory test, the concretes themselves weren´t tested but rather "model mortars" derived from them, which, with regard to the information needed, fully replaced the primary concretes.

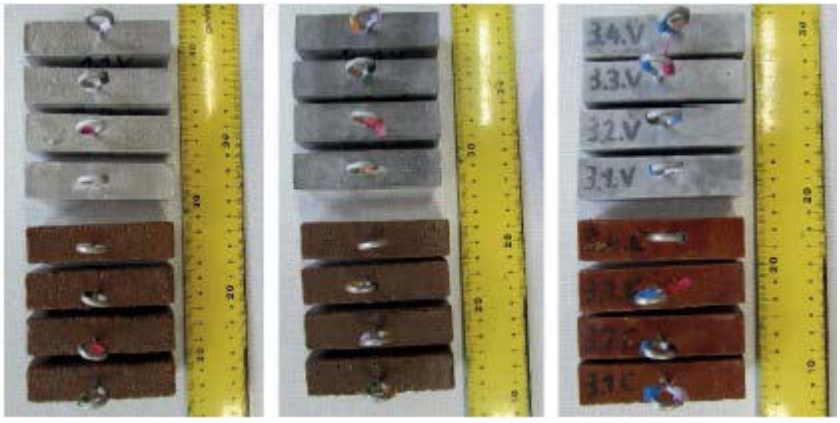


Fig. 14: specimens after testing: from left to right MM1 to MM3 (the individual photos show: below - specimens placed in an aggressive bath, and above – specimens placed in a reference bath)

Another sub-task of the project focuses on the comparison of the resistance of different variants of mainly high-performance concretes to the effect of sulphate ions.

Construction division - Metal and Timber Structures (KDK)

- **Ministry of Industry and Trade TRIO FV10317** - Advanced anchoring contact materials utilizing composites

  Execution of laboratory tests on composite contact materials with admixtures (nano additives), along with the preparation of tests involving the long-term loading of composite contact materials. Performance of tests on composite contact materials at low temperatures. Evaluation of conducted experiments.

- **TACR TH02020301** – Advanced design of the reinforcement of loaded steel structures

  Execution of laboratory research, evaluation of experiments, conclusions. Testing of algorithms. Basic functional version of the product - software for commercial use. Evaluation of feedback from users. Selected completed parts of the results of the conducted theoretical and experimental research are published continuously.

Construction division - Mathematical Modelling (MAT)

In the period under review, the members of the research group from the MAT institute dealt with theoretical issues related to the focus of the AdMaS Centre. Attention was given to research into the nature of solving differential equations with feedback, when delayed responses to impulses significantly influences the resulting solution of equations. Other work was devoted to quasi-gradient optimization methods and their implementation in i) the design of energy-saving buildings and ii) the identification of thermal and technical properties of building materials, as well as the convergence of selected implicit schemes in the dynamics of building structures and the evaluation of regression models of water consumption in buildings.

Within the period in question, research results were printed in 12 publications (out of which 7 were high-impact journals), in 2 other journals and in 4 conference proceedings (3 of which were added to the Web of Science database, and 1 to the Scopus database). There are several other articles concerning achieved results which are currently either in press or moving through the review process.

Transport Structures division – Roads, Highway Engineering (PKO)

Evaluation of bituminous characteristics from test sections of flexible pavement in the Plzeň district:

In 2015, 0, 30 and 50 % of RAP was used in the surface asphalt course while 0, 40 and 60 % of RAP was employed in the binder course. The special bitumen Storelastic, which is modified via the addition of rubber granulate, was used as a binder. The properties of the binder have been evaluated every year since 2015, both with conventional tests such as penetration and softening point, and with tests of functional properties using a Dynamic Shear Rheometer (DSR) and Bending Beam Rheometer (BBR) to address the ageing of the used binder, along with other structural changes to its properties.

Fig. 15: Test section Kaznejov – Mrtnik

- **TH02030194** - The use of an aggregate mixture with various resistances against polishing on the wearing course of roads in order to achieve acceptable long-term pavement surface skid resistance

  During 2018, the laboratory design of SMA 11-type asphalt mixtures with different ratios of aggregate basalt and graywacke fraction 8/11 was completed. Out of the five designed mixtures, three were selected for the laying of test sections in the grounds of a packaging plant. These were the following mixtures, classified according to the ratio of 8/11 fraction aggregates: 100% basalt; 50% basalt and 50% graywacke; 66% basalt and 34% graywacke. The remaining fractions consist of basalt aggregate. Bore samples will be taken from the test sections and analysed in the laboratory to determine the development of the coefficient of friction of their surfaces. Based on the results of the laboratory testing, one asphalt mixture will be selected for the production of a test section to be installed within an operational road structure.

Fig. 16: Photo of the laying of test surfaces made from the developed materials

Building Structures division – Building Construction (PST)

- **TRIO Ministry of Industry and Trade - FV10078** The development of retention materials based on recycled technologically combined vegetal construction elements using measured data with verification on a section of a prototype, investigator: RETEX a.s. and FCE BUT, Institute of Building Structures
- **Ministry of Industry and Trade OP PIK** – Knowledge Transfer Partnership, The repair and reconstruction of roof decks without needing to completely dismantle them, investigator: ROMEX s.r.o and FCE BUT, Institute of Building Structures
- **Ministry of Industry and Trade OP PIK** – Knowledge Transfer Partnership, Reducing the costs of repairs and reconstructions of flat roofs and eliminating the effects of roofs on the environment during their operation, investigator: ROMEX s.r.o and FCE BUT, Institute of Building Structures
- **SR12857085** - Oulu University of Applied Sciences Lgd - PaiBiRa - testing and analysis - Testing, analysis and structural/physical evaluation of local building materials of biological origin from the area of Oulu – Finland

Creative activities:

- VAJKAY, F.; BEČKOVSKÝ, D.; SELNÍK, P.: SWARD; SWARD – Software for designing vegetative layers for flat and sloping roofs. Website of the Institute of Building Structures at the Faculty of Civil Engineering. URL: https://pst.fce.vutbr.cz/en/software4u/. (software),
- VAJKAY, F.; BEČKOVSKÝ, D.; NOVÁKOVÁ, P.: FieldIns; Insolation of a plot of land LT. Website of the Institute of Building Structures at the Faculty of Civil Engineering. URL: https://pst.fce.vutbr.cz/en/software4u/. (software),

ŠUHAJDOVÁ, E.; NOVOTNÝ, M.; PĚNČÍK, J.; ŠUHAJDA, K. Multi-criteria analysis of the suitability of selected wood species for construction purposes. TZB-info, 2018, Year 1, No. 1, pp. 1-8. ISSN: 1801-4399.

In the field of building construction, research took place regarding the material characteristics of timber, and the behaviour of wooden elements and structures was studied. Also, research in the area of energy-autonomous buildings (using the ENVIHUT experimental building) is under way at the AdMaS Centre site. ENVIHUT features an independent photovoltaic system and a wind turbine for the production of energy. The construction of the building allows different outer cladding and roof decking variants to be exchanged. The structure is primarily used for research in the area of timber building construction, related composite systems and energy (mainly Hybrid and Off-Grid systems). In 2017, work began on research into the "Deformation of the non-stationary temperature field in the envelope structure of houses covered by earth" and the system of prefabricated vegetal façades.

Fig. 17: Photo of the Envihut experimental building

- **Ministry of Industry and Trade TRIO FV10075** – A new technology for multi-storey energy-saving buildings fabricated from sandwich-bonded panels, with the option of founding on ground screws, and using prefabricated sanitary core technology

  Stage 3 of the project was successfully completed at the beginning of 2018. It focused on the summary and design of test methods, and their technical support. Stage 4 - Determination of acoustic properties was successfully completed in August. Stage 5 – Verification of the fire resistance of selected compositions is currently under way and will be completed by the end of 2018; Stage 6 - Verification of mechanical properties and Stage 7 - Development of design materials for the design of multi-storey structures are also under way. The project investigators are EUROPANEL s.r.o. and Brno University of Technology, Faculty of Civil Engineering, the Institute of Technology, Mechanization and Construction Management and the Institute of Building Structures.
- **Ministry of Industry and Trade TRIO FV20606** – Technique for the bonding of large-format cladding elements

At the end of 2017, Stage 1 of the project "Material resources and initial research conditions" was completed successfully. Stage 2 - Summary and design of test methods and the equipment required for such testing was successfully completed in June 2018. Stage 3 - Testing of ceramic tiling elements and Stage 4 - Testing of cement adhesives are currently under way. The project investigators are Profibaustoffe CZ s.r.o. and Brno University of Technology, Faculty of Civil Engineering, the Institute of Technology, Mechanization and Construction Management and the Institute of Building structures.

Building Structures division (TST)

- **Ministry of Industry and Trade TRIO FV10075** – A new technology for multi-storey energy-saving buildings fabricated from bonded sandwich panels, with the option of founding on ground screws, and using prefabricated sanitary core technology
- The main goal of the implemented project is the development of a new production technology for multi-storey buildings based on the improvement of existing advanced EUROPANEL technology, i.e. a building system that utilises bonded sandwich construction panels composed only from rigid thermal insulation slabs clad on both sides with chipboard that is only 15 mm thick. It is a prefabricated, versatile, simple building system for the construction of energy-saving or passive wooden structures.

  In 2018, an experimental structure for the measurement of acoustics was built, see (Fig. 18). The structure consists of two dilatative sections. In the left part of the structure, the ceiling structure is made of Europanel panels, while in the right part it is formed from wooden beams. The company currently uses both types of structure in the construction of family homes. Preparatory in-situ measurements were performed with the aim of evaluating the insulation values in completed family homes in such a manner that it is clear from the results as to whether the same structural design would also be suitable for the much more demanding structures of apartment buildings.

Fig. 18: Experimental structure for the measurement of acoustics

Air and impact sound insulation measurements were taken at this experimental structure during Stage 4 of the project. Furthermore, the acoustics were tested in a certified laboratory with the aim of determining laboratory values for the designed compositions: see the example in (Fig. 19).

Fig. 19: Measurement of the impact sound insulation of a selected floor structure composition

In the second half of 2018, in Stage 6 - Verification of the mechanical properties, a series of measurements were performed to assess the shear strength of a wall panel. The geometry of the test assembly and the manner of failure of the test specimen can be seen in (Fig. 20).

