Annual Report on the Activities of the AdMaS Centre 2016

Foreword by the Dean

Dear colleagues,
You are now holding a summary of the results of the work of the AdMaS Centre for the year 2016, i.e. the second year of operation at our new premises. After the initial troubles involved in equipping the centre with furniture, this was a year when we managed to deal with everything successfully. Our employees now have the instrumentation and working environment they need for their engagement in the tasks assigned to them. All of the equipment obtained for the centre has started to be fully used in the achievement of the milestones set at the beginning of project implementation. Our second year was successful, both in the field of science and from the perspectives of administration and contract research. We still have three years of project sustainability ahead of us. The results from the second year show that the sustainability indicators will be fulfilled without any problems. I would like to thank all of those taking part for everything they have done.

It is becoming obvious that certain expectations upon which the strategy of the Centre was based when the project was in the planning stage are not being fulfilled. On the other hand, new areas are opening up for us. This is a natural phenomenon, as more than eight years have elapsed since the first plans were drawn up for the project and there have been significant shifts in the market. The management of the AdMaS Centre has thus updated the operational strategy of the centre. This modern centre has provided our faculty with one of the best-equipped scientific and technical facilities in Europe. I am very pleased that we are successfully taking advantage of these scientific and technical facilities.

In 2016 the AdMaS Centre intensified its mobility programme, with more employees than ever spending time at institutions overseas. The number of researchers visiting the AdMaS Centre from foreign universities also increased. In this way, awareness of the centre improved not only at the domestic level but also worldwide.

Thank you once again for all the work you have done up to now. I believe that 2016 was just the beginning of a long-lasting and successful journey for the AdMaS Centre and its staff.

Prof. Ing. Rostislav Drochytka, CSc., MBA, Dean

Contents

1. **Organizational structure** 4

2. **Activities in the area of Centre management and organisation** 6

3. **Seminars, training, presentations** 8

4. **Research staff mobility: research stays and collaboration with institutions abroad** 12

4.1. Research staff mobility and collaboration with institutions abroad within the framework of Research Programme VP1 13

4.2. Research staff mobility and collaboration with institutions abroad within the framework of Research Programme VP2 13

5. **Research staff mobility: collaboration with industry** 14

6. **Achievement of milestones** 15

7. **Research activities at the Centre** 18

7.1. Research Programme VP1 19

7.1.1. Research activities conducted for Research Programme VP1 19

7.1.2. Use of laboratory instruments in Research Programme VP1 21

7.1.3. Contract research within Research Programme VP1 24

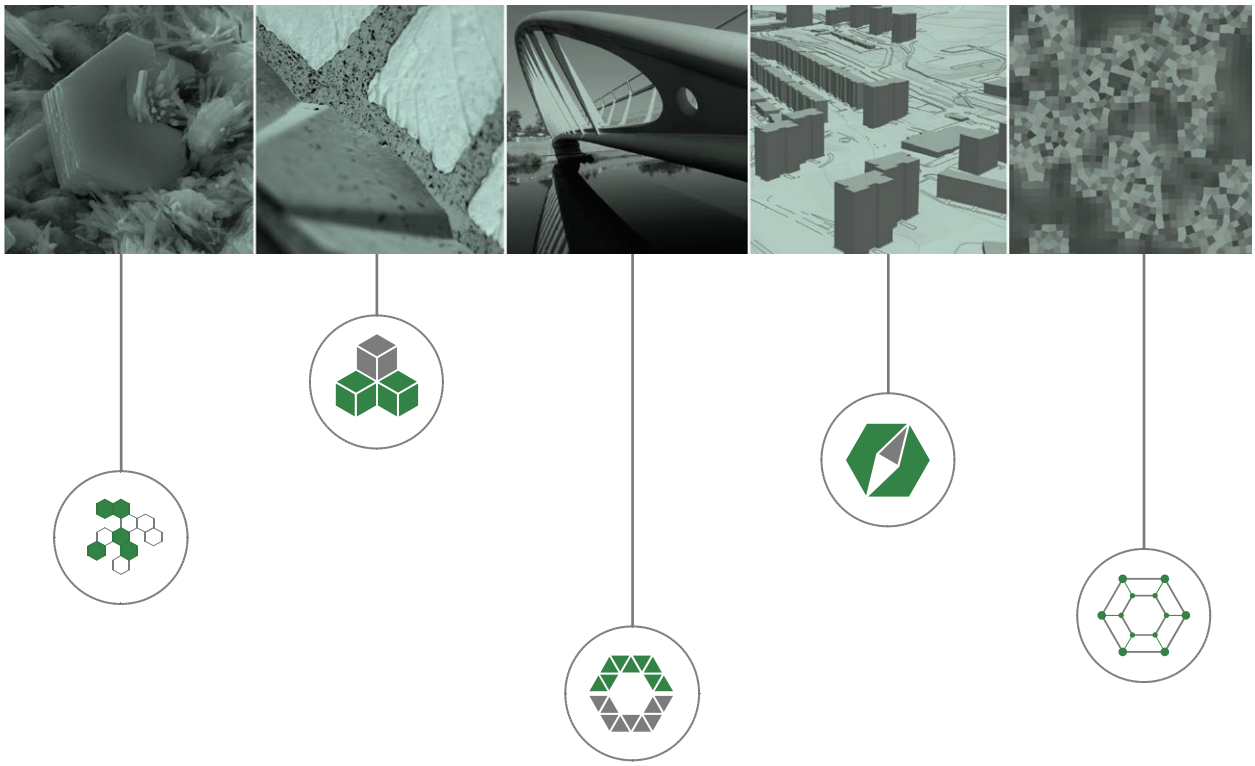
7.2. Research Programme VP2 26

7.2.1. Research activities of the Structural and Transport Engineering Research Group 26

7.2.2. Research activities of the EGAR Research Group 32

7.2.3. Research activities of the Mathematical Modelling Research Group 37

8. **Conclusion** 42



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

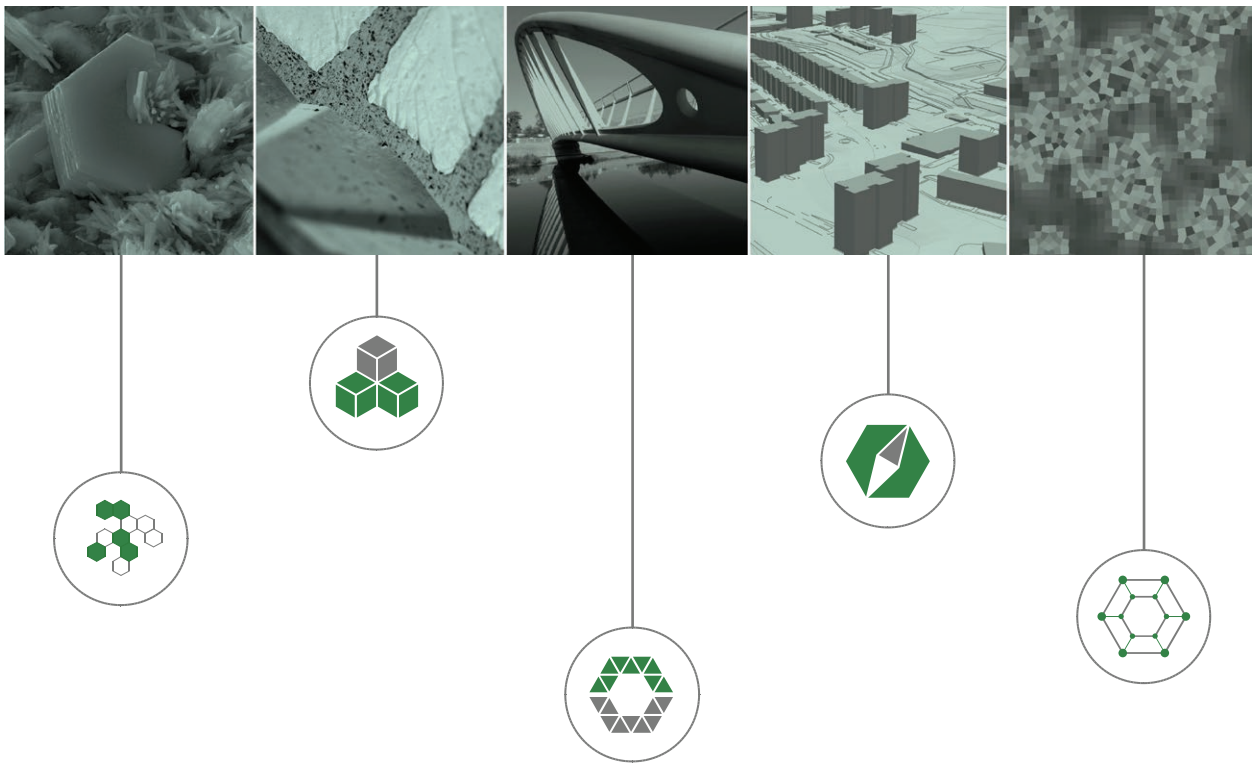
Head of Research Group	Assoc. Prof. Ing. Pavel Schmid, Ph.D..

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 2016 the first monitoring report from the sustainability period was produced. It was approved by the Regulatory Authority in June 2016. The profile brochure of the Centre was updated and printed in Czech and the web version of the profile brochure in English was updated. A brochure for foreign students entitled "International student´s guide – Civil engineering in the Czech Republic - ABOUT CURRICULUM & STUDENT'S LIFE AND ADMAS RESEARCH" was created.

On 14.3.16, an "AdMaS Centre Day" took place – in the morning, there was a tour of the Centre's laboratories at the Purkyňova Street site for faculty staff and students. In the afternoon, a presentation meeting was held with employees and Ph.D. students.

In 2016, the collective horizontal integration of research teams took place in accordance with recommendations made during international evaluation of the project. Meetings occurred between R&D staff from all of the Centre's research groups and from all positions and scientific posts. The Centre was also involved in promotional events focused on the popularization of science, for example Scientists' Night, Majáles, etc. Elements of a new HR policy were applied that involved (for example) the provision of support to young scientific researchers and for communication between research groups at the AdMaS Centre. Many events took place at the Centre in connection with the AdMaS Centre tour (see below). The Centre became a member of the Czech Smart City Cluster in 2016.

On 22nd June 2016 the first ever AdMaS Cup was held, a pétanque tournament featuring research centres that is planned to be an annual event. Teams from the Materials Research centre, the NETME Centre, STE CEITEC and, of course, our own AdMaS Centre took part in the tournament to win the Cup. The competing groups of researchers were joined by a team from Tourist Authority South Moravia.

During 2016, Centre management actively implemented the HR principles outlined in the Technical Annex. These mainly entailed the regular evaluation of R&D staff, personal and motivational interviews with Centre employees, support for new projects and mobility, and also active cooperation with the Representation of the South Moravian Region in Brussels with the aim of involving the Centre in foreign R&D projects within the framework of H2020. Regular monthly meetings of the Centre management (including the representatives of the individual research programmes (RP) and research groups (RG)) were organized.

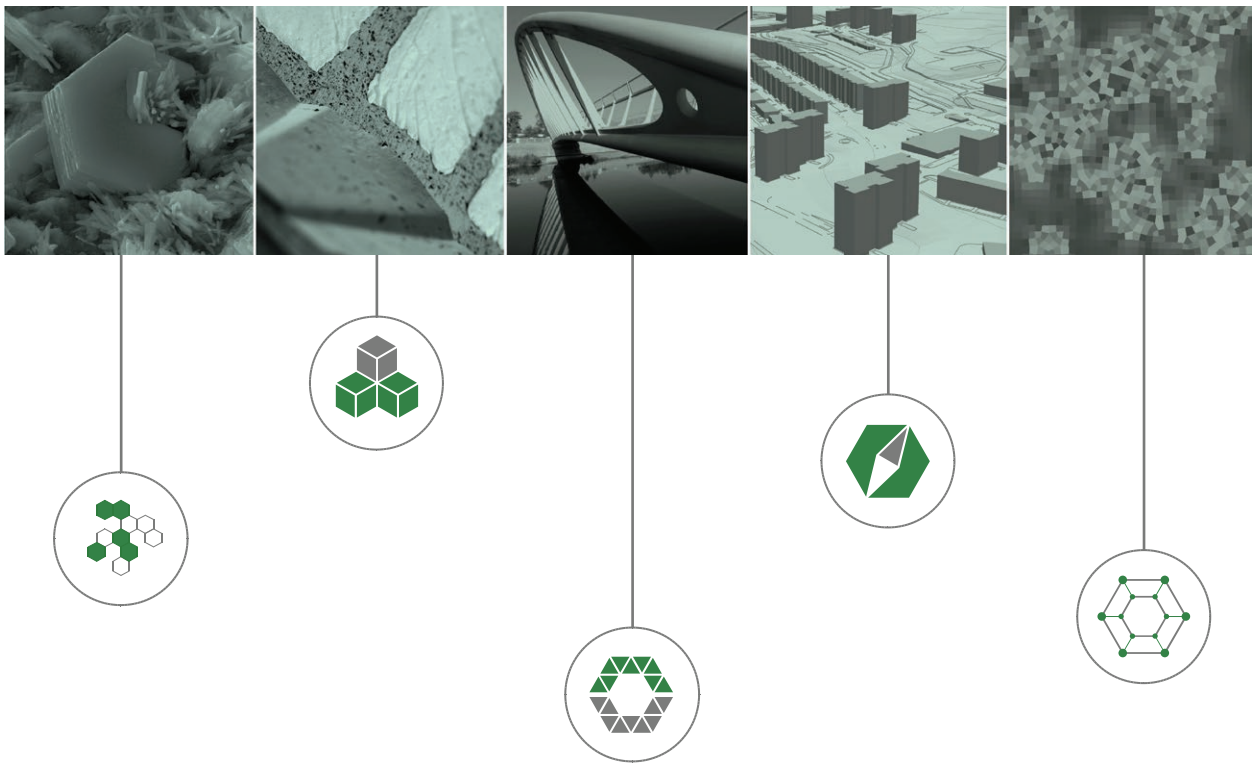
During 2016, several important national and local government representatives visited the Centre. To be specific, it was the Deputy Minister for Regional Development, JUDr. Jan Blecha (for negotiations concerning the implementation of BIM when entering public construction contracts), and also the Chairman of the Union of Towns and Municipalities of the Czech Republic, and Mayor of Kyjov, Mgr. František Lukla (a memorandum concerning cooperation with UTM CR was signed). We were also visited by Ing. Jiří Koliba, the Deputy Minister of Industry and Trade, with whom we discussed the "Stavebnictví 4.0" concept. Another visitor was Mgr. Kamil Rudolecký, the Deputy Minister of the Ministry of Transport, who discussed the options for the involvement of our experts in specialised teams investigating navigation systems.

