Content

A few words of introduction ........................................ 3
CEG members of staff .................................................. 4
About the Department ................................................... 8
Teaching ......................................................................... 10
Defended Diploma Thesis ................................................. 12
Membership of International Organisations ...................... 14
Projects .......................................................................... 15
Map of the Underground Area ......................................... 26
What else we succeed this year ........................................ 28
Selected publications ...................................................... 30
Contacts .......................................................................... 31
Dear Readers,

Another year in the “life” of our unique research facility has flown by and it is time to reflect on what we have achieved and where there is room for further improvement. On a positive note, we managed to financially cover the running costs of the Josef Facility from project funding and orders placed by our various clients. Several projects are ongoing and, moreover, we were selected by SÚRAO as the principal research party for the In-situ Interaction Physical Models project underway at the Bukov URF and, through a tender organised by the Technology Agency of the Czech Republic (TAČR), we received support for a new project that was launched at the Josef Facility.

Our team remained unchanged throughout the year and the “capacity” of our engineers and technicians is, at least for now, enough to cover all our project requirements. However, in view of long anticipated personnel changes in the CEG management structure, it is likely that it will soon be necessary to expand our team with the addition of young, skilled engineers, preferably from the ranks of doctoral students.

Although the “changing of the guard” with concern to the head of the Josef team was postponed practically at the last minute, I would like to conclude this introduction with a little nostalgia. Although my original idea (from as long ago as 2002) to construct an underground facility for the conducting of teaching and research in the Josef former exploratory gold mine was seen by many at the time as a foolish and non-feasible fantasy, thanks to support from Metrostav Ltd and the unwavering commitment, dedication and enthusiasm of the CEG team, a truly unique facility has emerged. I feel very proud of everything we have built, and I am convinced that the Josef complex and the surrounding area still offer huge potential for new ideas and projects. Therefore, I wish my successors the very best of luck in continuing the “good fight”!

Godspeed!

prof. Ing. Jaroslav Pacovský, CSc., Head of the CEG
prof. Ing. Jaroslav Pacovský, CSc.
Head of the CEG

He graduated from the Faculty of Civil Engineering at the CTU in Prague the branch of Structural and Transportation Engineering. Subsequently, he began working for the same Faculty in 1977. In 1998, he was the driving force behind the creation of a new university department, the Centre of Experimental Geotechnics (CEG). In 2004 he was appointed Professor in the Theory of Building Structures and Materials. He came up with the idea of opening the abandoned Josef mine for the conducting of teaching and research and also initiated the establishment of the science and technology park now known as the Josef Underground Research Centre (URC).

Ing. Jiří Svoboda, Ph.D.
Deputy Head of the CEG, Assistant Professor

He graduated from the Faculty of Civil Engineering at the CTU in Prague in 1999 in the field of Structural and Transportation Engineering. He completed his Ph.D. in Physical and Material Engineering in 2004. He first worked as a Ph.D. student on a part-time basis; he has been a permanent employee since 2004. He represents the CEG in international projects. For several years he has been involved in the design of monitoring and instrumentation systems for physical in-situ models constructed for the purpose of the verification of materials and technologies to be used in the construction of a deep geological radioactive waste repository.

Jana Večeřová
Economic Assistant

She completed her studies at the Budějovická Grammar School in 1991 and has been a member of the CEG team since 1 January 2016. She is responsible for the CEG’s economic, financial and personnel agendas. She is also responsible for the filing and control of tax documentation and project reports and participates in the administration of research projects.
Ing. Dana Pacovská
Assistant Professor

She graduated from the Faculty of Civil Engineering at the CTU in Prague in the Economics and Management of Civil Engineering. She joined the CEG as an external staff member in 2009, becoming a permanent employee in 2014. She prepares and provides presentations of the various activities in which the Josef Facility is involved, cooperates on the preparation of projects, performs laboratory tests as part of the research of bentonite materials and conducts tours of the Josef underground complex.

Ing. Radek Vašíček, Ph.D.
Assistant Professor

He graduated from the Faculty of Civil Engineering at the CTU in Prague in the field of Structural and Transportation Engineering in 2001 and, in 2007, he completed his Ph.D. in Physical and Material Engineering. He first worked at the CEG as a student and has been a permanent employee since 2007. In 2006 he completed a study course at the SKB Äspö Hard Rock Laboratory in Sweden. He is responsible for the teaching activities of the CEG; moreover, he is also responsible for the operation of the accredited geotechnical laboratory and acts as a co-researcher with respect to international projects.