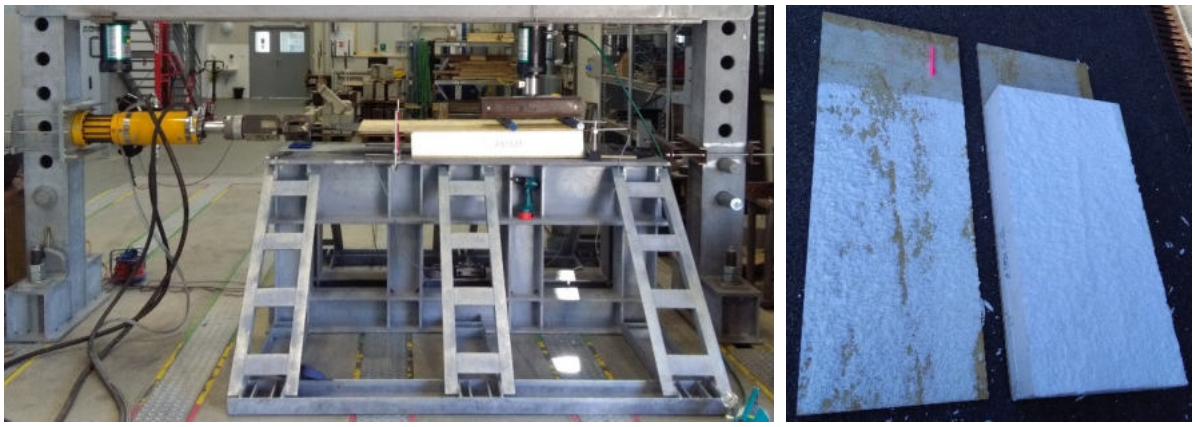


Fig. 20: Verification of the mechanical properties of bonded sandwich construction panels

- **Ministry of Industry and Trade TRIO FV20606** – Technique for the bonding of large-format cladding elements

  The main aim of the project is the development of a technology for the bonding of large-format cladding elements, i.e. tiling and floor tiling, using a thin-layer cement-based bonding mortar. Tiling and floor tiling have always had an irreplaceable position in the construction industry and this is still the case today. The range of useful properties and advantages of ceramic tiles remain, but aesthetic requirements change. At present, a clear and continuous increase is occurring in the popularity of large-format tiling elements.

  For the purpose of this project, the term "large-format tiling element" is held to mean a flat ceramic tiling element, usually made from vitreous china, where at least one of the dimensions exceeds 1000 mm. These elements appeared on the market approximately ten years ago in the formats 600 x 1200 mm x 8 mm and 600 x 1200 x 10 mm. Today, products with the formats 800 x 1800 x 10 mm, 800 x 2400 x 3 to 6 mm and 1500 x 3 000 x 3 to 6 mm are appearing more and more frequently.

  In 2018, in Stage 2, test methods were designed, along with the required technical equipment for their execution. Non-standardized tests were included in this design, the aim being to create a system of test methods for large-format tiling. For example, the influence of temperature changes on the internal stress in glued joints was tested, as this can cause damage to tiling.

Research Group EGAR

Examples of important R&D outputs:

- ULRYCH, J.; KRMÍČEK, L.; TESCHNER, C.; SKÁLA, R.; ADAMOVIČ, J.; ĎURIŠOVÁ, J.; KŘÍŽOVÁ, Š.; KUBOUŠKOVÁ, S.; RADOŇ, M. Chemistry and Sr–Nd isotope signature of amphiboles of the magnesio-hastingsite-pargasite-kaersutite series in Cenozoic volcanic rocks: Insight into lithospheric mantle beneath the Bohemian Massif. LITHOS, 2018, roč. 312–313, č. 2018, s. 308-321. ISSN: 0024-4937. Excelentní publikace (IF = 3.857),
- ŠTEFAŇÁK, Jan, Zdeněk KALA, Lumír MIČA a Arnoldas NORKUS, 2018. Global sensitivity analysis for transformation of Hoek-Brown failure criterion for rock mass. Journal of Civil Engineering and Management [online]. 24(5), 390-398 [cit. 2018-09-17]. DOI: 10.3846/jcem.2018.5194. ISSN 1392-3730. Dostupné z: https://journals.vgtu.lt/index.php/JCEM/article/view/5194,
- HLUŠTÍK, P.; NOVOTNÝ, J. The Testing of Standard and Recyclable Filter Media to Eliminate Hydrogen Sulphide from Sewerage Systems. Water, 2018, vol. 10, no. 6, p. 1-13. ISSN: 2073-4441,
- HLAVÍNEK, P.; ŽIŽLAVSKÁ, A. Occurrence and removal of emerging micropollutants from urban wastewater. In Water Management and the Environment: Case Studies. 1. Cham, Switzerland: Springer International Publishing, 2018. p. 231-254. ISBN: 978-3-319-79014-5,
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- ÚTERSKÝ, M.; STANKO, Š.; RAČEK, J.; KORYTÁŘ, I.; HLAVÍNEK, P. Výstavba zděných stok v České a Slovenské republice. Vodovod.info, 2018, č. 9, s. 1-16. ISSN: 1804-7157,
- ŠIMKO, M.; KRAJČÍK, M.; ŠIKULA, O.; ŠIMKO, P.; KALÚS, D. Insulation panels for active control of heat transfer in walls operated as space heating or as a thermal barrier: Numerical simulations and experiments. ENERGY AND BUILDINGS, 2017, vol. 158, no. Supplement C, p. 135-146. ISSN: 0378-7788,
- ČEKON, M.; PLÁŠEK, J.; SLÁVIK, R.; FEČER, T.; JURÁŠ, P. An experimental and numerical model of a solar facade prototype with transparent insulation and selective absorber. In 2018 Building Performance Analysis Conference and SimBuild. Ashrae Conference, Chicago, USA: 2018,
- ČURPEK, J.; HRAŠKA, J.; ČEKON, M., Multi-functional ventilated BiPV façade concept coupled with PCM, Seminar PCMs4Buildings: PCMs: Thermophysical characterization and buildings' applications, ISBN 978-989-99080-8-6, Assoc. for the Development of Industrial Aerodynamics, Coimbra, 2018,
- SLÁVIK, R.; ČEKON, M.; STRUHALA, K.; ČURPEK, J.; JURÁŠ, P., Experimental thermal and energy performance study of a solar facade prototype using honeycomb transparent insulation and selective absorber, ne-xt facades – Adaptive Facade Network, Munich, 2018,
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- ČEKON, M., Optical Performance of Polycarbonate Multi-Wall Panels in the form of Transparent

Insulation Based on Long-Term Outdoor Measurements, 7th International Building Physics Conference, IBPC2018, Syracuse, NY, USA, 2018,

- SLÁVIK, R. Dynamické parametre v stavebnej tepelnej technike. Tepelná ochrana budov, 2018, roč. 2018, č. 1, s. 14-20. ISSN: 1213-0907,
- KORYTÁROVÁ, J.; RUDOLECKÁ, M.; HROMÁDKA, V. Socio-Economic Impacts of Transport Infrastructure Projects on Regional Development. In 34th International Scientific Conference on Economic and Social Development – "XVIII International Social Congress (ISC - 2018)", Book of Proceedings. Book Series: International Scientific Conference on Economic and Social Development. Varazdin, Chorvatsko: Varazdin Development Entrepreneurship Agency, 2018. p. 215-220. ISSN: 1849-7535,
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- NOVÝ, M.; NOVÁKOVÁ, J.; WALDHANS, M. Recycled materials and project management of building constructions. In 18th International Multidisciplinary Scientific GeoConference SGEM 2018, Volume 18, Ecology, Economics, Education and Legislation, Issue: 5.3. International multidisciplinary geoconference SGEM. Sofia, Bulharsko: International Multidisciplinary Scientific GeoConferences SGEM, 2018. p. 663-670. ISBN: 978-619-7408-48-5. ISSN: 1314-2704.

The focus and aims of the EGAR Research Group according to the TA:

- Measurement of the thermal and microclimatic properties of buildings and subsidiary parts of buildings (including their properties with regard to exterior and interior conditions) with the aim of designing construction methods as well as technologies for the production of structural components with the primary goal of providing buildings with optimum energy and other parameters.
    - Membership in the Czech Smart City Cluster; provision of support during the methodical introduction of the Smart City concept under the conditions of the Czech Republic.
    - As part of the AdMaS UP project, utility model No. 30281 was produced and named "A set for determining the solar radiation transmittance of building materials".
    - Basic research primarily concerned Czech Science Foundation project 16-02430Y - Contemporary climatically active solar facade concepts integrating advanced material solutions.
    - In addition, work was begun on research and the extension of the experimental base of outdoor test cells for the verification of the behaviour of BIPV facade structures with the integration of materials which change their state under real outdoor conditions.

- Within other basic research areas in the field of construction physics, numerical algorithms for the simultaneous propagation of warmth and humidity in building structures were developed and validated. Certain activities were performed with the aid of UAVs (drones), particularly in the area of diagnostic analysis and research into buildings and their structures.
- Further investigation took place within the Intelligent Regions project – Information modelling of buildings and urban areas, technology and infrastructure for sustainable development, Project No. TE02000077. Development of activities at pilot locations in Nový Lískovec (measurement and monitoring of the indoor environment in apartments, and energy monitoring), and at the Karlova Studánka hot-water spa (monitoring of the indoor environment on the premises of the baths), and also at pilot buildings, these being building P4 at the AdMaS site (monitoring of energy and the interior environment) and the Open Garden building (energy monitoring). Furthermore, expansion of the areas of use of IoT technologies for the collection of data in power engineering took place, as did testing of the created Regions software tool for the prediction of warmth provided by centralised heat supply. In the first half of 2018 it was tested on an offline database, and from the beginning of November testing will occur in the online environment, i.e. the SW will be connected to a database run by the Teplárny Brno heating plant operator.

- The development of new technologies in the area of wastewater disposal and cleaning, the handling of waste, and the development of new procedures for the use of energy from wastewater, waste and sludge created during the cleaning of wastewater.
  - Contract research in the area of the execution of continuous measurements on a sewerage network, along with the provision of validated and authorized data, accompanied by an evaluation of the benefits of such data in the city of Znojmo (Vodárenská akciová společnost, a.s.).

