Annual report
2017
Josef URC
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Dear readers,

Our Department entered the second decade of its existence in 2017 and I am proud to report that the first decade can truly be considered a period of successful development in terms both of the performance of research projects and the teaching of students and those activities that are not directly related to the basic mission of the Josef Underground Laboratory.

Nevertheless, looking into the future my retirement from the position of Department Head is approaching and the search has begun among my younger colleagues for someone willing and able to gradually assume my responsibilities over the next two years or so. Last year witnessed significant changes in the composition of the Josef team with several of our staff moving on to “pastures new”. The remaining members of the team, however, still managed to efficiently accomplish all the tasks and duties assigned to them.

The process surrounding the acquisition of new research projects, i.e. securing the funds necessary for the continued operation of the Department, is becoming increasingly “challenging” due to the emergence of ever-stiffer competition. That said, we managed to attain the target we set ourselves during 2017 in this respect with the awarding of another European project (Beacon) and several significant commissions from the Czech Radioactive Waste Repository Authority (SÚRAO). Other activities included the completion of the construction of a multi-purpose area in the former compressor room and the significant extension of the portfolio of events hosted within the Josef Gallery complex.

prof. Ing. Jaroslav Pacovský, CSc., CEG Head
He graduated from the Faculty of Civil Engineering, CTU in Prague, the branch of Structural and Transportation Engineering. He has been employed at the Faculty since 1977. In 1998, he became the prime mover in the establishment of a new department - the Centre of Experimental Geotechnics (CEG). In 2004, he was appointed Professor in the branch of Theory of Building Structures and Materials.

He came up with the idea of opening an abandoned mine, the Josef Gallery, for instruction and research and has also initiated the establishment of the science and technology park, the “URC Josef Regional Underground Research Centre”. Under his supervision, a vast cavern in the Josef Gallery was gradually opened to the public during two years, it has been accessible for the public since 2015.

He graduated from the Faculty of Civil Engineering, CTU in Prague, the branch of Structural and Transportation Engineering, in 1999. He continued studying a Doctoral Degree programme, the branch of Physical and Material Engineering, and obtained the Ph.D. degree in 2004. During his studies, he first worked for CEG as a research student, and later, as a Ph.D. student, on a part-time basis. In 2004, he got a full-time contract. He is co-responsible for CEG research activities. As a senior researcher, he represents CEG in international projects.

On a long-term basis, he has been involved in the design of the monitoring and instrumentation system for physical in-situ models verifying the materials and technologies for the construction of a deep geological repository of nuclear waste.
Jana Večeřová
Economic Assistant

She completed the Budějovická Gymnasium (1991) and has been a CEG team member since 1st January 2016. She is responsible for the economic, financial and HR agenda of the Department. She files and checks tax documents, time sheets, participates in the administration of research projects.

Ing. Danuše Nádherná
Assistant Professor

She graduated from the Faculty of Civil Engineering, CTU in Prague in 1981. In 2006, she joined the CEG as an external staff member, becoming a full-time employee in 2008. She is in charge of all-round engineering services and acts as the Health and Safety Inspector in the Josef Gallery. She is responsible for the administration of the overground complex and participates in the preparation and administration of projects. She supervises laboratory tests carried out as part of research into bentonite, cooperates on activities for the Department presentation and organises guided tours for the public.

Ing. Dana Pacovská
Assistant Professor

She graduated from the Faculty of Civil Engineering, CTU in Prague, the branch of Economics and Management in the Building Industry, in 1979. She worked in cooperation with CEG on a part-time basis from 2009 and became its regular staff member in 2014. She prepares and organises the presentation of all Department activities, cooperates on the preparation of projects, supervises laboratory tests carried out as part of research into bentonite, participates in guided tours of the Gallery for the public.
Ing. Radek Vašíček, Ph.D.
Assistant Professor

He graduated from the Faculty of Civil Engineering, CTU in Prague, the branch of Structural and Transportation Engineering, in 2001. In 2007, he completed his Ph.D. study in the branch of Physical and Material Engineering. He first worked for CEG as a student getting a full-time contract in 2007. In 2006, he did an internship in the SKB Åspö Hard Rock Laboratory in Sweden. He is in charge of CEG educational activities, the operation of the accredited geotechnical laboratory and is responsible for research projects. He acts as a co-researcher of international projects.

Ing. Jiří Šťástka
Ph.D. Student

He has a part-time contract with CEG and, at the same time, studies in a doctoral degree programme, the branch of Physical and Material Engineering. In 2016, he represented the Czech Republic in a seminar of representatives of underground laboratories in Bure (France). Under his supervision, the physical model of the “Bentonites 95” project was assembled and installed in 2013. He was responsible for the preparation and construction of the bentonite layer for the pressure and sealing plug within the DOPAS project. In the overground complex of the Josef Gallery, he supervises the running of the in-situ experiment within the NAKI project.