Negotiations also took place at the Centre with managers responsible for technical development at multinational corporations which are involved in the construction industry. These were mainly representatives from Skanska (Sweden), Colas (France), Mageba (Switzerland), Cembrit (Denmark) and Wienerberger (Austria).

As far as mobility is concerned, employees (from all R&D categories) engaged in visits to foreign countries, while academics from abroad took up research stays at the AdMaS Centre, or participated in seminars and training sessions for professionals involved in the application of research results in industry. Active cooperation also took place with institutions engaged in the application of research, both in the area of contract research (the centre earned 36,737,000 CZK performing contract research in 2016), and of applied R&D projects (56,120,000 CZK was obtained via the Centre's R&D projects (not counting institutional support and the AdMaS UP Centre sustainability projects)).

During the year, the AdMaS Centre regularly published a newsletter which outlines new developments occurring throughout the Centre and is used as an active tool for increasing the mutual awareness of its employees.

The Supervisory Board of the Centre held meetings on 26.3.16 and 17.10.16. The International Scientific Board also met that year, with a new composition. Dialogues between the heads of research programmes and research groups and Centre management took place over three days. It was stated during the negotiations of the International Scientific Board that the aims of the Centre are being fulfilled in accordance with the plan and that there is no danger that problems may arise with regard to achieving the goals of monitoring indicators.



3. Seminars, training, presentations

As far as the activities of the whole Centre in 2016 are concerned, the following events took place:

- 28. 1. 2016 — A seminar for the staff of Brněnské komunikace, a.s., combined with a tour of our laboratories.
- 17. 2. 2016 — A presentation meeting with COLAS Group managers at the AdMaS Centre
- 23. 2. 2016 — The AdMaS Centre was visited by Prof. Oleg Modestovich Eparchin, the director of a branch of the Moscow State University of Railway Engineering in Jaroslavl.
- 9. – 11. 3. 2016 — Seminar for eight Mongolian construction company managers and employees from the Agency for Public Procurement and the Road Construction Authority of the capital city of Ulaanbaatar.
- 14. 4. 2016 — The AdMaS Centre was visited by around three dozen colleagues from universities in Bulgaria, Estonia, Finland, France, Cyprus, Latvia, Hungary, Germany, Poland, Greece, Slovenia, Spain and Great Britain as part of BUT International Staff Week (Erasmus staff training project).
- 4. 5. 2016 — Prof. Ing. Rostislav Drochytka, CSc., MBA, Dean of the Faculty of Civil Engineering, and Mgr. František Lukl, MPA, Chairman of the Union of Towns and Municipalities of the Czech Republic (South Moravian Region), ceremonially signed a contract concerning cooperation between the AdMaS Centre and the Union.
- 6. 5. 2016 — The AdMaS Centre was visited by three important dignitaries from University Sains Malaysia: Prof. Dr. Muhamad Jantan, Deputy Vice-Rector for Research and Innovation, Prof. Omar Osman, Vice-Rector, and Prof. Dr. Lee Keat Teong, Director of Research at the Centre for International Cooperation.
- 12. 5. 2016 — Seminar for staff from Brno City Council's Building Offices, accompanied by a tour of our laboratories.
- 17. 5. 2016 — The AdMaS Centre took part in a meeting between leaders of the Czech construction industry organized by the company CEEC Research.
- 18. 5. 2016 — The AdMaS Centre took part in a pétanque tournament during BUT's annual Sports Day.
- 9. 6. 2016 — The AdMaS Centre was visited by Lise Frank Kirkegaard and Zuzana Bodíková, R&D department staff from the company CEMBRIT.
- 20. 6. 2016 — A work of art was installed at the AdMaS Centre – a large-scale metal object with the name S355.
- 21. – 22. 6. 2016 — AdMaS Centre employees participated in the "Bezpečnost regionů" international conference.
- 22. 6. 2016 — Visit to the AdMaS Centre by students from a secondary technical school (specialised in civil engineering) located in Lipník nad Bečvou as part of a T-excursion event.
- 21. 7. 2016 — The AdMaS Centre was visited by the Dean of the Technical Faculty at Kamphaengsaen, Kasetsart University, Assoc. Prof. Bancha Kwanyuen, Ph.D., together with his colleague from the Department

of Civil Engineering, Assoc. Prof. Dr. Wichail Kijawatworawet.í.

- 30. 9. 2016 Scientists' Night took place for the second time at the AdMaS Centre.
- 4. 10. 2016 The AdMaS Centre was visited by Prof. Dr. Ravindra Gettu from the Indian Institute of Technology in Madras.
- 6. – 7. 10. 2016 Presentation of the AdMaS Centre by its director JUDr. Ing. Zdeněk Dufek, Ph.D. and other researchers at the Městské vody (Urban Water) conference in Velké Bílovice.
- 19. - 20. 10. 2016 The AdMaS Centre, together with the company SAINT GOBAIN ADFORS, presented their shared contract research at Silniční konference 2016 (Road Conference 2016) in Hradec Králové. The presented topic concerned slowing the occurrence of reflective cracking in the asphalt layers of pavement using a glass-fibre grid, GlasGrid®.

In addition, the following activities took place within the framework of Research Programme VP1:

- 3. 2. - 4. 2. 2016 ČEZ a.s. staff underwent laboratory training as part of a basic preparatory course entitled Construction Section of a Nuclear Power Station II. The course entailed 16 hours of tuition, mainly in laboratories. During the course, issues related to the design, preparation and quality control of fresh and hardened concrete were presented. Destructive and non-destructive tests for use with fresh and hardened concrete were presented and then tried out in practice. Attention was paid to the checking and remediation of concrete structures at nuclear power stations, the surface finishes of materials, and the pore structure as well as the inner structure of materials. Another part involved an introduction to the latest laboratory methods for the evaluation of construction materials. Time was also spent on the theoretical background to X-ray diffraction analysis, scanning electron microscopy and computed tomography.
- 23. 2. 2016 Training of employees from the company BEST a.s. - Training took place in the area of concrete products produced using vibration casting technology, such as concrete paving blocks, slabs, curbs, masonry elements, lost formwork blocks, palisades, and others. The main topic was the production, evaluation of the properties and assessment of the congruence of these concrete products. The training sessions also included a practical demonstration of tests conducted on concrete products in laboratories.
- 19. 5. 2016 TECHBET 2 Concrete Technologies training – organized by the Czech Concrete Society in cooperation with AdMaS (which provided space, expert lecturers and a tour of the Centre premises). The tuition covered the areas of aggregates in concrete, additives in concrete, admixtures in concrete and their effect on its final properties, concrete recipe design basics, and the testing of concrete properties. Tuition also included a practical demonstration of tests conducted on concrete products in laboratories.
- 29. 5. 2016 T-excursion for secondary school students – NANOTECHNOLOGY IN THE CONSTRUCTION INDUSTRY – At the beginning of the excursion, the students were familiarized with nanotechnology issues via a presentation. This was followed by demonstrations of instrumentation with expert commentary.
- 25. 11. 2016 T-excursion for secondary school students – DIAGNOSTIC TESTING OF BUILDING STRUCTURES – A VIEW INSIDE REINFORCED CONCRETE

– The students were familiarized with basic diagnostic methods. First, there were specialised lectures, and then these were followed by demonstrations of individual diagnostic methods: non-destructive localization of reinforcement using an electromagnetic probe, measurement of coating thickness, core drilling, acoustic tracing, electromagnetic measurement of coating thickness, and phenolphthalein testing.

Also, the following activities took place within the framework of Research Programme VP2:

- 21. 10. 2016 — Seminar for Ph.D. students on the options for the use of the strategic equipment and facilities of the AdMaS Centre in the preparation and realization of specific research projects.
- 23. 10. 2016 — Seminar on radiation defectoscopy centres led by Prof. Ing. Leonard Hobst, CSc.; also covered were the options for the use of the Centre's current equipment in prepared basic, applied and contract research projects.
- 15. 11. 2016 — Use of flexible elements in the construction of tram tracks with regard to the occurrence and propagation of noise and vibration.
- 22. – 24. 10. 2016 — Training sessions organised for the staff of the Road and Motorway Directorate of the Czech Republic. The topic was quality assurance during the construction of roads.
- 12. 12. – 15. 12. 2016 — Seminar for Bachelor's students as part of the tuition of the subject BI002 Testing and Technology at the AdMaS Centre
- 22. 11. 2016 — Seminar for Bachelor's students as part of the tuition of the subject BM001 Roads 1 at the AdMaS Centre.
- 1. - 9. 12. 2016 — Co-organized physics seminars at the AdMaS Centre for secondary school students.
- 6. 10., 13. 10., 21. 10. and 27. 10. 2016 — Lifelong learning course on the topic of geotechnical issues related to water management structures. The course is intended for individuals working as designers, in public administration, in water management, etc.
- 13. 12. 2016 — Design Builder software course: a one-day training session organized as part of the Technology Agency of the Czech Republic's Smart Regions Competence Centre project in order to deepen knowledge and make use of all the possibilities which the software offers.

4. Research staff mobility: research stays and collaboration with institutions abroad

In 2016 the AdMaS Centre intensified research staff mobility with regard to institutions abroad as part of its HR policy. There was also an increase in the mobility of staff from foreign universities to the AdMaS Centre. This fact contributed to the creation of new partnerships and new areas of international cooperation (for example with TU Wien, Bauhaus University Weimar, the Korea Transport Institute, etc.)

4.1. Research staff mobility and collaboration with institutions abroad within the framework of Research Programme VP1

In 2016 two Ph.D. students from the Institute of Environmental Engineering at the Technical University of Košice's Faculty of Civil Engineering took part in activities connected with the VP1 research programme at the AdMaS Centre. The students, Ing. Viola Hospodárová and Ing. Ivana Schwarzová, investigated research and development issues concerning cement-hemp fillers with modified binder (based on cement, magnesium maltose, etc.)

Another external worker that took part in our VP1 activities was Ing. Jaroslav Bureš CSc. from the company Lime Business Consulting s.r.o. He was directly involved in the investigation of subsidiary tasks from Czech Science Foundation project 15-08755S in cooperation with AdMaS Centre staff. He prepared samples of different grain sizes for burning, and took part in the burning of different types of limestone using selected burning modes. He performed the statistical evaluation of CaO particles after burning and cooperated in the preparation of the results for publication in a journal that is indexed in the SCOPUS database.

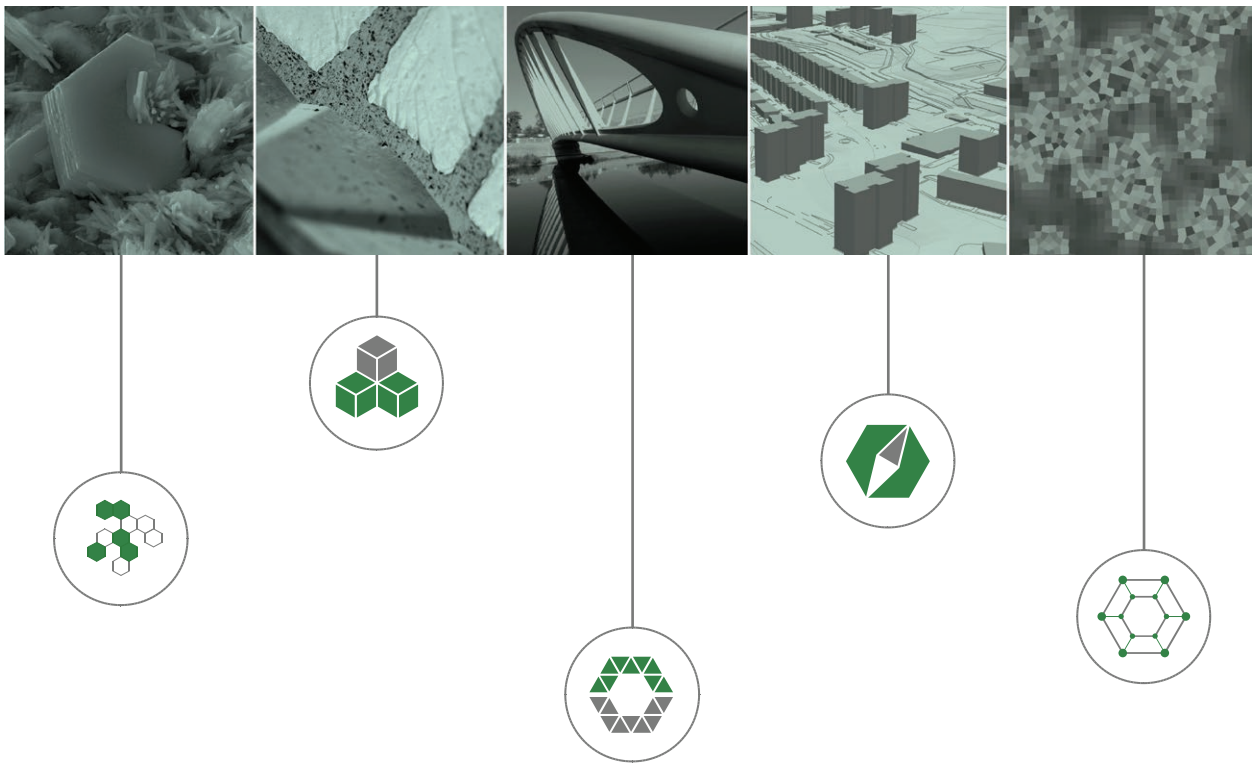
4.2. Research staff mobility and collaboration with institutions abroad within the framework of Research Programme VP2

Within the framework of the national technological platform "Interoperability of Railway Infrastructure", cooperation took place with our Spanish partners – the Spanish technological platform PTFE (Spanish Railways Foundation, Technical Secretariat of the Spanish Railways Technological Platform).