    Equipment: Devices for flow measurement and the automated collection of samples, along with the measurement of the basic electrochemical properties of wastewaters in sewerage networks and wastewater treatment plants.
  - Performance of contract research: Monitoring the sewerage network of the city of Brno to analyse the substance load of the Brno-Modřice wastewater treatment plant – in 2018.

    Equipment: Devices for flow measurement and the automated collection of samples, along with the measurement of the basic electrochemical properties of wastewaters in sewerage networks and wastewater treatment plants.
  - In 2018, research continued into the "Removal of antibiotics from drinking water matrix using advanced oxidation processes" at the pilot location of the Modřice wastewater treatment plant.

    Equipment: Pilot AOP unit, Hall P4 at the AdMaS Centre.
  - Publishing activities with various partners in areas defined by the TA.
  - Contract research in the area of the microwave depolymerisation of waste materials with a focus on the processing of sludge from wastewater treatment plants and waste containing carbon.

    Equipment: Hall P4 at the AdMaS Centre; the equipment of a stationary analytical laboratory for the assessment of urban engineering technologies.
  - Contract research with companies and towns concerning the optimization of the operation of wastewater treatment plants and the rehabilitation of utility networks.
  - Implementation of project FAST-S-18-55: Assembly of a filter column and testing of

filtration materials used to eliminate hydrogen sulphide gas (H2S). Hydrogen sulphide is produced in sewerage networks under typical conditions (long retention times, pressure systems, etc.) For sewerage network operators odour is a topical issue which needs to be addressed secondarily. The main objective of the testing of sorption materials is their direct application in problematic areas.

- Implementation of project FAST-J-18-5446: the project evaluates the effectiveness of the removal of antibiotics using advanced oxidation processes with the aid of a pilot unit which will be placed in the wastewater treatment plant in Brno-Modřice. The usability of advanced oxidation processes will be assessed in terms of decreases in the concentrations of monitored antibiotics at the outlet, and with regard to the operating costs incurred. The quality of the cleaned water will also be evaluated using ecotoxicological tests.

  Equipment: Hall P4 at the AdMaS Centre, pilot AOP unit.

- The provision of geodetic, photogrammetric and metrological support for construction activities and research (the surveying of built and natural structures; the creation of 3D models from aerial and ground sensor data – Lidar airborne scanner, ground scanners, camera arrays for use with bundle block adjustment, the determination of the exact geometry of individual elements, components, structures and buildings, the calibration of small and large dimensions). Determination of the absolute spatial position of buildings and other structures and the monitoring of short-term and long-term changes that affect them using global navigation satellite systems (GNSS - GALILEO, GPS, GLONASS).
  - Use of 3D scanning technologies continues to take place mainly in connection with linear structures and street corridors, while investigations are also continuing with regard to (e.g.) the determination of the spatial position of tram lines or the options for using mobile mapping technology (laser scanning) under the conditions specified by the track operator. In cooperation with Mendel University in Brno, we participated in a project concerning forest damage caused by road traffic. With the mobile mapping system, we took part in an "IRI precision measurement experiment" at the Kámen - Pacov airport. It was organised by the Directorate of Roads and Motorways of the Czech Republic through their Department of Structural Quality Control, and our facility took part together with our colleagues from the RG Constructions and Transport Structures. It should result in the certification of a device for this area of measurement.

    Equipment: A system of generally oriented images, mobile mapping system, LIDAR, portable mapping system, disc field, Hall P4 of the AdMaS Centre.
  - Development of activities for the creation of strategic decision-making methods using GIS tools. In 2018, research activities were simultaneously developed in connection with the automation of the creation of outputs from mobile mapping data (images and point clouds) and the use of laser scanning for the creation of construction drawings and BIM. These activities were performed both as part of a Master's thesis and as part of contracts for economic activities within the framework of pilot projects in cooperation with companies (for example, laser scanning of the industrial hall of a car factory). Research activities focused on automation, and the use of data from mobile mapping and laser scanning will continue over the following years.
- Verification of practical applications of terrain and laboratory measurements, the evaluation (via the use of e.g. mathematical modelling) and development of methods in the field of geotechnical research methods, and the diagnostic assessment of the foundation conditions of structures, both from the aspect of building design and during their remediation and the

analysis of their lifespan.

- In 2018 investigations continued within the project "Creation of a cooperative partnership between the company GEOtest and the regional AdMaS Centre": Reg. No. CZ.01.1.02/0.0/0.0/15_013/0004874.

  Equipment: A triaxial automated system, a system for measuring the pore pressure of a rock massif, a 3D in-place inclinometer/extensometer for measuring the horizontal and vertical deformation of a rock massif, a central datalogger for the measured profile and a device for remote data transmission, a device for the measurement of cracks (wire deformometer), a surface inclinometer (2-axial), pressure pads for the measurement of pressure caused by overlying rocks + a datalogger.
- Testing of sprayed concrete from a tunnel lining as part of Ministry of Industry and Trade project CZ.01.1.02/0.0/0.0/15_013/0004874 – deformationally controlled tests in uniaxial compression, triaxial tests, transverse tensile tests.

  Equipment: Triaxial automated system, system for measuring the pore pressure of a rock massif.
- Revision of regulation TKP 30 - Special ground structures, Directorate of Roads and Motorways of the Czech Republic.
- The results of special research project FAST-S-18-5356 were fully utilized in the testing of soils.

  Equipment: automated triaxial system, consolidation system
- Distribution of plastic points during the simulation of the degradation of the lining of a utility tunnel - use of the Shotcrete model (Fig. 21).

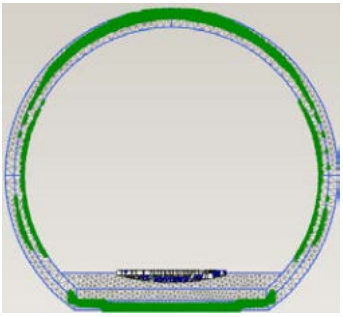


Fig. 21: An example of the use of the Shotcrete model

Examples of the R&D activities:

- **Testing of rocks**: Measurement of the deformation of rocks during uniaxial pressure tests and subsequent analysis of the data, with an evaluation of the phases of rock failure depending on volume deformation (Fig. 22 and 23).
- **Testing of sprayed concrete**: Usability of a new experimental method for the direct determination of the tensile strength of a material.
- **Mathematical modelling**: Modelling of the primary utility tunnel in Brno, design of a method for the determination of limit values of warning states for geotechnical monitoring, application of an advanced material model for sprayed concrete (Shotcrete model) during the analysis of the impacts of the possible degradation of a tunnel lining.

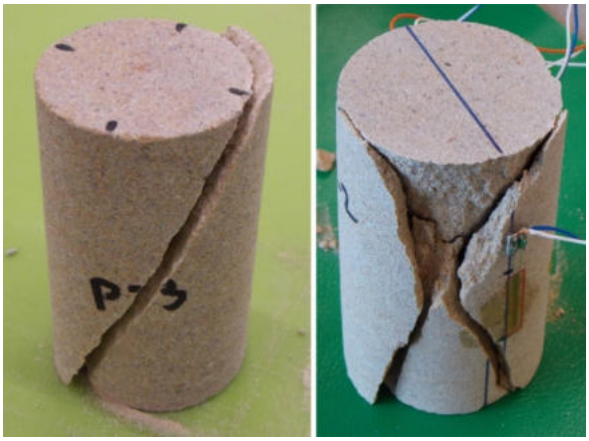


Fig. 22: Rock samples after their failure during triaxial and uniaxial pressure testing. In the second case, measurement was supplemented using tensometric sensors.

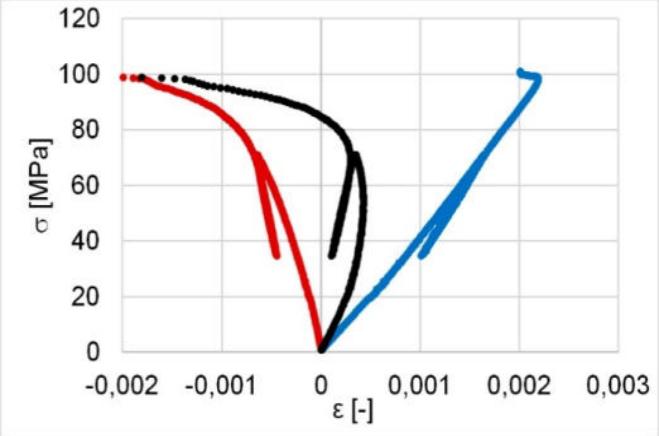


Fig. 23: Examples of the outputs of a stress-strain diagram of rock with individual deformation components - axial, radial, volume.

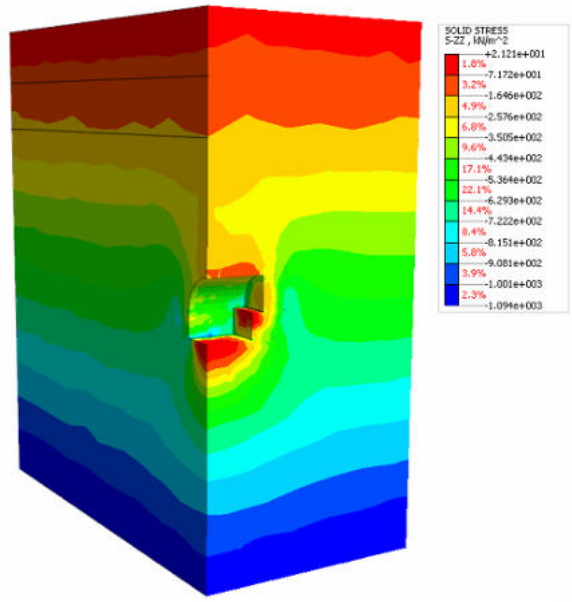


Fig. 24: Examples from the modelling of a primary utility tunnel: An analysis of changes in vertical tension as construction progresses.

- During basic research, an experimental and numerical model was developed and compared with a standard calculation of the thermal properties of a solar facade prototype with transparent insulation that was improved by the addition of a selective absorber with the

purpose of determining the approximate convective heat transfer in the air layer with a low-e absorber.