Šárka Fouknerová
Receptionist

She completed the Secondary School of Hotel Management and Trade in Příbram, the branch of Hotel Management and Tourist Trade, in 2004. She was a CEG team member from 1st January 2016 to 30th June 2017. She participated in running the underground facilities, the Josef URC building and the facilities situated in the overground complex of the Josef Gallery. She was responsible for checking and registering all persons entering the Josef Gallery and its underground facilities.
Josef Barták
Technician

He has worked for the CEG since 2010 and is in charge of the maintenance and operation of the Josef above-ground complex and machinery maintenance. He is involved in the technical support of teaching courses and research activities and the ongoing reconstruction and extension of the Josef underground complex.

Vladimír Kašpar
Technician

He has worked for the CEG since 1998 and is primarily involved in the installation of measurement equipment for research projects and is responsible for various physical construction tasks during the assembly of experiments. He also works on the ongoing reconstruction and opening of new sections of the Josef underground complex and the preparation of practical classes for students.

Josef Kožišek
Technician

He joined the technician team in January 2014 and is involved in the operation and maintenance of the Josef above-ground complex. He is involved in the technical support of teaching courses and research projects and the ongoing reconstruction and extension of the underground complex.
Josef Facility Maintenance and Security:

Ing. Milan Štěrba

They left the CEG team and set out for another “post“:

Ing. Lucie Hausmannová

Ing. Jan Smutek

Ing. Jaroslav Hloušek

Bc. Michal Roll

Petr Růžička
Technician

He has worked for the CEG since 2009 and is involved in the operation and maintenance of the above-ground complex. He participates in the technical support of teaching courses and research projects and the ongoing reconstruction and extension of the underground complex.
The days of the fully-loaded Renault Trafic staff transporter are over; however, our reliable means of transport continues to depart from the square in Zbraslav (south of Prague) with meticulous regularity on working days heading for the Josef Facility where the vast majority of our work-related activities are still conducted – research projects and experiments, student classes, guided tours and continuous modification and maintenance work in both the underground and adjacent surface complexes.

The CEG's teaching activities are primarily oriented towards the practical instruction of students in laboratory testing and experimentation methods in the field of geotechnics, in-situ testing and the taking of complex measurements related to foundation engineering and underground structures.

Josef Underground Laboratory

Since 2007 when the Josef Underground Laboratory commenced operation, this unique workplace has been used for the regular teaching of students, the conducting of research projects and training courses, field trips for both professionals and the general public.

The Josef Facility provides for teaching at both the Bachelor's and Master's Degree levels of study in the context of courses taught by the Faculty of Civil Engineering and other universities. In addition, we host students from the ICT Prague every semester and other active users of the Josef Facility include the MU Brno and the CU in Prague.
2017 was the final year of some research projects; thus, we are endeavouring to attract further research funding (both in the Czech Republic and abroad) for projects which address those topics corresponding to the broad professional interests of CEG experts and which, ideally, suit the research potential of the Josef underground complex.

The potential of the underground complex at the Josef Facility is far from being exhausted and new underground spaces are being systematically adapted and subsequently put into operation. Following final modifications concerned principally with health and safety issues, a 40-metre crash shaft in the Čelina West area was recently put into operation and an extensive multi-functional area nicknamed the “Café Underground” was opened in June following the reconstruction of the former compressor room.

2017 also saw the continuation of the traditional programme of events held at the Josef Facility. On the second Saturday in February, nature conservationists arrived for the seventh year running to count our resident hibernating bats! The “From Josef to Josef” bike race, which tests the fitness of cyclists at the start of the new season, took place at the beginning of May. The “Josef Day” was attended by students from the secondary technical school of civil engineering, Pilsen; the visitors took a guided tour of the underground complex, enjoyed playing the “escape game” in the maze, listened to music in the “cathedral” and finally verified their knowledge of the Josef Facility by means of a specially-designed test.

Professional field trips to the Facility mostly involved specialists from domestic institutions in 2017 – students from a secondary technical school of surveying, experts from a number of departments of building structures at various Czech universities, seniors from the FCE and students from a secondary technical school in nearby Příbram. Moreover, students and teachers from the Academy of Performing Arts in Prague, who are becoming regular users of the Josef Facility, held a workshop in March, the programme of which included a recital by the British musician John Kenny on an ancient Celtic instrument, the carnyx, while in October the Facility hosted the Zero Year of the Open Source Festival of Experimental Music.
The Facility’s outdoor complex also hosted a number of cultural “premieres”. In July, the Wild Sticks drummers’ group from České Budějovice performed a concert and, on the first Advent Sunday, over 200 people attended the “Nativity Scene Blessing” and a small Christmas fair. From May to October, the Facility is open to the general public; visitors can choose from three guided tours - Čelina, Mokrsko and the “underground cavern” (http://ceg.fsv.cvut.cz/o-nas/stola-josef).

