Annual Report on the Activities of the

AdMaS Centre

2017

Foreword by the Dean

Dear colleagues,

You are going to read about the work results of the AdMaS Centre in 2017. It was a year when everything was successfully managed and all the employees of the centre were provided with suitable conditions to deal with the assigned tasks. All the equipment purchased was fully used to reach the milestones set at the beginning of the project. It is very pleasing that the basic idea of establishing a versatile civil engineering centre integrating the knowledge from the different branches of research – material, structural, and technological – has been fulfilled. The year 2017 was successful both in terms of scientific research and administration and also accomplishing the volume of contractual research. However, there are still two more years of project sustainability ahead of us. The operation of the centre is significantly supported by the NPU I AdMaS UP project of the National Programme of Sustainability for the period of 2015-2019. The results of 2017 show that the sustainability indicators will be easily fulfilled over the entire sustainability period of the AdMaS project. For all this I would like to thank all the people involved.

The AdMaS Centre is a very sought-after and reliable partner for many companies and offices. It has turned out that some of the requirements which the strategy of the centre was based on when the project was being created are not being fulfilled. Nevertheless, other areas are opening up. It is a natural process as it has been almost ten years since the first business cases were introduced and there have been significant changes both in the market and in the research areas. The AdMaS Centre management responds to this situation and regularly updates the strategy for the operation of the centre. The Faculty of Civil Engineering has gained a modern workplace which is one of the best equipped scientific and technical facilities in Europe. We are now ahead of the other faculties which are similarly oriented and it is up to us how we will use the lead.

Thank you again for all the work done. I believe that in the following period the successful journey of the AdMaS Centre and its employees will continue.

I also want to thank the Dean, prof. Ing. Rostislav Drochytka, CSc., MBA, whose term finished on January 31, 2018 and who, therefore, significantly contributed to reaching the goals in the AdMaS Centre in 2017.

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

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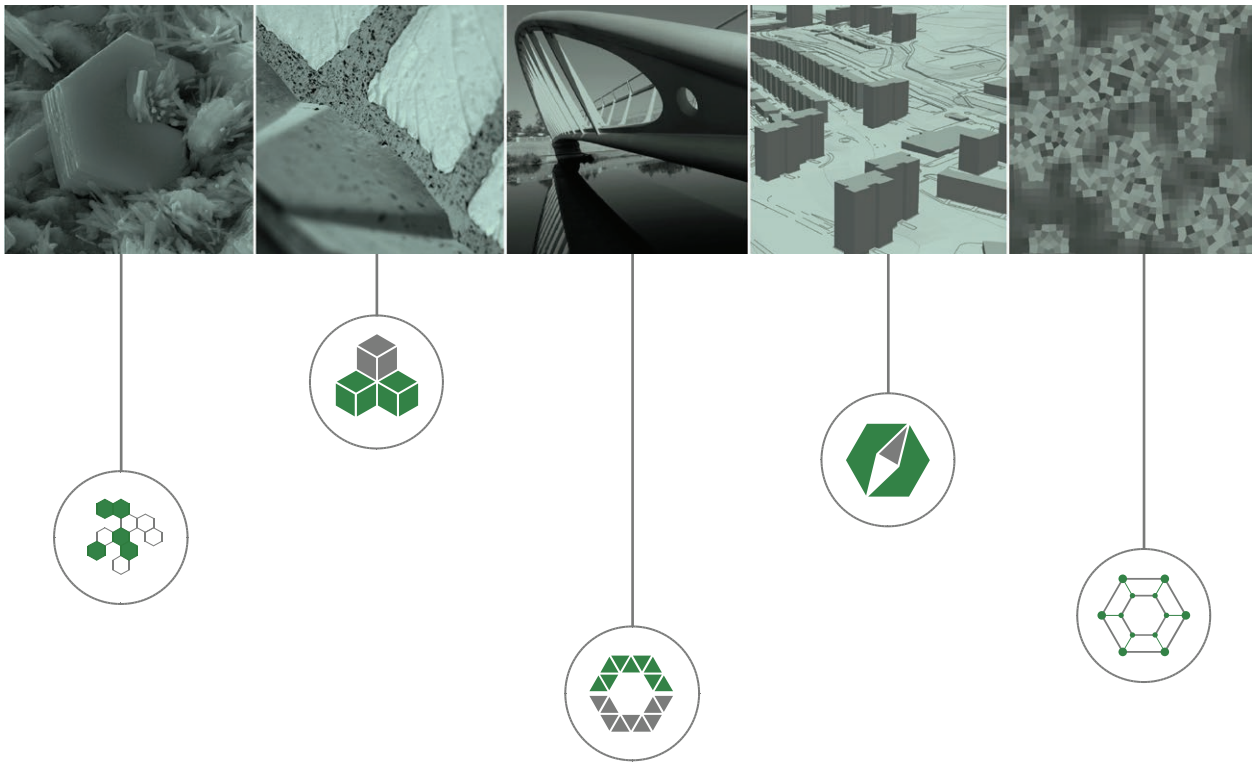


1. Organizational structure

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 Dionys Van Gemert	KU Leuven, Belgium
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	prof. Ing. Rudolf Hela, CSc.

Microstructure of Building Materials Research Group

Head of Research Group	doc. 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

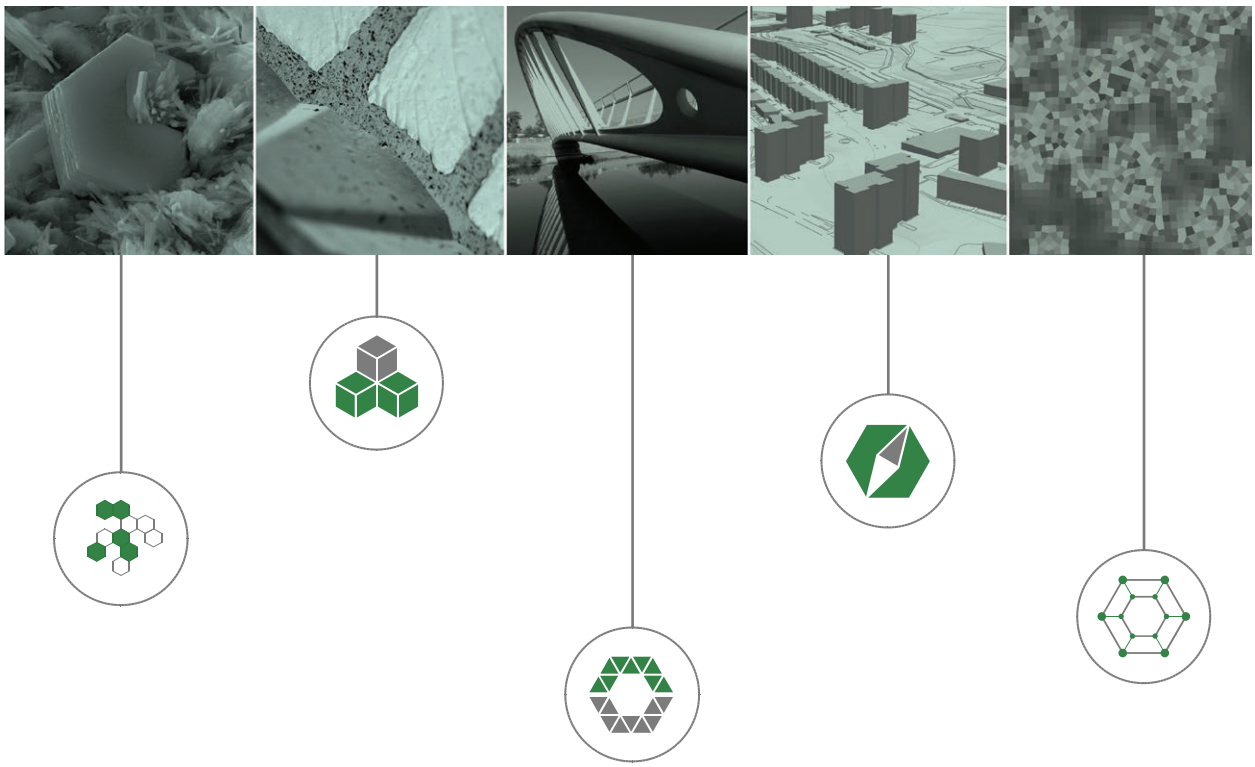
Head of Research Group	Assoc. Prof. Ing. Pavel Schmid, Ph.D..

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

At the end of January 2017, the second monitoring report (MR) on the sustainability period was written and it was approved by the governing body in September 2017. In 2017, a profile brochure of the centre was updated both in Czech and English.

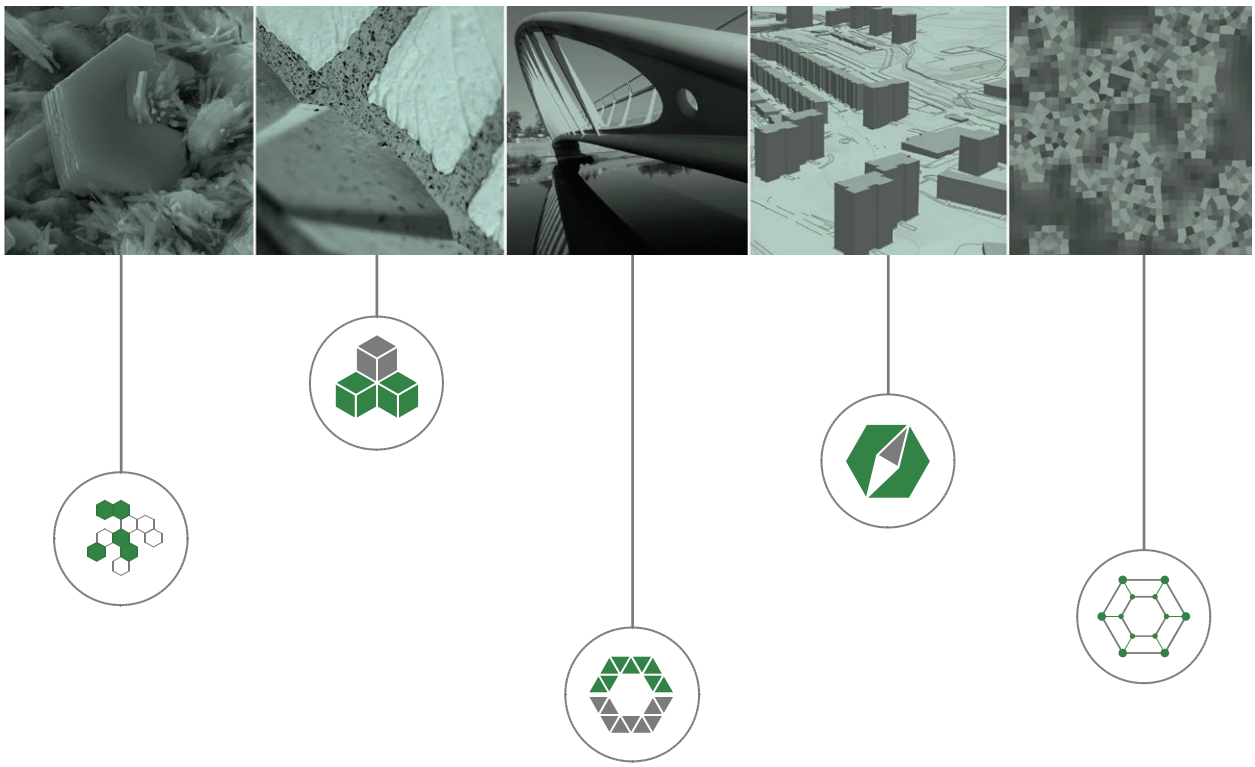
In 2017, in compliance with the recommendations of the international evaluation, common horizontal integrations of research teams continued – meetings of the R&D staff from various research groups and positions, involving the centre in promotion events such as The Night of Scientists, Majales (a festival for students) and others. Elements of a new HR policy were applied (introduced in the previous years) consisting in the support of young scientists and communication across the research groups of the AdMaS Centre. A lot of events which included excursions to the AdMaS Centre premises were also held (see below).

In compliance with the technical description of the project, the centre's management actively applied the principles set by the human resources policy. They included mainly regular assessment of the R&D staff, personal and motivational interviews with the centre's employees, the support for new projects and mobilities. Regular monthly meetings of the centre's management were held (including the representatives of each research site and research group).

There were international staff mobilities (in all the R&D categories), visits by colleagues from abroad to the AdMaS Centre and also training courses and seminars for the application sphere employees. There was also active cooperation with the application sphere both in contractual research and in applied R&D projects - the volume of funds within the centre's R&D projects (excluding the institutional support and the sustainability project of the AdMaS Centre UP) was /see MI 0603/ 87,292,000 CZK and 2,475,000 CZK /within MI111300/.

On March 6, the AdMaS employees gathered at the Faculty of Civil Engineering for the regular annual meeting where were presented results of year 2016 and future plans for year 2017.

On November 23 and 24, a meeting of the International Scientific Board of the Centre took place and on the November 9, 2017, met the Supervisory Board.



3. Seminars, events, presentations

The following is a list of the activities of the whole Centre in year 2017:

- On January 30, 2017, the Brno City Architect's Office staff visited the AdMaS Centre. There were 13 experts focused on urban planning and architecture of public spaces including the director, doc. Michal Sedláček. First, they were informed about the possibilities of cooperation and the specialization of the AdMaS Centre in the meeting room of the P2 pavilion. Afterwards, they were shown the laboratories in all the pavilions.

- On February 8 and 9, 2017, the AdMaS research centre was visited by prof. Dr. Ing. Wolfgang Uhl and Dr. Ing. Pawel Krzeminski from the Norwegian Institute for Water Research within the JOINTWATER project for the purpose of familiarisation discussions. There was an excursion to the AdMaS Centre and a discussion on the possibilities of future cooperation and submitting a common project in the Horizon 2020 programme. The JOINTWATER project is supported by the Fund for Bilateral Relations within the CZ09 Czech-Norwegian research programme.

- In February, we were visited by 3 groups of students from the Secondary School of Civil Engineering, Kudelova, Brno. The excursion to the research centre is part of the lessons on production technology and the properties of concrete for 3rd year students. The excursion included mainly an excursion to the laboratories in the P2 pavilion with a lecture on the properties of concrete, ceramics and materials in general. They were also shown the testing equipment and the possibilities of testing various types of building material. In May, students visited the centre again focusing on practical demonstrations of testing fresh and hardened concrete.

- The AdMaS Centre established cooperation with the INBAC organization, which organizes study visits for Brazilian students at Czech universities for the Brazilian embassy in the Czech Republic. As a result of this cooperation, there were four students in the centre from January to March 2017. The outcomes of the research tasks which the students had worked on were presented at the UNIGOU Academic Internship Seminar conference held on the February 24, 2017 in Prague in the National Library of Technology.

- On March 7, 2017, two representatives of the AdMaS Centre, doc. Ing. Jana Korytárová, Ph.D., and JUDr. Ing. Zdeněk Dufek, Ph.D., participated in the 13th Forum of the Czech Construction Industry in Prague, where they presented the findings of the centre related to public infrastructural projects as part of the discussion panel called "State Administration and the Construction Industry: Partners orEnemies?"

- On March 21, 2017, the AdMaS Centre was visited by the representatives of the Colas construction company from France and Hungary and also by the representatives of the Budapest University of Technology and Economics. They were especially interested in the testing method for determining the friction coefficient of the road surface after smoothing, which is not widely used abroad yet. The AdMaS Centre owns unique laboratory equipment for this testing. During the visit, a discussion on the possibilities of cooperation within international projects took place and the other parts of the centre were shown.

- On March 23, 2017, the annual general meeting of the ČAAG, the Czech Association of Geophysicists, was held. Part of it was an exhibition of Czech producers of geophysical equipment, which is quite rare and even unique in its extent in the Czech Republic. An invitation to participate in this exhibition was sent to the professional public as well as students and pedagogues not only from the BUT Faculty of Civil Engineering. An opportunity was also given to the researchers from Masaryk University or TUO - Technical University of Ostrava. After the initial introduction of the producers, a workshop was held, where it was possible to discuss the current trends in the development of geophysical equipment, where some of the Czech producers are still at the cutting edge in Europe. Some of the exhibitors were AGICO, GF Instruments, SatisGeo, W&R Instruments, ZH Instruments, GEORADIS and RS DYNAMICS. There was also an excursion

to some of the facilities of the AdMaS Centre focused mainly on the geotechnical laboratory, which has, for example, top-of-the-range triaxial apparatus for rock and earth testing. After this very successful meeting, the representatives of the ČAAG and the AdMaS Centre declared the intention to establish professional cooperation.

- Towards the end of 2016 and in the winter months of 2017, the AdMaS Centre and the C.Q.E. company organized together a training course for about 170 employees of the Directorate for Roads and Motorways. The main topic was „The performance of the construction supervisor in road construction". The different sections of the course were prepared and presented by experts from FCE as well as external experts. The general knowledge of roads and pipelines was covered by prof. Ing. Jan Kudrna, CSc. and Ing. Květoslav Urbanec, MBA. Concrete bridge objects, others and walls were presented by prof. Ing. Rudolf Hela, CSc., Ing. Adam Hubáček, Ph.D., doc. Ing. Jiří Brožovský, CSc., doc. Ing. Ladislav Klusáček, CSc. and Ing. Adam Svoboda. Geotechnical issues were presented to the participants by doc. Ing. Lumír Miča, Ph.D. and for steel bridge objects, an external expert, Ing. Miroslav Hubka, was invited. Some topics were covered in only one day and some were spread over three days. However, each topic was complemented by practical demonstrations in the centre's laboratories with the assistance of other staff. Based on the survey among the participants, the training course was very interesting and useful and there was more than one request for regular seminars. The AdMaS Centre also values this event very positively and looks forward to the cooperation and the preparation of similar educational events for the Directorate as well as other companies and organizations.

- In April, the AdMaS Centre was visited by a reporter from the iDnes.cz portal, Marek Osouch, to make a report on the mobile mapping system of the EGAR group. A mobile mapping system is used for detailed spatial documentation of cities and roads. The outcome is a high dense laser point cloud and georeferenced colour images used for creating 3D models of cities, road documentation, analysis of the state of roads including safety inspections, building surveys and inventorying. The whole article called „Auto za miliony vysílá laserový paprsek, který mapuje terén" (A car worth millions sends out a laser ray mapping the terrain) can be found at the following link: https://brno.idnes.cz/auto-laser-paprsek-mapuje-teren-vut-dbe-/brnozpravy.aspx?c=A170412_2318852_brno-zpravy_krut.