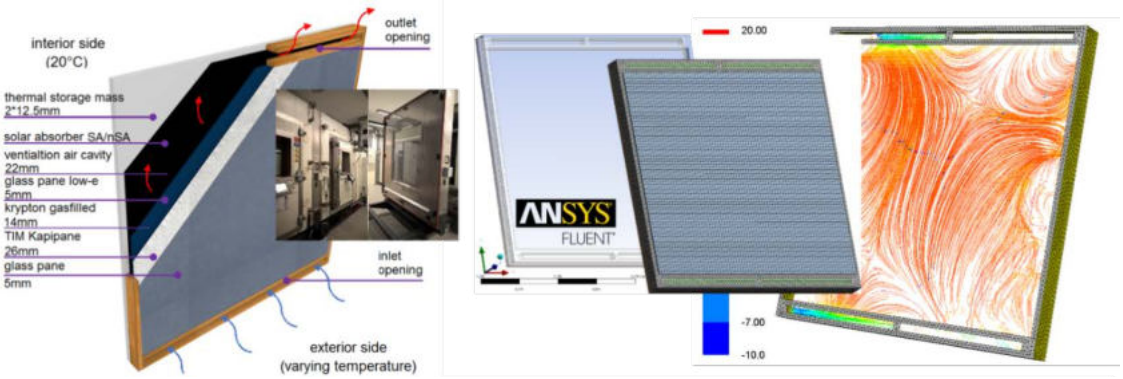
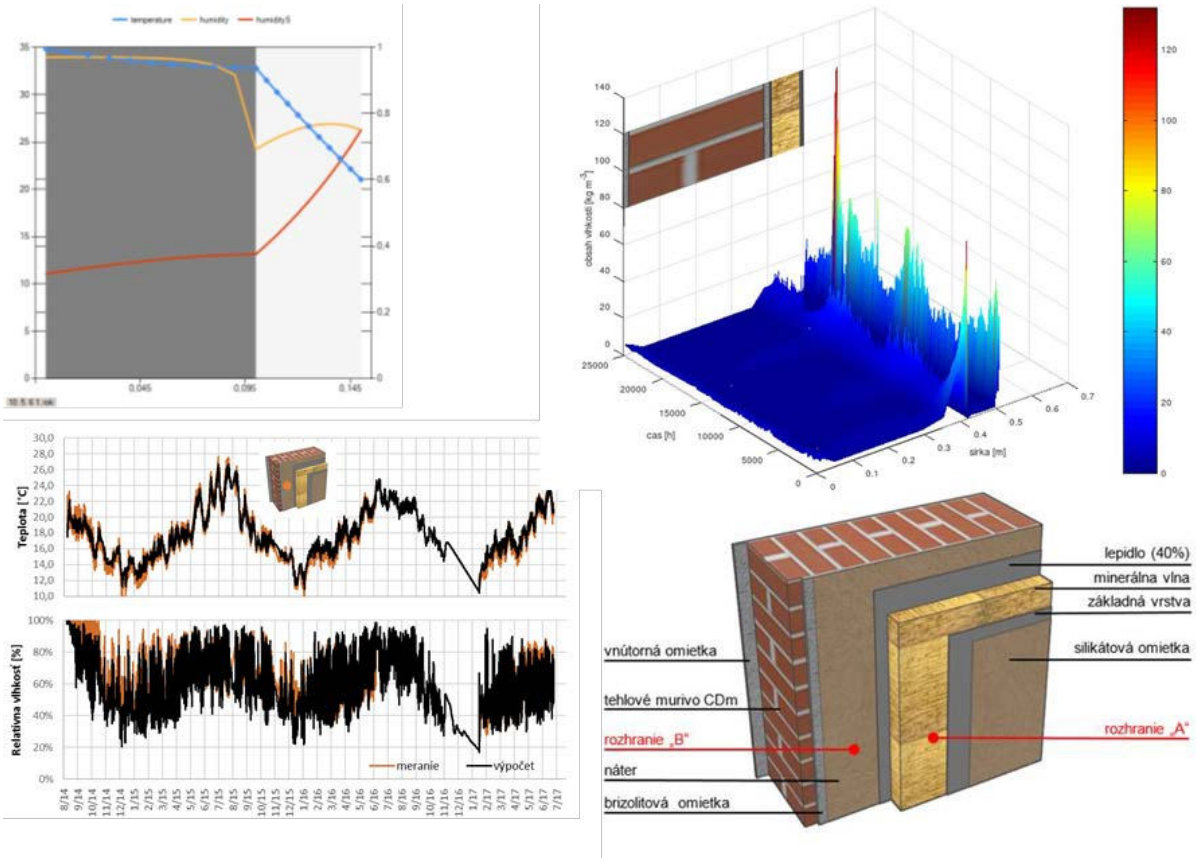


Fig. 25: Modeling Output Photos in Ansys Environment

- Expansion of the experimental base of testing cells under real outdoor conditions for the experimental measurement and verification of ventilated PF facades with and without PCM (Fig. 26).

Fig. 26: Experimental test cells at the AdMaS Centre

- Development of an algorithm for the propagation of warmth and humidity in building structures based on the finite element method. It enables the solution of nonlinear tasks (Graf 1).



Graf 1: Example of the development of algorithms in the area of heat and moisture propagation

- Work is continuing on the implementation of TAČR project TE02000077 – Intelligent Regions – concerning the information modelling of buildings and urban areas, technology and infrastructure for sustainable development. Hall P4 is one of the Centre's pilot buildings at which comprehensive measurements are taken with regard to the interior climate, energy monitoring, etc. In 2018 a pilot information model was created for the Nový Lískovec district of Brno in collaboration with Michaela Demková, a Geodesy and Cartography student who worked on it as part of her Master's thesis (see Fig. 27).

Fig. 27: Information model of Nový Lískovec (a municipal district of Brno)

- In 2018, investigations continued within the project "Creation of a cooperative partnership between the company GEOtest and the regional AdMaS Centre", Reg. No. CZ.01.1.02/0.0/0.0/15_013/0004874. The project focuses on issues related to geotechnical monitoring and its evaluation. The aim of the project is to appropriately detect and deal with problems affecting underground structures built in difficult natural environments, and to set up mechanisms for the detection of negative influences correctly, which requires the determination of the limit values of the monitored parameters. One important element of the transfer of knowledge during the project will be the opportunity to try out monitoring elements on an experimental polygon of the inspectional geotechnical monitoring system built for a selected section of the primary utility tunnel in Brno, or in other words to evaluate methods of inspectional monitoring and inverse analysis.
- Development of modelling methods and the use of simulation tools and methodological procedures for an economic evaluation of building production and construction-related investment projects.

Examples of collaboration with industry partners on R&D and contract research projects:

- In the area of contract research, extensive experimental measurements of radiant panels took place with the aim of quantifying parameters and indicators related to the indoor environments of buildings (Fig. 28).

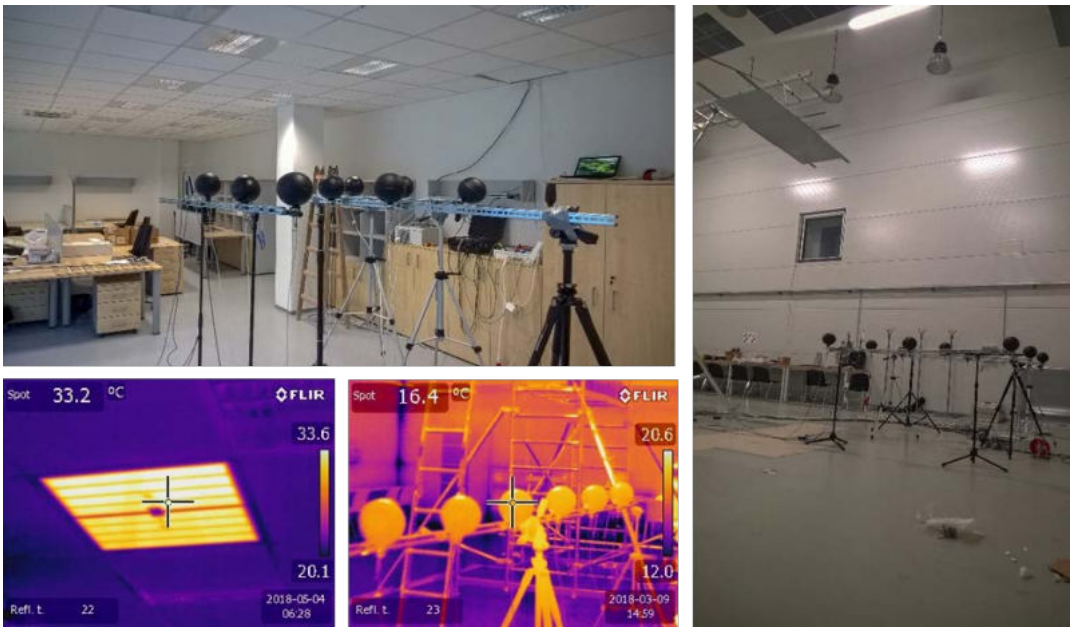


Fig. 28: Photographs from the research of a research task in the field of measuring radiant panels

- Contract research continued concerning the usability of "Bionicfuel", a unique instrument which utilizes the principle of microwave depolymerisation. The aims of the research include:
  - to study the use of carbon as the end product of microwave depolymerisation,
  - to optimize the procedure for the preparation of various materials for microwave depolymerisation via pelletisation,
  - to search for and prepare grant projects for the testing of pilot units in various areas of application (mainly the use of construction waste, sludge from wastewater treatment plants, etc.),
  - the economic analysis of the Bionicfuel process,
  - the performance of activities publicising the usability of the Bionicfuel device at

specialised events.

- Brněnské vodárny a kanalizace, a.s.; Monitoring of the sewerage network of the city of Brno to analyse the substance load of the wastewater treatment plant Brno-Modřice - 2018

  Equipment: Devices for flow measurement and the automated collection of samples, along with the measurement of the basic electrochemical properties of wastewaters in sewerage networks and wastewater treatment plants (Fig. 29).

Fig. 29: Installation and operation of automated ISCO samplers

- Vodárenská akciová společnost Znojmo, a.s. - a specific campaign on the Znojmo sewer network to determine and optimize hydraulic parameters.