Membership in the EURNEX network – preparation of projects within the framework of the EURNEX programme - MG-7.2-2017: Optimization of transport infrastructure including terminals. A collaborative project within the Aktion programme conducted with the University of Aplied Science in Sankt Pölten: Vorträge und Exkursionen zum Eisenbahnwesen in Österreich und der Tschechischen Republik. Launch of dialogue with VTT Technical Research Centre of Finland Ltd., Helsinki Espoo, about the possibility of collaboration and the preparation of documents for cooperation in H2020 projects and contract research.

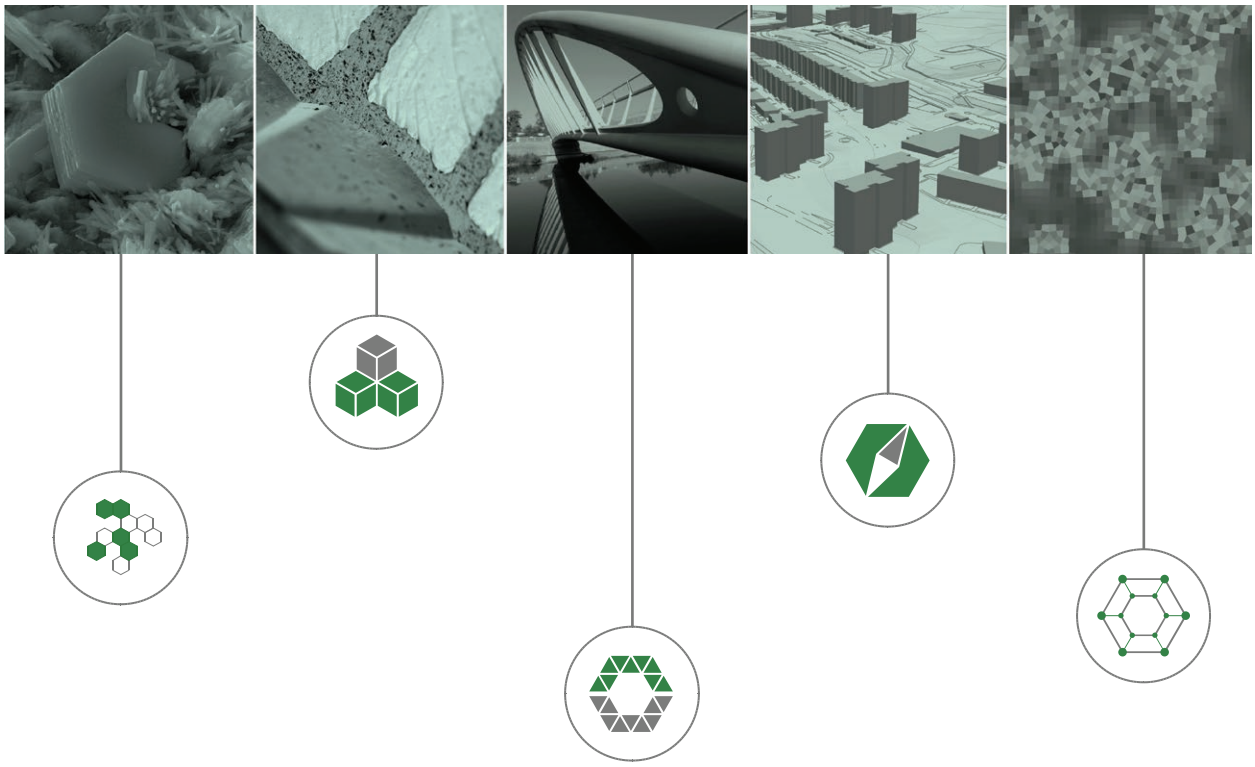
Within the framework of research programme VP2, Centre staff spent several days or weeks at many different European universities and research centres, e.g. TU Dresden and VGTU Vilnius; Delft University of Technology, Netherlands; University of Split, Split summer school, course: Structural Fire Engineering Analysis; Instituto Superior Técnico, Lisbon, Portugal; Oulu University of Applied Sciences, Oulu, Finland Reykjavik University, Iceland; VTT Technical Research Centre of Finland Ltd, Helsinki Espoo, Finland; Universität für Bodenkultur Wien; Hochschule für Life Sciences FHNW, Switzerland; Water Campus - University of Girona, Spain; Technical University in Košice, Faculty of Civil Engineering; ENSI AS, Oslo, Norway; Deutsches GeoForschungsZentrum Potsdam; and STU in Bratislava, SvF, Department of Building Services.

In 2016, Centre staff were successful in starting cooperation with several important foreign experts including Rolf L. Romer, Johannes Glodny (Deutsches GeoForschungsZentrum, Potsdam, Germany); Martin J. Timmerman, Edward Sobel (Universität Potsdam, Germany); Dejan Prelević (University of Mainz, Germany); Claudia Teschner (Ludwig-Maximilians-Universität München, Germany); Uni E. Árting (University of the Faroe Islands, Tórshavn, Faroe Islands); Anna Ladenberger (Geological Survey of Sweden, Uppsala, Sweden).



5. Research staff mobility: collaboration with industry

Research staff mobility in terms of collaboration with industry took place throughout the year. In the majority of cases, this entailed one-day trips for the purpose of carrying out particular experiments, taking measurements, training, consultation, etc.



6. Achievement of milestones

All of the project's binding milestones were achieved in 2016.

Research outputs of the project:

- publication in important international as well as domestic journals at least 5x every year until the end of the sustainability period 06/2019,
- publication at important international as well as domestic conferences at least 14x every year until the end of the sustainability period 06/2019,
- certified methodologies: at least 2x every year until the end of the sustainability period 06/2019
- submission of at least one utility model application once every two years during the sustainability period (by 06/2017 and 06/2019),
- submission of at least one patent application by 06/2016 and another one by 06/2017 and 06/2018.

During 2016, a total of 169 articles were published either in journals or as contributions presented at domestic and foreign conferences. Out of these, a total of 40 were in publications with high-impact factor. As far as conferences are concerned, more than 129 contributions were published at such events (see MI 110 502 – Other publications; also, many contributions which are not listed in the Information Register of R&D Results were published at conferences).

As far as certified methodologies are concerned, the following had been certified by the end of 2016:

- KUDRNA, J.; DAŠEK, O.; URBANEC, K.: Asphalt rubber; Methodology for the use of asphalt mixtures with asphalt modified with rubber granulate. Brno University of Technology, Faculty of Civil Engineering (certified methodology)
- PLÁŠEK, O.; HRUZÍKOVÁ, M.; KORYTÁROVÁ, J.; VÝSKALA, M. Decision-making process for the cladding and exchange of railway tracks (certified methodology), 2016.
- ZACH, J.; HROUDOVÁ, J.; BURÁŇ, F., Methodology for the application of developed materials in the insulation of building structures (certified methodology) 2016

As far as utility models are concerned, the following were issued in 2016:

- HLAVÍNEK, P.; RACLAVSKÝ, J., Devices for connecting a shaft to sewer pipes (utility model) 2016

As regards patents, the following were issued in 2016:

- TERZIJSKI, I.; KADLEC, J.; HORÁK, D.; Brno University of Technology, CZ: Joint mortar. 306156, patent. (2016)
- GIRGLE, F.; ŠTĚPÁNEK, P.; PROKEŠ, J.; Brno University of Technology, PREFA Kompozity a.s.: Assembly of elements for anchorage. 305718, patent. (2016)

The following certified technologies were issued in 2016:

- MELCHER, J.; KARMAZÍNOVÁ, M.; PEŠEK, O.: Lateral-torsional buckling of structural glass beams; Experimental procedure for the verification of the mechanism of the failure and deformation of structural glass beams exposed to lateral-torsional buckling. Test room operated by the Institute of Metal and Timber Structures at BUT, Faculty of Civil Engineering. URL: (certified technology)
- MELCHER, J.; KARMAZÍNOVÁ, M.; SCHMID, P.: Vacuum loading; Experimental verification of the process of deformation and the load-bearing capacity of structural elements and parts using the vacuum loading method in a horizontal metal chamber. Laboratory operated by the AdMaS regional research centre, building H. (certified technology)

- MELCHER, J.; KARMAZÍNOVÁ, M.; SCHMID, P.: Vacuum loading; Experimental verification of the process of deformation and the load-bearing capacity of structural elements and parts using the vacuum loading method in a metal chamber in an inclined or vertical position. Laboratory operated by the AdMaS regional research centre, building H. (certified technology)

- VARAUS, M.; KOUDELKA, T.: ACO 11+ 70/100 Prephalt 50% R- material; Asphalt mixture with a high RAP content. Unincorporated area between the villages of Olšovec and Potštát, II/ 440 (certified technology)

- ZACH, J.; HROUDOVÁ, J.; BURÁŇ, F., Technology for the production of insulation materials based on cellulose fibre and straw (certified technology) (Information Register of R&D results-Z/B)

- ZACH, J.; HROUDOVÁ, J.; BURÁŇ, F.; NOVÁK, V.; SEDLMAJER, M.; REIF, M., Technology for the production of blown-in insulation from natural fibres (certified technology) (Information Register of R&D results-Z/B)

Other outputs were created outside the plane of identical / equivalent research value according to the government methodology of the Section for Science, Research and Innovation (see MI 110504), where the aggregate value of this MI was 111 by 31.12.2016 (the required binding value for this MI is 55).

- Organization of at least one workshop focused on new findings regarding the behaviour of structures/buildings, technologies and materials in the last year of project implementation and every year during the sustainability period,

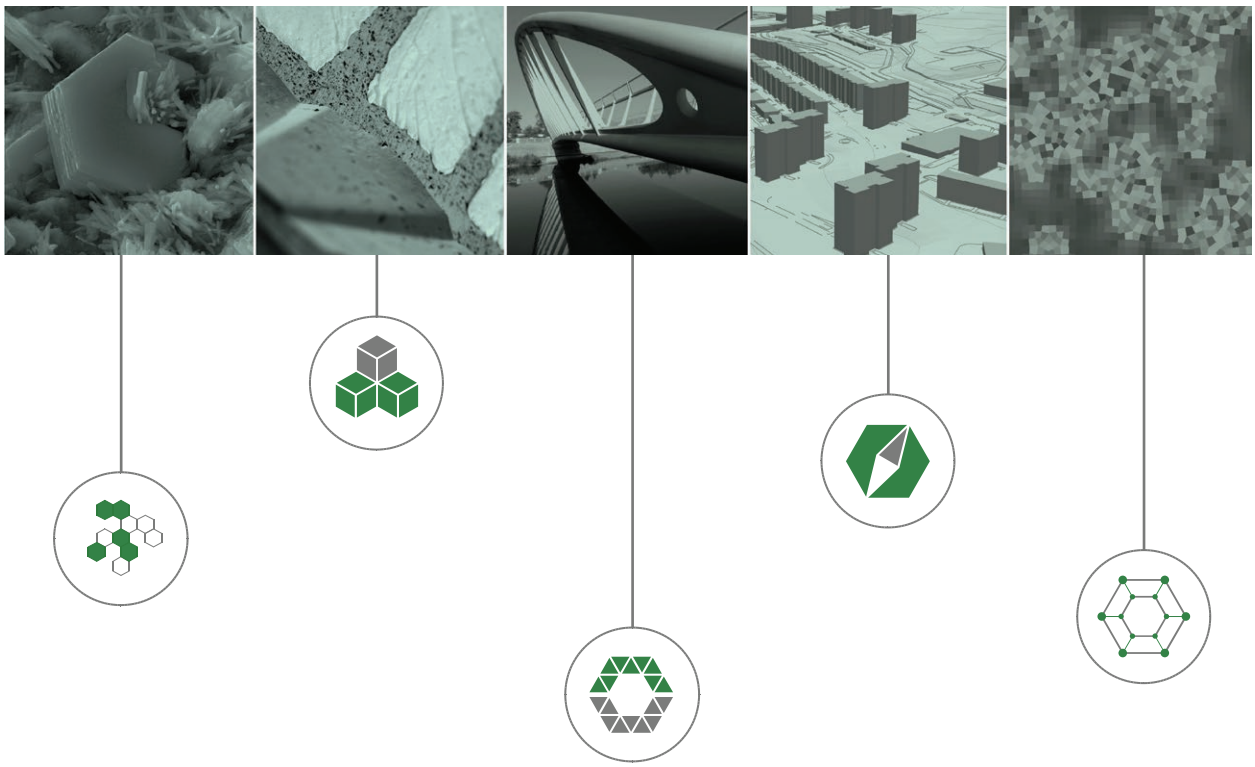
- Organization of at least one workshop focused on new procedures for the design and assessment of structures/buildings or technologies in the last year of project implementation and every year during the sustainability period.

In 2016, a total of 9 workshops and seminars were organized that focused on new findings concerning the behaviour of structures/buildings, technologies and materials, as well as in the area of new approaches to the design and assessment of structures/buildings or technologies – see above.

In the area of milestones connected with human resources policy, the following were relevant:

- Research stays undergone by external staff at the Centre: Duration 1-2 weeks, and at least 4 trips by staff per year within the context of mobility since 3Q/2014

Research stays were arranged for external staff within the framework of applied research projects (Ministry of Industry and Trade of the Czech Republic and TAČR projects) where the staff of companies involved in the application of research results took part in research activities at the AdMaS Centre. It is expected that external staff will undergo long-term research stays at the Centre in 2016.



7. Research activities at the Centre

7.1. Research Programme VP1

The achievement of the aims of Research Programme VP1: Development of Advanced Building Materials took place completely in accordance with the specialized focus and expected goals described in the TA for the year 2016.

7.1.1. Research activities conducted for Research Programme VP1

The aims of Research Programme VP1: Development of Advanced Building Materials were achieved completely in accordance with the specialized focus and expected goals described in the TA for the year 2016.

Researchers were involved in analysing the internal structure of concretes exposed to the influence of special hydrothermal conditions or high temperatures with the use of X-ray computed tomography. They also focused on the kinetics of the creation of the mineral tobermorite for various porous concrete mix compositions, including the influence of autoclaving mode. During research into the microstructure of building materials, the question of the effect of limestone characteristics and burning technique on the properties of lime was examined. One interesting topic which can be mentioned is a study of the interaction of cement putty with lightweight fly ash aggregate.