**URC Josef**

2017 was the seventh year of the operation by the CEG of the “Josef URC Regional Underground Research Centre” which, together with the Josef Underground Laboratory, makes up a unique experimental and teaching complex. The mission of the Josef URC Science and Technology Park is:

- technological development and innovation focused on new technologies and competitive products and services in the field of underground structures
- the more rapid transfer of research results to practical applications
- training and requalification programmes for those working in the field of underground structures
- marketing activities, expert services and accredited testing

Following the completion of their research projects, several lease-holders are leaving the Facility and our aim for the future is to attract new emerging and/or innovative firms. There is currently no other such facility in the Czech Republic, nor indeed in Europe, which is able to provide the infrastructure, environment and services provided by the Josef URC.
Courses taught by the CEG teaching staff are targeted primarily at students in the Structural and Transportation Engineering and Environmental Engineering fields. These courses, which are oriented towards experimental geotechnics, are taught both at the CEG’s laboratories and the Josef Underground Laboratory. The Josef Facility, particularly the underground complex, is also used for the teaching of courses on Geodesy and Cartography and by students of other universities (e.g. ICT Prague, MU Brno).

Bachelor’s Degree Study

Project 2 and Project D prepare students in the fields of Environmental Engineering and Structural and Transportation Engineering for the writing of their bachelor’s theses thematically oriented towards experimental geotechnics. Students are required to address practical problems related to selected issues working both in the CEG laboratories and the in-situ Josef Underground Laboratory. They extract the relevant information from both professional literature and internal CEG materials. Depending on the research projects currently underway at the CEG and personal preferences, students select from a choice of topics – from theoretical issues through laboratory research to topics related to the preparation, operation and evaluation of experiments underway in the real geological environment of the Josef Facility.

Bachelor’s Thesis offers students in the branches of Structural and Transportation Engineering and Environmental Engineering an opportunity to compile practically-oriented bachelor’s theses focused on topical issues in the field of geotechnics. To this end, they are encouraged to make full use of the above-ground geotechnical laboratories as well as the Josef underground complex. The topics follow up on issues addressed in the contexts of Projects 2 and D (see above).
Follow-up Master’s Degree Study

Geotechnical Laboratory comprises geotechnical in-situ as well as laboratory experimentation for the determination of rock and soil parameters which are of key importance with respect to the performance of subsequent geotechnical calculations and consist of mechanical and physical, hydrophysical and thermophysical properties, strength and deformation. The first part involves students performing the various tests necessary for the classification of soils under standards currently in force. This is followed by the measurement of characteristics essential for the design of geotechnical structures in compliance with load-bearing capacity and deformation criteria.

Experimental Analysis of Constructions – Geotechnical Part comprises practical classes conducted under real geological conditions in the Josef Underground Laboratory. After being instructed in the relevant Codes of Conduct, students attend all-day practical sessions concerning the monitoring of underground constructions, the application of sealing clay materials and the verification of their performance and the analysis of selected host rock parameters.

Diploma Seminar prepares students for the research of diploma thesis topics in the field of experimental geotechnics via an open literature study, literature searches and the investigation of respective issues using practical examples. The course is completed by the writing of a diploma thesis research concept.

Diploma Thesis is designed for students in the follow-up master’s degree branches of Structural and Transportation Engineering and Environmental Engineering who are required to write diploma theses in their chosen branch specializing in experimental geotechnics. The thesis topics are usually closely related to research projects underway at the CEG. Students use both the geotechnical laboratories and the Josef Underground Laboratory for research purposes.
Experimental Research into Radioactive Waste Disposal is an elective course which addresses issues surrounding the safe isolation of radioactive waste. Students are familiarised with the basic principles of radioactive waste disposal, the properties of bentonite-based materials for the construction of the engineered barriers of deep geological repositories by means of physical modelling and the solving of practical problems in the Josef Underground Laboratory. This course is also taught in English.

Doctoral Degree Study

In 2017, Ing. Lucie Hausmannová, working under the supervision of Ing. Radek Vašíček, Ph.D., successfully defended her dissertation entitled “Hydrophysical properties of smectitic clays in the conditions of a deep geological repository for radioactive waste” and was awarded a Ph.D. degree. A second Ph.D. student, Ing. Jan Smutek supervised by Ing. Jiří Svoboda, Ph.D., also successfully defended his dissertation on “Research into the gas permeability of a rock continuum based on experimental in-situ measurements”. In addition, Ing. Jiří Šťástka completed his dissertation on “Physical modelling in solving issues surrounding radioactive waste isolation” under the supervision of prof. Ing. Jaroslav Pacovský, CSc. and will defend it in 2018.