- On May 30 – June 1, 2017, the AdMaS Centre participated in the conference called „Transport Infrastructure 2017", held in Litomyšl. The centre's activities related to transport infrastructure such as modelling the movement of vehicles and pedestrians, development of asphalt roads, diagnosing concrete structures or the development of new railway structures were presented at our stall. Experts from the faculty also participated in the programme giving lectures. In particular, doc. Ing. Jana Korytárová, Ph.D. gave a lecture on monitoring the costs of the life cycle of transport structures and Ing. Michal Radimský, Ph.D. gave a lecture on the new version of the technical standard for designing roads.

- Doctoral students working in the AdMaS research centre took the first three places in the first year of the competition called „Transforming waste into resources", of the Ministry of Industry and Trade. The results were announced on Thursday, June 15, 2017 in the main hall of the Wallenstein Palace of the Czech Parliament Senate. In the 4.A category – „The best project of university students using reusable materials" – the first three places were taken by doctoral students of Building Material Engineering of the BUT Faculty of Civil Engineering. The students are working on their projects in the P2 pavilion of the AdMaS Centre under the supervision of prof. Ing. Rostislav Drochytka, CSc., MBA.

  1st place: Ing. Michaela Dvořáková – Development of new composite materials using waste polyester fibres from waterproofing production.

2nd place: Ing. Jindřich Melichar – New floor system for extreme load with increased content of reusable materials.

3rd place: Ing. Magdaléna Kociánová – Self-compacting grouts as a reverse form of soil utilization.

- On June 21, 2017 the Czech Smart City Cluster, in cooperation with ATOS IT Solutions and Services, and the AdMaS Centre prepared a Round table on Cybernetics and Security. The main idea of the Smart City is to build smart cities where social and technological infrastructure and solutions facilitate and accelerate sustainable economic growth and improve the quality of the city life for all their citizens. One of the many challenges that massive technology implementation brings is the provision of cybernetic, or information security. The participants of the Round table - representatives of municipalities, regional authorities and technological or energy companies - had the opportunity to obtain valuable information on how the information security is viewed from the legislative point of view, whether at the European and national legislation level, or from the point of view of threats identification and the possibility of their elimination. ATOS IT Solutions and Services provided its point of view on cyber security, which is a member of the Czech Smart City Cluster and has an opportunity to look at the problem not only from the Czech point of view but also based on its international experience. The AdMaS Centre has prepared for the participants a view at the current solution for modelling simulation of the movement of people and ensuring the safety of the inhabitants on selected, currently solved projects. Such certified projects of public buildings, such as football stadiums, underground stations, etc., help eliminate project mistakes, specify evacuation times, etc.

- The AdMaS Centre participated in the Public Procurement Conference. On September 18, 2017, the fourth annual conference in Prague focused on public procurement processes took place in Prague. The AdMaS Centre was represented by dr. Dufek at this event, who had a lecture on the possibilities of digitizing of procurements for construction works. His contribution was mainly focused on the possibilities of using the BIM tool. The development of BIM methods is one of the areas that our research centre has been occupied with.

- For the third year, the Science Centre was involved in the Night of Scientists event, this time on MOBILITY. The event took place on October 6, 2017. The following program was prepared:

  - Pavilion P2

    - How much do building materials last?
    - Can you recognize building material?
    - What's inside? A sample of X-ray computed tomography.
    - Do you know what it is when I increase it 100,000 times? Possibilities of electron microscopy.
    - The play of light and shadow - optical microscopy and its possibilities.

  - Pavilion P4

    - Unmanned vehicles and their use - testing the trainer.
    - Small-space exploratory robot.
    - Mapping vehicle "Google auto" - possibilities of using laser mapping.
    - Large format 3D printing options.

- Hala H

  - Demonstration of fire furnaces, demonstration of flammability of various building materials.
  - Crowd panic, myth or reality? Here you will see three-dimensional models evacuating people from domestic important buildings: the Underground line D and the football stadium Za Lužánkami. We'll explain how it works.

- Pavilion P1

  - Why are there ruts on the road?
  - Behaviour of asphalt binders at different temperatures.
  - Big Brother sees you.
  - How are traffic surveys done?

- On October 6, 2017, a workshop was held in the centre of AdMaS, which presented the current results of the research project "Creating Partnership Cooperation between GEOtest and the AdMaS Regional Centre". The aim of the project is to apply and evaluate the unique on-line geotechnical monitoring of the primary collector in Brno. One of the sub-sections is the assessment of the lining material of the mentioned primary collector. Within the workshop program, the geological situation in the site and the geotechnical monitoring of the structure will be presented.

- On October 5 - 6, 2017 under the auspice of the village of Velké Bílovice, the XVII. annual conference and exhibition of the City Water 2017 were held. This year's main topics presented at the conference were: rainwater management, sewerage networks, waste water treatment, pumping stations and new technologies for drinking water treatment. As every year, the conference welcomed an immense domestic and foreign participation, this year about 320 participants. The conference is supported by a number of important partners from professional companies or organizations - both water techniques manufacturers and water system operators. AdMaS presented its activities several times. Among the presented recent research and development results of the AdMaS Centre there were the authors Jan Ševčík, Petr Hlavínek, Jakub Raček, Tomáš Chorazy, Jiří Kučerík, Vladimír Novák and Zdeněk Dufek with their work "Microwave Pyrolysis - Technology for Effective Utilization of Sewage Sludge", further it was followed by "The Possibilities of Removal of Odour in the Sewer Network" by Petr Hluštík, Jiří Novotný, Ivo Korytář, Stanislav Malaník, and last but not least, the topic "Assessment of the Maximum Heat Gains for the Multifunctional Building Koliště-Vlhká" was presented by Jakub Raček, Michal Útterský, Tomáš Janas, Jan Ševčík, Martina Mikešová, Ladislav Roušar, Petr Hlavínek and Zdeňek Dufek. The AdMaS Centre was also presented via advertisement in an anthology and an information stand directly in the conference room. The overall possibilities for cooperation with the centre were presented by its director JUDr. Ing. Zdeněk Dufek, Ph.D.

- The AdMaS Centre hosted a distinguished visit on October 6, 2017 - a joint meeting of engineering organizations and chambers of the Czech Republic, the Slovak Republic, the Republic of Poland and the Republic of Hungary was held in Brno. During this session, there was an excursion for the Chambers' leaders in our centre. The issues of co-operation in lifelong learning and the application of research results in practice were discussed. As a specific example of cooperation with a course named Models of People Movement and Evacuation in Civil Engineering, which is guaranteed by member of our Research Centre, doc. Mgr. Tomáš Apeltauer, Ph.D., within the course of lifelong learning for the chambers' members. The course of the excursion was positively evaluated in his letter of thanks by the chairman of the Czech Chamber of Authorized Engineers and Technicians in Construction, Ing. Pavel Křeček, FEng.

- The AdMaS Center was presented on October 18-19, 2017 at the Road Conference in Brno - the largest professional event in the Czech Republic focused on the transport infrastructure. As a part of this event, the centre had an information stand at the exhibitor premises. The researcher of the Centre Ing. Michal Radimský, Ph.D. led the professional section of the Issue Area of ČSN 736101 review within the program. Furthermore, an expert excursion for the participants in the AdMaS centre was included in the conference agenda.

- On November 8, 2017, NOHARA representatives from Japan visited the AdMaS Centre. The representatives of Saint Gobain, with whom AdMaS cooperates, arrived together with them. Nohara Co., Ltd., founded in 1947 in Tokyo, is a traditional family Japanese company. Its main activity is the distribution of building materials, it also deals with the design and realization of interior constructions. Nohara owns a road marking plant and is one of Asia's leading manufacturer of marking. The company's headquarters are in Tokyo, it has 27 branches in Japan, and other 7 branches are located in overseas Asia. Nohara employs 706 workers and has an annual turnover of $ 8.5 billion. During the visit, primarily, the director of JUDr. Ing. Zdeněk Dufek, Ph.D., introduced the AdMaS Centre and its history and concept. Prof. Ing. Jan Kudrna, CSc., then introduced the ongoing research focusing on fiberglass reinforced grids. A tour of the centre followed. Particularly in the traffic engineering laboratory, the excursion often turned to a lively debate on the use of reinforcing geogrids in road construction.

- On November 10, 2017, the AdMaS Centre organized the excursion for the participants of the lifelong learning course focused on the so-called circulation economy. The course organizers, Faculty of Environmental Protection of the University of Chemistry and Technology in Prague and its partners, Institute of Circular Economics, z.ú., SUEZ Využití zdrojů, a.s. and the Czech Circulation Economy Association has selected the AdMaS Centre regarding its current activities in the area concerned, but also to the technical and technological background of the Centre. Due to the focus of the participants on the field of waste management and the focus of the course, AdMaS demonstrated capturing technologies for the energy recovery from waste water, the use of biochoura by microwave depolymerization technology, the possibilities of using the so-called grey water in the Czech Republic or the treatment of organically polluted water by anaerobic membrane unit technologies with nutrients capturing. The activities of individual research groups were also briefly presented, with an emphasis on the possibilities of comprehensive solution of problems in the field of construction and resource use. Technology and consulting companies, and university participants have learned the specific knowledge of the emerging discipline of circulatory economy supported by the European Commission, and which will influence a wide range of activities in the coming years from product development and production, recycling technology, waste management, through marketing, environmental protection, up to a corporate social responsibility. The transition from the linear to the cyclical economy will change the standard resource-use approaches and will have a major impact on the development of new procedures and technologies and entire employment in the EU.

- Centre representatives, assoc. prof. Ing. Jiří Zach, Ph.D. and Ing. Richard Slávik, took part in a networking event on "green" technologies and the possibilities of their use in buildings - Green Technology Solutions for the Building Sector on November 11, 2017 in Vienna. Within the framework of this event, the results of the Centre and the possibilities for the cooperation with other research organizations from the Central European region were presented, with the aim to establish partnerships for international projects.

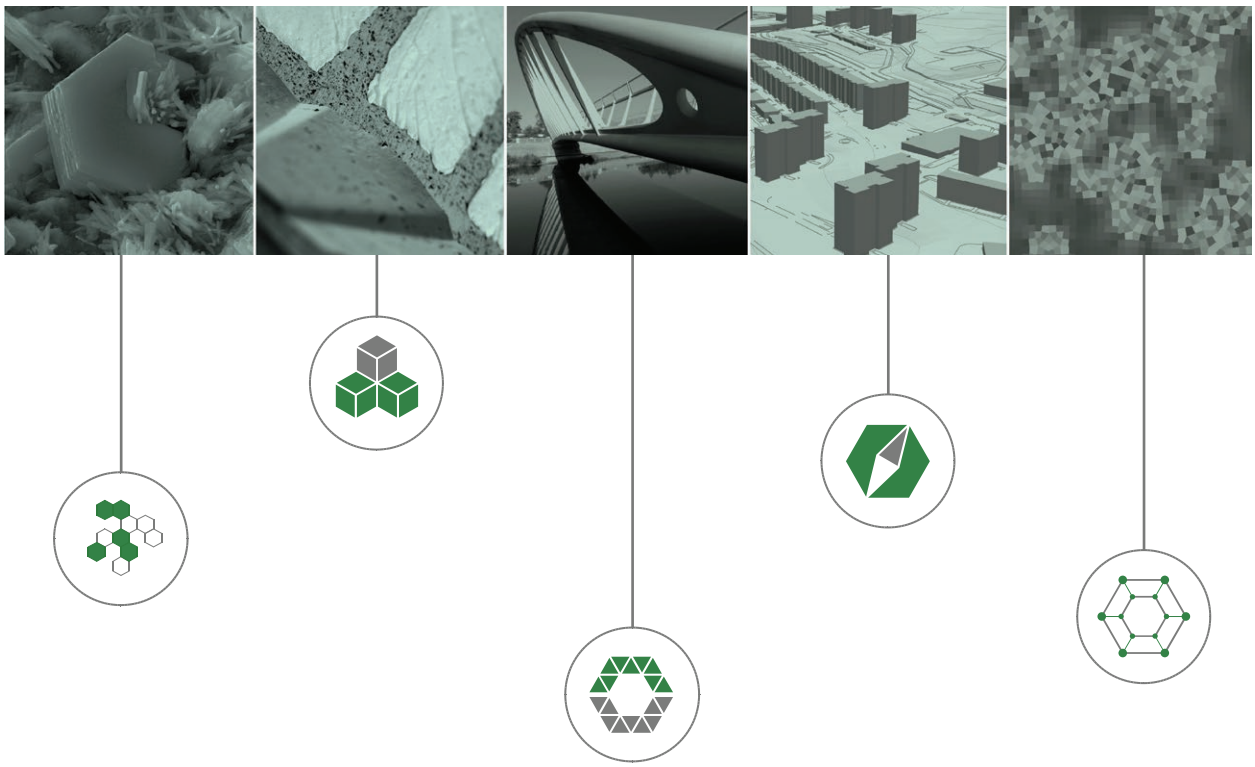
- With the support of the Association for Foreign Investment, a workshop on "How to increase the application of R & D results in practice" took place on December 13, 2017 at BUT. Participants from research organizations and industrial enterprises have obtained from the initial overview lectures the information about the contribution of the Technology Agency to Applied Research, which is supported by several project programs predestined to implement new practices and ideas into practice based on collaborative cooperation. In the second part

of the workshop the selected projects were presented on which the University of Technology cooperates with industry. Ing. Pavel Šperka presented the project "Reinforcing Asphalt Layers with Fiberglass Grids". The cooperation takes place within the framework of the research project of the Technology Agency of the Czech Republic TH01011292 "Research and application of new technologies for the construction and repair of roads with a reduced thickness of asphalt layers" the with SAINT-GOBAIN ADFORS company.

Detailed data about the partial activities are listed below for each Research Programme.

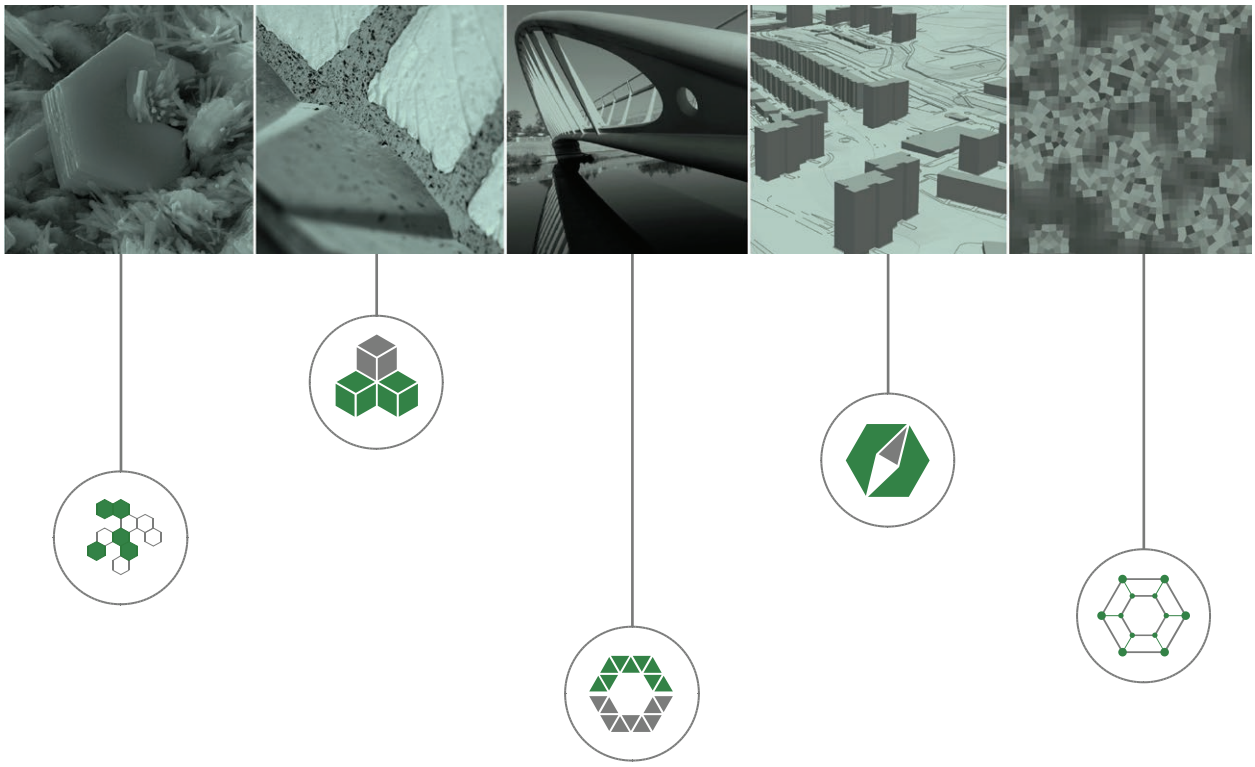
4. Mobility of researchers and the cooperation with foreign countries

In 2017, the AdMaS Centre intensified the mobility of its staff abroad within the Human Resources Policy, aiming to further increase the number of staff mobility from foreign universities to the AdMaS Centre. This fact has contributed to the creation of new partnerships and to new areas of international cooperation (for example, with Burch University of Sarajevo, NOHARA from Japan, XI'AN Technological University, etc.).
Detailed data and examples of mobility are listed below for each Research Programme.



5. Mobility of researches toward the application sphere

Mobility of researchers towards the application sphere was ongoing throughout the year. In most cases, it was a one-day journey to perform partial experiments, measurements, training, consultations, etc. Detailed data and examples of mobility are listed below for each Research Programme.



6. Achievement of monitoring indicators and leading indicators for 2017

In 2017, most of the planned values of monitoring indicators were fulfilled and, in some cases, the planned annual values were significantly overfilled.