In the area of ceramics, research was focused on aluminous cement-based anorthite porcelain shard. This included the evaluation of the influence of liquidifiers, the content of water and other suitable fluxes (bone ash, limestone) on the properties of that shard in comparison with shard made from traditional kaolin-based porcelain.

One of the most significant areas of the research activities of Research Programme VP1 has long been concrete technology. In this area attention was mainly focused on activities such as the study of the methods of dispersion of nanoparticles in cement composites, the use of more environment-friendly fluid bed combustion (FBC) ashes in concretes, or the use of foam concrete for the remediation of floors. This is relevant for manufacturing of new prefabricated components made from HWC and HPD for special applications.

In 2016, several specific research projects were investigated in which Ph.D. and Master´s students were heavily involved. In the area of cement composites these projects focused on (for example) the verification and analysis of the resistance of cement composites to the effects of high temperatures, the study of the use of fly ash from fluid combustion in the production of cement-based composites, the study of the technology of cement-based light building materials, and research and development with regard to advanced materials for industrial floors. Other projects dealt with, e.g. research and development issues connected with polymer-based cement and reprofiling materials utilizing secondary raw materials. A very interesting topic being investigated by Ph.D. students is the influence of the manner in which ultrasound energy is supplied on the quality of carbon nanotube distribution and damage.

The staff working in the physics part of the programme are intensively involved in researching problems related to acoustic methods. Specifically, they study the use of acoustic methods in testing the state of concrete degraded by high temperatures, or the correlation between acoustic emission parameters and fracture characteristics obtained from three-point bending. Other areas include the evaluation of the static elastic modulus in relation to the strength of concrete compression, and the comparison of the dynamic Young´s modulus obtained by ultrasound impulse and resonance-based measurement methods.

In the area of insulation materials, researchers examined the theoretical and experimental analysis of the effect of thermal moisture load on the behaviour of thermal insulation and remediation materials. They also studied the transport of heat and moisture within the structure of insulation materials based on lightweight filler made from waste PUR foam. A new area of cooperation with staff working in research programme VP2 is (for example) the investigation of various issues concerned with the reuse of excavated soil in the form of self-compacting grouts.

The activities of individual VP1 researchers are continuously being published in important international periodicals, at conferences and workshops, where not only the latest R&D findings are presented but also the Centre as a whole. New contacts are being established for future cooperation in the area of R&D and individual commissions. The achieved results are also being registered in the form of functional samples, verified technologies, etc.

It is not only important research workers in senior researcher positions that are significantly involved in the activities of the research groups, but also (and indeed mainly) young people in junior researcher positions who also cooperate closely with Bachelor´s, Master´s and Ph.D. students and pass on their experience to them.

As far as the fulfilment of tasks according to the TA is concerned, the following examples can also be mentioned:

- An application to register a utility model (No. 2016-327282016) in the area "The designing of efficient uses of substances and materials in building structures with regard to their lifespan and economic application" was submitted on 23.8.2016. The utility model is named "Adhesive bridge-screed system for extreme mechanical stress and chemical resistance." 15 functional samples of new advanced materials were registered in 2016. These included materials for the treatment of surfaces to prevent the penetration of liquids or to increase chemical resistance, or to harden the surface of silicate floors, etc. During the development of new materials, emphasis was primarily placed on increasing the lifespan of building materials and structures while ensuring the competitiveness of the new materials. The resistance and high lifespan of the new materials was tested at high temperatures and in all types of aggressive environments in corrosion chambers. Competitiveness is ensured via the efficient use of raw materials, including those of the secondary type.

- In the area "Development of new non-destructive methods that can be employed in the quality control of materials as they exit manufacturers´ premises or after their implementation in structures", mainly optimized X-ray computed tomography, georadar and acoustic emission methods were verified. In the case of X-ray computed tomography, the option of carrying out the non-destructive analysis of the structure can be used with advantage, as can the technique´s ability to determine where weak points often occur, as they can be a source of defects. Apart from the diagnostic analysis of the state of concrete structures and the detection of various structural elements, the georadar was mainly useful in the pilot verification of the possibility of detecting caverns in reinforced concrete footings under essential service water pipelines at Temelín nuclear power station. The acoustic emission method can monitor the state of a newly implemented structure efficiently and identify locations where possible defects could occur in a timely manner.

- In the area "Creation of legislative documents (methodology, technical standards) for the production and testing of building materials", the concept for a Czech ČSN class 73 technical standard entitled "Structural inspections of reinforced concrete cooling towers in industrial facilities" was completed in 2016. The next stage in the preparation of the standard involved the selection of a specific publisher and the readying of the process for the approval of the standard. It is expected to be published in 2017. In addition, several verified technologies were designed and methods introduced for experimental work and for checking the quality of manufactured products in a laboratory environment and also under the operating conditions of a production plant.

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

    - 16-25472S - Dynamics of the degradation of cement composites modified with secondary crystallization

    - 15-07657S - Study of the kinetics of events taking place in a composite system at extreme temperatures and during exposure to an aggressive environment

    - 15-08755S - Monitoring of the influence of burning technique on the properties of lime

- 15-23219S - Study of nanoparticle dispersion methods and the determination of conditions limiting their repeated clustering for application in cement composites
- 14-31248P - Study of the influence of built-in hazardous waste on the properties of cement matrix
- 14-25504S - Research into the behaviour under extreme conditions of composites based on inorganic matrices
- 14-31282P - Theoretical and experimental analysis of the influence of moisture load on the behaviour of thermal insulation and remediation materials
- 14-32942S - The influence of fly ash on the thermodynamic stability of hydraulic binders
- 13-21791S - Study of heat and moisture transport within the structure of natural fibre-based insulation materials
- 13-23051S - Alumina cement-based anorthite porcelain shard

7.1.2. Use of laboratory instruments in Research Programme VP1

While implementing and investigating projects, efficient use was made of our new instruments such as an X-ray computed tomography scanner, an X-ray diffractometer with Rietveld refinement, high-temperature chambers and SAXS, an REM with an environmental probe and 3D display, and an XRF fluorescence spectrometer.

The REM was used for:

- the identification of phases occurring during the hydration of cement with active pozzolanic admixtures (GA14-04522S),
- the analyses of the structure of materials incorporating fly ash of both the high-temperature and the fluid combustion type (TAČR TA04010425),
- observing the microstructure and phase composition of the products of the reaction of alkali-activated materials (GA14-25504S),
- observing the structure of organic fibres (TAČR TA04020749),
- observing the influence of milling processes on the structure of silicates, and primarily on the size of crystallites (GA15-08755S),
- observing burning in order to monitor the ratio of tridymite to cristobalite in silica refractories,
- measurements conducted during Bachelor's and Master's thesis research concerning the use of fly ashes and epoxides, the preparation of agloporites, etc.

The X-ray diffractometer was used not only for the above-mentioned Czech Science Foundation projects but also (for example) for research in the following areas:

- the thermodynamic stability of ettringite-based AFT phases (Master's thesis – Jana Mokrá)
- the thermodynamic stability of thaumasite-based AFT phases (Bachelor´s thesis – Pospíšilová),
- the amortization of materials processed via milling (Bachelor´s thesis – Ravaszová, GA15-08755S),
- the influence of raw material and limestone burning technique on the properties of lime (Bachelor´s thesis – Sklenářová, GA15-08755S),

- the characterization of samples of geopolymers and alkali-activated materials (GA14-04522S),
- the analysis of the level of crystallization of crystalline admixture for addition to concrete (GA16-25472S),
- the analysis of the microstructure of concrete, in particular from the aspect of the presence of corrosive waste (GA14-25504S),
- the monitoring of burning for the ratio of tridymite to cristobalite in silica refractories,
- monitoring for the presence of akeranite (GA13-23051S),
- the evaluation of andesitic raw materials used in the production of porous concrete (Master's thesis – Ján Fleischhacker),
- the mineralogical analysis of a set of fly ashes (Master's thesis – Ťažký),
- measurements conducted during Bachelor´s and Master's thesis research concerning the use of fly ashes and epoxides, the preparation of agloporites, etc.,
- the evaluation of the microstructure of polymer cement composite containing increased amounts 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 agents) and extreme temperatures over a long period of time (GA 15-07657S),
- the evaluation of the connection of fibres made from waste cellulose in lightweight mortar on the basis of a mixed matrix with regard to resistance to high temperatures (Master's thesis – Bc. Petr Zaťko, GA 15-07657S),
- the monitoring of microscopic flaws and failures occurring in newly developed coatings intended for cement-bonded particleboards exposed to the effects of an aggressive environment representing common phenomena affecting real structures (TAČR TH01020282).

In 2016 our X-ray computed tomography scanner was used for the analysis of thermally-loaded repair mortars, samples of a layered silicate floor system, fracture failures of cement-bonded particleboards, and welds in the cooling system piping of Dukovany nuclear power station. Also, in cooperation with CEITEC, components such as range-finders, turbine blades, filters used in automobiles, connectors, electric coils, etc. were analysed.

In 2016 the XRF fluorescence spectrometer was used (for example) for the determination of the chemical composition of input raw materials used when investigating the FAST-S-16-3184 project "The use of fine fractions of limestone aggregate in limestone mortars", and also when producing Bachelor´s, Master's and Ph.D. theses concerning the analysis of the composition of aggregate, glass, slag and brick dust (Aneta Gottwaldová, Bc. Tomáš Žižlavský, Ing. Olesia Mikhailova).

As in the previous year, the QUV and Q-SUN instruments were used to (among other things) test the resistance of newly developed surface treatments for cement-bonded particleboards as part of investigations conducted for project TH01020282. This project deals with structured surface finishes for cement-bonded particleboards with extreme resistance and high lifespan. With the help of the devices mentioned above, it was possible to observe the effect of a combination of increased temperatures, UV radiation (at a temperature of 60°C) and condensed moisture (at 40°C) on changes to the properties of surface finishes applied directly to cement-bonded particleboards. The listed conditions were alternated cyclically. The obverse surface was stressed with the aid of QUV, and the exposure of all surfaces took place within the Q-SUN, with a focus on the edges, which are particularly problematic. During the course of exposure, a CMD-600D spectrophotometer was used to observe changes in colour parameters (CIELAB, using the CMC equation). In 2016, in contrast with the previous year, the focus was on longer-term exposure - the polymer coatings were tested with the aid of the QUV chamber for twice the length of time employed in 2015, i.e. 4000 hours. Apart from the activities listed above, samples for research into, and the modification

of, glues ensuring the durability of a FRP/wooden joint during moisture exposure were tested principally according to the procedure laid down in the ČSN EN 927-6 Standard.

Test chambers and equipment – with regard to order No. HS 125N1035, a Köhler Automobiltechnik GmBh (Lippstadt, Germany) corrosion cabinet was used to evaluate the durability of steels used as a material in the load-bearing structures of very high voltage distribution networks. Specifically, steels with FeZn surface treatment and low-alloy steels with higher resistance to atmospheric effects (Atmofix) were tested. Measurements were carried out to determine the corrosion of the sample. The corrosion resistance test was conducted in a climate chamber and followed a procedure outlined in the ČSN EN ISO 9227 Standard. During the test, the samples were subjected to a graded period of exposure for intervals of 48, 96 and 240 hours. After the individual exposure periods, the corrosion damage to the samples was measured. After the tests were complete, visual and microscope analyses were performed on the surfaces of the tested materials. A TESCAN electron microscope was used for these purposes. The surface of the sample was also evaluated metallographically: the steel samples were cut after the end of exposure and then monitored within the field of vision and recorded digitally via a LEICA DM400 light microscope + LEICA video camera.

During Bachelor´s thesis research (Jan Krpálek), a HK 800/M/WTG corrosion chamber was used to simulate an environment which contains aggressive gases. Emphasis was specifically placed on the achievement of an environment in accordance with the provisions defined in the ČSN EN ISO 3231 technical standard which describes a procedure for the verification of resistance to exposure in humid atmospheres containing sulphur dioxide. This is a relatively aggressive gas whose effect is potentiated by increased temperature and humidity, which cause extremely unfavourable conditions to arise that significantly accelerate the degradation of the tested material. Newly developed structured coatings for cement-bonded particleboards (TAČR TH01020282) were tested in this way at the highest concentration listed in the quoted standard, i.e. 2.7l of gas in an area with a volume of 0.8 m3. The boards subjected to this exposure were evaluated both continuously during the test (via the observation of hue changes using a spectrophotometer and the taking of photographs in the "macro" mode), and after the end of the required number of cycles (testing of adhesion to the base, thickness, scratch resistance, etc.)

The VP1 mobile laboratory. In 2016, the mobile laboratory was used for a total of 117 trips for the purpose of taking measurements and samples, which is approximately 45% of all the working days in the year. These were mainly trips to production plants and specific projects involving jobs of the following type:

- the execution of boreholes with individual diameters of 100 and 150 mm, cast and vibration cast products for street inlets, cisterns, water shafts, shaft bottoms, shaft covers, draft tube extensions, well casings with internal diameters of 250, 500 and 100 mm, etc. Laboratory tests were performed on the boreholes to evaluate compressive strength and resistance against chemical de-icing agents. The volumetric mass density was also determined. The whole products were then subjected to individual tests, such as the determination of the thickness of the cover layer over reinforcement, absorbability, load-bearing capacity of steps for underground man entry chambers in the vertical and horizontal direction, peak load bearing capacity, etc., subsequently leading to the optimization of recipes,

- the taking of aggregate samples, and their use for the determination of grain size using sieve analysis, the volumetric mass density of the grains, water absorption, shape index, sand equivalent, loose bulk density, void content, resistance against freezing and thawing, and compressive strength, along with the evaluation of fine particles,

- the "in-situ" testing of fresh concrete regarding characteristics such as air content and consistency (using a slump test or flow-table test), and the preparation of laboratory samples on which physico-mechanical properties were subsequently tested: compressive strength, depth of ingress of pressurized water, resistance against chemical de-icing agents,

- the production of test specimens (cubes, prisms, cylinders): the samples were subsequently subjected to frost resistance testing, the determination of tensile flexural strength, compressive strength, resistance to chemical de-icing agents, depth of ingress of pressurized water, static modulus of elasticity, water tightness, spacing factor,

- the taking of samples for tests on small concrete products such as flat tiles, interlocking tiles, curbs, slope blocks and lost formwork, for which the following characteristics were determined: flexural strength, transverse tensile strength, compressive strength, abrasion resistance, resistance to chemical de-icing agents, water absorption,

- the collection of light aggregate from the company Tech Trading (commercial name Liapor): determination of the basic parameters of the material and further testing of its suitability for use in light concretes,

- the execution of technical surveys in the field: tear-off tests, semi-destructive strength testing, analysis of the durability of structures, crack widths,

- the quality control testing of fresh concrete when concreting a motorway: determination of consistency and air content, and the taking of samples for further laboratory testing,

- the execution of research concerning the durability of anhydrite floors, the testing of relative deformation and slip resistance, and the measurement of moisture content.