Ing. Jaroslav Hloušek, working under the supervision of prof. Ing. Jaroslav Pacovský, CSc., is currently the only continuing Ph.D. student; Ing. Alexey Manaenkov changed his supervisor and thus the university department during the year.
The three-year Determination of the Thermophysical Properties of the Bentonite Barrier project continued in 2017, with concern to which Ing Jiří Šťástka retained the position of senior researcher assisted by his supervisor, prof. Jaroslav Pacovský. Heat transfer makes up one of the key requirements for bentonite barriers which constitute an essential structural element in deep geological repositories for spent nuclear fuel. The thermophysical parameters of bentonite consist of thermal conductivity, thermal capacity and thermal diffusion and it is important to be aware of the differences between the properties of loaded (i.e. as affected by heat and water) and unloaded bentonite.

In the third year of the project, the determination of the thermophysical properties of bentonite pellets continued. The term pellets refers not only to bentonite pressed into the form of rolls, but also crushed bentonite pellets and blocks. Two types of bentonite pellets were tested – pellets made of Czech B75 bentonite and pellets of sodium bentonite supplied by the Swiss NAGRA agency. It is assumed that both types of pellets will be used in in-situ experiments recently prepared in the Josef Underground Laboratory. The finding that Czech bentonite in pellet form is suitable for certain deep geological repository construction applications was considered a significant project conclusion.

A team composed of Ing. Jaroslav Hloušek and Ing. Jiří Šťástka is currently conducting research project entitled Optimization of the Selection of Sites for In-Situ Experiments at Josef Gallery based on Groundwater Characteristics. The main output of the project consists of an 18-month measurement campaign with the objective of characterising mine waters in the Josef underground complex and evaluating the effect of the rock medium, in-situ experiments and building constructions on the hydrochemistry of the complex as a whole. The measurement is underway of the basic physical and chemical characteristics (pH, electric conductivity, total mineralization and temperature) and ion concentrations (calcium, magnesium, potassium, sulphates).
Defended Diploma Theses

Kateřina Weisserová
Alternative Fire Safety Design of a Road Tunnel

The diploma thesis addressed fire prevention in a road tunnel, i.e. the prevention of fires, the reduction of fire risks and ensuring fire safety throughout the whole service life of the structure. The objective of the thesis was to compare fire documentation compiled for the Těšnov tunnel prior to its reconstruction in 1999 and a new fire safety design which fully complies with standards currently in force.

The first part of the thesis deals with road tunnels and their equipment in general. The second part develops a technological and structural design with respect to fire safety precautions in tunnel structures. The third part includes a literature search on a selected tunnel with a long operational history and presents an assessment of the original fire safety design as seen in the light of standards currently in force. The final and principal part of the thesis presents an alternative fire safety design of the selected tunnel and compares present-day regulations and standards and the fire safety concept employed at the time of reconstruction.

The alternative, newly-designed fire safety concept of the Těšnov tunnel is based on today’s legislation and standards, e.g. ČSN 73 7507, the Design of Road Tunnels for technological facilities, ČSN 73 0802 the Fire Safety of Buildings – Non-Industrial Buildings and several more. The new fire safety design incorporated different subdivisions into fire compartments and changes to the content of fire safety classifications, water collection points and the number of SOS boxes and fire extinguishers.
Cooperation with international institutions is an effective way for the CEG to promote awareness of its activities and to support its involvement in various international projects. It represents a significant stimulus for the development of both theoretical and practical knowledge and provides opportunities for comparing levels of knowledge in numerous areas of interest.

**ENEN – European Nuclear Education Network**

The ENEN association is a non-profit international agency established in 2003. Its mission is the protection and further development of professional knowledge in the area of nuclear engineering through education and practical training. The association has 51 members. The CEG is involved in the field of the deep geological disposal of radioactive waste.

http://www.enen-assoc.org/

**IAEA URF Net: Training and Demonstration of Waste Disposal Technologies in Underground Research Facilities (URF Network)**

The URF network is an IAEA (International Atomic Energy Agency) network which brings together underground research facilities for the purposes of practical training and the demonstration of technologies concerning the deep geological disposal of radioactive waste. As part of CEG’s association with IAEA URF, the Josef Underground Laboratory offers research training courses and international professional field trips.