Implementation of monitoring indicators of AdMaS project was the following:

Tab. 1: Personnel MI

Indicator code	Indicator	2017	
		plan	reality
110815	Number of students of all grades who use the built infrastructure / involved in the Centre activities	88	85
110300	Number of newly created working places, R & D employees	93,0	129,7
110302	Number of newly created working places, R & D employees - women	27,9	37,1
071700	Number of newly created working places, researchers total	68,9	112
071800	Number of newly created working places, researchers - women	20,7	30,8
071900	Number of newly created working places, researchers under 35 years old	32,0	69,9
072000	Number of newly created working places, researchers under 35 years old - women	9,6	14,7
074901	Number of successful graduates of master's degree programs	62	157
074902	Number of successful graduates of doctoral study programs	11	14

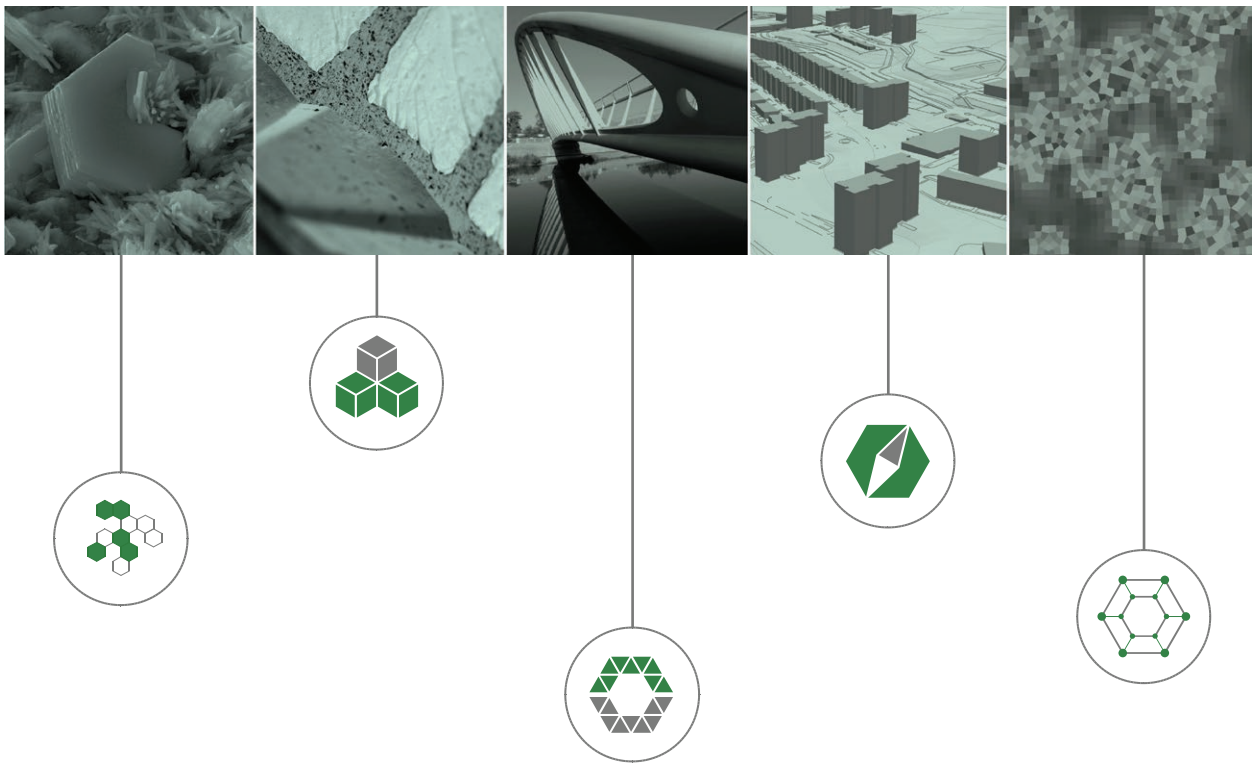
Tab. 2: R & D outputs

Indicator code	Indicator	2017	
		plan	reality
110502	Publications (impacted journals) (Jimp)	3	23
	Publications (other)	43	54
	Scientific publications total	46	77
110503	Patents (national)	1	1
	Patents (international, triadic (EU, US, Japan))	0	0
	Results of research protected under a special legal regulation 1	1	1
110504	Pilot, certified technology, variety ... (Z, T)	9	3
	Prototype, methodology, useful and average pattern .... (S)	27	18
	Applied research results 1	36	21

Tab.3: Financial MI

Indicator code	Indicator	2017	
		plan	reality
111200	Contract research volume	20730	20100
111300	Volume of R & D funds obtained from foreign sources	9090	2475
110720	Number of cooperation projects of application sphere with regional R & D centres	16	29
0603	Amount of funds received in the public tender for targeted support for R & D of national sources	42319	87292

Note: The AdMaS project is the most significant project within the AdMaS Center. The results of the AdMaS Center presented in the final recapitulation are the sum of all projects incuded in the AdMaS Center.



7. Research activities at the Centre

7.1. Research Programme 1: Development of Advanced Building Materials

7.1.1. Activities of RP1 in the area of management in 2017

In 2017 fulfilment of the aims of Research Programme 1 (RP1): Development of Advanced Building Materials was fully in accordance with the specialized focus and expected goals described in the Technical Annex (TA):

1. The development of new technologies in the area of concrete technology, particularly self-compacting concretes, high-performance concretes, ultra-high strength concretes, concretes with increased fire resistance and sprayed concretes.
2. The development and verification of various alternative input raw materials for the production of construction products such as prefabricated components, masonry elements, small concrete products, and others.
3. The development of new materials for the execution of surface finishes (coatings, plasters, waterproofing materials, grouts, etc.) which are intended for use as secondary forms of protection for buildings and other structures.
4. The development of new binders and silicate materials with high utility properties, some of which will contain raw materials from industrial waste.
5. The design of energy-saving and environmentally friendly new materials on the basis of standard mineral, secondary and renewable raw materials.
6. The achievement of high durability for new building materials in standard as well as aggressive environments; these materials should maintain their properties when exposed to physicomechanical effects (the impact of loading, the effects of humidity and frost, temperature gradient, etc.) and influences of a physico-chemical nature, i.e. primarily aggressive environments as well as biogenic influences.
7. The proposal of efficient uses for materials in built structures with regard to their lifespan and economic application.
8. The development of new nondestructive methods usable in the quality control of materials before they leave their place of manufacture, or after their addition to a structure.
9. The creation of legislative documents (procedures, technical standards) for the production and testing of building materials.
10. Basic research – the comprehensive range of equipment at the Centre enables the determination of the elemental composition of materials or the concentrations of evaluated components within them, as well as their microstructure, thermal, technical and other properties.

Within the framework of the planning and coordination of research activities in 2017, 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). During the meetings, brief informative summaries about current activities were presented. Topics included 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 contract research projects with industrial partners, or other information with regard to current needs.

In order to improve mutual awareness and cooperation between individual RGs within the entire AdMaS Centre, an open meeting was organized for Centre employees in May 2017 in the form of a pétanque tournament.

7.1.2. Training and seminars

- On 10.1.2017 and 11.1.2017, a specialized seminar entitled Durability and Remediation took place in cooperation with WTA CZ. Its aim was to familiarize workers from specialized construction

companies with the latest findings regarding the durability of concrete and reinforced concrete structures, diagnostic analysis methods for ascertaining the current state of structures, remediation planning strategies, approaches to the selection and application of suitable patching materials, and inspection activities when a structure is undergoing remediation or in everyday use. Prof. Drochytka (head of RP1) and Assoc. Prof. Bydžovský (head of RG MBM) were the guarantors of the seminar.

- On 12.1. and 9.5.2017, laboratory work took place as part of a basic preparatory course organised for ČEZ a.s. staff. The course timetable comprised 16 hours of tuition, most of which was in laboratories. During the course, issues concerning the design, preparation and inspection of the quality of fresh as well as hardened concretes were presented. Destructive and nondestructive concrete tests were presented and then conducted on fresh and hardened concrete. Attention was given to the inspection and remediation of the concrete structures of nuclear power stations, the surface finishes of materials, the pore structure as well as the internal structure of materials. Another part of the course involved familiarization with the most modern laboratory methods for the evaluation of building materials. The theoretical foundations of X-ray diffraction analysis, electron scanning microscopy and computed tomography were presented.
- On 15.2. staff from the company BEST a.s. underwent training in the area of concrete products produced using vibropressing technology, such as concrete paving blocks, slabs, curbs, masonry elements, blocks of lost formwork, palisades, etc. The main topic was the production, evaluation of properties and assessment of conformity of these concrete products. The training also included a practical demonstration of the testing of such concrete products in laboratories.

7.1.3. Mobility of research staff and cooperation with foreign countries

In 2017, RP1 intensified its activity with regard to staff mobility, i.e. trips made by its employees to institutions in foreign countries. 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, the University of Žilina, Universität Rostock, Germany, and others.)

7.1.4. Mobility of researchers towards the application sphere

In 2017, in the period between 5.6.2017 and 19.6.2017, two employees from BETOSAN s.r.o., ing. Pavel Dohnálek, Ph.D., and Ing. Zdeněk Vávra, took part in RP1 activities at the AdMaS Centre. They were involved in the verification of a technology for the creation of a floor system as part of the implementation of a joint project funded by the Technology Agency of the Czech Republic, project no. TA04010143 – Research and development of a new silicate-based floor system for extreme mechanical and chemical stress. The research stay involved the execution of a local investigation at selected places for the verification of the "Technology for the creation of a new floor system for extreme mechanical and chemical stress".

Another external researcher that took part in RP1 activities was Ing. Jaroslav Bureš, CSc., who came to the Centre from the company Lime Business Consulting s.r.o. He was directly involved in work on sub-tasks for Czech Science Foundation project 15-08755S in the period 29.5.2017-16.6.2017 and also 2.10.2017-13.10.2017. The investigation was conducted in cooperation with AdMaS Centre employees. Ing. Bureš was involved in the evaluation of the results of part of the research, as well as the preparation of the results for publication and presentation within the framework of the seminar "Lime, cement, ecology 2017". He also took part in the processing of subsidiary results concerning the mineralogical composition of minority phases contained in high-percentage limestone, and in the preparation of materials for the publication "An innovative approach to the characterisation of the inner structure of limestone by X-ray computed nanotomography".

Other mobility: Visits by RP1 researchers to industrial entities 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 RP1

Fulfilment of the goals of Research Programme RP1: Development of Advanced Building Materials was fully in accordance with the specialized focus and expected goals described in the TA. Researchers examined the possibilities offered by alkali-activated brick body and slag, they monitored the behaviour of cement composites under extreme temperatures and in environments with increased concentrations of sulphate ions, and they monitored the influence of crystallization additives on the durability of cement composites. Research was carried out regarding the options for the liquefaction of soil for subsequent use in excavation work. A professor from outside the Czech Republic, Ulrich Diderichs, was partially involved and so became the co-author of a publication listed in the Thomson Reuters and Scopus databases. 2017 was the first year of the execution of a project focused on the kinetics of tobermorite formation in various autoclaving modes.

One of the very important areas of RP1 research is concrete technology. Centre employees examined (for example) the influence of the environment on the corrosion of concrete from the aspect of chemical reactions, as well as the resistance of fine-grained concretes to sulphate corrosion in waste systems. Investigated areas that proved very interesting included the effect on strength of adding basalt fibres, and the possibilities afforded by the nondestructive determination of modulus of elasticity using ultrasound impulse methods.

In 2017, several specific research projects were investigated with the wide involvement of students from PhD and Master´s degree courses. One area concerns the possibilities of using fly ash. Research focused on monitoring the effect of fly ash after selective non-catalytic reduction on the physical and mechanical properties of porous concrete. This is being investigated in cooperation with the Faculty of Chemistry at BUT. Other projects focused on the options for the use of fly ash contaminated by the effects of denitrification technology, or the use of fluid fly ash in the production of cement composites. Projects also examined e.g. the monitoring of the properties of limestones during thermal loading using DKTA, DSC and HT-XRD, and the study of the hydration process of anhydrite-based sulphate binder. As far as surface finishes are concerned, mainly the influence of surface finish technologies on the durability of concrete paving was examined, as well as special adaptations of the surfaces of architectural concretes. An investigation carried out into the options for the use of recycled concrete in the production of new concrete should be mentioned, along with the development of a new technology that enables treated soil to be reused. One project also focuses on the study of analytical methods for the evaluation of the relationship between the properties of building materials and changes in their structure. This mainly required the use of our X-ray CT scanner.

Staff engaged in the physical part of the programme examined the possibilities of using acoustic methods when monitoring the solidification and hardening of cement composites, using the methods to create a corelationship between acoustic emissivity and the fracture characteristics obtained during three-point bending.

In the area of insulation materials, researchers were involved in the development of an ecologically degradable insulation material, the modification of existing ETICS constructions systems using alternative, ecological and natural materials, and the investigation of their properties. They were also involved in the measurement of thermal insulating plasters using the electrical impedance spectrometry method (EIS) and the determination of humidity using a capacitive hygrometer. In addition, research activities focused on the processing of shredded waste polyester material and other polymer fillers for use in lightweight concretes brought very interesting results. Due to the uniqueness of the solution, one patent and one utility model were submitted regarding the gained know-how.

Furthermore, the development of advanced vacuum insulation panels (VIP) took place, as did the development of new thermal insulators based on easily renewable materials. Interesting experiments were carried out in the area of fire testing, during which the compositions of fire partition structures with the developed insulators were investigated.

RP1 staff members constantly and actively publish the programme's achieved results at significant scientific conferences and in prestigious international journals, and thus present not only the latest findings from the area of research and development but also the AdMaS Centre

itself. This also includes gaining new contacts for future cooperation in the area of R&D as well as subsidiary tasks. The achieved results are also registered in the form of functional samples, verified technologies, etc. Not only important research staff members in senior researcher positions but also (and mainly) young researchers in junior researcher positions are taking part in the activities of the Centre's research groups. These young employees are also cooperating closely with students taking Bachelor´s, Master´s and PhD courses and passing their experience on to them.

As far as the fulfilment of goals according to the TA is concerned, the following examples can be listed:

- A patent application, PV 2017-2950 "Cement composite with a polymer additive", was submitted in connection with the AdMaS UP project.
- In the area of the "Research and development of a new silicate-based floor system for extreme mechanical and chemical stress", the production of two utility models was achieved: PUV 2016-32728, 30228, with the title "Adhesive bridge-screed system for extreme mechanical stress and chemical resistance", and PUV 2017-33963, 31072, with the title "Material for the treatment of floor surfaces for extreme loading in industrial plants". An application for another utility model, PUV 2017-33983 "Floor system for extreme mechanical loading and chemical resistance", was submitted. Two functional prototypes were registered, these being a "Floor system for floor restoration in specific industrial plants" and a "Floor system for the construction of new floors in specific industrial plants". A verified technology with the title "Technology for the creation of a new floor system for extreme mechanical and chemical stress" was processed and a certified methodology entitled "Methodology for the evaluation of the suitability of a floor system in extreme "in situ" conditions" is currently in the process of verification by an authorized person.
- Within the framework of the project "New structured surface finishes for cement bonded particleboards with extreme resistance and high lifespan", a verified technology with the title "Application of extremely resistant surface finishes to cement bonded particleboards" was prepared, a functional prototype with the title "Application of extremely resistant surface finishes to cement-bonded particleboards" was registered, and a utility model with the title "Structured surface coating with extreme resistance and high lifespan, compatible with cement bonded particleboards" was submitted.
- In the area "A complex system of special patching materials utilizing secondary raw materials for industrial plants", a utility model was registered with the title "Filled grout material".
- In the area "Research and development of advanced materials for industrial floors", two verified technologies were created with the titles "Technology for the execution of adhesive bridges based on epoxy resin" and "Technology for the surface treatment of industrial floors to increase their resistance".
- With regard to basic research, mainly Czech Science Foundation projects were investigated, such as:
  - 15-07657S – Study of the kinetics of events taking place in a composite system at extreme temperatures and exposed to an aggressive environment,
  - 15-23219S – Study of methods of dispersing nanoparticles, and the determination of conditions to limit their re-aggregation for application in cement composites,
  - 16-25472S – Dynamics of the degradation of cement composites modified via secondary crystallization,
  - 17-14198S – Kinetics of silicate microstructure formation in relation to hydrothermal conditions and type of input raw materials,
  - 17-00243S – Study of the behaviour of insulation materials under extremely lowered pressure,
  - 17-24954S – Conditions for the thermodynamic stability and transformation of AFt phases,
  - 16-00567S – Alkali-activated aluminosilicate composites with increased electrical conductivity,
  - 16-02862S – Low-energy binders based on alkali-activated waste brick dust.

Within the framework of the project, lab 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 an XRF spectrometer.

The REM was used in the following areas:

- The analysis of the structure of materials where use was made of fly ash of both the high-temperature and fluid type (TAČR TA04010425),
- Monitoring the effect of milling processes on the structure of silicates, particularly those of crystallite size (GA15-08755S),
- BMAS research concerning thermal barriers in aircraft engines,
- 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 synthesis of pure silicate phases and their properties,
- Research into alpha plaster using the pressureless method,
- The thermodynamic stability of ettringite and thaumasite,
- Hydration processes in ternesite clinkers,
- The development of historical binders for historical mortar and plaster,
- Anhydrite binders,
- The monitoring of firing regarding the ratio of tridymite to cristobalite in refractory materials,
- Measurements taken during research for Bachelor´s and Master's theses in the areas of the use of fly ashes, epoxides, the preparation of light weight aggregate, the adaptation of recipes for products made from porous concrete, etc.

The XRD system was used not only for the above-listed Czech Science Foundation projects but also for research in the following areas:

- The thermodynamic stability of ettringite-based AFT phases (dissertation thesis – Jana Mokrá),
- The thermodynamic stability of thaumasite-based AFT phases (Diploma thesis – Pospíšilová),
- BMAS research concerning thermal barriers in aircraft engines,
- Research into the reactivity of lime produced via desulphation,
- Effect of sample preparation on binder properties,
- The influence of the genesis and type of limestone on the properties of lime and hydrates, and the production process,
- The influence of mechanical activation and milling on the properties of hydraulic binders,
- The development of new methods to improve the grindability of samples,
- The synthesis of pure silicate phases and their properties,
- Research into alpha plaster using the pressureless method,
- The thermodynamic stability of ettringite and thaumasite,
- Hydration processes in ternesite clinkers,
- The reactivation of crystalline slag using mechanical activation,
- The development of historical binders for historical mortars and plasters,
- anhydrite binders,
- The depreciation of milled materials (Master's thesis - Ravaszová GA15-08755S); the influence of raw materials and lime burning technology on the properties of lime (Master's thesis - Sklenářová GA15-08755S),
- Analysis of the level of crystallization of added crystallization admixture for concrete (GA16-25472S),
- The monitoring of firing with regard to the ratio of tridymite to cristobalite in refractory materials,
- The mineralogical analysis of sets of fly ashes (dissertation thesis – Ťažký),
- Measurements taken during research for Bachelor´s and Master's theses in the areas of the use of fly ashes, epoxides, the preparation of agloporits, etc.,
- The evaluation of the microstructure of a polymer cement composite with an increased content of alternative raw materials when the developed material was exposed to the synergic effect of an aggressive environment (sulphates, carbon dioxide and frost in

combination with chemical defrosting materials) and extreme temperatures on a long-term basis (GA 15-07657S),

- The monitoring of microscopic flaws and failures occurring in newly developed coatings intended for cement bonded particleboards which were exposed to the effects of an aggressive environment representing typical influences affecting real structures (TAČR TH01020282).