7.1.3. Contract research within Research Programme VP1

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

The following specific cases can be named as examples:

- cooperation with the company CIDEM Hranice, Cetris Division, during the execution of TAČR project TH01020282 – New structured surface finishes for cement-bonded particleboards with extreme resistance and high lifespan. The producer of new surface finishes is fully cooperating in their development and testing under operating conditions.

- cooperation with the companies BETOSAN s.r.o. and KOMFORT, a.s. during the investigation of TAČR project TA04010143 – Research and development concerning a new system of silicate-based floors for extreme mechanical and chemical loading. Within the framework of this cooperation, the R&D activities of BETOSAN and BUT are connected synergistically with a representative of the area of industry where their findings could be applied – the company KOMFORT.

- cooperation with the companies P O K O R N Ý, spol. s r.o., HRADECKÝ PÍSEK a.s. and Lena Chemical s.r.o., during the implementation of TAČR project TA04010425 - A complex system of special repair mortars utilizing secondary raw materials for industrial operations.

- cooperation with the company Lime Busines Consulting s.r.o. in the investigation of Czech Science Foundation grant project 15-08755S - A study of the influence of the samples preparation on the resultant properties of inorganic binders, where the know-how and many years of experience of the co-investigator are advantageously combined with the latest knowledge from the field of specialization of the investigator from BUT..

In 2016, new cooperation began not only in the execution of basic and applied research but also within the framework of contract research. The newly-started projects include:

- MPO TRIO FV10284 with the company PORFIX CZ, a.s.

- MPO TRIO FV10118 with the company KOMFORT, a.s.

- MPO TRIO FV10680 with the company Prefa Brno, a.s..s.

- GAČR GA16-25472S

Fig. 1
Preparation of concrete blocks for research into anchoring adhesives within project TA04010425

Fig. 2
Preparation of a sample of a floor system for project TA04010143

Fig. 3
Preparation of a sample of a floor system for project TA04010143

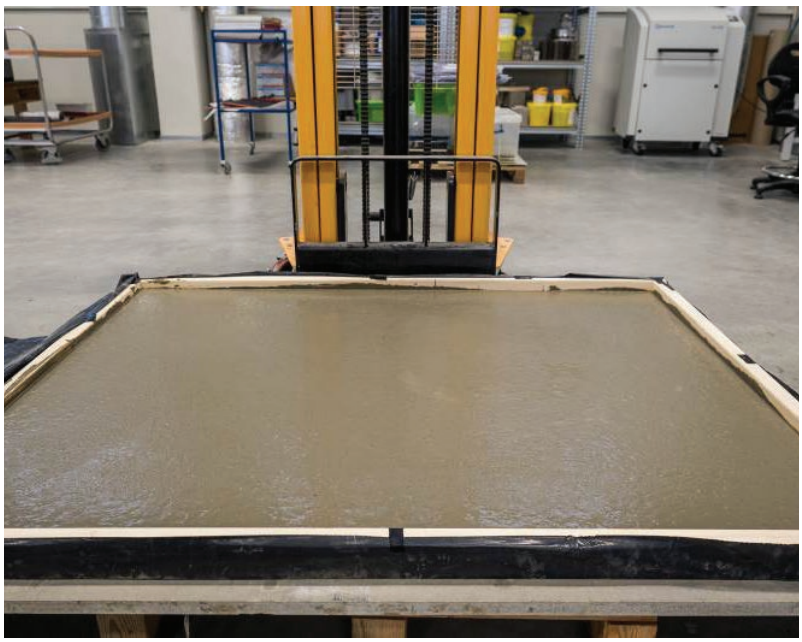


Fig. 4
The testing of anchoring adhesives within project TA04010425

7.2. Research Programme VP2

7.2.1. Research activities of the Structural and Transport Engineering Research Group

The achievement of the aims of Research Programme VP2: Development of Advanced Structures and Technologies took place completely in accordance with the specialized focus and expected goals described in the TA for the year 2016.

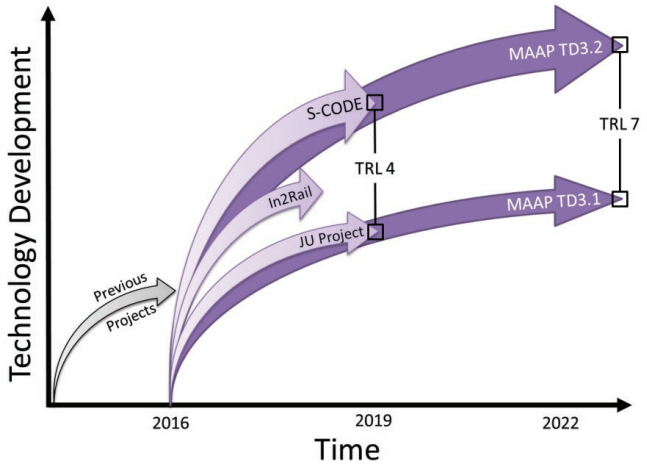
In the area of structural and transport engineering work began on the realisation of Project S-CODE, Switch and Crossing Optimal Design and Evaluation - Horizon2020, Shift2Rail-RIA (H2020-S2RJU-OC-2016-01-2). Coordinator: University of Birmingham. Consortium: DT - Výhybkárna a strojírna, a.s., Ferrovial, Rhomberg-Sersa Rail Group, Rail Safety and Standards Board, COMSA, Loughborough University, Brno University of Technology, University of Pardubice.

The project is aimed at the radical improvement of the structures of switches and crossings in concordance with Technical Demonstrator TD3.2 – Next Generation Switch & Crossing System. The basic aim of the S-CODE is research & development, validation and the initial integration of a radically new conception in switch & crossing construction that will have the potential to increase capacity, reliability and safety while simultaneously lowering investment and operating costs.

The project will focus on the use of advanced diagnostic and monitoring systems, the construction of rail track superstructure and substructure, and the development of new switch control systems.

The project is being investigated as part of the Shift2Rail Joint Undertaking, open call S2R-OC-IP3-01-2016 – Research into new radical ways of changing trains between tracks, and will be coordinated together with the open call for JU members S2R-CFM-IP3-01-2016 – Research into enhanced track and switch and crossing system, project IN2TRACK. The relationship between the two projects, and the TRL achieved, is summarised in Fig. 5.

Fig. 5
The relationship between the two projects, and the TRL achieved

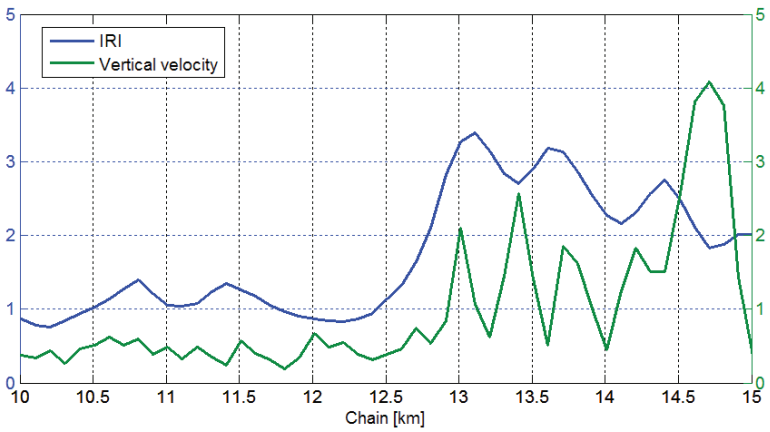


The Transport Engineering division is primarily engaged in the testing of construction materials and the verification of new technologies that could be used to prolong the lifespan of transport structures.

In cooperation with the company Saint-Gobain ADFORS work is underway on the verification of the usability of glass fibre reinforcement in asphalt pavement, where it will aid in decreasing pavement thickness and limiting the spread of cracks, which will result in the lowering of construction and repair costs. It will also help limit the use of natural resources. A special approach was developed for the purposes of testing.

The research group is involved in collaborative measurement-taking with Škoda Auto as part of a special project aimed at determining the relationship between changes in the parameters commonly used to measure the performance of personal vehicles (transverse and vertical acceleration, the revolutions of individual wheels, etc.) and the parameters of the road surface (the IRI road roughness index, anti-skid characteristics, etc.), which are ascertained by special measuring vehicles. The aim of the project is to increase vehicle safety and verify new options for determining the characteristics of road surfaces. The following figure displays a graph comparing changes in the index of longitudinal roughness (IRI) with the vertical acceleration of a vehicle over a certain travelled distance:

Fig. 6
Graph of changes in the International Roughness Index (IRI) compared with the vertical velocity of a vehicle over a certain travelled distance



AdMaS Centre equipment is also used in the development and testing of asphalt binders, asphalt mixtures and road surfaces with longer-lasting anti-skid characteristics. These topics are investigated within research projects as well as contract research.

Investigations are focused on the properties of asphalt binders during their evaluation via European and American approaches. The American approach appears to be more sophisticated from the perspective of the use of functional tests on binders. The research included the mutual comparison of both approaches. Also performed was a comparison of various methods of aging asphalt binders under laboratory conditions – in particular, the effect of long-term aging on empirical qualities.

Recently, aside from asphalt binders, attention has also been given to the preparation and testing of asphalt mixtures with a high RAP content. Tests are performed on reference mixtures without RAP and mixtures with up to 50% RAP, which also include various types of rejuvenator that are intended to activate the aged binder in the RAP and improve it to the level of the newly added binder. These mixtures are then subjected to functional tests to ascertain their resistance to the formation of frost cracks and permanent deformation, and their toughness.

The comparative tests also entail the determination of the parameters of the mixtures, which will be included in the 2nd generation of European norms for asphalt mixtures.

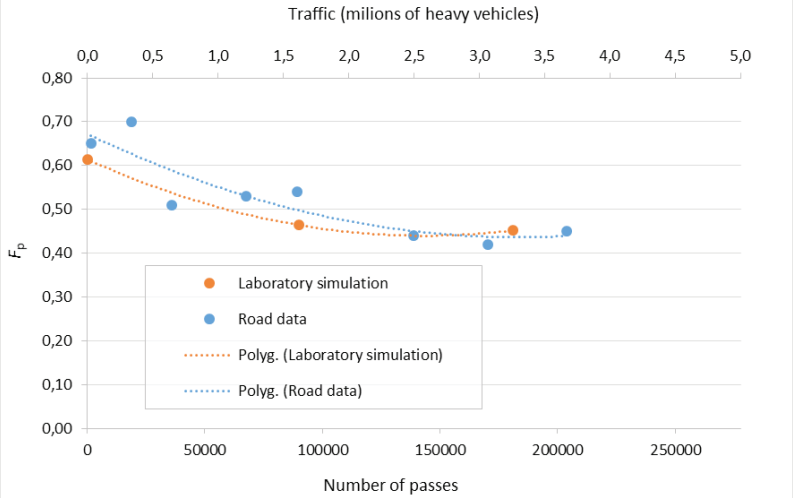


Fig. 7
Example of the laboratory prediction of changes in the friction coefficient of a road surface in comparison with their real evolution

In the case of construction, a typical example of collaboration with domestic partners in contract research is the testing of the mechanical resistance of sandwich panels composed of plasterboard sheets and a polyurethane core, which was performed in the first quarter of 2016. The described cooperation was with the company ISMAT solution, s.r.o.

Sandwich panels with a polyurethane core have a wide range of applications in construction. They are most often used as cladding for buildings. They can be used as self-supporting elements without stiffeners, or they can be fitted with stiffeners. Their rigidity can prevent adjacent support beams from buckling laterally and so increase their bearing capacity or enable the transfer of shear forces within their plane. The outer skin of sandwich panels is often made up of thin sheets, either smooth or profiled, which also have standards documents prepared for them. Other possible panel skin material solutions include laminate, fibreglass fabric, aluminium, etc. Sandwich panels also see application in the structures of walk-in freezers, where their thermal isolation parameters are exploited. Panels with gypsum fibreboard skins are also used for this purpose. However, the mechanical resistance of panels with such skins is not described in standards documents and little research has been carried out in this area to date. Sandwich panels were tested in cooperation with the company ISMAT solution, s.r.o., which used the panels for (among other things) the construction of a test house without the use of any other load-bearing frame.

When a sandwich panel is subjected to flexural stress, the layers of the skin transmit tensile and compressive stress within the plane of the panel. The shear stiffness of the core material prevents the upper and lower skins from undergoing mutual shear and transfers normal stress perpendicular

to the plane of the panel. A global type of failure can occur as the result of the bulging or crushing of the skin in compressed regions, the tearing of the skin in areas under tension, the shear failure of the core material, or the debonding of the skin from the core material. The static behaviour and possible manners of failure during loading with axial pressure are assumed to be similar to that of panels with skins made from metal sheeting.

Laboratory tests were carried out in three variants. The bearing capacity of sandwich panels under axial pressure was tested, along with the bearing capacity in flexural stress under distributed load and the bearing capacity in shear of the core of the cross section when loaded in four-point bending.

Fig. 8
Sandwich panel prepared for testing under axial pressure..