Ing. Danuše Nádherná
Assistant Professor

She graduated from the Faculty of Civil Engineering at the CTU in Prague in the Economics and Management of Civil Engineering. In 2006 she joined the CEG as an external staff member, becoming a permanent employee in 2008. She is responsible for the engineering and safety supervision of both the underground and surface complexes of the Josef Facility. She also participates in the preparation and administration of research projects and organises tours of the Josef underground complex. She is also co-responsible for the operation of the accredited geotechnical laboratory.
Ing. Jiří Šťástka, Ph.D.
Assistant Professor

He graduated from the Faculty of Civil Engineering at the CTU in Prague in Environmental Engineering (BSc.) and Construction Management (Ing.). He obtained a Ph.D. in Physical and Material Engineering in 2018. The physical model of the “Bentonite 95” project was constructed and installed under his supervision. He was also responsible for the construction of the bentonite layer for the DOPAS project pressure and sealing plugs. He is co-responsible for the first Czech model of a disposal space for spent nuclear fuel (the Mock-up Josef experiment). He is also involved in the development of pelletised bentonite for DGR use.

Josef Barták
Technician

He has worked for the CEG since 2010 and is co-responsible for the maintenance and operation of the Josef surface complex and the maintenance of machinery. He is involved in the technical preparation of teaching courses, the technical support of research projects and the ongoing reconstruction and commissioning of new sections of the Josef underground complex.

Vladimír Kašpar
Technician

He has worked for the CEG since 1998. He is mainly responsible for preparatory work for the taking of measurements with concern to research projects and for the engineering and construction work involved in the construction of experiments. He is also involved in the ongoing reconstruction and commissioning of new sections of the Josef underground complex and the preparation of practical classes for students.
Josef Kožíšek
Technician

He has been a member of the team of technicians since January 2014. He is co-responsible for the maintenance and operation of the Josef surface complex. He is also involved in the technical preparation of teaching courses, the technical support of research projects and the ongoing reconstruction and commissioning of new sections of the Josef underground complex.

Petr Růžička
Technician

He has been working for the CEG since 2009. He is co-responsible for the maintenance and operation of the Josef surface complex. He is also involved in the technical preparation of teaching courses, the technical support of research projects and the ongoing reconstruction and commissioning of new sections of the Josef underground complex.

Josef Facility Maintenance and Security
About the Department

The Centre of Experimental Geotechnics (CEG) is a department with two bases - the Josef URC and the Faculty of Civil Engineering in Prague. The Josef Facility forms the exclusive base of the technicians, while other members of staff divide their place of work according to the needs of the department between Prague and the Josef URC. Our trusty Renault Trafic minibus continues to transport staff to the facility from Prague and back on a daily basis.

The Prague offices and laboratories are used for the administration of the CEG as well as for the teaching of the department’s syllabus. The CEG’s teaching activities are focused primarily on the practical introduction to students of laboratory tests and in-situ experiments in the field of geotechnics.

Josef Underground Laboratory

For twelve years, this unique complex has been used for regular student teaching, the conducting of research projects, training courses, visits from both the professional and general public and partner presentations.

The complex serves for the teaching of both bachelor and master’s degree courses offered by the Faculty of Civil Engineering; teachers and students from the Geodesy and Cartography department make up the most frequent visitors while courses are also taught by the Geotechnics department. We also regularly welcome students from other universities such as the University of Chemistry and Technology, Prague, Masaryk University, Brno and the Charles University, Prague.

Although the time when workers from various institutions and companies came and went on a daily basis is a thing of the past, in 2018 the Josef underground complex was subjected to the gathering and assessment of data in preparation for the launching of two long-term research projects for SÚRAO (DOPAS and Mock-Up Josef) and saw the continuation of the SWICAS and “Tracer 2” projects.
Other projects are also underway in the surface complex of the Josef Facility or at other locations with CEG participation. Information on the various research projects currently underway is provided in a separate chapter of this report. The potential of the underground areas of the Josef Facility is far from exhausted. Of course, the filling of the remaining areas is related to the search for suitable research grant programmes (both in the Czech Republic and abroad) concerning topics that correspond to the various fields covered by the CEG and for which we can offer the services of the Josef URC.

The underground laboratory continues to attract visitors, especially experts on underground construction and spent nuclear fuel disposal. In 2018, for example, the Josef Facility welcomed colleagues from the Faculty of Transportation in Pardubice, participants at a meeting of underground construction departments from various Czech universities and students attending a summer school organised by ÚJV Řež. In addition, young experts gathered for the third time at the Josef Facility for the Young Generation Meeting concerned with deep geological repository design issues.