In 2017, the X-ray CT scanner was used to analyse thermally loaded patching materials, layered samples from a silicate floor system, the brittle fracture of cement-bonded particleboards, concrete samples treated with a water jet, the structure of anchoring materials in a concrete base, the structure of porous concrete samples fabricated via a recipe adapted to use waste materials, and - in cooperation with CEITEC - also components such as range finders, turbine blades, filters and restraining systems for cars, connectors, electric coils, etc.

Just like last year, QUV and Q-SUN devices were used for, among other things, the testing of the resistance of newly developed surface finishes for cement bonded particleboards, which is being investigated within the framework of project TH01020282. This project investigates structured surface finishes for cement bonded particleboards with extreme resistance and high durability. The above-mentioned devices enabled the observation of the influence of a combination of increased temperatures, UV radiation (at a temperature of 60 °C) and condensed moisture (at a temperature of 40 °C) on changes in the properties of surface finishes applied directly to cement bonded particleboards. This involved the cyclic alternation of the conditions described above. The front surface was stressed using the QUV accelerated weathering tester, while all surfaces were exposed in the Q-SUN xenon test chamber, with a focus on edges, which are a more problematic part. During the exposure, changes in the colour parameters - CIELAB (CMC equation) – were monitored with the help of a CMD-600D spectrophotometer. Unlike last year, attention was focused on exposure over a longer period. In 2017, polymer coatings were tested using the QUV chamber for double the period used previously, i.e. a total of 4000 hours. Apart from that mentioned above, the Q-SUN device was also employed in the exposure of samples which had been used for research into (and the modification of) adhesives providing durability to FRP/wooden joints during humidity exposure principally according to the procedure described in the ČSN EN 927-6 standard.

During the production of a Master's thesis (Petra Hudečková), use was made of an HK 800/M/WTG corrosion chamber, which enabled the simulation of an environment containing aggressive gases. Specifically, emphasis was placed on the achievement of an environment in accordance with the provisions of the ČSN EN ISO 3231 technical standard where the procedure for the verification of resistance during exposure to humid atmospheres containing sulphur dioxide is described. 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 structured coatings for cement bonded particleboards (TACR TH01020282) were tested in this way at the highest concentration stated in the cited standard, i.e. 2.7 l of gas (for a volume of approx. 8.8 m3). The evaluation of boards subjected to this exposure took place both continuously (via the monitoring of changes in hue using the spectrophotometer, and the taking of photographs in the "macro" mode) and after the completion of the required number of cycles (adhesion to the base, thickness, scratch resistance, etc.).

In 2017, the RP1 mobile laboratory was used for trips to perform measurements and take samples. These were mainly visits to production plants and specific sites where something project-related was being carried out. Specifically, these trips involved the following types of work:

- taking 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 the thickness of the cover layer of the reinforcement, 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,
- taking aggregate samples 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 defrosting, compressive strength, the evaluation of fine particles – methylene blue test, bulk weight of loosely poured and shaken aggregate, quantity of washoff particles, the determination of lightweight polluting substances and the potential presence of humus, determination of granulometry,

- in-situ testing of fresh concrete, including: air content, consistency (by slump test), the density of fresh concrete, the preparation of laboratory samples on which physicomechanical tests were subsequently performed: compressive strength, the depth of penetration of water under pressure, resistance to chemical de-icing agents, absorptivity, determination of 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, depth of penetration of water under pressure, static modulus of elasticity, watertightness, spacing factor, and the determination of shrinkage,
- the taking of samples for the testing of small concrete products such as: flat tiles, 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 chemical de-icing agents, absorptivity, and measurement of the slip resistance properties of the surface via the pendulum test, adhesion tests, tear tests, and qualitative tests of dimensional tolerance and flatness,
- 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 absorbability and density,
- execution of preliminary, main and complementary 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 and analysis of reinforcement corrosion, design of remedial measures,
- inspectional testing of fresh concrete during the concreting of a motorway: the determination of consistency via slump test, air content, the determination of the density of fresh concrete, the taking of samples for further laboratory testing,
- investigation of anhydrite floor durability, testing of relative deformation and the slip resistance of the surface, measurement of humidity.

Fire test furnaces were used for contract research in collaboration with (for example) the companies Icynene, LIKO-S, SK-TEX and CIMEM, and also as part of joint R&D experiments performed with the company CIUR a.s. in the area of the development of new insulation materials based on renewable raw materials.

Collaboration with partners on projects funded by the Ministry of Industry and Trade, the Technology Agency of the Czech Republic and the Czech Science Foundation took place at an excellent level, as it did with our contract research partners, and the activities of the individual cooperating organizations complemented one another effectively. The collaborating entities included producers of raw materials, materials and parts, future appliers of research findings, and other research organizations. Specifically, the following examples can be named:

- collaboration with CIDEM Hranice, Cetris division, in carrying out the TACR TH01020282 project – New structured surface finishes for cement-bonded particleboards with extreme durability and long lifespan. The producer of new surface finishes is cooperating fully in the development of the finishes and their testing under operational conditions,
- cooperation with BETOSAN s.r.o. and KOMFORT, a.s in carrying out the TACR TA04010143 project – Research and development of a new silicate-based floor system for extreme mechanical and chemical stress. This cooperation synergically connects the development activities of BETOSAN and BUT with a representative of industry, KOMFORT,
- cooperation with P O K O R N Ý, spol. s r.o., HRADECKÝ PÍSEK a.s. and Lena Chemical s.r.o. in carrying out the TACR TA04010425 project – A complex system of special patching materials using secondary raw materials for industrial plants,
- cooperation with Lime Business Consulting s.r.o. in carrying out Czech Science Foundation

project 15-08755S – Study of the influence of the samples preparation on the resultant properties of inorganic binders. In this project, the know-how and many years of experience of the co-investigator are combined advantageously with the latest knowledge from the field of the investigator from BUT,

- cooperation with FATRA a.s. and Tomas Bata University in Zlín in carrying out the TACR TH01030054 project – The options for the processing of waste PES shredded material and other technical waste,
- cooperation with PORFIX CZ a.s. on a Ministry of Industry and Trade project, TRIO FV10284 – Advanced technology for the production of Autoclaved aerated concrete
- with added secondary raw materials and more efficient use of natural resources. The many years of practical experience of the producer of porous concrete PORFIX CZ a.s. provide ideal support for the development of materials using new sources of raw materials at BUT,
- cooperation with 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; research findings from BUT and industry, represented by KOMFORT a.s., are combined in this project.

In 2017, new cooperation began in the execution of basic and applied projects, and also within the framework of contract research. These newly started projects included:

- Ministry of Industry and Trade OPPIK CZ.01.1.02/0.0/0.0/15_019/0004734 – Research and development of mechanically and chemically resistant composites based on cement and non-cement binders and secondary raw materials; the project is being investigated with the company Redrock Construction s.r.o.,
- MPO TRIO FV20149 – A comprehensive system for the remediation of chemically attacked and stressed structures; the project is being investigated in cooperation with BETOSAN s.r.o.,
- MPO TRIO FV20530 – A unique formwork system with a protective anti-corrosion function; the project is being investigated in cooperation with FEVA, s.r.o.,
- MPO TRIO FV20303 – Progressive polymer materials utilizing secondary raw materials and dangerous waste in chemically highly aggressive environments; the project is being investigated in cooperation with Redrock Construction s.r.o.,
- MPO TRIO FV20086 – Development of lightweight modern building materials utilizing light glass powder-based aggregate with the company Refaglass s.r.o.,
- MPO TRIO FV20127 - Research and development of advanced thermal and acoustic/insulation materials based on waste textiles and natural fibres with the company RETEX a.s.,
- Czech Science Foundation GA17-14198S – Kinetics of silicate microstructure formation in relation to hydrothermal conditions and type of input raw materials,
- Czech Science Foundation GA17-00243S – Study of the behaviour of insulation materials exposed to extremely lowered pressure,
- Czech Science Foundation GA17-24954S – Conditions for thermodynamic stability and the transformation of AFt phases.

Fig. 1 Verification of technology for the production of cement-based thermal insulation composite within project TH01030054

Fig. 2 Application of a coating with alternative structural fillers within project TH01020282

Fig. 3 Verification of technology for the execution of industrial floors for project TA04010143

Fig. 4 Diagnostic analysis of the executed industrial floor from project TA04010143

7.2. Research Programme 2: Development of Advance Structures and Technologies

7.2.1. Activities of RP2 in the area of management in 2017

In 2017 fulfilment of the aims of RP2: Development of Advanced Structures and Technologies was fully in accordance with the specialized focus and expected goals described in the TA:

1. Increases in the technical lifespan of selected existing and designed structures, reinforcement and remediation. The creation of models of the procedure for estimating lifespan with reference to the current state of knowledge.
2. Development and verification of interdisciplinary approaches to the evaluation and design of structures (simulation methods, nondestructive testing methods, the development and use of materials with defined functionality, the development and verification of practical applications of field and laboratory measurements, the procedures proposal for construction and production technology).
3. Expansion of the experimental verification of the short-term and long-term behaviour of structures during the process of dynamic and thermal loading, with the possibility of their static and/or dynamic loading during the course of the tests.
4. Development and verification of procedures for the use of materials and construction systems for the construction of transport structures which are specific in the manner of their loading and the conditions under which they will operate.
5. Creation of geodetic, photogrammetric and metrological support for construction activities and research (the surveying of both built and natural structures, the creation of spatial models from data obtained from aerial and ground sensors – Lidar aerial scanner, ground scanners, camera arrays for use with bundle block adjustment, the determination of the exact geometry of individual elements, parts, structures, and the calibration of small and large dimensions). Determination of the absolute spatial position of built structures and other objects, and the monitoring of short-term and long-term changes to them utilizing global navigation satellite systems (GNSS - GALILEO, GPS, GLONASS).
6. Verification and development of new technologies for the cleaning of wastewaters and for drinking water treatment, optimization of the operations management of wastewater treatment plants and water treatment plants, verification and development of elements for the management of wastewater drainage and drinking water distribution, modelling of the quality of drinking water during its distribution (including risk analysis). The focus of the development and optimization of the stated technologies will mainly be on low energy consumption. The work also includes the development and verification of technologies for the use of energy from wastewater, waste and sludge created during the cleaning of wastewaters.
7. Development and verification of a methodology for the verification of practical applications of field and laboratory measurements, the evaluation (including Mathematical Modelling) and development of methodologies in the area of geotechnical research methods and the diagnostic analysis of conditions related to the foundations of structures, with regard to both the design of structures and their remediation and lifespan analysis.
8. Development and verification of methodology for the measurement of the thermal and microclimatic properties of buildings and subsidiary structures (including their properties with regard to outer and inner conditions) with the aim of designing methodologies for construction and technologies for the production of building components primarily aimed at achieving buildings with optimum energy and other parameters.
9. The design and realisation of methodology for the measurement and modelling of traffic flow, emissions and noise pollution, and the modelling of transport. With regard to risk analysis, the achievement of progress in the area of crowd evacuation dynamics when fire is spreading in enclosed spaces.
10. The improvement and application of a comprehensive methodology for the complex analysis of elements fabricated from cement composites.
11. The creation of information systems for models of buildings which cover their whole life cycle (BIM – Building Information Modelling, or Building Information Management).

The members of Research Group RP2-RG1 Engineering and Transport Structures act as the guarantors for individual areas of R&D. Operational and coordination meetings are led by the head of the research group, Assoc. Prof. Ing. Pavel Schmid, Ph.D. with his 1st deputy, Ing. David Bečkovský, Ph.D., and from 1.11.2017 with his 2nd deputy Ing. Pavla Nekulová and a team of the above-mentioned guarantors. The guarantors and deputy heads are drawn from among the research group's young researchers. They provide the head of the RG with coordinated research activities 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 aim of eliminating the need for colleagues in senior researcher positions to spend time doing paperwork.

Research group RP2-RG2 EGAR has a structure which saw no changes in 2017. A coordination meeting is organised once a month for all the heads of the applied scientific areas. At such meetings, the work activities of the EGAR research group and the individual sub-groups are discussed. The heads of the sub-groups organize working meetings as needed, but at least once a month. In 2017, special emphasis has been placed on gaining an awareness of national and international grant programmes – the options for the submission of projects concerning individual areas of application are discussed at every meeting, and topics are sought where it will be possible to involve several groups, or which deal with complex themes.

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 makes a significant contribution to the holding of public events. In 2017, these included:

- The Annual General Meeting of the Czech Association of Geophysicists was held at the AdMaS Centre, accompanied by an exhibition of geophysical instruments and a guided tour of the geotechnical laboratory. The event took place with the participation of professional members of the public and students from several universities.
- A report on the excellent equipment of the Centre for the iDnes online media portal – a presentation of our mobile mapping systém.
- The 2017 Night of Scientists saw staff giving demonstrations of e.g. unmanned vehicles, popular devices for the inspection of utilities, and our mobile mapping system.

The EGAR group uses shared data storage to keep 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 look for cross-cutting 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 being monitored, e.g. in the form of papers and outputs from specialized conferences presented at the above-mentioned meetings. Information about business strategy is submitted to the management of RG EGAR.

Research group RP2-VS3 Mathematical Modelling continued its investigations in 2017 with an emphasis on basic research, which is related to the greater number of basic research projects being investigated, mainly for the Czech Science Foundation. The strategy for an increase in the volume of applied research from non-public sources (contract research) focused on foreign countries – cooperation with Austrian universities.

The management of the MM group remained the same in 2017, 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

- Workshop "Latest information from the area of the evaluation of interoperability", VUZ a.s. in cooperation with the national technology platform "Association for the interoperability of railway infrastructure" (BUT is a member), Brno, 29. 6. 2017.
- Workshop "Evaluation of dynamic effects in railway track", Prague, 15. 7. 2017. Co-organization

of physics seminars at the AdMaS Centre for secondary school students.

- Training of the employees of the Directorate of Roads and Motorways on the subject of the "Performance of construction supervision at road construction sites", January – March 2017.
- On 21. 3. 2017 the Annual General Meeting of the Czech Association of Geophysicists (Česká asociace geofyziků, o.p.s.) took place at the AdMaS Centre along with an exhibition of geophysical instruments. It included a relatively unusual exhibition by Czech producers of geophysical equipment that by Czech standards was unique in its scope. It was attended by professional members of the public, and students and teaching staff from BUT, Masaryk University and VŠB – Technical University of Ostrava.
- 22. 3. 2017 Seminar: Measurements in sewerage networks, camera surveys. Presentation of the current options for the measurement of selected physical parameters in sewerage networks (flows, levels) and the technical specifications of the surveying of sewerage networks using cameras, with regard to the equipment and experience of the AdMaS Centre. Intended for FCE BUT students.
- 6. 10. 2017 Workshop: laboratory tests as a basis for the analysis of a primary collector at the Leitnerova – Hybešova site in Brno. 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 professional members of the public.

7.2.3. Mobility of research staff and cooperation with foreign countries

Mobility of AdMaS employees to foreign countries to the AdMaS Centre:

- Ing. Richard Svoboda, Ph.D.: 3.-7.4.2017, University of Žilina, Faculty of Civil Engineering
- Ing. Miroslava Hruzíková, Ph.D.: 27.-31.3.2017, University of Žilina, Faculty of Civil Engineering
- Ing. David Bečkovský, Ph.D.: VTT Technical Research Centre of Finland Ltd, Helsinki Espoo, Finland, Oulu University of Applied Sciences, Oulu Finland, 18.5.2017 – 24.5.2017
- Ing. Radim Kučera: VTT Technical Research Centre of Finland Ltd, Helsinki Espoo, Finland, Oulu University of Applied Sciences, Oulu Finland, 18.5.2017 – 24.5.2017
- Ing. Jaroslav Pospíšil: VTT Technical Research Centre of Finland Ltd, Helsinki Espoo, Finland, Oulu University of Applied Sciences, Oulu Finland, 18.5.2017 – 24.5.2017
- Ing. Jakub Král: VTT Technical Research Centre of Finland Ltd, Helsinki Espoo, Finland, Oulu University of Applied Sciences, Oulu Finland, 18.5.2017 – 24.5.2017
- Ing. Jakub Dohnal: internship at VTT Technical Research Centre of Finland Ltd, Helsinki Espoo, 1.5.2017 – 28.6. 2017
- Ing. Ondřej Anton, Ph.D.: Technical University of Košice, Faculty of Civil Engineering, 4.-9.6.2017
- Ing. Věra Heřmánková, Ph.D.: Technical University of Košice, Faculty of Civil Engineering, 4.-9.6.2017
- Ing. Iva Rozsypalová: Vienna University of Technology, Faculty of Civil Engineering, Austria, 1. 2. 2017– 30. 4. 2017
- Ing. Miroslav Čekon, Ph.D., Technical University of Košice, Faculty of Civil Engineering
- Ing. Tomáš Macsek, Kompetenz Zentrum Wasser Berlin GmbH
- Assoc. Prof. Ing. Jana Korytárová, Ph.D., Szent István University
- Assoc. Prof. Ing. Tomáš Hanák, Ph.D., University of Rijeka
- Assoc. Prof. Ing. Tomáš Hanák, Ph.D., Cracow University of Technology
- Assoc. Prof. Ing. Vít Hromádka, Ph.D., Ss. Cyril and Methodius University in Skopje
- Assoc. Prof. Ing. Vít Hromádka, Ph.D., Stiftelsen SINTEF, Trondheim
- Prof. Ing. Jitka Mohelníková, Ph.D., The University of Bath, UK, London Metropolitan University, UK, TU Delft.NL
- Ing. Josef Plášek, Ph.D., TUKE Košice, Faculty of Civil Engineering
- Assoc. Prof. Ing. Ondřej Šikula, Ph.D., University of Malaga
- Ing. Jakub Raček, Ph.D., Universita Degli Studi Di Pavia