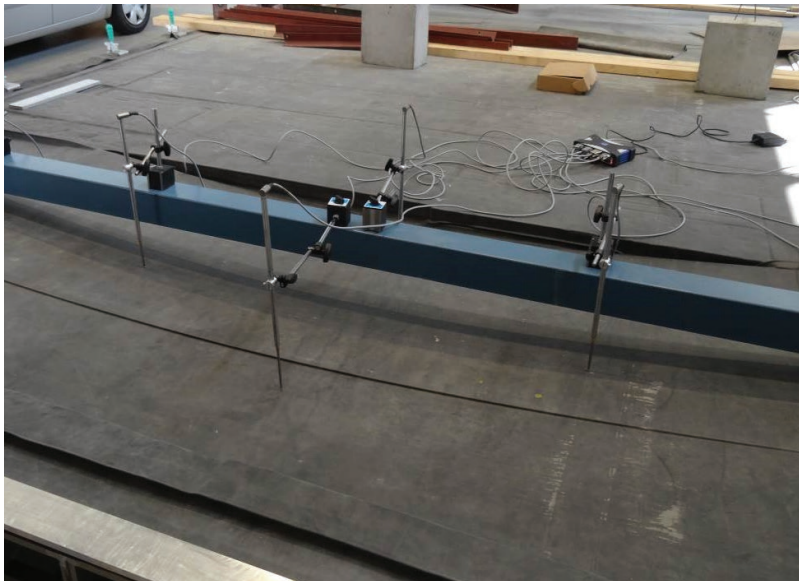


Fig. 9
Close up of the positioning of sensors for the measurement of vertical deformation during the course of testing under distributed load.

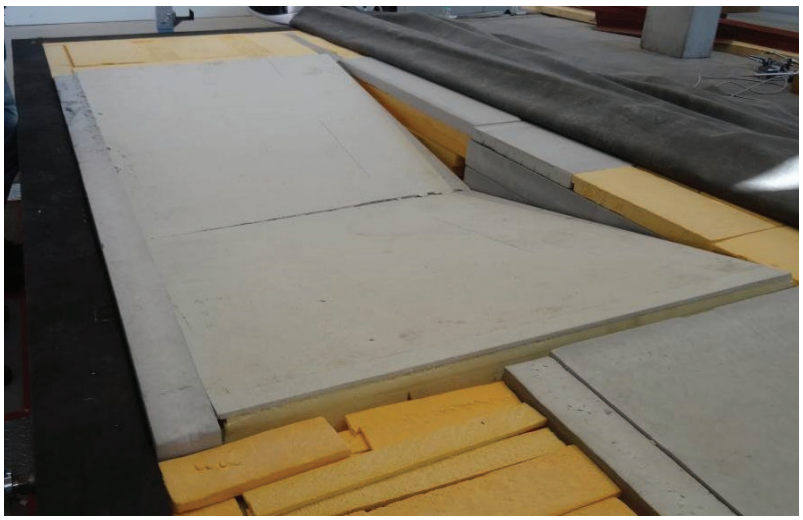


Fig. 10
Sample damaged during distributed loading.

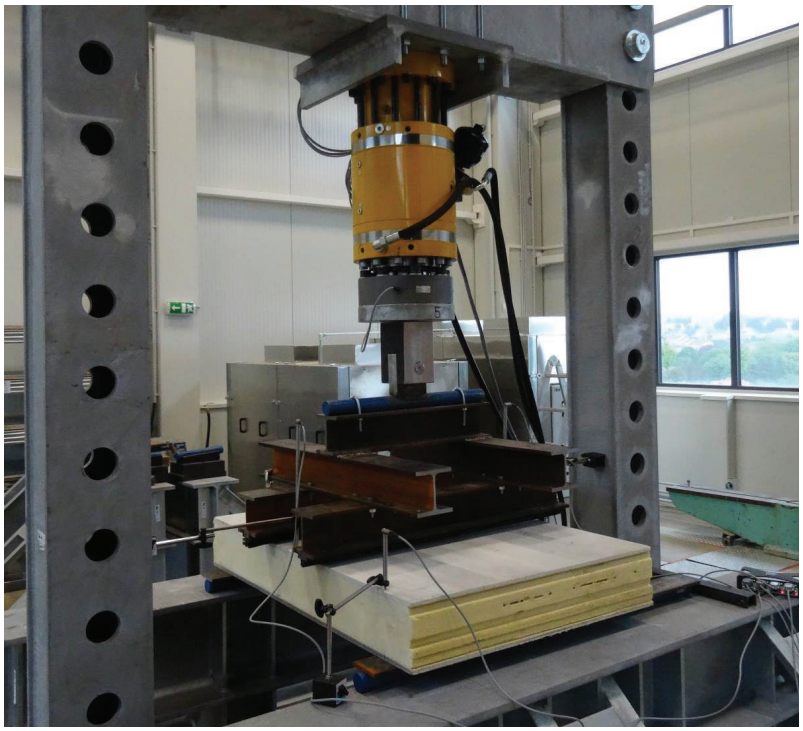


Fig. 11
Test equipment set up to test the bearing capacity in shear of the core of the cross section under four point bending.

Fig. 12
Sample after shear failure of the cross section core.

Due to the massive cross section of the tested panels, no loss of stability occurred during axial pressure loading. Instead, the skins failed at the supports. Stiffeners could potentially be used to increase the bearing capacity of these panels under axial pressure, but this would only make sense if they had the same length as the panel itself.

The panels tested by being stressed in flexure by uniform distributed loading failed via the tearing of the lower layer of the skin half way across the span of the panel, causing the panel to break as a result.

During loading in four-point bending, the use of narrow loading platens led to the local failure of the skin at the points where the load was applied, in combination with shear failure. With wider loading platens, in one case shear failure occurred, and in another the skin layer failed under the edge of a platen. The team of authors developed specific methods for the testing and evaluation needed for the experimental analysis. The topic is currently being processed as an application for applied research support from the Trio grant awarded by the Ministry of Industry and Trade.

In the field of building construction, research took place regarding the material characteristics of timber and the behaviour of wooden elements and structures. In addition, a test building called the EnviHut was constructed at the AdMaS Centre site. It is a small, moveable house based on the load-bearing structure of a container cell. The floor area is 3 x 7.5 m, and the height is 3.5 m. The building is totally energy autonomous, being fitted with its own photovoltaic system and a wind turbine for energy generation. The construction of the building allows the exchange of different outer cladding and roof decking variants.

The structure is primarily used for research in the area of timber building construction, related composite systems and energy (mainly Hybrid and Off-Grid systems). R&D outputs are planned for these areas in 2017 and beyond.

Fig. 13
The EnviHut: the original visualisation and the real test building

7.2.2. Research activities of the EGAR Research Group

Within the context of the AdMaS Centre's Research Programme VP2, i.e. research and development in the area of advanced structures and technologies, the EGAR Research Group mainly participates in the accomplishment of goals in the area of advanced technologies. In 2016, the achievement of such aims took place completely in accordance with the specialization of the group, which is declared and described in the TA of the regional AdMaS Centre.

Aims and goals of the EGAR Research Group according to the TA:

Measurement of the thermal and microclimatic properties of buildings and subsidiary parts of buildings (including their properties with regard to exterior and interior conditions) with the aim of designing construction methods as well as technologies for the production of structural components with the primary goal of providing buildings with optimum energy and other parameters.

Within the scope of the stated aim, both grant projects and contract research are conducted by the EGAR Research Group. The group is investigating areas related to what are known as Smart Cities – cities where, in line with current trends, technologies are installed which mainly aim to increase the quality of life in urban residences, and attempt to improve safety and the quality of the environment. In order to improve the diagnostic methods focused on the energy and ecological aspects of buildings, functional prototypes of an interior environment sensor with integrated carbon dioxide measurement capability and a digital wood moisture sensor were developed and applied during the real operation of a building. Experiments aiming at identifying the most suitable method of measuring temperatures in structures were carried out, and suites for the measurement of the thermal and optical properties of building structures under real climatic conditions were also developed. The application of a photo diode as a substitute for a pyranometer was verified and optimised experimentally with the help of corrective factors. It can be used in many areas of structural diagnostic analysis, particularly for the monitoring of components of solar radiation. It has the potential to be used in the development of diagnostic and monitoring methods and tools in buildings and regions. In addition, monitoring of the energy balance of radiant flows from the sky was launched with the aim of quantifying and modelling the resultant energy flows of buildings and regions in interaction with the surrounding outdoor environment.

The most significant activities of the EGAR Research Group in this area include:

- contract research in the area of interior environment monitoring for the company GOOPAN (methodology and installation of an in-house developed monitoring system within a standardized wooden structure); long-term measurements and evaluation,
- Czech Science Foundation project – climatically active solar facades; installation at the AdMaS Centre,
- TAČR research project – Competence Centre – Intelligent Regions – information modelling of residences, technologies and infrastructure for sustainable development,
- design of a Smart City concept for the town of Újezd u Brna,
- design of a Smart City concept for the town of Židlochovice, including the application of thermal imaging measurements, and specialized lectures on energy saving for the public,
- internal research is also being carried out to investigate, e.g.:
    - the determination of corrective factors for the use of a photo diode in monitoring the intensity of solar radiation,
    - the development of a digital sensor for the monitoring of wood moisture, including sensor calibration and verification,
    - the development of an interior environment sensor capable of indicating CO2 concentration

- work and development work with UAV and UAS in the area of aerial imaging and aerial thermography
- testing of the diagnostic analysis of building structures from the air via UAV and UAS

Within Czech Science Foundation project GJ 16-02430Y, an experimental mobile suite was set up to enable the testing of modern solar-activated façade concepts at full-scale. It is possible to observe the interaction between the internal environment maintained in the test cubicle, the experimental building structure and its external environment. The aims of the project include:

- the development of an experimental mobile full-scale test suite
- the development of a solar building envelope concept – a prototype solar façade panel
- the development of a suite for the determination of the solar radiation throughput of building materials

Fig. 14
Experimental mobile full-scale test suite for solar-activated facades

Fig. 15
An AdMaS Centre meteorological station fitted with a sensor for measuring the longwave component of thermal radiation from the sky

The focus and aims of the EGAR Research Group according to the TA: The development of new technologies in the area of wastewater disposal and cleaning, drinking water treatment and distribution, the handling of waste, and the development of new procedures for the use of energy from wastewater, waste and sludge created during the cleaning of wastewater.

The EGAR Research Group is engaged in both grant projects and contract research for the purpose of achieving the above aims. In the area of water management, the group is involved in what are known as Smart City applications – in line with current trends, technologies are installed and utilized in urban areas with the goal of achieving an increase in the quality of life in the residences there, increasing safety and improving the quality of the environment (management of grey and rainwater, smart management of wastewater treatment plants, intelligent water meters, etc.) As far as technologies are concerned, the group is mainly examining the options for the application of membrane separation methods to industrial waters, along with the use of advanced oxidation processes as part of

the testing of an AOP pilot unit that removes chemical pollution from water. In connection with our successful cooperation with the company Bionic, in 2016 research began into the possibilities offered by processing water treatment sludge using microwave pyrolysis technology.

The most important activities of the EGAR Research Group in this area include:

- cooperation with Černá Hora brewery; the installation and operation of a pilot anaerobic reactor with membrane separation capability; the development of new technologies for the cleaning of industrial wastewater with a high content of organic substances,
- the development of a device for connecting a shaft to sewer pipes. 29444, utility model. (2016),
- contract research in the area of the monitoring and optimization of sewer networks in the localities of Prasklice, Bobrová and Znojmo, using automated collection of samples with measurements of basic electrochemical quantities of wastewater in sewer systems,
- the investigation of project FAST-J-16-3424 "Use of an AOP pilot unit for the removal of chemical pollution from water",
- the investigation of project FAST-J-16_3547 "Removal of antibiotics from communal wastewater using advanced oxidation processes (AOP)",
- the application of principles enabling more effective wastewater treatment plant management, and the options for the use of grey water, etc. when designing a Smart City concept for the town of Židlochovice

In 2016, a specific research project (FAST-J-16-3547) was investigated which focused on the removal of antibiotics from wastewater. For this purpose two kinds of antibiotics were selected that appear in wastewater abundantly: sulphoamides, which are represented by the substances sulphathiazole, sulphamethazine and sulphamethoxazole, and macrolides, represented by the substances erythromycin and roxithromycin. Furthermore, a group of anti-inflammatory non-steroid substances were added to the solution of "raw" water, including ibuprofen, naproxenum natricum and diclofenac, which also can be found in great quantities in wastewater. The monitored active substances were obtained from pure analytical standards and from freely available medications which were dissolved into the solution in the concentrations in which they can be found in communal wastewater.

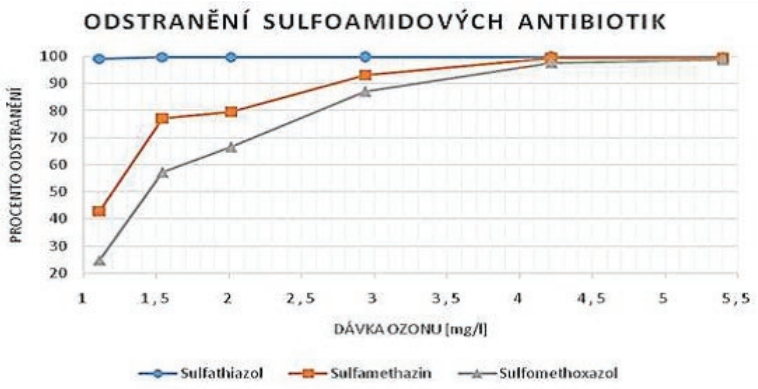


Fig. 16
Percentage of removed sulphoamide antibiotics with increasing ozone dose concentration

Note: In the group of sulphoamide antibiotics it is obvious that sulphathiazole is almost completely removed at even very low concentrations of O3, while sulphamethazine and sulphamethoxazole are removed to a satisfactory degree (98%) at a dosage concentration which is several times higher.