Other events during the year consisted of the annual bat count in February (for the eighth time), in May the Josef to Josef cycling race was held (for the sixth time), June saw a visit from our university Dean’s office (for the ninth time) and in November we welcomed secondary school students to the Josef Open Day (for the eighth time).

**URC Josef**

The Josef Regional Underground Research Centre (URC) operated by the CEG was established eight years ago. Together with the Josef underground complex, it consists of a unique experimental and educational complex. While the technical facilities (the experimental hall, workshops, laboratory) are used intensively, the premises available for rent, i.e. the offices and meeting rooms are only partially occupied. Naturally, we would like to reverse this trend and attract new users to conduct their research at the Josef URC and in the underground laboratory complex.
Teaching

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.

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. 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.
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.

Experimental Analysis of Constructions – Geotechnical Part comprises practical classes conducted under real geological conditions in the Josef Underground Laboratory. 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.

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.
Defended Diploma Thesis

Mária Kollárová
The influence of heat on the geotechnical properties of bentonite

Bentonite materials will most likely be used for the sealing of the Czech deep geological repository (DGR) multi-barrier system. Hence, it is essential to determine whether the heat emitted from the spent nuclear fuel container will affect the geotechnical properties of the material.

The first part of the research was devoted to a comparison of the geotechnical properties, i.e. the Atterberg limits and swell index, of B75 2010 bentonite loaded over the long term with a temperature of around 200°C and a reference unloaded sample of the same bentonite. The second part of the thesis focused on how heat affects selected geotechnical properties of the bentonite during the loading process in oedometers under heated laboratory conditions (60°C) and at 20°C. The development of swelling pressure and changes in the bulk density, which make up important properties with respect to the selection of the bentonite to be used in the sealing layer, were investigated.

The following conclusions were drawn from the testing phase: with concern to the heat-loaded bentonite, the liquid limit value was reduced by approximately 25% while the plasticity limit value was reduced by an insignificant amount. Oedometer tests on samples with various bulk densities revealed the influence of heat on the progress and values of swelling pressure. In order to confirm the conclusions, it will be necessary to conduct research over a longer time horizon than that limited by the time constraints set by the thesis.
Michael Tůma
The influence of bentonite inhomogeneity on selected geotechnical properties of sealing layers

The aim of the research was to verify the influence of the inhomogeneity of bentonite on its basic geotechnical properties. Czech BCV bentonite (Černý vrch bentonite) supplied by Keramost Ltd was used in the research. A substantial part of the work was devoted to measuring and comparing the swelling pressure and hydraulic conductivity of the two materials.

Swelling pressure can be measured using oedometers or a permeameters. With respect to the oedometers, two measurement procedures were applied - two samples were saturated with water from the beginning of the measurement procedure and three samples were saturated upon the consolidation of the samples. Concerning the permeameters, to date the swelling pressure has been measured in the standard way as a single point with a strength sensor installed only on the upper part of the piston. Subsequently, the idea emerged to verify the swelling pressure via a modified permeameter that measures the swelling pressure both on the top and bottom of the sample.

The experiments suggested that the swelling pressure as measured by means of oedometers does not depend on the initial material consolidation and that inhomogeneity does not affect the degree of swelling pressure at a given bulk density. The swelling pressure of the powdered bentonite was found to be higher when measured via the permeameters. The comparison of the measurements obtained from the standard and modified permeameters was not conclusive due to the relatively small number of comparative measurements taken due to time constraints.
Membership of International Organisations

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.

**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 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. (http://www.iaea.org/OurWork/ST/NE/NEFW/wts_URF_homepage.html)

**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)
Projects

Introduction to projects

Although the number of projects being conducted in the Josef underground laboratory is lower than a few years ago, projects and research commissions continue to represent our main source of income. In 2018, we were partially successful in terms of obtaining support for our preferred long-term research theme, i.e. the construction of a “hot” mock-up physical model in which the bentonite sealing layer will be loaded with temperatures of up to 200°C and which will occupy one of the niches of the underground laboratory complex. A further important domestic research project concerns a contract awarded by SÚRAO – “In-situ interaction models at the Bukov URF”.

Other projects involving our participation during the year were conducted according to the relevant time schedules. The DOPAS and Mock-Up Josef projects continued in the Josef underground complex; the SWICAS project involving the testing of a sealing element continued in a borehole in one of the underground niches, as did the NAKI project underway in the Josef surface complex. With concern to major European projects, we are involved in a number of work packages concerning the Annette, Beacon, CEBAMA and Modern2020 projects.