- Bc. Jakub Hlavínek, International Relations Division, Germany
- Assoc. Prof. Ing. Stanislav Seitl, Ph.D., Vienna University of Technology, Austria, 28.9.2017 – 3.10.2017
- Assoc. Prof. Ing. Stanislav Seitl, Ph.D., Ghent University, Belgium, 24.8.2017 – 27.8.2017
- Assoc. Prof. Ing. Stanislav Seitl, Ph.D., Vienna University of Technology, Austria, 15.5.2017 – 19.5.2017
- Assoc. Prof. Ing. Stanislav Seitl, Ph.D., Universidad de Oviedo, 14.2.2017 – 17.2.2017
- Ing. Jakub Sobek, Ph.D., Universidad de Oviedo, 5.6.2017– 11.6.2017
- Ing. Martina Šomodíková, Ph.D., BOKU University, Vienna, 1.6.2017 – 31.8.2017
- Ing. Václav Sadílek, Ph.D., RWTH Aachen, Germany, 16.5. 2017 – 20.5.2017
- Ing. Martina Šomodíková, Ph.D., BOKU University, Vienna, 1.9.2017 – 30.9.2017
- Prof. Ing. Miroslav Vořechovský, Ph.D., RWTH Aachen, Germany, 16.5.2017 – 20.5.2017
- Assoc. Prof. Ing. David Lehký, Ph.D., BOKU University, Vienna, 5.6.2017 – 10.6.2017
- Prof. Ing. Miroslav Vořechovský, Ph.D., Ghent University, Belgium, 18.4.2017 – 22.4.2017
- Prof. Ing. Drahomír Novák, DrSc., Hohai University, Nanjing, China, 14.8.2017 – 12.9.2017
- Prof. Ing. Zbyněk Keršner, CSc., Koszalin U. of Technology, Poland, 4.6.2017 – 9.6.2017
- Prof. Ing. Zbyněk Keršner, CSc., University of Borås and Research Institutes of Sweden (RISE), Sweden, 10.10.2017 – 16.10.2017
- Ing. Hana Šimonová, Ph.D., Koszalin U. of Technology, Poland, 4.6. 2017 – 9. 6.2017
- Ing. Hana Šimonová, Ph.D., University of Borås and Research Institutes of Sweden (RISE), Sweden, 10.10. 2017 – 16.10.2017

Mobility of foreign students to the AdMaS Centre:

- Bernardo Branco, Federal University of Rio de Janeiro, January – March 2017
- Barbie Bajaj, PEC University of Technology, March – June 2017
- Manjinder Singh, Punjab Engineering College, March – June 2017
- Bevilacqua Amauri Costa, Federal University of Rio de Janeiro
- Assoc. Prof. Ing. Michal Krajčík, Ph.D., Slovak University of Technology in Bratislava
- Ing. Renata Kozik, Ph.D., Cracow University of Technology
- Assoc. Prof. Ing. Edyta Plebankiewicz, Ph.D., Cracow University of Technology
- Prof. Ing. Adjlout Lahouari, Ph.D., Université des Sciences et de la Technologie d'Oran., Algeria
- Prof. Ing. Imine Omar, Ph.D., Université des Sciences et de la Technologie d'Oran., Algeria
- Prof. Ing. Mohamed Aounallah, Ph.D., Université des Sciences et de la Technologie d'Oran. Algeria
- Ing. Gabriela Kalinová, Ph.D., STU Bratislava
- Prof. Hideo Koide, Tohoku Institute of Technology, Japan, 15.5.2016 – 19.1.2017
- Prof. Rafat Siddique, Thapar University, India, 2.4.2017– 2.10.2017
- Jacek Domski, M.Sc. Ph.D., Koszalin University of Technology, 19.6.2017 – 23.6.2017
- Assoc. Prof. Jacek Katzer, Koszalin University of Technology, 19.6.2017– 23.6.2017
- Prof. Wouter De Corte, Ghent University, 12.7.2017– 15.7.2017
- Bc. Sofia Gonzáles Menéndez, University of Oviedo, 12.9.2016 - 13.6.2017
- Maria Hevia Villanueva, University of Oviedo, 1.2.2017- 30.5.2017
- Claudia Oliver Figueri, University of Oviedo, 12.9.2016 - 13.6.2017
- Dipl.-Ing. Dr.techn. Ildikó Merta, Vienna University of Technology, Austria, 1.7.2017– 30.9.2017

Other examples of cooperation with foreign research institutions and companies in 2017:

- Cooperation within the national technology platform "Interoperability of railway infrastructure" with Spanish partners – the Spanish technology platform PTFE (Spanish Railway Foundation and the Technical Secretariat of the Spanish Railways Technological Platform)
- Membership in the EURNEX network – preparation of projects within the Horizon2020

programme

- Joint education programme within the Aktion programme in cooperation with the University of Applied Sciences in Sankt Pölten: Vorträge und Exkursionen zum Eisenbahnwesen in Österreich und der Tschechischen Republik
- The EGAR research group managed to obtain support for a project entitled "JOINTWATER" from the CZ09 Czech-Norwegian research programme from the Fund for Bilateral Cooperation. The "JOINTWATER" project focuses on the reinforcement of mutual relationships with the Norwegian Institute for Water Research (NIVA) and on support for the submission of joint projects for international programmes such as H2020, COST, LIVE +, etc. The project was launched on 1. 2. 2017 and ended on 30. 4. 2017. The leader of the project was Prof. Ing. Petr Hlavínek, CSc., MBA
- Cooperation with Hohai University, China, studying reliability issues using a neural network
- Cooperation with the Technical University of Denmark on issues concerning imperfections in steel columns.

7.2.4. Mobility of researchers towards the application sphere

- Ing. Marek Kervitzer – 1 FTE from 02/2017 to 12/2017 within the programme Knowledge Transfer Partnership OPPIK, The repair and reconstruction of roofs without needing to completely dismantle them, ROMEX s.r.o.
- Ing. David Bečkovský, Ph.D. – 0.3 FTE from 02/2017 to 12/2017 within the programme Knowledge Transfer Partnership OPPIK, The repair and reconstruction of roofs without needing to completely dismantle them, ROMEX s.r.o.
- In 2017, investigations began for the project "Creation of a cooperative partnership between the company GEOtest and the AdMaS regional research 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 different Mathematical Modelling approaches – an advanced material model. The main transfer of know-how will take place via the placement of a first-year Ph.D. student, Ing. Martin Závacký, at GEOtest, a.s. in the position of a knowledge transfer assistant.

7.2.5. Research activities of the RP1

The following major projects were investigated by the Engineering and Transport Structures Research Group in 2017:

TE01020168 The Technology Agency of the Czech Republic's Competence Centre, the Centre for Effective and Sustainable Transport Infrastructure (CESTI). The recipient is Czech Technical University in Prague, and BUT is a member of the consortium, see www.cesti.cz.

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 the 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 roofs without needing to completely dismantle them, ROMEX s.r.o and FCE BUT, Institute of Building Structures.

TACR TA04030110 - Exploitation of the advantages of FRP composites in transport infrastructure
Continuous evaluation of obtained data from loading tests of details of joints using static and repeated (cyclic) loading. Creation and testing of functional prototypes of footbridges made from FRP composites.

Ministry of Industry and Trade TRIO FV10317 - Advanced anchoring contact materials utilizing composites
Preparation of laboratory tests and a working draft for an experimental methodology for the

execution of experiments according to the type of realized tests, along with the production of test specimens and elements. Performance of laboratory research – static loading. Evaluation of conducted experiments. Creation of a functional prototype (test preparation).

TACR TH02020301 – Advanced design of the reinforcement of loaded steel structures
Launch of the pilot version of a programme which enables the analysis of the rods and subsystems of steel structures, including the appropriate joints. A detailed design was produced for the product and user interface.

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.
In May 2017, the 1st stage of the project "Material resources and initial research conditions" was completed successfully. Implementation of the 2nd and 3rd stages of the project – "Investigation of the construction details of the new technology" and "Preparations for the execution of laboratory tests, the summarization of testing procedures, the design of test methodology and the production of test specimens", is currently under way. The investigator is EUROPANEL s.r.o. along with FCE BUT's Institute of Technology, Mechanization and Construction Management and Institute of Building Structures.

Ministry of Industry and Trade TRIO FV20606 – Technique for the bonding of large-format cladding elements
The 1st stage of project implementation has been launched. This stage focuses on the processing of research into relevant material resources and the selection of suitable materials for achieving the project's aims. The investigator is Profibaustoffe CZ with FCE BUT's Institute of Technology, Mechanization and Construction Management and the Institute of Building Testing.

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
Within the framework of the project, a new asphalt mixture is being designed using aggregates which are typically considered to be unsuitable for use on wearing courses, resulting in the lowering of construction costs.

FV10526 - Dissipative asphalt mixtures
The goal of the project is the development of compacted asphalt mixtures that dissipate energy. Such mixtures resist the effects of extreme transport loading and thus prevent the occurrence of failures in the structure of highway pavement. New asphalt mixtures will be developed that are intended to resist the formation of permanent deformations (in the form of ruts) and cracks. In other words, the mixtures will dissipate the load from traffic and weather effects into other forms of energy.

The following major contract research projects were investigated:

SR12757 087 Execution of dynamic tests on a detail of the connection of rail track to a frame column (execution of dynamic tests on a detail of the connection of a rail track to a frame column using a special gusset plate in order to verify the fatigue resistance of the joint). Investigator: Prof. Melcher; Contractual partner: Nedcon B.V. (Netherlands)

SR12757 118 Execution of three dynamic tests on a detail of the connection of rail track to a console welded to a girder (execution of dynamic tests on a detail of a rail track connection in order to verify the fatigue resistance of the joint). Investigator: Prof. Melcher; Contractual partner: Nedcon B.V. (Netherlands)

The following major contract research commissions were investigated within the framework of contract research:

SR12757108 Calculation of the track grid of tramway points – determination of bending moments on point sleepers for tram lines. Investigator: Assoc. Prof. Plášek; Contractual partner: ŽPSV a.s.

SR12557249 Monitoring of a test section with EVA V plastic sleeper anchors. Investigator: Dr. Richard Svoboda; Contractual partner: Chládek & Tintěra Pardubice, a.s.

SR12757010 Calculation of the acoustic response of a selected railway wheel in TWINS. Investigator: Prof. Smutný; Contractual partner: BONATRANS GROUP a.s.

SR12757055 Execution of tests in accordance with the relevant technical standards on PROFIBLOX 300 BRUS block masonry fragments in order to determine the material and strength characteristics of masonry panels. Investigator: Ing. Miloš Lavický, Ph.D.; Contractual partner: TVARBET MORAVIA a.s.

HS126N1076L Determination of the causes of failure of ceramic tiling in selected rooms in a complex of buildings for tuition and the keeping of fish, Faculty of Fisheries in Vodňany; Investigator: Ing. David Bečkovský, Ph.D.; Contractual partner: IMOS Brno, a.s.

HS12657258 Analysis of the minimisation of the influence of heat and humidity load on workers and buildings at HUHTAMAKI production plants. Investigator: Ing. David Bečkovský, Ph.D.; Contractual partner: HUTAMAKI Česká Republika, a.s.

SR12757002 Analysis of the air permeability of the envelopes of halls and the occurrence of surface condensation. Investigator: Ing. David Bečkovský, Ph.D.; Contractual partner: S.O.K. stavební, s.r.o.

HS12657273 Execution and evaluation of loading tests (execution and evaluation of loading tests conducted on supporting cross beams and cable grid hinges). Investigator: Prof. Melcher; Contractual partner: BESPLAST s.r.o.

SR12757042 Preliminary Evaluation Report and EQ documentation on seismicity, JEDU (production and submission of the Preliminary Evaluation Report and EQ documentation on seismicity for the event "5239 Earthquake-proofing of the load-bearing structures of HVB II"). Investigator: Prof. Karmazínová; Contractual partner: EGP INVEST, spol. s.r.o.

SR12757111 Diagnostic analysis of 4 masts, including the evaluation and production of a final report (diagnostic analysis of 4 masts, including the evaluation and production of a final report from the event OE-2002836 Hostinné - Poříčí). Investigator: Prof. Bajer; Contractual partner: Ing. Hugo Thiel

SR12757092 Diagnostic and static analysis of bridge 4325-5A
Execution and evaluation of a diagnostic analysis of a continuous prestressed bridge structure, including the evaluation of the obtained data, the subsequent execution of an advanced static analysis of the structure, including its nonlinear solution, and the design of a suitable and effective reconstruction procedure; Investigator: Assoc. Prof. Klusáček

SR12757093 Diagnostic and static analysis of bridge 122-011
Execution and evaluation of a diagnostic analysis of a continuous prestressed bridge structure, including the evaluation of the obtained data, the subsequent execution of an advanced static analysis of the structure, including its nonlinear solution, and the design of a suitable and effective reconstruction procedure; Investigator: Assoc. Prof. Klusáček

HS12754006L Expert evaluation of the documentation for the execution of change No. 7690: The replacement of the pipes of the super-emergency power pump in the 3rd and 4th block of Dukovany nuclear power station
Investigator: Assoc. Prof. Ing. Pavel Schmid, Ph.D.; contractual partner: CR – State Office for Nuclear Safety, Senovážné nám. 9, 110 00 Prague 1, ID No. 48136069

SR12757106 Expert evaluation of the secondary insulation of the main circulation pump at the Dukovany nuclear power station – 1st and 2nd stage
Investigator: Assoc. Prof. Ing. Pavel Schmid, Ph.D.; contractual partner: CR – State Office for Nuclear Safety, Senovážné nám. 9, 110 00 Prague 1, ID No. 48136069

HS12745013L Study concerning the traffic situation and parking system on land belonging to the town of Boskovice
Processing of traffic surveys from the town of Boskovice and a description of traffic at rest on town land, including a proposal to improve the situation.

HS12754041L Brno – dynamic structure

Determination of the dynamic structure of traffic at selected localities in Brno for a feasibility study for the introduction of low-emission zones in the statutory city of Brno.

HS12754051L Traffic survey – Křížová junction

Execution of a direction survey in the surroundings of the crossroads of Křížová, Vídeňská and Poříčí streets as support documentation for the decision to prevent left turns from Křížová Street.

HS12754052L Traffic survey – Vídeňská junction

Execution of a direction survey in the surroundings of the crossroads of Křížová, Vídeňská and Poříčí streets as support documentation for the decision to approve left turns from Vídeňská Street.

Other major activities include **the international project H2020, which is being investigated by the Transport Structures division – Railway Engineering (ŽEL). The name of the project is S-CODE, Switch and Crossing Optimal Design and Evaluation**. It is a Horizon2020, Shift2Rail-RIA project (H2020-S2RJU-OC-2016-01-2).

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 project is the research, development, validation and initial integration of a radically new concept in the construction of switches and crossings. This has the potential to lead to an increase in capacity, reliability and safety, while lowering investment and operating costs. The project will focus on the use of advanced diagnostic and monitoring systems, on the structure of the railway superstructure and substructure, and on the development of a new switch control system.

The project is being investigated within the framework of the Joint Undertaking Shift2Rail, open call S2R-OC-IP3-01-2016 – "Research into new radical ways of changing trains between tracks", and it will be coordinated together with the call for members S2R-CFM-IP3-01-2016 – "Research into an enhanced track and switch and crossing system", project IN2TRACK. The relationship between both projects and the level of achieved TRL is shown in the figure below:

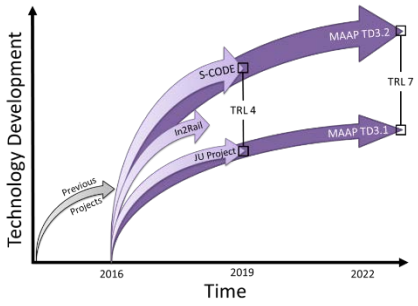


Fig. 5 Relationship between the projects and the level of achieved TRL

In the area of building construction, research is taking place in the area of the material properties of wood and the examination of the behaviour of wooden elements and structures. Furthermore, research is being carried out in the area of energetically autonomous buildings (ENVIHUT) at the AdMaS Centre site. The building has its own photovoltaic system and a wind turbine for the production of energy. Its structure enables its peripheral walls and roof cladding to be changed between different compositional variants. The building is mainly suitable for research in the areas of wooden structures, related composite systems and energy provision (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 prefabricated vegetal façade system.

Fig. 6 Photos of the ENVIHUT model building

In the area of the execution of buildings, the implementation of the Ministry of Industry and Trade project TRIO FV10075 was launched – 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.

The main goal of the investigated 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 sandwich-bonded construction panels composed only from rigid thermal insulation slabs clad with chipboard on both sides that is only 15 mm thick. It is a prefabricated, versatile, simple building system for the realization of energy-saving or passive wooden structures. The basic building unit is a universal panel which will be used for the walls, ceilings and floors, as well as the roof structures. The aim of the project is thus the development of an advanced building system based on the new construction principles of the EUROPANEL technology.

It would also enable the construction of multi-storey energy-saving buildings from bonded sandwich panels. However, the construction of such buildings involves many more demanding considerations as regards the evaluation of structures on the basis of valid legislation in the area of acoustics, fire safety and statics. In 2017, as part of the 2nd and 3rd stage of the project, measurements of building air and impact sound insulation were conducted in currently existing and inhabited buildings. These were preparatory in-situ measurements 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.

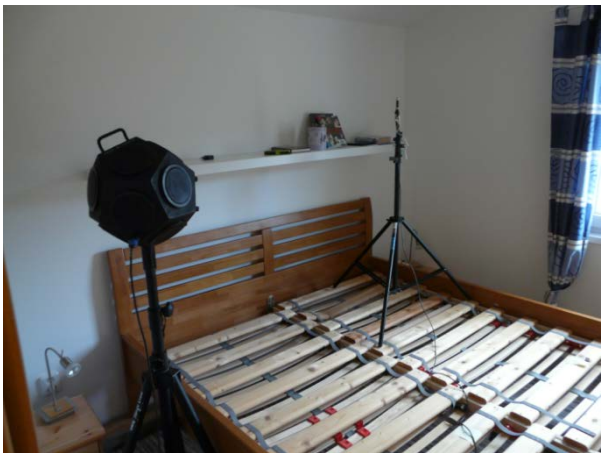


Fig. 7 Photographs from the measurement of airtight sound insulation of a structure made from panel EUROPANEL

In the area of Mathematical Modelling, researchers investigated selected theoretical problems related to the focus of the AdMaS Centre, particularly in the area of delay differential equations, differential geometry, homogenization of the quantitative characteristics of materials with porous structures, and computational optimization during structural design.

In the area of the Transport Structures division – roads (Institute of Road Structures), the TACR project TH01011292 Research and application of new technologies for the construction and repair of highway pavement with decreased asphalt layer thickness (recipient: BUT; other investigators: CONSULTEST s.r.o., SAINT-GOBAIN ADFORS s.r.o.) was investigated. Asphalt beams reinforced with a glass fibre grid are being produced and tested. The beams are tested in four-point bending in accordance with American standard ASTM 7460. For comparison, several specimens were tested using a different type of test which stressed the sample via a combination of shear and bending.