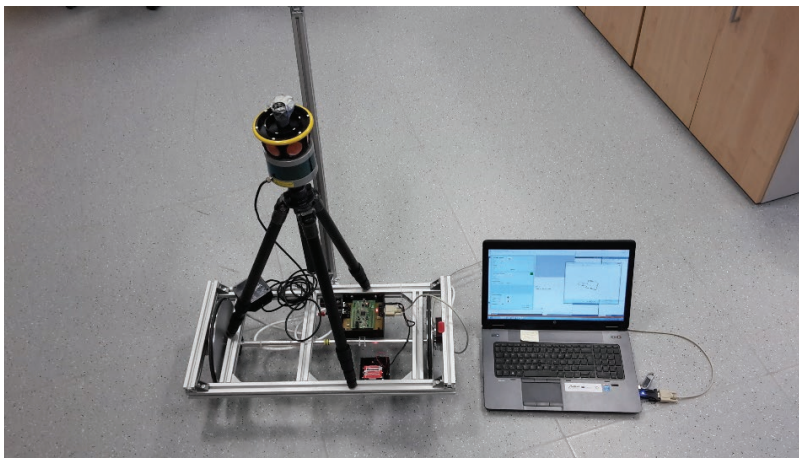
Fig. 17
Pilot AOP unit

The focus and aims of the EGAR Research Group according to the TA: provision of geodetic, photogrammetric and metrological support for construction activities and research (the design of building structures and natural objects; the creation of 3D models from aerial and ground sensor data – Lidar airborne scanners, ground scanners, beam cameras; the determination of the exact geometry of individual elements, parts, structures and buildings; the calibration of small and large dimensions). In addition, the determination of the absolute spatial position of building structures and other objects and the monitoring of short-term and long-term changes that affect them using global navigation satellite systems (GNSS - GALILEO, GPS, GLONASS)

In 2016, the achievement of the goals detailed in the TA in the area of geoinformatics mainly occurred via the performance of contract research regarding the use of 3D scanning technologies in connection with linear structures. A method of determining the spatial position of tram lines was produced and verified for Brno Public Transport Company (DpmB, a.s.), which administers the lines in Brno. Work was also performed for the SŽDC railway track authority concerning verification of the possibilities of using mobile mapping technology (laser scanning) under the conditions specified by the track operator. Furthermore, research was carried out via a Faculty of Civil Engineering specific research project regarding the applications of a mobile mapping system.

Up to now, this technology has mainly been used outdoors, but technological development has already made it possible for the carrier of a mobile mapping system (MMS) to be not only a vehicle but also a person. This trend enables the use of MMS in interior spaces, though it requires the sufficiently accurate determination of the carrier's trajectory without the use of a GNSS. The aim of the project is the creation of a functional MMS for the mapping of interior spaces. Service software was created as part of the project. It is for the collection of data for monitoring the trajectory of the carrier (a trolley) using a robotic total station and an inertial unit. At the same time, the software collects a 3D cloud of points from a laser scanner. The software takes the form of a desktop application for the Windows OS. It enables communication with sensors using COM ports and stores data in output files for further processing. The user interface enables the operator of the device to see the important values from individual sensors in real time. The software also calculates the resultant cloud of points in relation to the trajectory.

Fig. 18
Experimental model of a mobile mapping system for use in interior spaces



The focus and aims of the EGAR Research Group according to the TA: Verification of practical applications of terrain and laboratory measurements, the evaluation (including mathematical modelling) and development of methodologies in the field of geotechnical research methods and the diagnostic assessment of the foundation conditions of structures, both from the aspect of building design and during their remediation and the analysis of their lifespan.

The geotechnics group also investigated many interesting grant projects and contract research commissions in 2016. Some of the most engaging were:

- specific research project FAST-S-15-27 "Laboratory testing of geomaterials and the identification of input parameters for material models using optimisation methods." The testing of rocks and sprayed concrete exposed to uniaxial and triaxial loading was carried out using a triaxial automatic system for the testing of rocks.

- TAČR research task TA04031092 "Interpretation and correlation of dynamic and static penetration tests for the more efficient design of transport structures." The first set of penetration probes was executed in 2016 in an adapted experiment pit in Pavilion P1 with the aim of obtaining an effective tool for checking the compaction of fills used in utility networks. The performed work is part of a research task which was investigated in cooperation with the companies Geostar, spol. s r.o. and GEOtest, a. s.

- TAČR research task TA04031092, which is focused on the geotechnical monitoring of tension when filling a pit and during the penetration of poured fill material in the experimental pit. This was carried out under simulated real-world conditions at the AdMaS Centre.

Fig. 19 and 20
Geotechnical monitoring of tension

7.2.3. Research activities of the Mathematical Modelling Research Group

In 2016 the MM division investigated many topics in accordance with the TA. Some of the most important results of the division include the following items:

One of the investigated topics was the implementation of numerical erosion when solving numerical tasks using the finite element method (FEM), which is still one of the most widely used tools for the calculation of numerical simulations. Due to the possibility that excessive reshaping of the finite element network may occur, there is a danger of problems arising when it is used, for example the locking of elements or the occurrence of negative volumes. As a result, numerical extensions often need to be used so that the required simulations can be carried out at all. When examining local failures of structures such as the penetration or perforation of the surface shell, it is almost essential to implement the numerical erosion of elements within the simulations. However, when using numerical erosion, the dissipation of matter and energy from the computational model occurs in the mathematical background of the calculations. This can eventually give rise to a discrepancy between the simulations and corresponding real-world experiments. One solution to this problem is to cause the eroded elements to be transformed into Smoothed Particle Hydrodynamics (SPH) particles. These newly created elements can then assume the characteristics of the original elements, thus preserving the matter and energy of the numerical model, as is shown schematically in Fig. 21. The aspects, use and implementation of the described algorithm were published in Shock and Vibration, a high-impact journal, in an article by Kala & Hušek (2016).

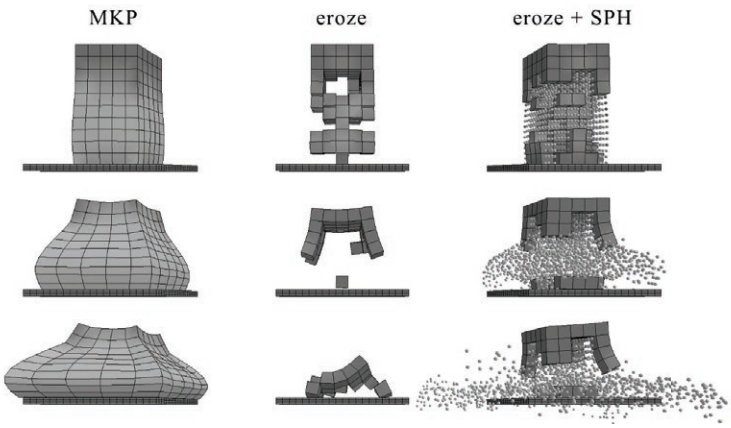


Fig. 21
The impact as a concrete specimen falls onto a hard surface. From the left: a model without FEM erosion, a model with FEM erosion, and a model with FEM erosion and its transformation into SPH particles.

A long-term subject of investigation by the division is the execution, evaluation and numerical simulation of fracture mechanics experiments. Many methods are used (effective crack, Double-K, Double-G, work-of-fracture), along with a great variety of tests, numerous test specimen and stress concentrator shape variants, and a whole range of materials. In 2016, the quasistatic behaviour was evaluated along with the fatigue testing of materials, the results of the latter activity being corrected using the approximation of the influence of age on the basic parameters. The main test configuration used was the 3-point-bending (3PB) test in which load is imposed on test specimens via a stress concentrator, i.e. a notch in the area where fibres are under strain. As far as the specimens were concerned, they were mostly prisms with a standard straight notch, though they were supplemented with cylindrical specimens with a chevron-shaped notch (arrow notch) – see Fig. 22.

Fig. 22
Selected cylindrical specimens from core samples taken from an existing reinforced concrete structure after fracture testing (chevron-shaped notch used).

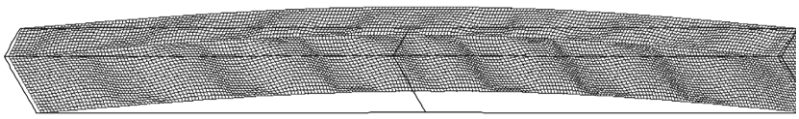
Another type of fracture test was the wedge splitting test (WST), where the specimens were most frequently cubes with a groove and a notch. The investigation also included very advanced combinations of 3PB and WST tests with one or two stress concentrators.

The studied materials were mainly: concretes with standard filler, concretes with aggregate from secondary raw materials, a fine-grained composite based on alkali-activated slag reinforced with carbon nanotubes, and mainly silicate-based composites with scattered reinforcement (fibre, wires). In the case of materials that were not reinforced with fibres, attention was paid not only to the determination of fracture mechanics parameters, but also to the shape and size of the fracture process zone. In the case of composites with scattered reinforcement, research also involved (aside from what has already been mentioned) the quantification of the influence of the fibres/wires and the matrix on the values of the above-mentioned parameters, while the analysis also considered the influence of the conditions under which the specimens are stored as they mature. In this way, the potential of the advanced analysis of measured force vs. displacement diagrams was demonstrated via the decomposition of the diagrams.

Furthermore, research was carried out focusing on the determination of shape and compliance functions for atypical specimens, which are a combination of test configurations for three-point bending and wedge splitting tests. It is known that a change in the geometry of such elements leads to different interference behind the growing crack front and acts in this way to cause stable or unstable crack propagation in typical specimens. The study took place using a series of specimens which were tested in cooperation with TU Wien in 2015. With further fracture analyses it became necessary to gain dimension-free shape functions via the Williams expansion (the basis for multi-parameter linear elastic fracture mechanics) with the aid of the over-deterministic method. The ANSYS tool and developed ODeMApp tool were used for this purpose. The compliance functions of specimens were also determined numerically and naturally for every specimen configuration. The output of the research was a set of successfully achieved results published at a prestigious Spanish conference that is an annual meeting point for fracture mechanics experts.

Another topic investigated by the MM division was the probability analysis of the reliability of a compressed imperfect steel column with a thin-walled box cross section (see the article Kala et al. (2016) published in the International Journal of Mechanics). The thin-walled column was modelled with the help of shell finite elements in the Ansys programme. Initial geometrical imperfections were introduced according to the local and global shapes of deviation (Fig. 23). The stochastic computational model was based on the geometrically and physically non-linear finite element method and the numerical simulation method Latin Hypercube Sampling, which was applied in the creation of numerical realizations of initial random imperfections. The influence of the nominal thickness of a hollow right-angled cross section on the ultimate limit state was studied.

Fig. 23
Thin-walled rod with initial imperfections

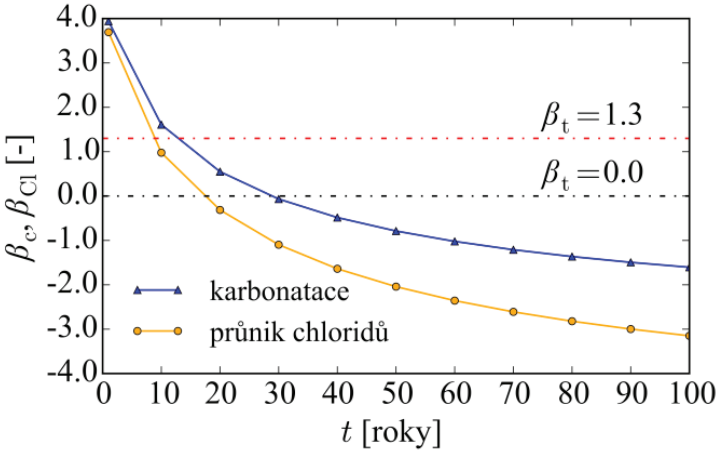


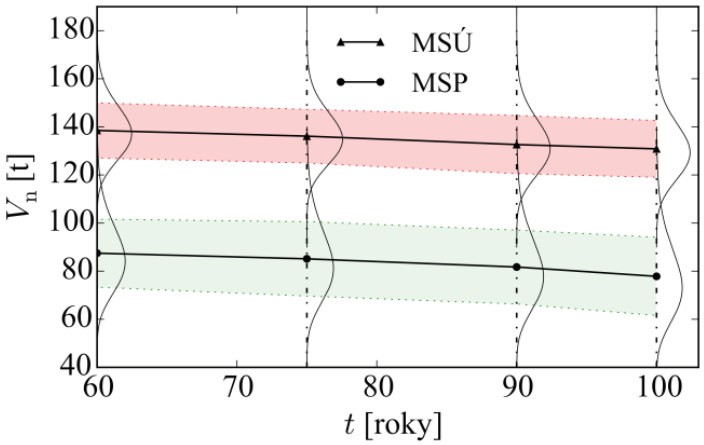
Another analysis focused on issues concerning the stability of steep von Mises trusses with rods featuring IPE400 steel rolled sections (see the article by Kala & Kalina (2016) published in the International Journal of Mechanics). The investigated von Mises beams either had an ideal geometry or a geometry with initial geometrical imperfections. A numerical study was made of the static balance states of three steep von Mises trusses with inclinations of 45°, 55° and 60°, which were forced to undergo the vertical and horizontal displacement of the top joint. The article describes the procedure of calculating and drawing potential energy surfaces. In the first stage of programme tuning, a real initial imperfection was introduced. It was a thousandth of the length of the rod, like those which commonly occur in industrially manufactured rods in reality. In the second step, the initial imperfection was increased artificially to a tenth of the length of the rod, thanks to which new and graphically interesting 3D surfaces transformed by potential energy were obtained. These can be used to examine the stability and bifurcation points of these nonlinear systems.

Another area investigated by the MM division was the modelling of degradation processes in concrete and the determination of the reliability and lifespan of reinforced concrete structures, particularly road bridges. Determination of reliability and lifespan is currently a very relevant topic when designing new concrete structures, or evaluating existing ones. The probabilistic approach to the modelling and evaluation of the lifespan and level of reliability of building structures is also emphasized in new international documents. If information from structural examinations and diagnostic surveys is also available about the state of existing bridges, their levels of loadability and reliability can be determined for individual limit states. This can be performed not only for the current time, but also for future years (see Fig. 24) in the form of predictions based on suitable analytical models that take into account the degradation of material due to (for example) the carbonation of concrete, or to chloride penetration. One important aspect of the modelling of degradation phenomena is the effect of mechanical loading, due to which changes to the porous structure of concrete occur and cracks appear or develop, which significantly influences the speed of degradation. Attention was thus also focused on the expansion of analytical models to include

the influence of mechanical loading. The modelling results were compared with measurements taken from real structures. The results of the analyses were published in the high-impact journal Engineering Structures in an article by Šomodíková et al. (2016), and in the reviewed journal Beton TKS in an article by Teplý et al. (2016).

Fig. 24
Drop in the level of reliability during the lifespan of a bridge due to the influence of material degradation (left); prediction of loadability for the ultimate limit state (ULS) and serviceability for a bridge age of 60-100 years (right).