  Equipment: Flow Measurement and Automated Sampling with Measurement of Basic Electrochemical Quantities of Sewage in Sewerage Networks and WWTP.

Research Group MM

Examples of important R&D outputs:

Specialised book – foreign language

- LUC TAERWE, KONRAD BERGMEISTER, ALFRED STRAUSS, DRAHOMÍR NOVÁK, DAVID LEHKÝ, BŘETISLAV TEPLÝ (2018). Safety and performance concepts - Reliability assessment of concrete structures, strany 373, ISBN 978-2-88394-126-7.

Chapter in a specialised book - foreign language

- BŘETISLAV TEPLÝ, PAVLA ROVNANÍKOVÁ, TOMÁŠ VYMAZAL (2018). Sustainability quantification of concrete structures, Advances in Environmental Research, strany 231-248, ISBN 978-1-53613-919-8.

Article in a high-impact journal

- DAVID LEHKÝ, ONDŘEJ SLOWIK, DRAHOMÍR NOVÁK (2018). Reliability-based design: Artificial neural networks and double-loop reliability-based optimization approaches, Advances in Engineering Software 117, ISSN 0965-9978. Impakt Faktor 3.198,
- ALFRED STRAUSS, SAEED KARIMI, MARTINA ŠOMODÍKOVÁ, DAVID LEHKÝ, DRAHOMÍR NOVÁK, DAN M. FRANGOPOL, KONRAD BERGMEISTER (2018). Monitoring based nonlinear system modeling of bridge–continuous welded rail interaction, Engineering Structures 155, ISSN 0141-0296. Impakt Faktor 2.755,
- MIROSLAV VOŘECHOVSKÝ, ROSTISLAV RYPL, ROSTISLAV CHUDOBA (2018). Probabilistic crack bridge model reflecting random bond properties and elastic matrix deformation, Composites Part B 139, ISSN 1359-8368. Impakt Faktor 4.727,

- JIA-LIANG LE, ZHIFENG XU, JAN ELIÁŠ (2018). Internal Length Scale of Weakest-Link Statistical Model for Quasi-Brittle Fracture, J. Eng. Mech. 144(4), ISSN 0733-9399. Impakt Faktor 1.346,
- STANISLAV SEITL, PETR MIARKA, VLASTIMIL BÍLEK (2018). The mixed-mode fracture resistance of C 50/60 and its suitability for use in precast elements as determined by the Brazilian disc test and three-point bending specimens, Theoretical and Applied Fracture Mechanics 97(C), ISSN 0167-8442. Impakt Faktor 2.215,
- JAN PODROUŽEK, ROMAN WAN-WENDNER (2018) Uncertainty analysis of the power law extrapolation techniques for adhesive anchors, Structural Concrete, ISSN 1751-7648. Impakt Faktor 1.384,
- ALFRED STRAUSS, MARTINA ŠOMODÍKOVÁ, DAVID LEHKÝ, DRAHOMÍR NOVÁK, KONRAD BERGMEISTER (2018). Nonlinear finite element analysis of continuous welded rail–bridge interaction: monitoring-based calibration, Journal of Civil Engineering and Management 24(4). Impakt Faktor 1.66,
- DAVID LEHKÝ, LIXIA PAN, DRAHOMÍR NOVÁK, MAOSEN CAO, MARTINA ŠOMODÍKOVÁ, ONDŘEJ SLOWIK (2018). A comparison of sensitivity analyses for selected prestressed concrete structures, Structural Concrete, ISSN 1751-7648. Impakt Faktor 1.384,
- BŘETISLAV TEPLÝ, MARKÉTA ROVNANÍKOVÁ, LADISLAV ŘOUTIL, RICHARD SCHEJBAL (2018). Time-Variant Performance of Concrete Sewer Pipes Undergoing Biogenic Sulfuric Acid Degradation, Journal of Pipeline Systems Engineering and Practice 9(4), ISSN 1949-1190. Impakt Faktor 0.971.

Article in a Czech/Slovak journal

- TOMÁŠ VYMAZAL, BŘETISLAV TEPLÝ, PAVLA ROVNANÍKOVÁ (2018). Metodika hodnocení trvalé udržitelnosti betonu, BETON - technologie, konstrukce, sanace 2018(1), ISSN 1213-3116,
- JAN PLÁŠEK, TOMÁŠ RIDOŠKO, JAN EKR, JIŘÍ KYTÝR, ROMAN GRATZA (2018). Impact of creep on flange clamping force, THE CIVIL ENGINEERING JOURNAL 2018(2), ISSN 1805-2576.

Contribution to an overseas conference indexed in the WoS (Web of Science) or Scopus

- ŠIMONOVÁ, H., TOPOLÁŘ, L., ROVNANÍK, P., SCHMID, P., KERŠNER, Z. (2018). Crack Initiation of Alkali-Activated Slag Based Composites with Graphite Filler. NENADÁLOVÁ, Š., Et Al (eds.) Key Engineering Materials: Non-Traditional Cement and Concrete, strany 57–60, Brno, ISSN 1662-9795,
- MARTINA ŠOMODÍKOVÁ, BŘETISLAV TEPLÝ, DITA VOŘECHOVSKÁ (2018). Input Value Correlation in Chloride Ion Ingress Modelling and Concrete Structures Reliability, Key Engineering Materials – Proceedings from 6th International Conference Non-Traditional Cement & Concrete, strany 127-130, ISSN 1662-9795,
- RADOMÍR PUKL, DAVID LEHKÝ, DRAHOMÍR NOVÁK (2018). Towards nonlinear reliability assessment of concrete transport structures, IABSE Conference 2018, strany 330-337, Kuala Lumpur, ISBN 978-3-85748-159-8,
- PETR MIARKA, STANISLAV SEITL, WOUTER DE CORTE (2018). Numerical Analysis of the Failure Behavior of a C50/60 Brazilian Disc Test Specimen with a Central Notch, Luis Rodríguez-Tembleque, Jaime Domínguez and Ferri M.H. Aliabadi (eds.) Advances in Fracture and Damage Mechanics XVII, strany 570-575, Seville, Spain, ISBN 978-3-0357-1350-3, ISSN 1662-9795,
- MARTINA ŠOMODÍKOVÁ, ALFRED STRAUSS, IVAN ZAMBON, BŘETISLAV TEPLÝ (2018). Monitoring-based quantification of input parameters for chloride ion ingress models, Powers, N., Frangopol, D. M., Al-Mahaidi, R., & Caprani, C. (eds.) Maintenance, Safety, Risk, Management

and Life-Cycle Performance of Bridges – Proceedings and Monographs in Engineering, Water and Earth Sciences (IABMAS 2018), strany 2424–2431, Melbourne, Australia, ISBN 978-1-138-73045-8,

- TEPLÝ BŘETISLAV, VYMAZAL TOMÁŠ, ROVNANÍKOVÁ PAVLA (2018). Introduction to an Approach to Performing Sustainability Quantification of Concrete Structures, Solid State Phenomena, strany 273-279,ISSN 1662-9779,
- BŘETISLAV TEPLÝ, TOMÁŠ VYMAZAL, PAVLA ROVNANÍKOVÁ (2018). Methodology for the quantification of concrete sustainability, 3rd Scientific Conference Environmental Challenges in Civil Engineering (ECCE 2018) strany 1-7, Opole, Poland, ISSN 2261-236X.

The focus and aims of the Research Group MM according to the TA:

The MM group has been cooperating with the other RGs over the long term, providing theoretical and numerical tools for the fulfilment of the more practical goals of individual RGs. This cooperation also occurred in 2018.

- The goals of the RG MM, which are stated in the TA, and which were successfully achieved independently in 2018, are primarily:
- the creation of suitable numerical models for the multicriteria stochastic optimization of the design of load-bearing elements made from steel-concrete, with consideration given to environmental aspects,
- the development of approaches for the verification of numerical model results with the aid of physically equivalent models and processes in the field of load-bearing structures,
- the quantification of the influence of the widths and numbers of macrocracks on the intensity of chloride penetration in loaded fibre-reinforced concrete structural elements.

Examples of R&D activities:

The research activities of parts of the MM team included several subsidiary topics concerned with issues affecting built structures. The following items provide a description and examples of research activities carried out by the MM RG.

- The research activities of the part of the team working on fracture mechanics were primarily focused on the deepening of selected aspects of fracture experiments, their evaluation and numerical simulation. The work involved various configurations of fracture tests and variations in specimen and stress concentrator shape. Evaluation concerned classic and specially prepared quasi-brittle materials. With regard to test specimen loading, in addition to the evaluation of quasi-static behaviour the fatigue testing of materials was also assessed, with the results being corrected by approximating the effect of ageing on the values obtained for basic parameters.

  The primary fracture test configuration used was the 3-point bending test (3PB), which was applied to fibre-reinforced concrete beam specimens with a notch-type stress concentrator at the location where the fibres are in tension. The 4-point bending test (4PB) was also used in tests carried out at the Centre of Excellence Telč in connection with measurements and a specialised internship (see the illustrative image in Fig. 30). As far as the specimens were concerned, they were mostly beams with a standard straight notch, though they were supplemented with cylindrical specimens with a chevron-shaped notch (arrow notch). The fracture experiments were carried out on a LabTest 6.1000 universal testing machine housed at FCE BUT's AdMaS Centre in building P1 (Fig. 31). The main investigated materials were: cement-based concretes, concretes with aggregate sourced from secondary raw materials, fine-grained composites based on alkali-activated slag and fly ash, and fine-grained

composites with special fillers (glass spheres).

Another fracture mechanics experiment was the testing of Brazilian disc-type test specimens in two variants: (i) without a notch (to determine indirect transverse tensile strength) and (ii) with a notch to determine the behaviour of a specimen stressed in the combined mode.