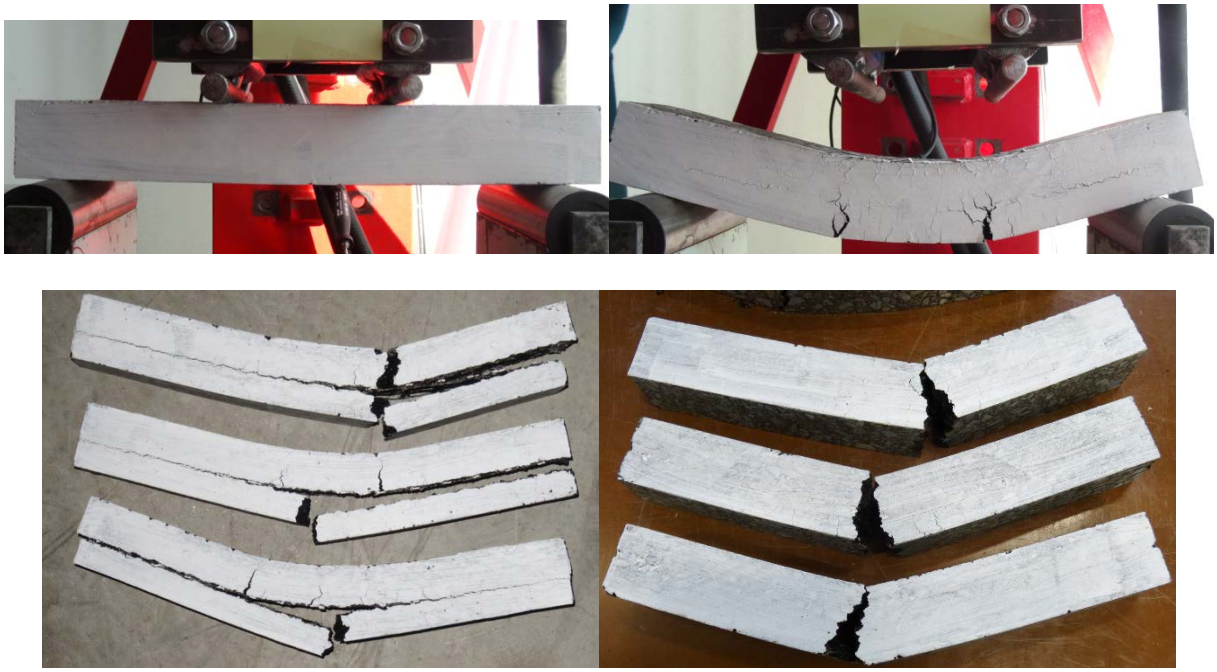


Fig. 8 Layers with glass fibre reinforcement (left) and without reinforcement (right) after testing via dynamic cycling loading

Investigations were launched within a new TACR research programme that examines the use of aggregate with a lower polished stone value for the wearing course of highway pavements. This research was prompted by the lack of aggregate resistant to polishing in certain areas of the Czech Republic. In the first year of the project, asphalt mixtures with various aggregates were designed and the lifespan of the anti-skid properties of the surfaces of test specimens fabricated from these mixtures was assessed using special laboratory equipment (see Fig. 9 below).

Fig. 9 Device for the determination of the friction coefficient after smoothing (left); a test specimen composed of asphalt mixture

In the case of the EGAR research group, the fulfilment of research targets took place in the following way:

Fulfilment of the research target: Measurement of the thermal and microclimatic properties of buildings and parts of buildings (including their properties with regard to exterior and interior conditions), with the aim of designing construction procedures and technologies for the production of construction parts to achieve (in particular) optimum energy and other parameters for structures.

- Methodological leadership of the statutory city of Brno's Smart City working group (regular participation in meetings – Assoc. Prof. Hirš); ongoing activity.
- 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.
- Contract research concerning the evaluation of the options for lowering energy requirements and implementing renewable energy resources in buildings and premises operated by the company STAREZ – SPORT, a.s.
  Equipment: thermal imaging camera, datallogers for PC connection (a suite for measuring the properties of the interior environments of buildings), building simulation software.
- Contract research for the measurement of the interior environment of selected buildings at the Military Research Institute, state enterprise; monitoring and ergonomic study of the interior environment of the HF-46A army tent.
  Equipment: datallogers for PC connection (a suite for measuring the properties of the interior environments of buildings).
- Czech Science Foundation research project – Contemporary climatically active solar facade concepts integrating advanced material solutions; installation at the AdMaS Centre; continuous implementation and evaluation of the project.
  Equipment: Hall P4 at the AdMaS Centre, HP Workstation Z820 laboratory workstation including accessories, datallogers for PC connection (a suite for measuring the properties of the interior environments of buildings).
- TACR research project – Competence Centre – Intelligent Regions – information modelling of urban areas, technology and infrastructure for sustainable development; continuous implementation and evaluation of the project.
  Equipment: Hall P4 at the AdMaS Centre; HP Workstation Z820 laboratory workstation including accessories, multifunctional measurement control system for the energy analysis of building services.

- Contract research related to a selection and design programme for chimney silencers for the company Schiedel
  Equipment: Hall P4 at the AdMaS Centre
- Internal research investigating e.g. the following topics:
  - The integration of an infrared sensor for monitoring the effective temperature of the sky as a cheaper, integrated alternative to the existing procedure conducted using a commercial pyrgeometer,
  - Cardboard-based packaging components made from modern materials employed in the packaging industry – their effectiveness and application in future renewable forms of thermal insulation for buildings.

Fulfilment of the research target: Development of new technologies in the area of drainage and wastewater treatment, the treatment of drinking water and its distribution, waste handling, the development of new procedures for the use of energy from wastewaters, wastes and sludge created during the cleaning of wastewaters.

- Cooperation with the Černá Hora brewery; installation and operation of a pilot device – an anaerobic reactor using membrane separation; development of new technologies for the cleaning of industrial wastewater with a high content of organic substances. Cooperation ended in 2017 with the production of a research report.
  Equipment: A pilot anaerobic reactor
- 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 the project. Reconstruction and completion of the sewerage system in Brno.
  Equipment: Devices for the inspection of utility networks.
- Performance of contract research in the area of the execution of continuous measurements on a sewage network, along with the delivery of validated and authorized data, accompanied by an evaluation of the benefits of the project. Reconstruction and completion of the sewage system in Brno.
  Equipment: Devices for flow measurement and the automated collection of samples, along with the measurement of the basic electrochemical quantities of wastewaters in sewerage networks and wastewater treatment plants.
- In 2017, performance of contract research continued in the area of the monitoring and optimization of sewerage networks in the localities of Sudice, Znojmo and Kroměříž.
  Equipment: Devices for flow measurement and the automated collection of samples, along with the measurement of the basic electrochemical quantities of wastewaters in sewerage networks and wastewater treatment plants; Equipment for the inspection of utility networks.
- In 2017, research continued into the "Removal of antibiotics from drinking water matrix using advanced oxidation processes".
  Equipment: Pilot AOP unit, Hall P4 at the AdMaS Centre.
- Publishing activities with various partners in areas defined by the TA.
- Contract research with the company Bionic in the area of the microwave depolymerisation of waste materials with a focus on the processing of sludge from wastewater treatment plants.
  Equipment: Hall P4 at the AdMaS Centre; the equipment of a stationary analytical laboratory.
- Contract research with the companies Herolds, Huber and VH Atelier in the area of the use of the energy potential of wastewater as part of an investigation of a heat exchanger for a multi-purpose building in Brno.

Fulfilment of the research target: 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 scanners, 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 built structures 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).

- In 2017, the fulfilment of TA goals in the area of geoinformatics mainly occurred via the performance of contract research concerning the use of 3D scanning technologies in connection with linear structures. In cooperation with the Brno Public Transport Company, investigations are continuing in a project concerning the determination of the spatial position of tram lines. During work for the SŽDC railway track authority, other options for the use of mobile mapping technology (laser scanning) were tested under the conditions specified by the track operator. Contract research projects mainly focused on issues concerning the reflectivity of objects when LIDAR aerial laser systems are used.
- Equipment: A system of generally oriented images, a mobile mapping system, LIDAR, a portable mapping system, Disk data storage, Hall P4 at the AdMaS Centre.

Fulfilment of the research target: Verification of the practical applications of field and laboratory measurements, the evaluation (including Mathematical Modelling) and development of methodologies in the field of geotechnical research methods, and the diagnostic analysis of the foundation conditions of structures, both from the aspect of designing structures and of their remediation and lifespan analysis.

- In 2017, investigations were initiated for 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 the measurement of 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.

Examples of the R&D activities of RG EGAR in 2017:

1. Investigations are continuing regarding Czech Science Foundation project No. 16-02430Y: "Contemporary climatically active solar facade concepts integrating advanced material solutions".

   Within the framework of the project, long-term measurements have been performed using a mobile experimental suite, and the testing and optimization of modern solar-activated facade concepts have been taking place at full scale. It is possible to monitor the interaction between the interior environment maintained in the test cell, the experimental construction component and the outer environment. The issues that were investigated include:
   - the determination of the thermal and optical properties of integrated materials of a solar facade panel.
   - the numerical modelling, optimization and testing of a climatically active solar facade in relation to the dynamic effects of the surrounding environment and the influence of solar radiation.

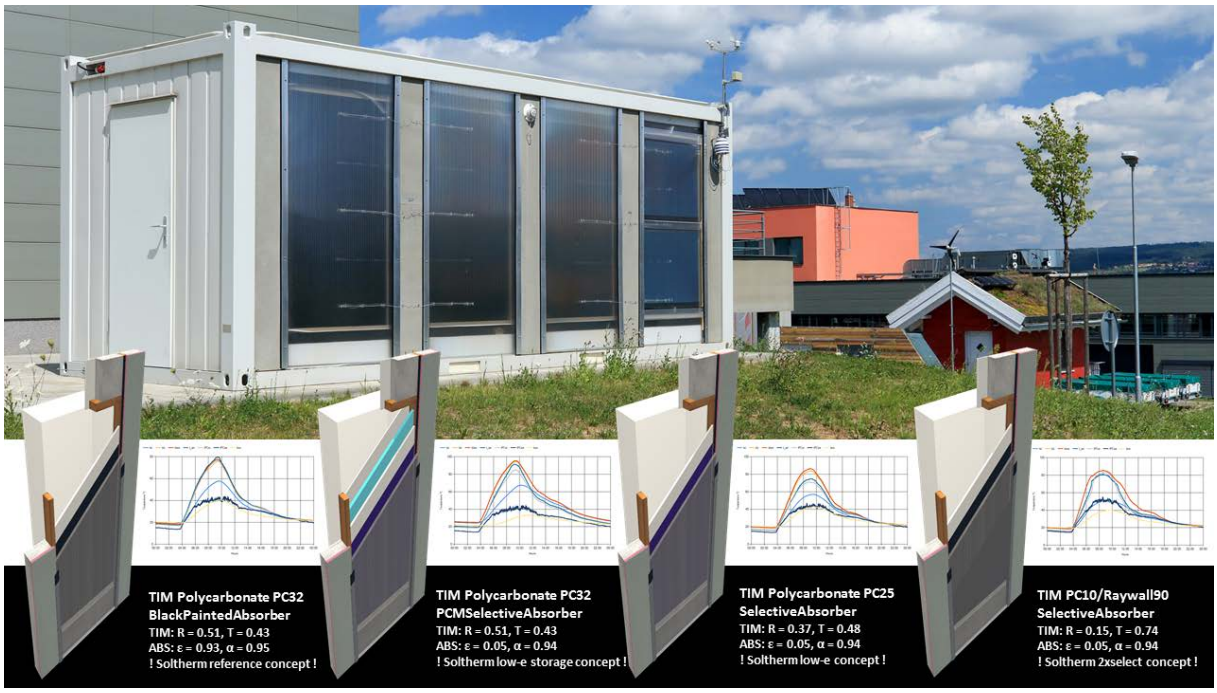


Fig. 10 Mobile experimental full-scale testing suite for solar-activated facades and related concepts

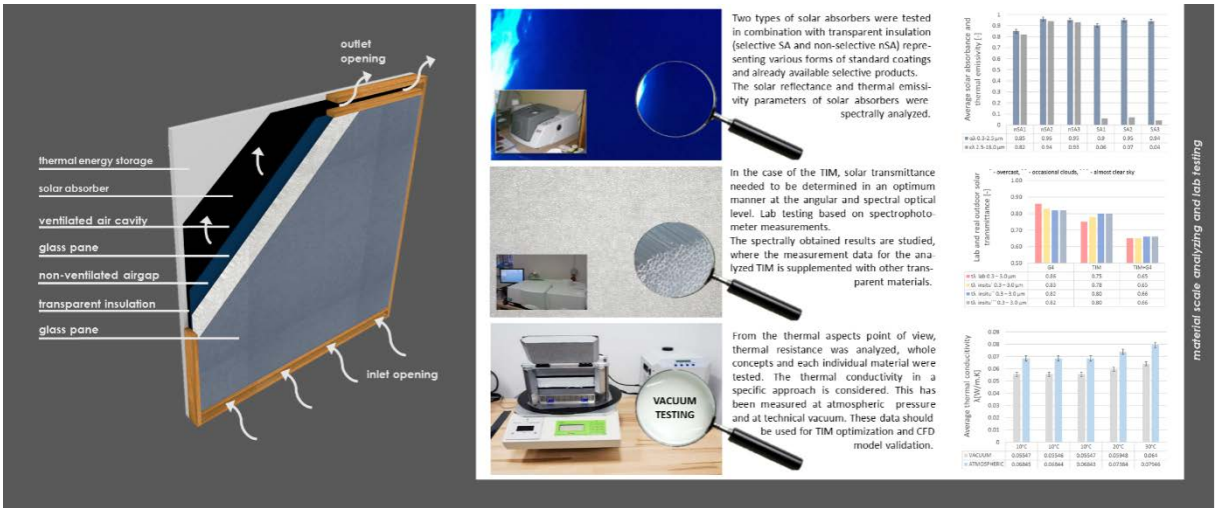


Fig. 11 Development and testing of a solar facade prototype integrating honeycomb transparent insulation material, selective absorbers and advanced layers with latent thermal energy storage

2. The application of an IR sensor as a substitute for a pyrgeometer was verified experimentally and optimised. It can be used in many areas of the diagnostic analysis of buildings, particularly in the monitoring of the thermal radiation component with potential possible application in the development of diagnostic and monitoring methodologies and tools for buildings and regions. This provides with the more affordable form of monitoring the energy balance of radiant energy flows to and from the sky for the quantification and modelling of resultant energy flows of buildings and regions in interaction with the surrounding outdoor environment.
3. A more detailed analysis of the thermal and environmental effectiveness of current materials used by the packaging industry was performed with regard to their possible use in future renewable forms of thermal insulation for buildings. The aim was to evaluate the thermal insulation and environmental properties of selected cartboard-based packaging components available on the Czech and Slovak markets and obtained mainly as waste, and their comparison with standard insulation materials.
4. The development began of infrastructure to be used for testing during research into an intelligent facade system comprising solar-activated facades with adaptive functions for BiPV/T and BiPV-PCM combined hybrid systems integrated into building envelopes.

5. Implementation of TAČR project TE02000077 – Intelligent regions – the information modelling of buildings and urban areas, technology and infrastructure for sustainable development. Hall P4 is, along with other buildings, one of the pilot localities where the comprehensive measurement of interior climate is taking place alongside energy monitoring, etc.
6. In 2017, investigations were initiated for 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_013/000487. The project focuses on issues concerning geotechnical monitoring, and its evaluation. The aim of the project is to detect and deal with problems affecting underground constructions 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. An important element of passing on knowledge within the framework of the project will also be the opportunity to try out the monitoring elements on an experimental polygon of the inspectional geotechnical monitoring system built for a selected section of the primary utility network collector in Brno, or in other words to evaluate methods of inspectional monitoring and inverse analysis.

From the executed laboratory tests it was possible to extract basic values for the calibration of the SC model under conditions of triaxial tension and with reinforcement of the material. The triaxial test simulates the real tension in the sides of the collector. The obtained parameters will be used during numerical modelling (using the finite element method) of the monitored structure in the next stages of the project.

Tab. 4 Sets of calibrated parameters of the input values of the SC model for both localities

Parameter	Marking	Units	Š12	Š13A
Modulus of elasticity of mature concrete	E_{28}	MPa	15500	13500
Poisson's ratio	ν	-	0,2	0,2
Uniaxial compressive strength of mature concrete	$f_{c,28}$	MPa	36	44
Tensile strength of mature concrete	$f_{t,28}$	MPa	2.4	3.8
Normalized initially mobilized strength	f_{c0n}	MPa	0	0
Deformation during plastification under uniaxial compression	ε_{cp}^{p}	-	0.0016	0.0015
Growth parameter ε_{cp} with medium stress	a	-	24	18
Maximum angle of internal friction	φ_{max}	°	39	40

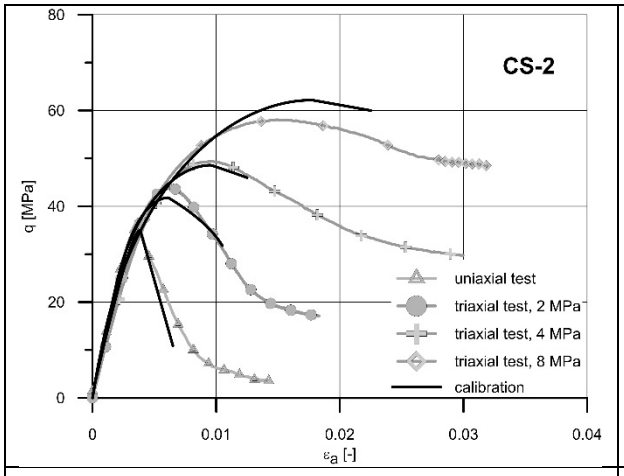


Fig. 12 Comparison of the individual tests and simulation results of the SH model for S12

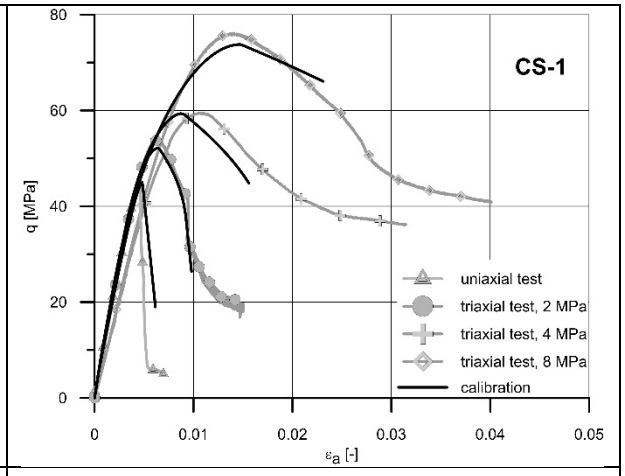


Fig. 13 Comparison of the individual tests and simulation results of the SH model for S13A

Within the framework of collaboration between RG EGAR and industry, the following major contract research projects were investigated:

1. One research task was the production of a mathematical calculation for noise attenuation according to contract for the client's product range of noise absorbers, based on materials provided by the contractor. Specifically, a comprehensive calculation of noise

attenuation was produced which includes the absorber´s own noise and the pressure drop that affects it when flue gas flows through it.