Of course, we continue our efforts with our various partners aimed at securing participation in new projects organised by the relevant domestic and European institutions.
The aim of the project is to increase the level of safety and reduce the costs of the construction of the deep geological repository (DGR). DGR safety is based on a system of barriers that prevent the spread of contaminants into the environment. To date, research in the Czech Republic and abroad has focused on the temperature of the waste disposal package (WDP) of up to 100°C. However, accepting higher temperatures on the surface of the WDP (150°C - 200°C) will lead to significant financial savings due to the potentially higher disposal density which, in turn, will result in the need for less overall disposal capacity.

The first year of the project concerned the compilation of the structural-geological, petrographic, mineralogical and hydrogeological documentation on the selected experimental location and its surroundings. The key technical parameters were identified including the dimensions and location of the main components of the model, the choice of materials and the instrumentation of the model. The heater intended for the simulation of the development of heat was designed and tested and work commenced on the instrumentation.

Černý vrch bentonite (BCV) in the form of pellets was selected for the construction of the barrier inside the physical model. From the point of view of the study of the behaviour of the microbial populations in the rock environment at high temperatures, work commenced on the selection and characterisation of a set of the most suitable candidates - thermoresistant exospores for installation in the thermally-loaded physical model.
DOPAS consisted of an extensive European project in which the Czech Republic was represented by the Faculty of Civil Engineering CTU, ÚJV Řež and the Czech Radioactive Waste Repository Authority (SURAO). The aim of the Czech participation in the project was the assembly of an experimental pressure and sealing plug (EPSP) in a granite massif in the Josef underground complex. Sealing plugs will provide a secure barrier between already-filled and unfilled DGR disposal spaces. The EPSP experiment was constructed in mid-2015. The construction of the plug served to confirm that the technologies and materials employed are suitable for application in the future DGR.

In order to verify the required functioning of the plug, it was decided that the testing of the EPSP should be prolonged into 2018. Experimental work during the year concerned the pressurisation of the plug with water (at a constant pressure of approx. 1.25 MPa), general monitoring and the monitoring of the outflow from the experiment. The monitoring process included the recording of the various parameters of the plug and the surrounding rock mass at 10-minute intervals. The discharge rate from the filter was measured both electronically and manually. Samples were taken from the outflow for basic chemical analysis purposes.

The monitoring results revealed the gradual development of the saturation of the sealing part of the experiment with a simultaneous gradual increase in swelling pressure; the outflow from the experiment was reduced to a steady state. The most significant development consisted of the increase in pore pressure within the experiment. The results strongly suggest that, on the whole, the plug performed its function.
The objective of the project, awarded through a public tender, consists of the construction and operation of 10 physical interaction models at the Bukov Underground Research Facility (URF). The main aim is to verify the behaviour of bentonite sealing layers loaded with groundwater saturation in interaction with cement materials while, at the same time, subjected to temperatures of between 100°C and 200°C.

At the beginning of 2018, research was conducted on similar in-situ interaction experiments, the conclusions of which were used for the modification of the physical models. Subsequently, an implementation project was compiled which served as the basis for the production of models in the CEG’s experimental hall.

At the same time, structural-geological and hydrogeological documentation was compiled on the site at which the physical models will be emplaced. Documentation available on drill cores previously extracted at the site was subjected to detailed study and representative rock and groundwater samples were taken for subsequent laboratory testing purposes.

In April, CEG technicians drilled 10 wells (5 with a diameter of 250 mm, 5 with a diameter of 100 mm) at the Bukov URF for the emplacement of the physical models. The boreholes were subjected to a video inspection that revealed no noticeable inflows of groundwater. The construction of all the physical models was completed at the end of the year and preparations were concluded for their installation at the Bukov URF.
The Mock-Up Josef experiment consists of an in-situ physical model, the first of its kind in the Czech Republic to simulate the vertical disposal of a spent nuclear fuel container. The experiment involves research into the effects of heat and groundwater on a bentonite sealing barrier, the so-called buffer, that will surround the spent nuclear fuel container in the future deep repository.

The main objective of the project was to describe the behaviour of a bentonite barrier loaded over the long term with heat and saturated with water from the surrounding rock massif. According to the project contract, 2018 was the last year of the prolongation of the project. Pressure, temperature and relative humidity were continuously monitored within the barrier via five horizontal and one vertical profile. Changes were also monitored in the surrounding rock mass by means of sensors that recorded the spread of heat up to a distance of 3 m from the axis of the experiment, rock stress and fracture opening; the deformation of the surroundings of the borehole was monitored by means of the convergence measurement technique.