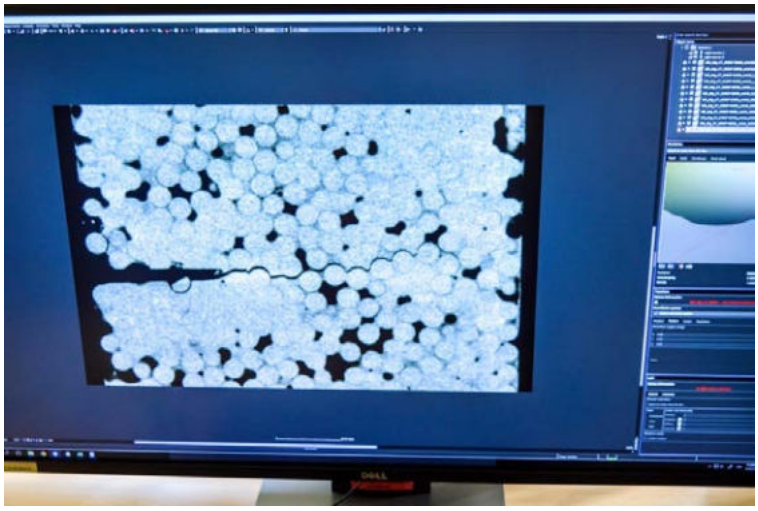


Fig. 30: Illustration showing the processing of measurement results at the Centre of Excellence Telč during a specialised internship.

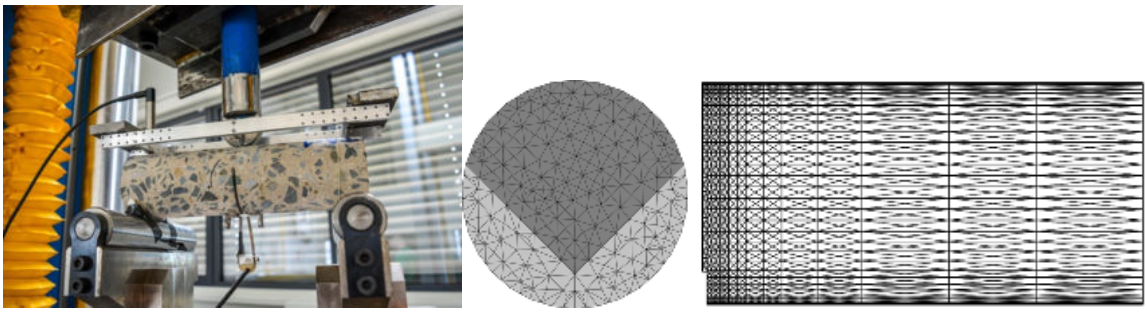


Fig. 31: View of a testing machine with a specimen and a numerical model of a cylindrical specimen with a chevron-shaped notch.

The materials investigated using this test configuration were primarily C 50/60 cement-based concretes and high-performance concretes (HPC), which could serve as suitable replacements for existing mixtures. The experiment was supplemented by a suitable simulation in finite element software using the concrete damage plasticity (CDP) model. An example of the simulation is shown in Fig. 32.

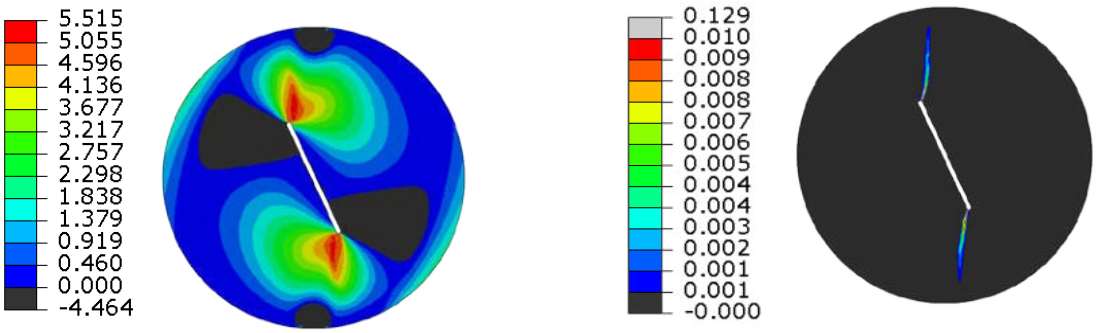


Fig. 32: Example of results from the numerical simulation of the testing of notched Brazilian discs: left - stress fields and right - plastic deformation a/R = 0.4 and C = 25°, F = 505.4 N.

- Another important area is reliability optimization during the design and evaluation of structures. The group dealing with this topic are developing two approaches in parallel:
  - the traditional method known as direct optimization based on the double-loop approach in combination with the method of aimed multilevel sampling (see Fig. 33),
  - the inverse analysis of reliability based on artificial neural networks.

  Both of the above methods have been tested and applied to a range of theoretical tasks as well as during the optimization of selected parameters from the structure of a bridge. The results of the analysis were compared and discussed together with the advantages and disadvantages of individual methods in an article in the journal Advances in Engineering Software. In addition, other variants were presented for the solution of the reliability design of a prestressed bridge with the aid of inverse reliability analysis methods.

  The expansion of reliability optimization methods then represents an effective connection of the above-mentioned methods during the solution of tasks with a larger amount of optimized parameters than the amount of boundary reliability conditions. In the method known as inverse reliability optimization, reliability tasks are solved along with a set of optimized parameters divided into two parts (see the diagram in Fig. 34):
  - the part containing "free" parameters, which are searched for directly with the aid of optimization techniques,
  - the part containing "bound" parameters, which are determined for the given set of free parameters and required level of reliability through the application of inverse reliability analysis. The greatest advantage of the proposed solution is the significant time savings that result when the time-consuming quantification of reliability indicators in the internal reliability loop with the aid of several numerical simulation methods is replaced by the direct application of an analytical inverse relation between optimized parameters and reliability indicators.

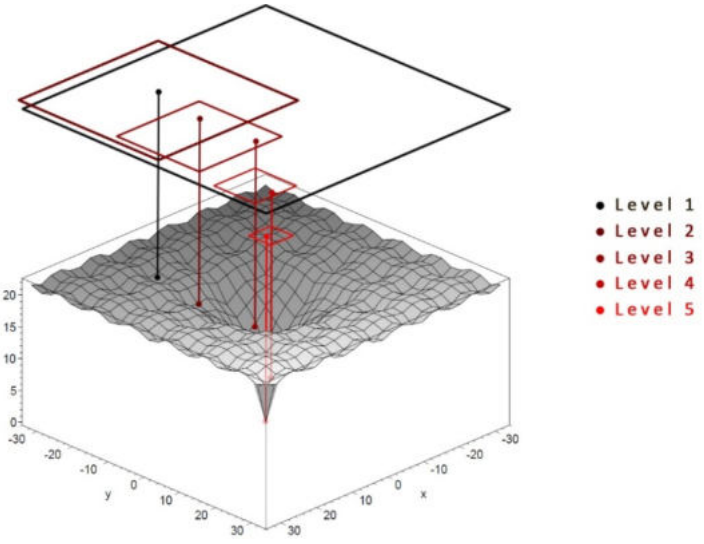


Fig. 33: Optimization approach with the aid of multilevel sampling methods.

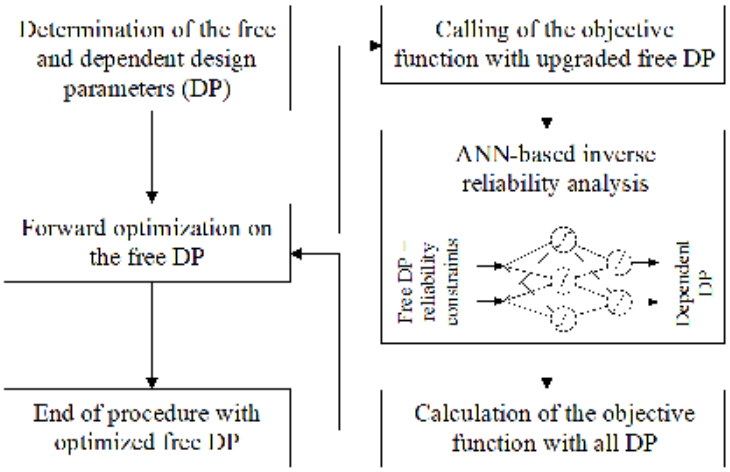


Fig. 34: Diagram showing inverse reliability optimization methods.

- Part of the MM team continued studying the degradation of structures due to the effects of concrete carbonation and the penetration of chlorides with a focus on the reinforced concrete bridges of the Czech Republic. Two influences are usually taken into account during the experimental evaluation of the degree of degradation of concrete (e.g. in concrete bridges). These are the degree of concrete carbonation (which can be estimated by measuring the pH of the concrete) and the amount of free chloride ions in the concrete (determined via solution in drilled concrete specimens). On the basis of the combination of these two parameters it is possible to estimate the ability of concrete to protect its reinforcement against corrosion. In the case of numerical modelling the corrosion initiation time is most often evaluated. Most of the models used assume the influence of either carbonation or free chloride ions on concrete. This differs from real-world practice, where both parameters are evaluated.

  During research work an analysis was carried out on experimental data from five reinforced concrete bridges in the Czech Republic. One of the goals was to compare the chloride profiles and pH of bridges of different ages. Another aim was to determine the mutual correlation between the degree of concrete carbonation (pH), the amount of free chlorides (Cl-) in the concrete and the ability of the concrete to protect its reinforcement against corrosion (c(Cl-)/c(OH-)). An example of such a correlation for a specific bridge is given in Tab. 4. The publication Šomodíková et al. deals with correlation, in this case between the input parameters of numerical models. From the analysis it is possible to deduce that the influence of carbonation and the amount of free chloride ions in concrete are two independent components. However, both parameters have a great influence on the ability of concrete to protect its reinforcement against corrosion. It is thus necessary during numerical calculations to consider both components together and not separately, as was done previously in the majority of cases.

Tab. 4: Correlation between individual parameters for bridge No. 57-039 (a bridge over the River Jičínka in Šenov).

57-039

	pH	%Cl-	c(Cl-)/c(OH-)
pH	1.000000	-0.377016	-0.624812
%Cl-	-0.377016	1.000000	0.476358
c(Cl-)/c(OH-)	-0.624812	0.476358	1.000000

In 2018 further work was performed on the topic of the quantification of input parameters for the probabilistic modelling of chloride ingress and concrete carbonation in cooperation with the University of Natural Resources and Life Sciences in Vienna. The aim of evaluating the state of built structures is to determine their current state and estimate the further evolution of this state with a maximum degree of accuracy and minimum effort. The data collected during visual inspections should provide information about the most serious problems affecting a structure. On the basis of such findings it should be possible to propose the most effective scheme for the expansion of performed inspections via monitoring, supplementary measurements and/or laboratory tests. An article describing individual levels of the setting of input values for existing analytical models of the process of chloride ingress into concrete was accepted for publication in the high-impact journal Structural Concrete. Subsidiary analyses were presented at the international conference IABMAS 2018 in Australia.