The output of this research task is a Selection and Design programme for chimney silencers manufactured by the company Schiedel s.r.o. Based on entered input data regarding requirements for attenuation or flow speed, the programme enables a calculation to be performed that leads to the subsequent selection of specific chimney silencers made by the manufacturer. The output is a silencer with a graphic expression of its acoustic properties, mainly the input attenuation in defined frequencies, the silencer´s own noise and its pressure loss depending on the amount of air conveyed. The programme is intended for the design of chimney silencers by designers and professional members of the public.

Fig. 14 View of the measuring track, showing measurements being taken to determine the real properties of selected examples of chimney silencers manufactured by Schiedel

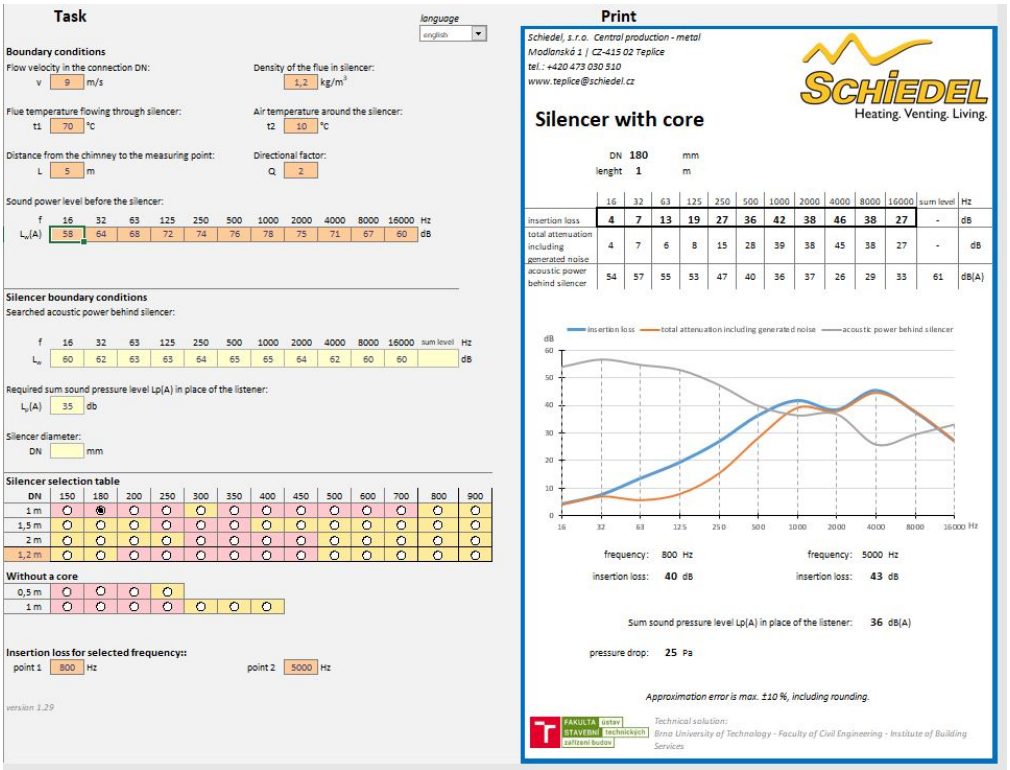


Fig. 15 An example of output from the developed selection software made for the chimney silencer producer Schiedel

2. Research into the usability of a device entitled "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;
    - the optimization of 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 proces;
    - activities publicising the usability of the Bionicfuel device at specialised events;

Fig. 16

3. The town of Židlochovice: an analysis of the interior environment of a selected classroom at a basic school and kindergarten in Židlochovice, based on measurement data from the "transition period" of the calendar year. Interior microclimate parameters were monitored and the data compared with legislative requirements. Equipment: control panels for PC connection (a suite for measuring the properties of the interior environments of buildings).

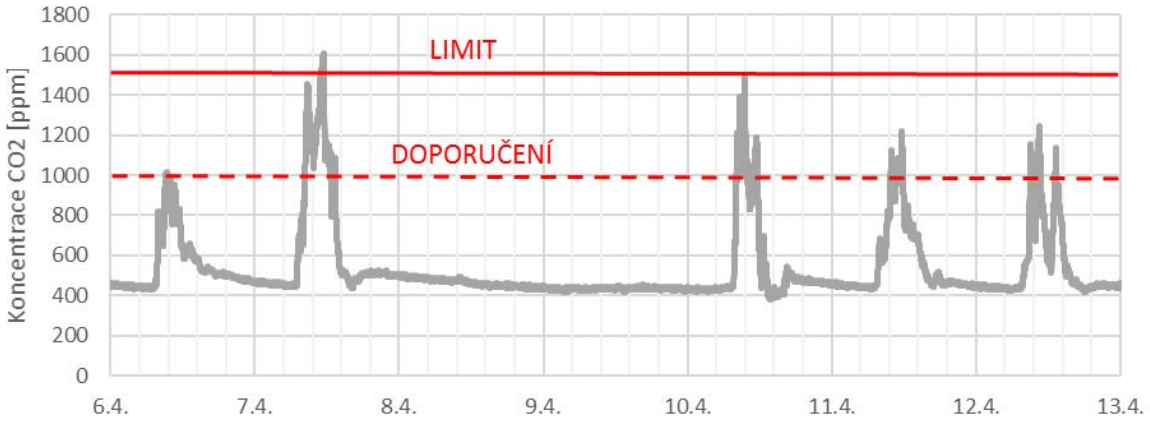


Fig. 17 Development of carbon dioxide concentration in a classroom

4. Brno City Municipality: execution of continuous measurements in the city sewage network; provision of validated and authorized data with an evaluation of the benefits of the project "Reconstruction and completion of the sewerage network in Brno".
Equipment: Devices for flow measurement and the automated collection of samples, along with the measurement of the basic electrochemical quantities of wastewaters in sewerage networks and wastewater treatment plants.

Fig. 18 Installed ISCO laser velocity sensor

5. STAREZ-SPORT, a.s.: General assessment of the options for reducing energy requirements and implementing renewable energy resources in the buildings and premises operated by the company.
   Equipment: thermal imaging camera, datallogers for PC connection (a suite for measuring the properties of the interior environments of buildings), building simulation software.
6. HEROLDS, HUBER, VH Atelier: the uses of the energy potential of wastewater within the framework of investigations concerning a heat exchanger for a multi-purpose building in Brno.

As regards the field of **Mathematical Modelling**, the MM research group has been collaborating with other research groups for many years. It provides individual groups with theoretical and numerical tools to support them in attaining their research goals of a more practical nature. This cooperation also occurred with other research groups in 2017.

The goals of the RG MM, which are stated in the TA, and which were successfully achieved independently in 2017, are primarily:

1. the development and improvement of methods of designing new structures (and the reinforcement of existing ones) while adhering to criteria for reliability and functionality, sustainable development and lifetime assessment.
2. the formulation of mathematical, physical and computational models of processes and phenomena that are fundamental to the quantification of the reliability, lifespan and durability of built structures.
3. the improvement and application of a comprehensive methodology for the complex analysis of cement composite members.

In essence, all of the publications presented below are the result of the group's efforts to achieve the stated goals.

The research activities of part of the MM team were again aimed at a multitude of subsidiary areas concerning issues related to built structures. The following entries summarise and describe the activities of the most significant groups in the MM team.

1. One of the traditionally important topics for the team is fracture mechanics. The group dedicated to this area focused on the deepening of knowledge concerning selected aspects of fracture mechanics experiments, their evaluation and numerical simulations. Their work involved various fracture test configurations and a variety of test specimen and stress concentrator shapes, which were used to evaluate a wide range of materials. With regard to the loading of test specimens, quasistatic behaviour was assessed along with the fatigue testing of materials. Results were adjusted with the aid of approximations of the effect of age on basic parameter values.

   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 specimens were most often prisms with a standard straight edge notch, though supplementary experiments

were conducted using cylindrical specimens with a Chevron notch and specimens for Brazilian disc testing. In the case of the cylindrical specimens with a Chevron notch, some fairly general terms were derived for the area of the ligament.

Another configuration was a modified fracture test utilising eccentric tensile loading (Compact Tension). The modification of the test configuration for use with quasibrittle materials involved a change in the eccentricity of the tensile force causing marked changes in the distribution of stress in the test specimen. The experiments follow on from a parametric study aimed at optimising the method of loading samples via eccentric tensile force while considering size effect and attempting to determine a suitable length for the initial notch employed for this loading method. The pilot experiments were carried out on a LabTest 6.1000 universal tear testing machine housed at FCE BUT's AdMaS Centre in building P1 – see Fig. 19.

The main investigated materials were: cement-based concretes with standard types of filler material, concretes with aggregate sourced from secondary raw materials, fine-grained composites based on alkali-activated slag, and cement and lime mortars.

With selected fine-grained cement composites attention was focused on the interfacial transition zone (ITZ), which is the region of cement paste in the area of its interface with each grain of aggregate. The specific characteristics of this zone can have a significant impact on the resulting behaviour of the composite if it has a crack that is propagating towards that interface while under loading. The fundamental microstructure of the ITZ was explored with the aid of a MIRA3 TESCAN scanning electron microscope at the AdMaS Centre. In addition, the behaviour of this type of composite was analysed via numerical modelling.

Fig. 19 View of the testing machine with an attached specimen, and selected close-ups from the experiment

Also investigated was the response of concrete specimens loaded or damaged by fire. These were test samples taken from experimental panels which had been thermally loaded by an AdMaS Centre furnace for the fire testing of construction materials and small-scale components.

2. In 2017, R&D activities were also focused on issues connected with the probabilistic computation of the degradation and load-bearing capacity of concrete structures. The group of researchers involved have been conducting investigations in this area for a long time. They primarily concentrated on the probabilistic modelling of chloride ingress into concrete and the prediction of the lifetime of reinforced concrete structures with an

emphasis on several subsidiary problems, such as the time dependence of the diffusion coefficient and / or chloride concentration on the surface of concrete, the modelling of the synergy of degradation processes, and the effect of the mutual statistical correlation of input variables on level of reliability.

Corrosion of steel reinforcement is one of the most commonly stated causes of the degradation of reinforced concrete structures. This issue is very closely connected to the evaluation or planning of the lifespan of structures. The significance of this fact rises when one factors in the assessment of the life-cycle costs of structures, along with the issue of quality in the construction industry. Under the conditions prevalent in our region, reinforcement corrosion is most often caused by chloride ingress from de-icing salts applied to roads during the winter. The penetration of chlorides into concrete is a complex phenomenon and complex mathematical models are often required in order to describe it in a precise and accurate manner. Unfortunately, such models are not suitable for everyday use by practicing engineers. Simpler analytical models do exist, though they often cannot provide adequately reliable predictions of chloride ingress in many real cases. For this reason, the evaluation and comparison of diffusion models of chloride ingress was performed with an emphasis on the time dependence of input variables – the diffusion coefficient and surface concentration of chlorides. It was demonstrated that these variables are extremely sensitive to enumerated concentrations of chloride ions at a given depth and time. Because of this, the group also studied the effect of the mutual statistical correlation of input variables on the resulting reliability level of the studied structure. The results of the performed analyses were published in the peer-reviewed journal BETON TKS and at the ICOSSAR and NTCC international conferences.

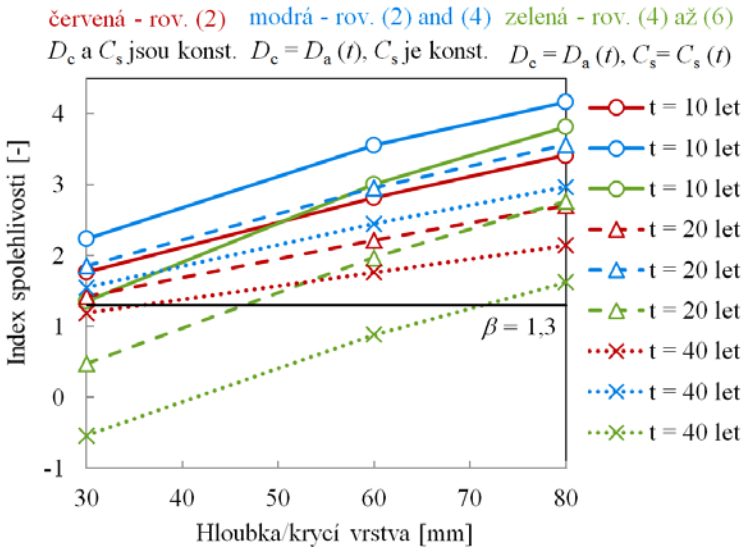


Fig. 20 The effect of the temporal variability of the diffusion coefficient and chloride concentration on the reliability index for various cover layers and structure ages

An important aspect of the modelling of degradation phenomena is the simultaneously acting mechanical loading that causes changes in the pore structure of concrete as well as the initiation or propagation of cracks, thus significantly influencing the speed of the degradation process. Attention was therefore also focused on the expansion of existing analytical models to include the influence of mechanical loading. The results of modelling were compared with measurements from real structures, and the conclusions were published in the high-impact journal Computers and Concrete.

The level of reliability, described with the aid of the failure probability or reliability index, can be determined using standard simulation or approximation methods. This is also true in cases when the structural response is determined using a calculation based on the finite element method. An important step during the creation of a model is the correct definition of random input variables, while simultaneously considering their mutual correlation. For this reason a comparison was made between various methods of determining the sensitivity indicator while determining selected design parameters during the inverse analysis of the reliability of a prestressed bridge. The results were

presented at the ICOSSAR international conference.

3. Another important topic of investigation in 2017 was fatigue in steel structures, and in bridges in particular. Approaches to verifying the reliability of structures subjected to the dominant effects of static loading were compared to approaches focused on fatigue limit states, which need to be verified for the load-bearing structures of bridges. Research was conducted regarding computational models for analysing the fatigue resistance of bridges which were designed last century on the basis of relatively imperfect design methods. Today these bridges are loaded by unacceptable axle weights and crossed by an excessively high amount of vehicles – a situation that the original designers did not take into consideration.

   Research concentrated on assessing the reliability of steel construction members, which was mainly carried out with the aid of reliability index βThis index is widely used in both analytical and numerical simulation approaches, and is considered to be a clearer indicator than failure probability. Reliability index βevaluates reliability on the basis of the variability of experimental measurements. In contrast with reliability assessment on the basis of failure probability, reliability index βprovides better options for the inclusion of other types of knowledge uncertainties that are not contained in simulation data or experimental measurements, and which it is necessary to interpolate or extrapolate in order to predict suitable answers.

   One of the fundamental limitations of this approach is the assumption of analytically functional relationships based on two-parameter Gaussian or log-normal probability density functions, which are the foundation stone of the standard probabilistic analysis of limit state assessment. Generally speaking, the probability density functions of the random variables involved are roughly bell-shaped with low skewness and kurtosis values. For this purpose, on the basis of a literature review, Hermite's probability density function was derived. This function is very good at approximating histograms with roughly bell-shaped distributions of probability density with low skewness and kurtosis. For skewness and kurtosis values that diverge more greatly from a Gaussian probability density distribution, numerical studies were prepared that delimited the domains of definition of Hermite's probability density function, and so a "truncated Hermite's probability density function" was defined. This was applied in an example study in which the not insignificant influence of skewness and kurtosis on the time dependence of fatigue limit state failure was identified. It was demonstrated that the inclusion of the effects of skewness and kurtosis can be an important part of the probabilistic analysis of the limit states of steel structures.

   An example evaluated using linear fracture mechanics and the Latin Hypercube Sampling method showed that the fatigue resistance of steel members with an initial random crack exhibit appreciable skewness and kurtosis values. It also demonstrated that the probability density function of random resistance, which was tested by Pearson's chi-squared test, cannot be reliably approximated via a log-normal probability density function.

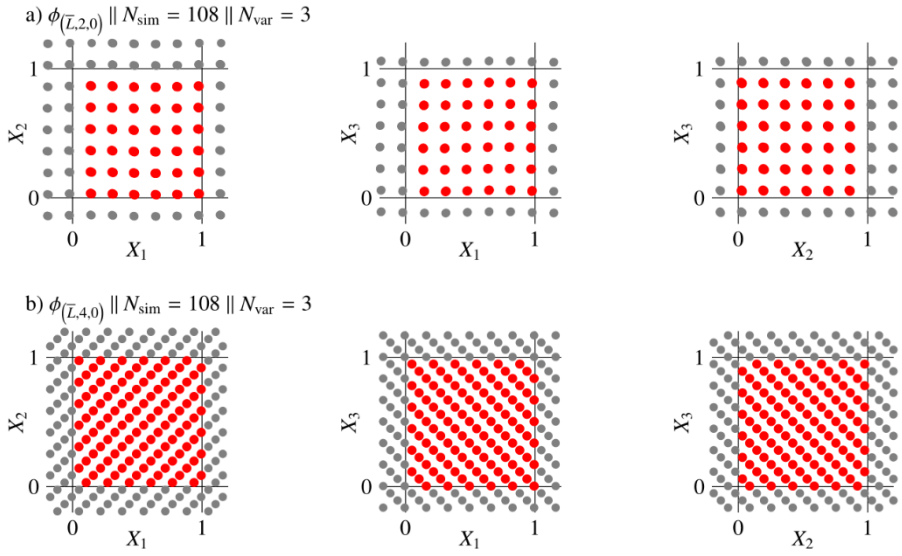


Fig. 21 Three mutually orthogonal projections of an optimised 3D design: a) the original criterion with the power parameter p = 2, b) supercritical power parameter of potential energy p = Nvar + 1

4. At the same time, work was carried out concerning topics from the area of Design of Experiments (DoE). A technique was developed for the creation of designs with the aid of the dynamic simulation of interacting particles which mutually repel one another. The individually charged particles represent points in a unit hypercube, which is simultaneously the design space. The coordinates of points in the space can be used directly as the coordinates of an optimal design. The dependence of the repulsive forces on the distance between particles is derived from optimality criteria, which can be understood as the general potential energy of the system. The derivation of expressions for each pair of particles according to radial distance allows the exact required constitutive law to be obtained. The method has been shown to be exceptionally effective. The system starts with randomly placed particles which are caused to move via the effects of mutual forces. The system is damped, so it stabilises in a configuration which corresponds either to a state with minimum potential energy, or to a metastable state with low potential energy. Parallelisation of the algorithm with the aid of the CUDA environment on GPU cards results in an effective implementation which achieves a stabilised solution within a short amount of real time. The research group utilised their previous experience with the development of PAE optimality criteria, which saw the introduction of periodic boundary conditions. Even with dynamic simulations it is necessary to use a trick with periodic metrics (the method known in molecular dynamics as "minimum image convention"). This removes the influence of boundaries and achieves true statistical uniformity of particle occurrence probability throughout the whole design space. Work concentrated on the derivation of a suitable power parameter in the rules for potential energy in order that equilibrium could be ensured between the proportion of short-range to long-range particle interactions. It was demonstrated that the power parameter of inverse Euclidean distance must exceed a critical limit, which is simultaneously the dimension of the space in question, Nvar. The optimum choice would seem to be the power parameter p = Nvar + 1. Fig. 21 shows that when overly low power parameters of the constitutive law are used, points have the tendency to organise themselves into regular orthogonal rasters, while when sufficient power parameters are used, points move themselves into self-similar generalised triangular grids.
5. Another topic that was investigated was the development of a multilevel probabilistic model of crack bridging in cement composites reinforced with short bundles of glass fibers (glass fiber reinforced concrete – GFRC). GFRC is a modern alternative material which is intended to increase the range of applications of cement composite to include thin-walled elements by lowering the thickness requirements for the cover layer above reinforcement in standard reinforced concrete. This provides a marked degree of flexibility when it comes to the shape of manufactured products. The use of short bundles of fibers significantly increases the usable deformation range, and furthermore increases crack propagation resistance. The randomness and disorganised structure of the reinforcement is crying out for the use of probabilistic approaches. Modelling, and thus also the development of design and evaluation procedures, is greatly complicated by

the fact that it is not possible to separate the scale of the internal structure and e.g. cracks. An acceptable alternative to simple continuum models are multilevel models where the basic unit is a crack bridge, i.e. a crack bridged by bundles of fibers. A probabilistic model was developed for crack bridges. The results gained from the developed model are compared with calculations gained with the aid of a discrete model featuring detailed differentiation of individual fiber bundles. The discrete model is very computationally demanding and the publication shows that the developed multilevel probabilistic model provides identical results. The tensile and shear strengths of the fiber-matrix interface are modelled as random variables, as are the geometric parameters of the reinforcing bundles. At the same time, correct consideration is given to the fact that the number of reinforcement fibers bridging the crack is random, which increases the variability of the strength of the crack bridge.