**IGD-TP: Implementing Geological Disposal – Technological Platform**

With support from the European Commission, this institution was founded in 2007 by a number of European organisations responsible for radioactive waste disposal. It presently brings together organisations from a total of 23 countries. The principal mission of IGD-TP is to initiate and put into practice strategic planning and technical cooperation for the gradual implementation of a safe method for the deep geological disposal of spent nuclear fuel.

http://www.igdtp.eu
Introduction to Projects

As already mentioned above, the “struggle” to obtain research projects that can be conducted in the Josef Underground Laboratory is becoming increasingly difficult. Nevertheless, we are determined to continue our work and are surviving against tough competition by continuing to be involved in several prestigious projects.

2017 was the final year of the PAMIRe project, while research continues with respect to other projects according to the respective time schedules. SÚRAO extended the duration of two already officially completed projects – DOPAS and Mock-Up Josef since their long-term operation is considered crucial for the verification of the results and the various technologies and materials employed. A new research project supported by the Technology Agency of the CR via the Epsilon programme addresses sealing methodology with respect to hydrogeological boreholes, while another new project entitled “In-situ interaction physical models in the Bukov Underground Research Facility” has been commissioned by SÚRAO. Moreover, since June 2017, the CEG has made up one of a number of research establishments involved in the European Beacon project.

One topic that we feel deserves greater attention consists of the experimental research of so-called “hot” mock-up physical models in which the bentonite sealing layer is loaded with temperatures in the range 150°C – 200°C. To date, no financial support has been raised for such research; however, we are confident that the relevant institutions will show greater interest in this topic in due course.
DOPAS consisted of an extensive European project in which the Czech Republic was represented by the Faculty of Civil Engineering CTU in Prague, ÚJV Řež and the Czech Radioactive Waste Repository Authority (SÚRAO). The objective of the Czech participation in the project was the assembly of an experimental pressure and sealing plug (EPSP – Experimental Pressure and Sealing Plug) in a granite massif in the Josef Gallery. Sealing plugs will make up an important component of the future Czech deep geological repository (DGR) for radioactive waste. Their function is to provide a secure barrier between already filled and unfilled DGR disposal areas. The EPSP experiment was assembled in the first half of 2015.

The initial experimental testing of the plug consisted of its short-term loading with water or a bentonite suspension under pressures ranging from 0.1 to 3 MPa. Following the grouting of the pressure chamber, the plug was exposed to long-term water pressure of up to 1.2 MPa. In order to verify the efficient functioning of sealing plugs, it is essential that the experimental phase continues over a relatively long-term period. The research included the study of the effects of the pressurization of the plug, general and discharge monitoring and detailed follow-up analysis. The plug was exposed to a constant pressure of around 1.25 MPa and the development of various parameters with concern both to the plug itself and the surrounding rock massif was monitored at 10-minute intervals.

The results of monitoring performed throughout the last year indicate the gradual saturation of the sealing section with a simultaneous slight increase in swelling pressure; the discharge from the experiment can be seen to be decreasing slightly.
Projects name: CEBAMA - Cement-based Materials, Properties, Evolution, Barrier Functions

Duration: 2015-2019

Co-recipients: 27 institutions and universities from Europe and Japan

Source of funding: Horizon 2020 EU Programme

CEBAMA is a four-year European project involving 27 institutions from Europe and Japan. The project is being coordinated by one of the German partners – Karlsruher Institut für Technologie (KIT). The objective of the project is the research of interactions between the various materials to be employed in DGR construction. It is presumed that, depending on the DGR construction concept adopted in the respective country, cement will be used as one of the structural materials. The interaction of cement with the other materials used may affect both their behaviour and long-term stability.

All the experimental work performed by the Czech project partners (ÚJV Řež, FNPE CTU and the CEG) involves the study and modelling of the changes and interactions which impact cement-based materials exposed to different environments (groundwater, contact with bentonite, high temperatures, etc.). Laboratory testing includes the interaction of Portland cement and binders with reduced pH, Czech Ca-Mg bentonite and groundwater taken from the Josef Underground Laboratory, all at temperatures of 10°C to 95°C. The maximum length of the laboratory interaction studies is envisaged to be 27 months. Many specimens have already been sampled and analysed over time intervals of 9 and 18 months. The in-situ experiment includes the long-term monitoring of the behaviour of compact bentonite, cement mixtures and groundwater in a real geological environment over an interaction period in this case of 72 months.
Projects


Duration: 2015-2019

Co-recipients: 28 organisations from Europe and Japan

Source of funding: Horizon 2020 EU Programme

This European project was launched in June 2015 and the various participants in the project are coordinated by ANDRA (the French equivalent of SÚRAO). The Czech Republic is represented by the Faculty of Civil Engineering CTU in Prague, SÚRAO and the Technical University of Liberec (TUL). The project aims to develop and implement an effective programme for the monitoring of deep geological repositories for radioactive waste taking into account the specific requirements of the various national programmes. New technologies are being developed for monitoring purposes including wireless data transfer, alternative power sources and new types of sensors and geophysical methods.