Information on the use of purchased scientific equipment

The research division MM used the following purchased scientific equipment:

- **An Aramis instrument for the measurement of 3D deformation:**

  The instrument for measuring 3D deformation was used in tensile and flexural tests conducted on plastic beams and plastic (PP and PE) welded connections (a total of 140 experiments were performed, of which around 100 were with Aramis). Measurement of the surface displacement field was conducted at different loading speeds (Fig. 35). The results are used for the determination of material parameters for a numerical computational model employed by one student, Martin Procházka, in connection with his Master's thesis. The device was also used during tensile tests on helical reinforcement (Fig. 36) and during the testing of bent beams fabricated from standard concrete and from concrete reinforced with dispersed non-metallic reinforcement (Fig. 37).

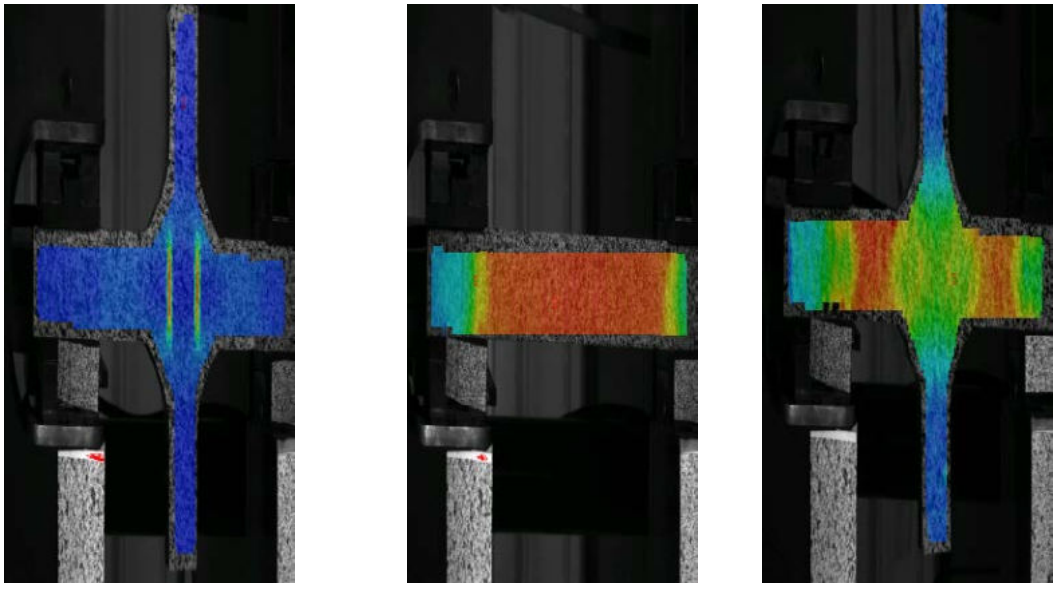


Fig. 35: Deformation field recorded by the Aramis device during the testing of parts made from welded plastic in order to verify the behaviour of different connection variants.

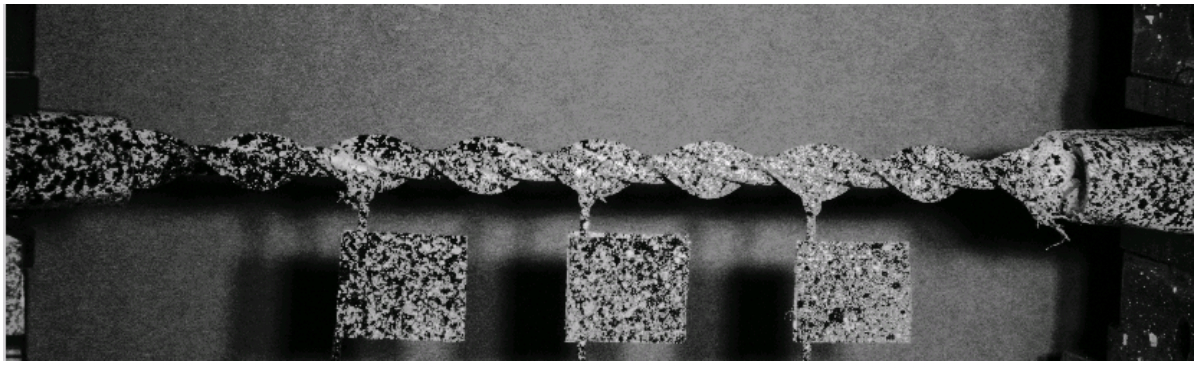


Fig. 36: Recording of the deformation of helical reinforcement, including verification of the degree of warping.

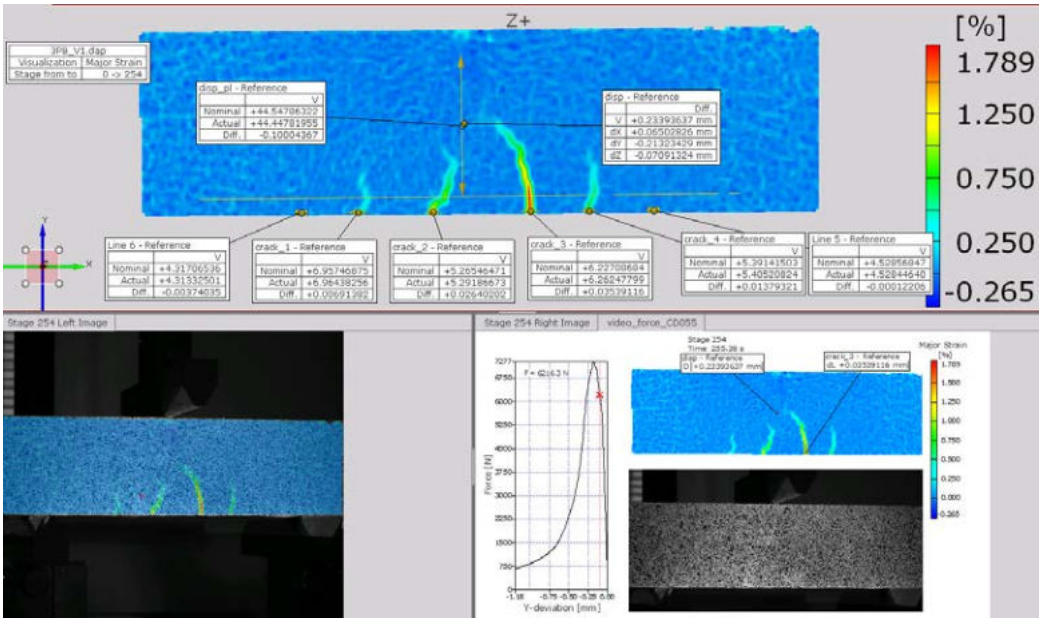


Fig. 37: Use of the Aramis instrument during testing of bent beams fabricated from concrete reinforced by dispersed non-metallic reinforcement.

- **Computational equipment**

  Computational equipment was used for numerical analysis when investigating subsidiary research topics. For example:

  - Optimisation of Design of Experiments – calculation of criteria for the evaluation of the quality of designs, and the subsequent application of these criteria during the generation of designs and the reverse analysis of the characteristics of new designs,
  - Combination of the Importance Sampling and Asymptotic Sampling methods,
  - Estimation of the resultant strength of random particle models on the basis of the characteristics of input random fields,
  - Analysis of random fields,
  - Calculations and evaluation of probabilistic analyses of a finite element model of a notched beam.

- **3D printer**

  The device was mainly used for research into auxetic and spatial materials and structures, their 3D printing and the study of their mechanical characteristics for use in the optimization of fillers for construction components and their outer shapes; see the overview of tested 2D and 3D fillers in Fig. 38.