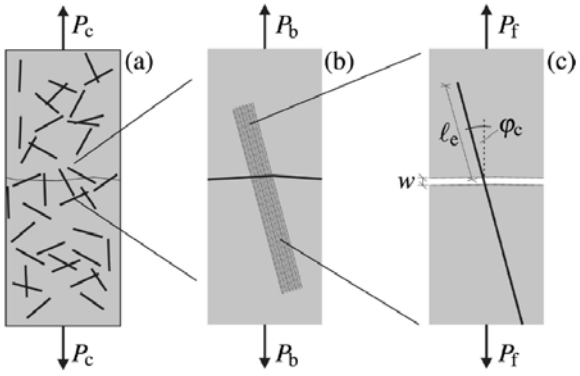


Fig. 22 Multiscale approach to GFRC modelling: (a) a crack in composite bridged by several multifiber bundles; (b) a fiber bundle; (c) an individual fiber with a description of its random geometry in relation to the crack.

Information about the use of purchased scientific equipment

- *ARAMIS*

An ARAMIS 3D deformation measurement system was used in the tensile, compression and flexural testing of specimens of various lengths made from plastic tubes. Loading was applied at various speeds. The results are used for the determination of material parameters for a numerical computational model employed by one student, Jan Ekr, in connection with his dissertation project. The device was additionally used in the analysis of crack development in specimens during the testing of concrete under transverse tension using cylindrical specimens (Brazilian test).

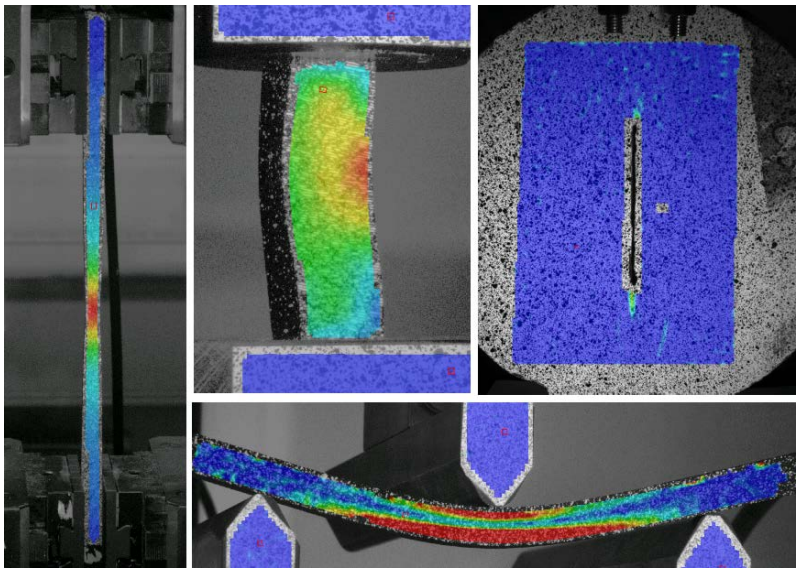


Fig. 23 Outputs from the Aramis system

- *Computational equipment*

Powerful computers were used for calculations and the extension of the database of results when such computers were needed for computationally demanding tasks. These tasks were primarily connected with Design of Experiments – the calculation of criteria for the evaluation of the quality of designs, and the determination of their minimum values. Subsequently, the generation of optimised designs is performed on the basis of the above criteria, and their properties are analysed. Other investigated topics include: a) the use of Voronoi diagrams for design optimisation; b) the question of whether the even distribution of a design generally leads to more precise estimation, which is an area that involves the use of Kriging, and c) the calculation of the strength of a bundle of brittle Weibull fibers.

Another topic was the nonlinear analysis of the influence of temperature on changes in tension in railway track on a railway bridge. The new analyses were aimed at the calibration of the boundary conditions of a model according to the results of measurements performed on structures. The topic was worked on in cooperation with the University of Natural Resources and Life Sciences in Vienna (BOKU) and the results published in an article accepted for publication in the high impact journal Engineering Structures.

- *3D printer and 3D scanner*

Both pieces of equipment were used in the investigation of spatial materials, including mathematical and biological surfaces, and printing them in 3D. The mechanical properties of the materials were also studied using these devices in order that the findings might be used in the optimisation of the fillings and outside forms of construction components.

Examples of collaboration with industrial entities on R&D and contract research projects:

In 2017 active contracts for collaboration existed between the RG MM and the following companies: Červenka Consulting, and the structural engineering office of Ing. Pavel Bušina. Intensive cooperation took place with both companies, resulting in (among other things) the publication of articles. The first of the articles concerns the modelling of fiber concrete materials and structures built from them. The second is devoted to the modelling of subsoil during static and dynamic loading calculations.

As part of the group's supplementary activities, an analysis was performed regarding the stiffness of foundation elements of a vertical machining centre manufactured by TOS Hulín. These elements included the machine's non-homogenous base, its solid concrete foundation, anchors with drilled anchor holes and its rectification base. The analysis also included verification with the aid of experimental measurements.

Another supplementary activity was the printing of a geometrically complex object using a 3D printer.

Within the framework of supplementary activities the group collaborated with several foreign institutions based in Vienna: the Institut für Tragkonstruktionen Betonbau of TU Wien, and BOKU. In the first case cooperation involved the performance (and subsequent evaluation) of experiments on concrete girders. The aim was to achieve the experimental/computational determination of material parameters on the basis of 18 concrete beams provided by the client according to a mutual agreement. The output of the investigation took the form of a research report. The client used the obtained values in the numerical simulation of the failure of beams in shear. The result of cooperation with the Institute of Structural Engineering (IKI) at BOKU, Vienna was the production of a document concerning the design of the shear resistance of prestressed concrete beams. This was the first part of a longer period of collaboration on the setting of "guidelines" for the company Oberndorfer entitled "Conception and deterministic approach".

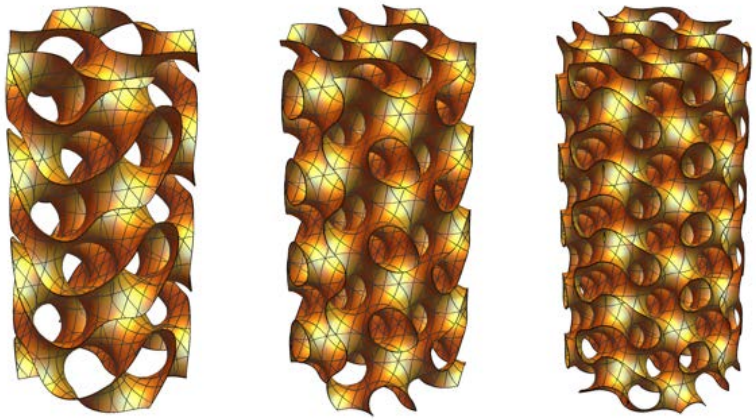


Fig. 24 Example of the use of a 3D printer and 3D scanner

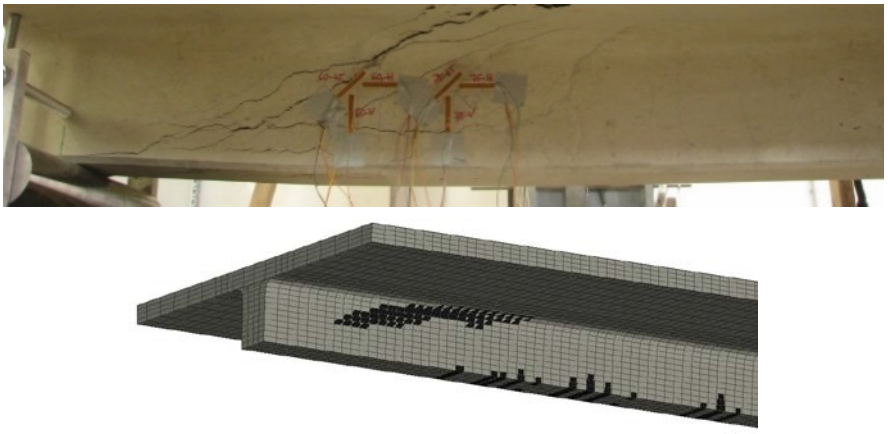
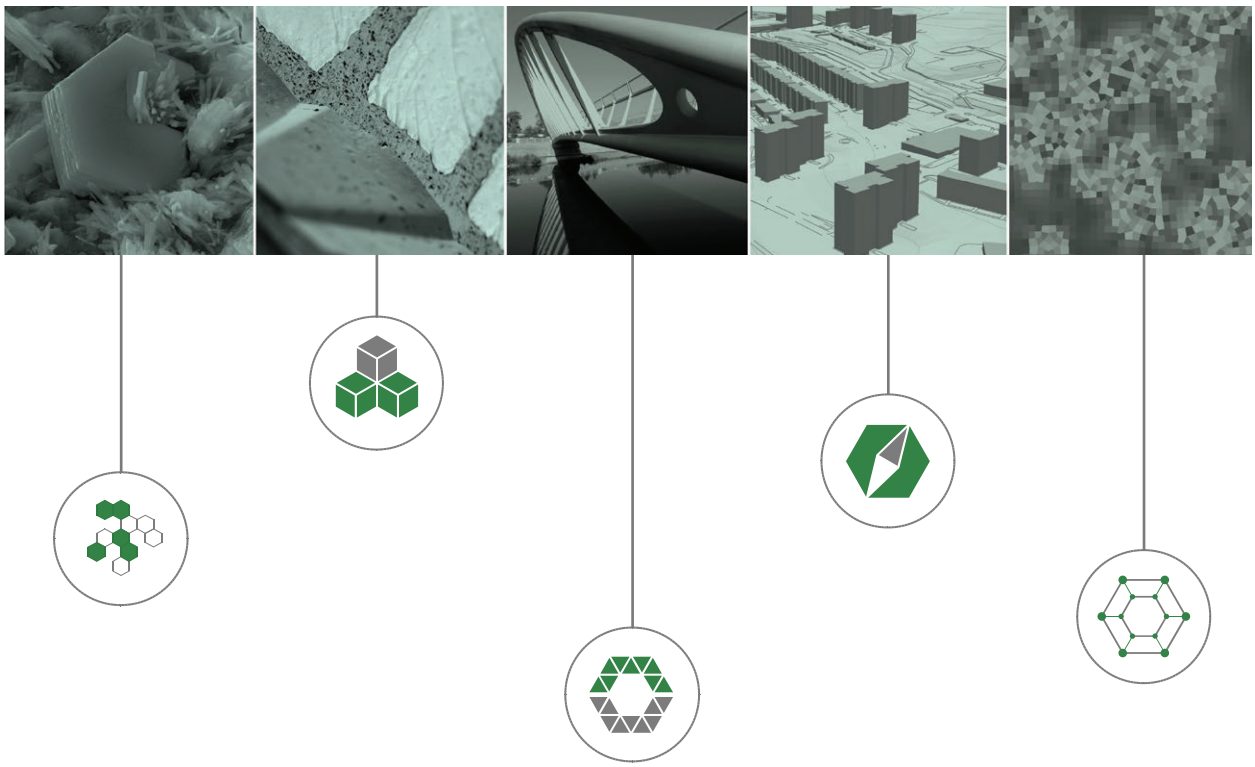


Fig. 25 The failure of a prestressed concrete beam: experiment and numerical simulation



8. Conclusion

The Centre has the third year of full operation behind it at the Purkyňova 651/139, Brno. In 2017, the investigation of R&D projects from previous years continued, including the international project Shift2Rail within the framework of the H2020 programme. A total of 59 projects involving cooperation with industry were investigated by regional R&D centres in 2017, and the Centre continued its own intensive collaboration with industry both in the area of contract research and with regard to shared R&D projects. In 2017, the staff mobility to institutions abroad continued, as did the number of foreign academics visiting the Centre. This contributed to the creation of new partnerships and opened up new areas of international cooperation. Centre management considers the development of international collaboration and internationalization to be one of the highest priorities for the coming years.

All monitoring indicators were achieved in 2017, and the yearly planned values were exceeded in practically all cases.

Number of jobs (FTE) for R&D staff: 134

Number of successful Ph.D./Master´s degree graduates: 14/157

Publication in high-impact journals: 23

Publication in periodicals rated with regard to R&D methodology: 54

National patents: 1

Results of applied research (pilot operation, prototype, functional sample, etc.): 21

Number of contract research projects: 281

Number of R&D projects: 78 + 4 international

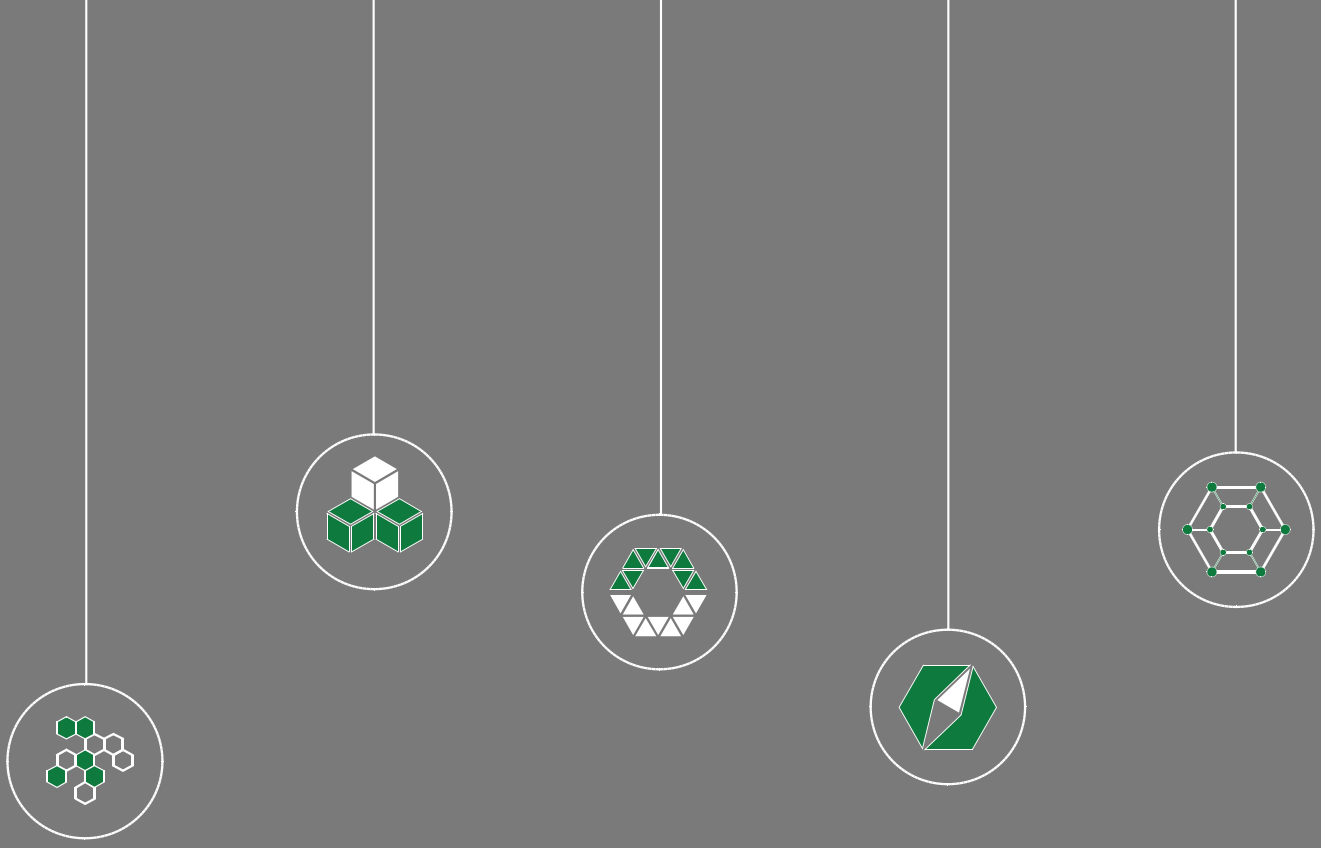
Total income from commercial activities: 53.615 Mil. CZK

Amount of the above commercial income gained from contract research: 27.433 Mil. CZK.

Income from non-commercial activities: 147.774 Mil. CZK.

Total income of the Centre: 201.389 Mil. CZK.

Generally, our cooperation with industry has undergone significant development and the turnover of the Centre in the area of contract research was retained. It is a positive fact that the contract research we are doing is taking place in all of the areas of focus of the research centre, and the many individual projects that are underway are being conducted with a good number of customers. It is thus not the case that the prosperity of the Centre is linked to just a few clients, meaning that the diversification of risks is possible.



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