The research involved in the project is divided into six work packages (WP), with the CEG participating in WP3 (the research and development of monitoring technologies) and WP4 (the demonstration of their use under in-situ conditions). Consequently, the first prototype of a multi-functional pressure cell (80 mm in diameter and 25 mm in height) for the measurement of stress, pore pressure, relative humidity and temperature was jointly produced and tested by the CEG and TUL in 2016. The steel body of the pressure cell houses sensors for the measurement of the above variables. The pressure cell was tested in a thermal test chamber in the temperature range -20°C to +90°C. At higher temperatures, the oil medium in the sensors intended for the measurement of pressure was found to expand; therefore, a second prototype was manufactured, which is presently being tested and prepared for in-situ installation.

The third general assembly of all the partners involved in the Modern2020 project took place in Montpellier (France) in June 2017 at which the interim results of all the WPs were presented. (http://www.modern2020.eu/)
The need for this project is based on the requirement for the detailed assessment of the bentonite structural components used in the engineered barriers of deep geological repositories (DGR) for radioactive waste in terms of their long-term safety. Since these issues concern many European countries and are extremely complex, it was concluded that this topic would be best addressed via mutual cooperation at the European level by developing and testing tools for the assessment of the hydro-mechanical development of a non-homogeneous bentonite barrier. The project was launched in June 2017 with SKB, the institution responsible for radioactive waste disposal in Sweden, acting as the main coordinator. The research is being conducted in the form of nine WPs.

The CEG is active in the following four WPs. WP2 involves the collection of relevant information from other projects which contributes towards providing the knowledge necessary for the understanding of the long-term mechanical development of bentonite in relation to its use in DGRs. WP3 concerns the development of numerical models. WP4 concentrates on laboratory testing aimed at providing input parameters for the development and validation of the numerical models, as well as experimental studies aimed at limiting the uncertainties concerning the various phenomena that affect bentonite homogenization. WP5 involves the testing and verification of the models for subsequent in-situ experimentation.
This project, which commenced in November 2017, involves the drilling of 10 horizontal test boreholes into the rock mass which hosts the Bukov Underground Research Facility (URF). The boreholes will eventually house physical models which will simulate the disposal of waste disposal packages in a deep geological repository (DGR). The objective is to verify the behaviour of a bentonite sealing layer exposed to saturation with groundwater on interaction with cement-based materials simultaneously loaded with temperatures of from 100°C to 200°C.

The boreholes which will house the experiments will be drilled in the form of cored boreholes with water flushing. A borehole diameter of 97 mm and a length of 115 cm are envisaged for the experiments with no heat sources and a diameter of 220 mm and a length of 140 cm for those with heat sources. The boreholes will be situated around 2 m apart. The length of the boreholes and the form of construction of the experiments will be adjusted if necessary according to the local geological conditions, particularly with respect to fracture networks.

The first phase of the research was completed in 2017. Based on the exploitation of existing geological data and analytical methods employed in the fields of structural geology, petrology, petrophysics and hydrogeology, the Czech Geological Survey performed the characterization of the rock medium and groundwater in the selected rock niche. The second phase, which is presently in the preparation stage, will include literature searches aimed at providing an overview of research findings from related domestic and foreign in-situ experiments.
Mock-Up Josef consists of an in-situ physical model, the first to be constructed in the Czech Republic, which simulates the vertical emplacement of a container with spent nuclear fuel. The experiment involves research into the effects of heat and groundwater on the sealing bentonite barrier, the so-called buffer, which will surround containers with spent nuclear fuel in the future Czech deep geological repository.

The project continued in 2017 since the processes at work inside the bentonite barrier were found not to have fully stabilized. The pressure, temperature and relative humidity inside the barrier are monitored on a continuous basis in five horizontal and one vertical profile. Specially mounted sensors also monitor changes underway within the surrounding rock massif.