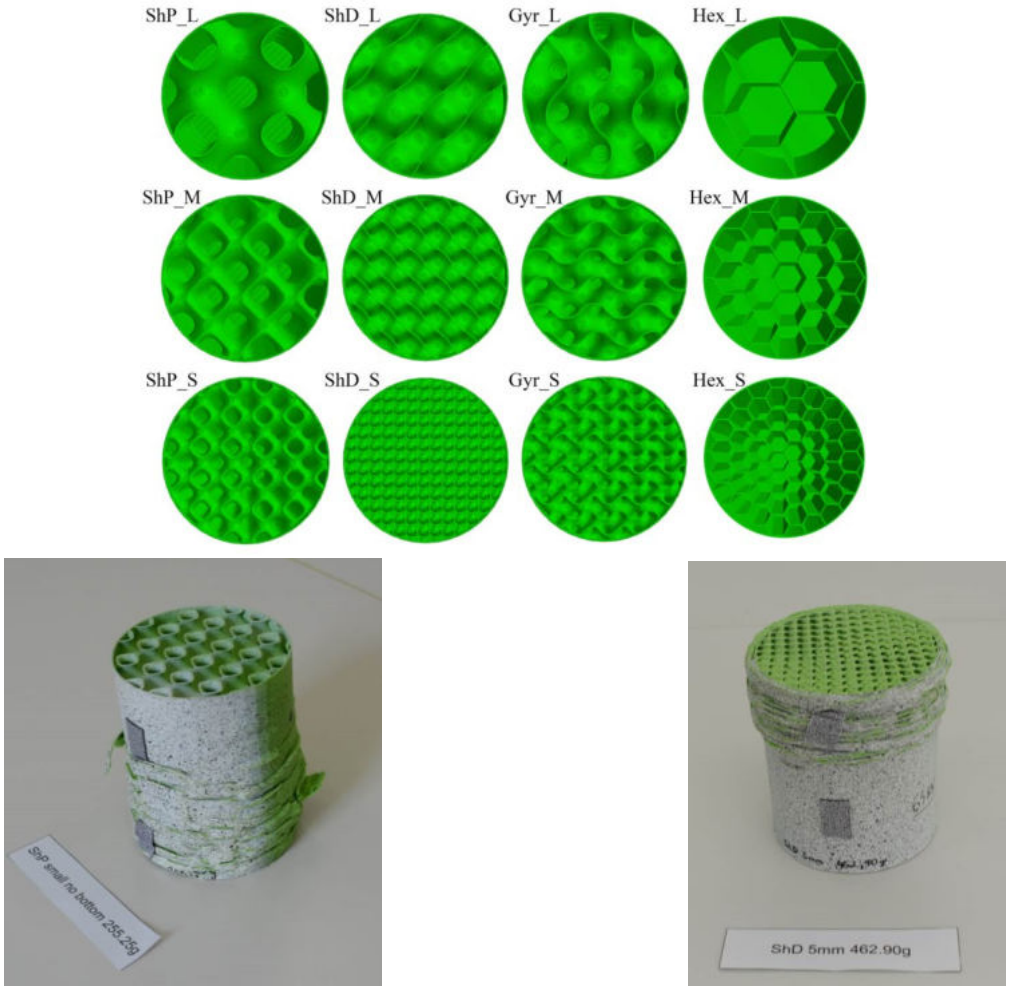
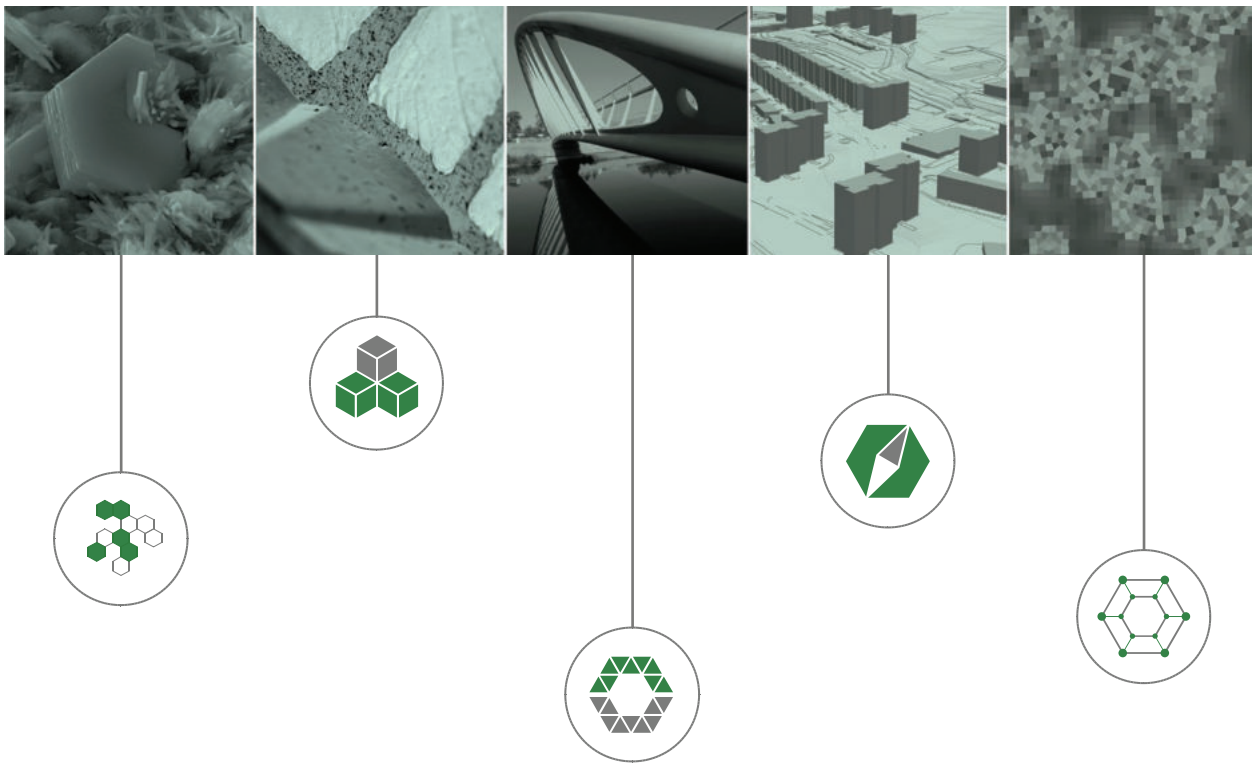


Fig. 38: Overview of the studied structures of fillers used in construction components (above) and an example of the resultant shapes of two selected samples after a compression loading test.

Examples of collaboration with industry partners on R&D projects and contract research projects:

- Within the framework of supplementary activities (continuing from 2017) the group collaborated with several workplaces abroad at the Institut für Tragkonstruktionen Betonbau of TU Wien. This cooperation involved the numerical simulation of the shear failure of load-bearing beams, supported by experiments on concrete beams and their subsequent evaluation. The topic was the randomisation of a deterministic model with the statistical evaluation of bearing capacity in shear and the determination of design bearing capacity.



8. Conclusion

The center is in its fourth year of full operation at Purkyňova 651/139, Brno. In 2018, it continued to be the center of R&D solutions from previous years, including the international Shift2Rail project under the H2020 program. In total, 50 projects were solved in 2018, including cooperation projects between the application sphere and regional R&D centers and 3 international projects (H2020, Norwegian Funds and the Ministry of Science and Education of the Russian Federation project). The Center continued its intensive cooperation with the application sphere, both in the area of contractual research and in the area of joint R&D projects. In 2018, the mobility of workers abroad and foreign workers to center continued, contributing to the creation of new partnerships and new areas of international cooperation. The management of the Center considers the development of international cooperation and internationalization as one of the top priorities for the coming years.

In 2018, most of the monitoring indicators were met and, to a large extent, their annual planned values were overfulfilled.

Number of jobs (FTE) of R&D personnel:: 120

Number of successful doctoral / master graduates: 16/169

Publications in impacted journals: 31

Publications in periodicals within the R&D methodology: 64

Applied research results (pilot plant, prototype, functional sample, etc.): 9

Number of contract research projects: 199

Number of R&D projects: 50 + 3 international (Horizon 2020, Russian Mobility, Norwegian Funds)

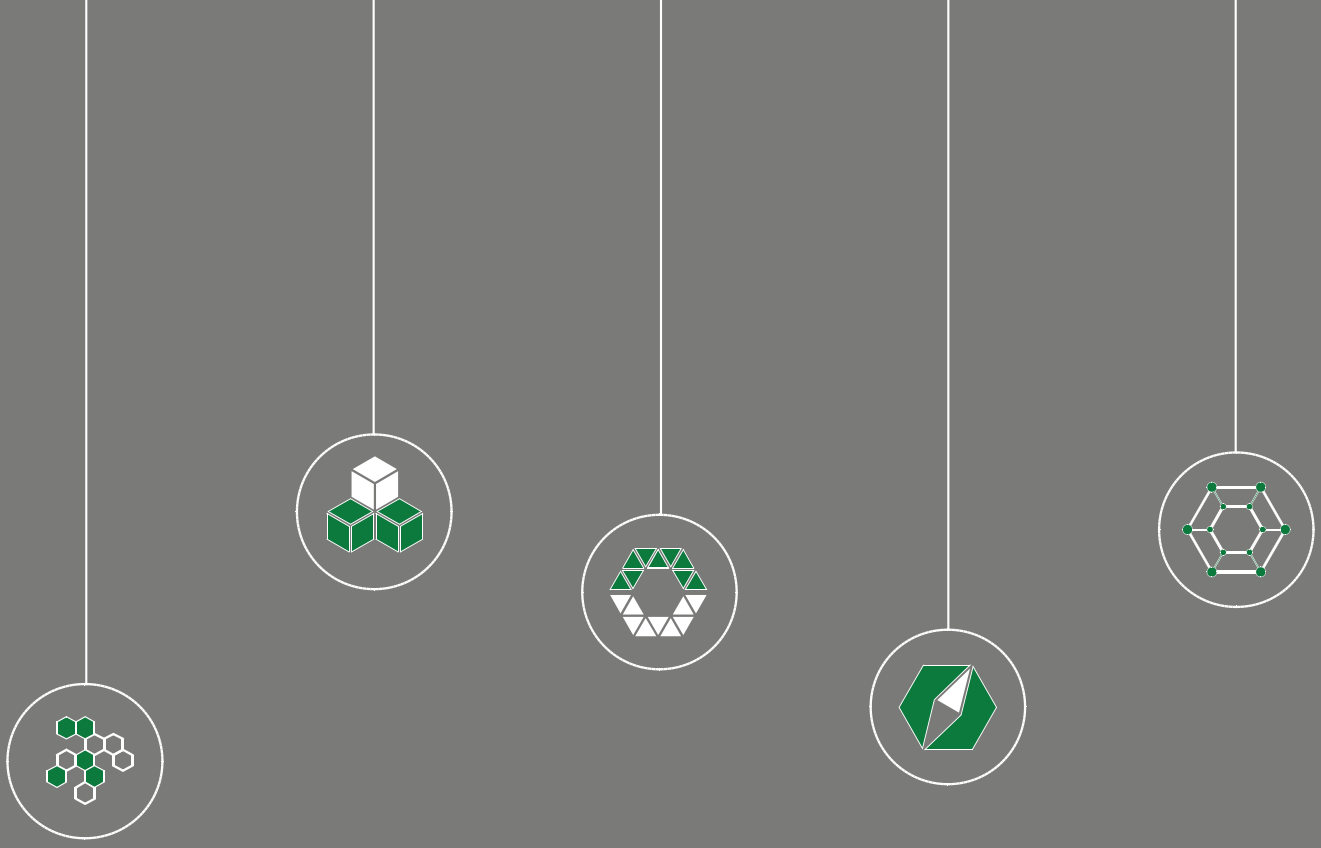
Total commercial revenue: 52,8 mil. CZK

Of which contract research and other economic activities: 23,7 mil. CZK

Income from non-commercial activity: 116,7 mil. CZK

Total income: 169,5 mil. CZK

Generally, there has been a significant development of cooperation with the application sphere and the center's turnover in contract research has been maintained. A positive phenomenon is that contract research is carried out in all areas of the research center and individual projects are related to a number of customers. Thus, the center's prosperity is not only tied to a few customers, allowing diversification of risks.



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