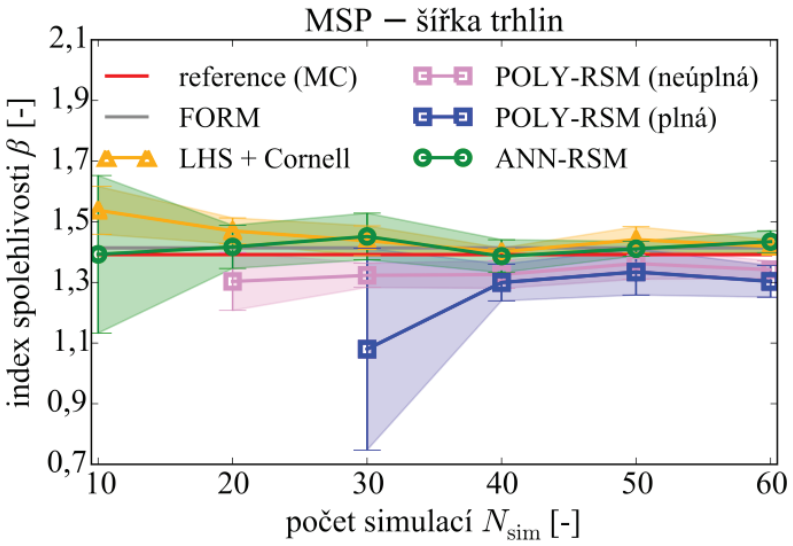




In cooperation with the University of Natural Resources and Life Sciences in Vienna, modelling of the interaction between the load-bearing structure of railway bridges and rail track was carried out with regard to the influence of temperature on stress growth; this was also published at the IABMAS 2016 conference in Brazil in two articles by Strauss et al. (2016ab).

The level of reliability, which is described using failure probability or the reliability index ,can be determined using standard simulation and approximation methods. Due to the time-consuming nature of the calculation, the application of simulation methods to extensive structures is not viable. Because of this, an approximation method based on an artificial neural network (ANN-RSM) was developed within the framework of the group´s activities. Its efficiency has been demonstrated both for simple structures where the failure function was defined explicitly, and for bridge structures with a failure function that is implicitly defined on the basis of a simulation of the response of the structure using the finite element method (see Fig. 25). The designed method can also be used in inverse reliability tasks, i.e. when determining the design parameters of a structure while achieving the required reliability level.

Fig. 25
Comparison of reliability indexes determined on the basis of various methods.



Applications of the ANN-RSM method when determining reliability indicators as well as when determining selected design parameters of prestressed bridges were published in the high-impact journal Neural Computing and Applications in an article by Lehký & Šomodíková (2016), and at an important international bridge conference in Brazil, IABMAS 2016, in an article by Lehký at al. (2016).

Another investigated topic was the correlation between the selected parameters of concrete of various strength classes. The aim was to determine the static dependence between basic mechanical parameters such as compressive and tensile strength or elasticity modulus, and also parameters describing the fracture behaviour of composites, represented here by specific fracture energy. Correlation analysis was carried out using the results of two types of laboratory tests – compressive tests conducted on cubic specimens and three-point bend tests performed on beams with a central notch. Another set of fracture mechanics parameters was obtained using inverse analysis. The individual statistic dependencies were determined using nonparametric sequence correlations. The results of the analysis are two recommended correlation matrices, one for concretes of strength class C30/37, and a second one for concrete with strengths corresponding to class C40/50 and higher. The results are summed up comprehensively in an article by Zimmermann et al. (2016) published in the high-impact journal Structural Concrete.

Topics from the area of experiment design (DoE – design of experiments) were also dealt with. Random Monte Carlo (MC) or Latin Hypercube Sampling (LHS) method designs can be optimized on the basis of various criteria. The criterion examined by our group is based on the distance between all pairs of design points. It is known as the AE criterion (Audze, Eglajs, 1977); its periodic variant, PAE (Eliáš, Vořechovský, 2016), and generalized variant, p(Morris, Mitchell, 1995), were also studied. The work focused on the calculation of these criteria on a regular orthogonal grid containing a large number of simulations (= points), see Fig. 26. The distances between all pairs of points can be expressed using a combinatorial number. For a great number of simulations, the numbers of all distances are also great and therefore it is not possible to go through all distances. In the case of a regular grid, regular repeating of the same lengths can be utilized. The obtained criterion on the orthogonal grid appears as the bottom limit that can be achieved for the location of points in the investigated domain, and therefore can be used as a criterion for an interruption during optimization.

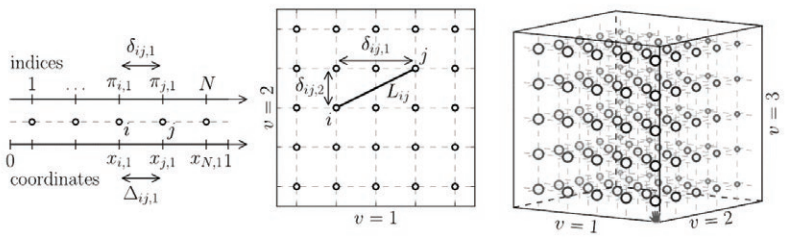
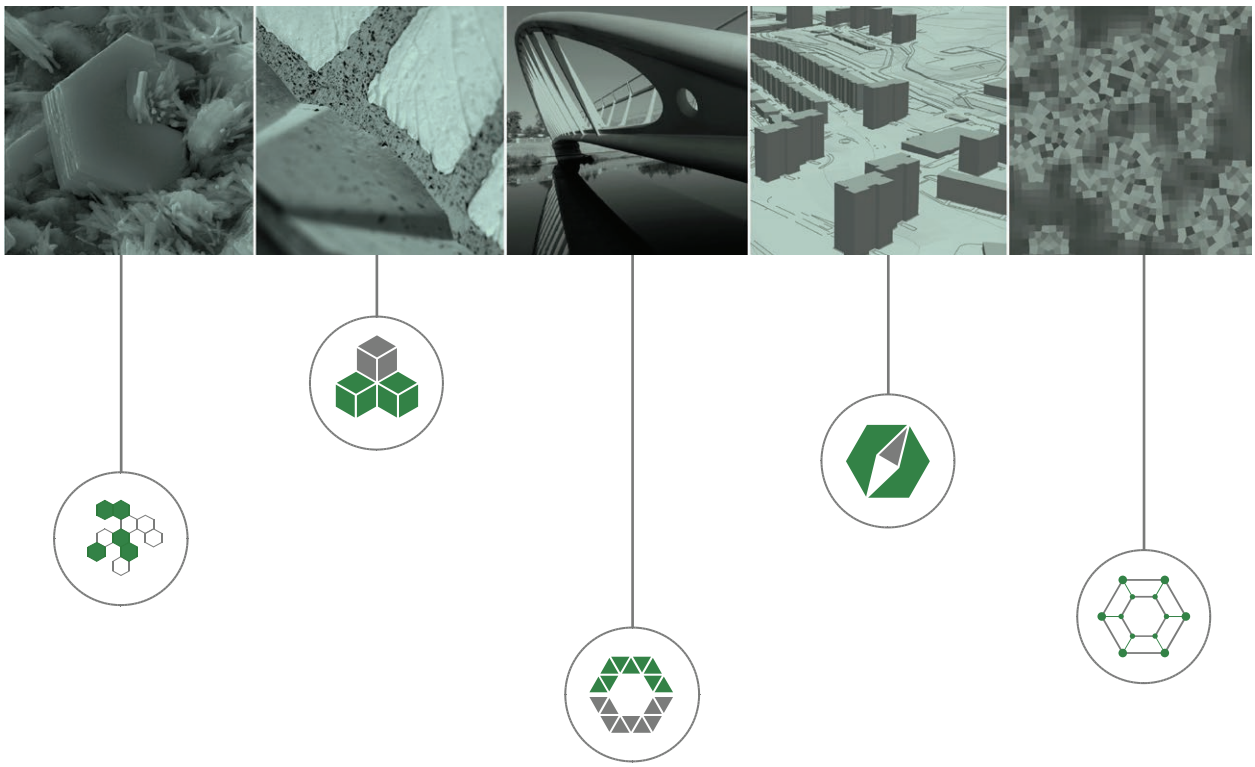


Fig. 26
Regular orthogonal grids - 1D, 2D and 3D - with an identical number of points in dimension n= 5; the number of simulations (points) for the individual designs is 51, 52 = 25, 53 = 125



8. Conclusion

After four years, the construction of the AdMaS Centre research facility at the Purkyňova 651/139, Brno site was successfully completed on 31.12.14, and the Centre now has the second year of full operation behind it. In 2016 the investigation of R&D projects from previous years continued and new projects began, including the international project Shift2Rail within the framework of the H2020 programme. A total of 24 projects involving cooperation with industry were investigated by regional R&D centres in 2016, 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 2016 the amount of staff mobility to institutions abroad increased, 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 2016, and the yearly planned values were exceeded in practically all cases.

Number of jobs (FTE) for R&D staff: 130

Number of successful Ph.D./Master´s degree graduates: 23/146

Publication in high-impact journals: 40

Publication in periodicals rated with regard to R&D methodology: 129

National patents: 2

Results of applied research (pilot operation, prototype, functional sample, etc.): 70

Number of contract research projects: 169

Number of R&D projects: 60 + 2 international

Total income from commercial activities: 58 Mil. CZK

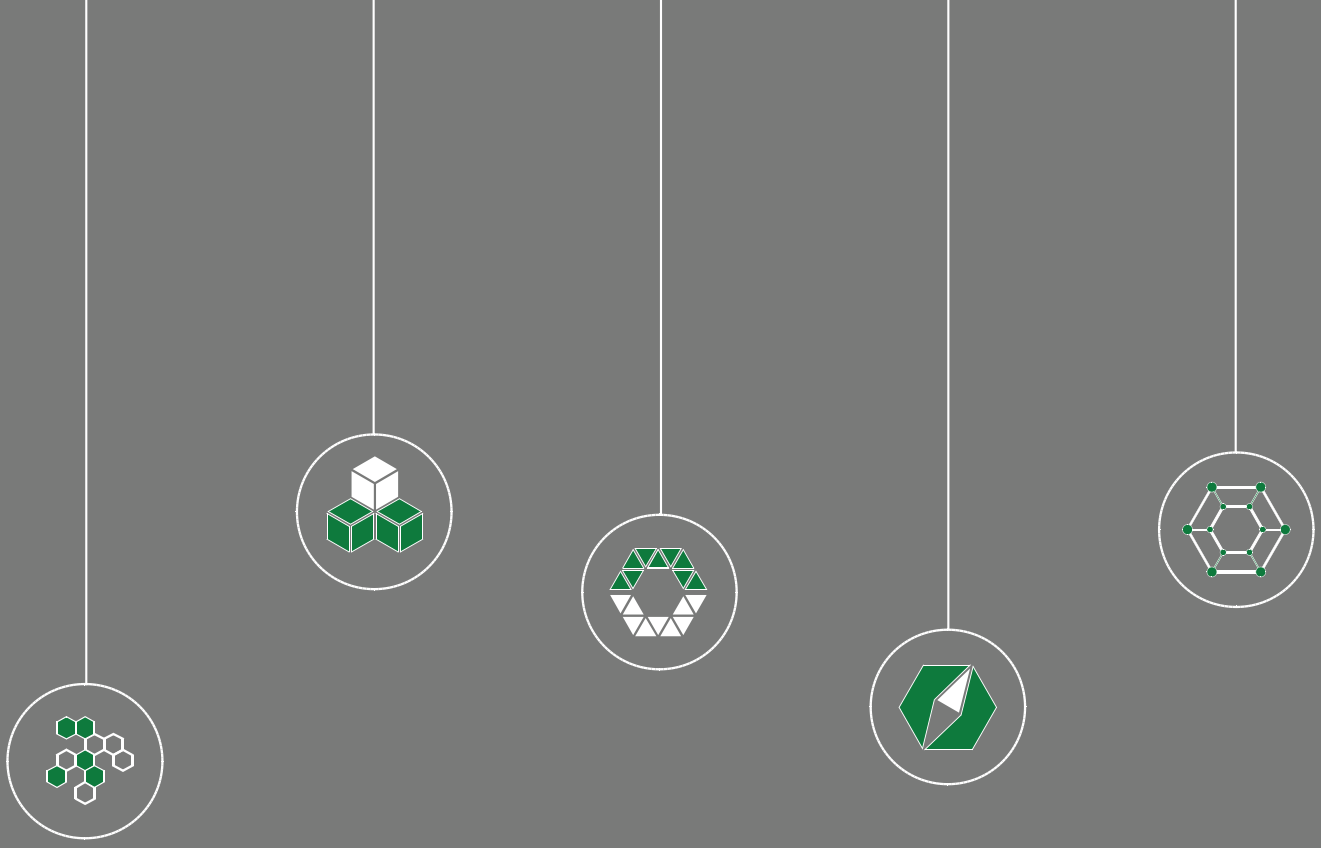
Amount of the above commercial income gained from contract research: 37 Mil. CZK.

Income from non-commercial activities: 150 Mil. CZK.

Total income of the Centre: 208 Mil. CZK.

The most important industry partners were the Road and Motorway Directorate, the SŽDC railway track administration, selected regional authorities and bodies involved in road maintenance, and the company FRAYSSINET CS, a.s. The Centre is successfully continuing its cooperation with the important geoinformation company Hansa Luftbild AG in the field of geoinformatics. In the area of material research, the key partners of the Centre are VERTEGO, spol. s.r.o., BEST, a.s., CEMEX Czech Republic s.r.o. and TRANSBETON s.r.o. Other key partners include ČEZ, a.s., the Institute of Applied Mechanics and the Centre for Research and Development s.r.o. Also, our cooperation with BIONIC E&M spol. s.r.o., which focuses on the use of waste from wastewater treatment plants, seems very promising. An important commission was a project for the E.ON group which focused on the analysis of the potential for the use of liquefied natural gas (LNG) in the Czech Republic, and on the design of safety regulations for the construction of LNG refuelling stations.

Generally, our cooperation with industry has undergone significant development and there has been a marked increase in the turnover of the Centre in the area of contract research. It is a positive fact that, despite the overall economic slowdown in the construction industry in the Czech Republic in 2016, the Centre managed to increase its turnover slightly. Another positive phenomenon is 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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