The sixth vertical sampling of the loaded bentonite took place in August 2017 employing higher-quality equipment than that used previously. The borehole reached a depth of 82 cm and provided samples with a diameter of 32 cm. A total of 120 samples were analysed with respect to dry volume density, moisture content by weight, the degree of saturation, hydraulic conductivity and swelling pressure. The values obtained were compared to those obtained from previous sampling campaigns and, based on the findings, predictions were formulated concerning the future development of the various parameters. Based on the assessment of the samples and the results of the monitoring campaign, it is clear that the various phenomena inside the experiment have not yet fully stabilized. A specially set up web interface provides an overview of the functioning of the system and the experimental log book. (http://uef-josef.uef-josef.eu/misc/mereni/)
Projects:

Projects name: PAMIRe - Transfer of the Migration Parameter Values of Granitic Rocks from the Microscale to the Real Rock Massif Scale
Duration: 2014 - 2017
Recipient: ÚJV Řež, a.s.
Co-recipients: AARCADIS CZ, Division of Geotechnics, Faculty of Civil Engineering, CTU, Institute of Geonics AS CR.
Source of funding: TA ČR – ALFA Programme

2017 was the final year of the project, the objective of which was based on the necessity to reduce to the maximum extent uncertainties accompanying the transfer of the results of laboratory research and simulations to in-situ conditions. The PAMIRe project was concerned specifically with migration processes at work within the host rock of a future deep geological repository for radioactive waste. The project was coordinated by a team from ÚJV Řež, who conducted most of the research work.

Laboratory work included the completion of penetration diffusion experiments with $^3$H, $^{36}$Cl and $^{125}$I on small-sized samples (50 mm in diameter). Medium-sized samples with a diameter of 115 mm were also exposed to diffusion experiments with concern to $^3$H and $^{125}$I only. In addition, electromigration experiments involving the $^{131}$I active isotope were performed on medium-sized block-shaped samples.

In-situ work at the Josef Underground Laboratory focused on the conducting of tracer tests employing a radioactive tracer. Following negotiations with the State Office for Nuclear Safety, the formal approval process was completed and two tests using a tritium active tracer ($^3$H), prepared in 0.01M NaCl, tracer activity (2 MBq.1-1), application time 10 minutes, grouting discharge $Q$ of 50ml.min-1, were conducted on 22 September and 6 October 2017. The results of $^3$H activity measured in both the tests were consistent and the development of the two tests was observed to correlate to a high degree. This test was the first of its type to be conducted in the Czech Republic and the results can be considered to have made a significant contribution to the process of gathering real data to be used in the safety assessment of the future Czech deep geological repository for radioactive waste.
Projects name: Maintenance, Repair and the Monitoring of Dams of Historic Ponds as part of our Cultural Heritage
Recipient: Faculty of Civil Engineering CTU
Duration: 2016 – 2020
Source of funding: Ministry of Culture CR – NAK I II Programme

This five-year project concerning which the Centre of Experimental Geotechnics is working closely with the University’s Department of Irrigation, Drainage and Landscape Engineering is focused on securing and conserving the dams of historic fish-farming ponds which form an important part of the Czech cultural heritage. The objective is to design suitable technology for the repair of the dam structures of such historic ponds and experimentally verify the proposed technology by means of a sectional physical model.

In 2017, the construction of an in-situ model composed of two sections with dimensions of $3 \times 17$ m and a height of $2.5$ m was completed. The inside walls were sprayed with a specially prepared and tested mixture of bentonite labelled REC MIX I on contact with the embankment. The construction was reinforced by means of steel sections in the upper part so as to provide for the stability of the side walls against the pressure exerted by the body of earth and water in the section above the dam. The dam model was constructed on the basis of a detailed search of historical literature on the topic and featured slopes of differing angles on both the upstream and downstream faces. A monitoring system was installed within the experiment for the measurement of seepage and other physical processes underway within the earth body.

Based on the altimetric data available to date, the shapes of the dams of historic ponds were determined in the Kostelec and Kouřim regions – seven historic ponds have already been subjected to detailed assessment. Information on the homogeneity of the dam bodies and potential seepage points was obtained via the appli-
Projects name: Integrated Bentonite Sealing for Preventing the Negative Effects of Hydrogeological Boreholes on Groundwater

Duration: 2017 – 2020
Recipient: CHEMCOMEX, a.s.
Cp-recipient: Faculty of Civil Engineering CTU
Source of funding: TACR – EPSILON Programme

The objective of the project is to prepare and verify the applicability of an original sealing component to be placed between the screening and the wall of a hydrogeological borehole (i.e. in the annulus of the borehole). It is expected that the sealing component will be used in both domestic water supply wells and in monitoring/technological boreholes that require the separation of surface water and groundwater or two separate groundwater sources. The sealing of boreholes with respect to aquifer isolation makes up the principal standard requirement for the protection of the environment (groundwater) during the well construction process.

Research in the first year focused on the construction of the sealing component. The sealing and binding materials were then selected based on criteria defined for the sealing component – usability (the absence of health hazards, declared swelling capacity), feasibility (production in the required shape, easy handling) and sufficient sealing ability. The primary sealing material consists of bentonite pellets.

Of two potential structural technologies determined, the one that will result in the production of the sealing component in the form of a casting constructed from bentonite pellets with either filled voids or with an open structure was selected. It is vital that the sealing component maintains a sufficient degree of sealing ability. Further development will concentrate on the conducting of tests on the annulus model, first under laboratory conditions and then under in-situ conditions at the Josef Facility.
CEG participation in other projects

The CEG also participated in several other projects and specific partial tasks during the year, one of which was the four-year European ANNETTE project - Advanced Networking for Nuclear Education and the Training and Transfer of Expertise which forms a follow-up to previous projects concerned with the field of the education of experts in radioactive waste issues conducted in the context of the Horizont 2020 EU programme. This joint project, involving 27 European institutions, is being coordinated by the European Nuclear Education Network (ENEN). One of last year’s outputs consisted of the design of courses aimed at the training of experts in the above issues and organised by the project’s various participants. The courses on offer include a five-day course that will take place at the Josef Regional Underground Research Centre and which will provide practical laboratory as well as in-situ training.

As part of a nine-member consortium, the CEG is involved in the RINGEN research infrastructure (Research Infrastructure for Geothermal Energy) which specializes in research into the potential use of geothermal energy in the Czech Republic. The research infrastructure (RI) is under construction at the former Jiřík barracks complex in Litoměřice and its main objective is to establish a professional support facility for research into the effective exploitation of deep geothermal energy. In order to attain this objective, the RI is concerned primarily with the development of measurement procedures for the evaluation of information from medium and greater depths, e.g. seismic monitoring procedures. The RI also aims to provide research services in the wide range of areas covered by the institutions involved. The Institute of Rock Structure and Mechanics of the Czech Academy of Sciences is currently conducting long-term research into micro displacements in fault zones in the Josef underground complex.

The “Research Support for the Safety Assessment of a Deep Geological Repository” assigned by the Radioactive Waste Repository Authority (SURAO) is being conducted in the form of so-called assignment sheets (AS), all of which are related to specific research areas. The CEG is involved in a number of such AS, e.g. the “Behaviour of DCA (disposal containment assemblies) for Spent Nuclear Fuel and Radioactive Waste/Microbial Corrosion”, the “Assessment of Localities”, “Gas Permeability” and “Transport 7".

After a practical course in the underground
As part of the research programme for the “Multi-Generation Tracers” project under the Enterprise and Innovations for Competitiveness operational programme implemented by a consortium made up of PROGEO s.r.o. and WATRAD spol. s r.o., CEG staff are currently constructing a test polygon at the Josef Facility for the in-situ testing of fluorescent tracers.
LEGEND
1. Prefabricated TOM lining (with convergence measurement sample)
2. Display of mining mechanised technology
3. 1:1 model of historical tunnel timing – Austrian system
4. Training wall – core boring
5. Contact stress measurement
6. Convergence measurement
7. Anchoring technology (ORICA)
8. „Café Underground“
9. Anchoring technology (HILTI Ltd)
10. Tank with processed water
11. Model of backfilling of a deep repository access gallery (BACKFILL)
12. Information centre for the BACKFILL project
13. EU TIMODAZ experiment
14. Information centre for the TIMODAZ project
15. Bore diagram and the teaching of destruction work
16. Bore diagram

- Accessible parts
- Inaccessible parts
- Experiment, teaching point
- Projects included in the Annual Report
- Others

Map of the underground area
Map of the underground area

LEGENDA

17. Rescue chamber
18. Ventilation shaft
19. Tank with processed water
20. Anaerobic laboratory
21. DOPAS technological centre
22. DOPAS project
23. Mock-Up Josef experiment
24. Inter-University underground laboratory (MeziLab)
25. Inter-University underground laboratory (MeziLab II)
26. PAMIRe project
27. Multi-Generation Tracers project

Magmatites – Slapy graniodiorite rocks
Jílové zone volcano – sedimentary rock
WHAT WE ACCOMPLISHED THIS YEAR

We are doing our job better and better...
... and it is our pleasure!
SELECTED PUBLICATIONS

David, V.; Šťástka, J.; Vrána, K.; Davidová, T.
Experimentální objekt pro testování hrází

Šťástka, J.
Stanovení termo-fyzikálních vlastností bentonitové bariéry
*Odborná zpráva o postupu prací a dosažených výsledcích za rok 2017*

Hausmannová, L.
Vliv sytícího tlaku na hydraulickou vodivost a bobtnací tlak českých bentonitů

Smutek, J.
Research on gas permeability of rock environment based on experimental in-situ measurement

Palmu, P. M.; Vašíček, R.
Translating the Experience from Full-scale Plugs and Seals Experiments into a Comprehensive DOPAS Training Workshop

Svoboda, J.; Vašíček, R.; Dvořáková, M; Havlová, V
DOPAS EPSP Experiment
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