In September 2018, the seventh sampling campaign was conducted via the vertical drilling of the loaded bentonite. The borehole was drilled at the site of a previously drilled borehole and bentonite samples were collected from a depth of 133 cm. In total, more than 100 samples were analysed. Currently, the research proponent (SÚRAO) is deciding whether the experiment will continue with the same or an alternative bentonite barrier loading regime or whether to commence the disassembly phase of the experiment.
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 that make up a part of the Czech cultural heritage. The objective is to design a suitable technology for the repair of the dams of such historic ponds and to experimentally verify the results by means of a sectional physical model. A further aim of the project is to verify methodology for the non-invasive diagnostic assessment of the dams of historical ponds.

The aim of the third stage of the project consisted of the operation and monitoring of experimental dam sections, the continuous evaluation of the measured data and the testing of clay mixtures on the surface of the test dam bodies. A test bentonite mixture labelled REC MIX I was sprayed by means of an innovative nozzle onto the leading face of the in-situ model of the dam. Subsequent monitoring revealed that the permeability of the body had decreased several times.

This stage also included the conducting of an analysis aimed at determining the form of the dams of historic ponds in the Blanicko area. At the same time, the locations of historical dams were identified via the use of old maps (military and stable cadastral maps). The previous stage of the project included the application of geophysical methods – multi-electrode resistance profiling, georadar and dipole electromagnetic profiling for the assessment of the structure and properties of such dams.
The aim of the project is to construct and verify the functionality of an original sealing element to be located between the frameworks and walls of hydrogeological boreholes (in the annulus). The sealing element is destined for use in domestic wells as well as monitoring or other technological wells that require the separation of surface and groundwater, i.e. two separate groundwater collectors.

In the second year of the project, the research team focused on perfecting the properties of the sealing element and the production technology. A series of verification tests were performed using the same composite material from which the first functional sample was produced in 2017 and an improved production process. The aim of the tests was to adapt the shape of the sealing element so as to allow for trouble-free installation while maintaining the required degree of tightness. Testing was conducted both at the Josef Underground Laboratory and the Pátek hydrogeological test site.

A number of sealing elements were then manufactured and tested. The error rate during production was a maximum of 1/10. The main output of the second year of the project consisted of a functional sample as well as a detailed description of the production process that represents a “verified technology”.

Projects

- Production of a sealing element
- Testing of composite proper
- The emplacement of a sealing element in a borehole
The project emerged due to the requirement to assess the long-term safety of bentonite structural components in deep geological repository (DGR) engineered barriers. This issue is faced by a number of European countries and, given the level of complexity, cooperation is necessary at the European level in order to develop and test tools for the assessment of the hydro-mechanical development of a non-homogeneous bentonite barrier. The main coordinator is SKB (the Swedish equivalent of SÚRAO) and the project has been split into nine work packages (WP). The first annual meeting of the various project participants took place in May 2018 on the Greek island of Milos.

The CEG is involved in three of the WPs. WP2 consists of the collection of relevant information from completed or ongoing projects. WP3 is focused on the development of numerical models that will predict the long-term behaviour of the DGR engineered barriers. WP4 involves the conducting of laboratory tests the aim of which will be to provide input parameters for the compilation and validation of numerical models.

The following sub-aims were achieved in 2018: data from previous relevant experimental research (WP2) was collected and presented at a workshop meeting. Basic conditions for the compilation of mathematical models based on the finite element method were formulated for WP3. With concern to WP4, laboratory tests on the swelling pressure of bentonite were performed for the purpose of calibrating the mathematical models. In addition, the first physical models were prepared which, due to their size, allow for the research of various spatial configurations as well as materials with differing initial bulk densities.
Project 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 the cooperation of 27 institutions from Europe and Japan. All these national organisations and research institutions are involved either in the construction of, or research into the development of deep geological repositories (DGRs). The project is being coordinated by one of the German partners - the Karlsruher Institut für Technologie (KIT). It is assumed that cement will be used as one of the construction materials, and it is further expected that the interaction of cement, bentonite and groundwater may affect the behaviour and long-term stability of the DGR.

The dismantling phase of the in-situ experiments (10°C) conducted in the Josef Underground Laboratory formed the conclusion of a long-term experiment focusing on interactions between Czech B75 bentonite, a cement material and groundwater. The second part of the experiment consisted of the research of the above-mentioned interactions with the simultaneous loading of heat (95°C) under laboratory conditions. The laboratory research involved the use of Portland cement (OPC) and a low pH reference cement mix (RPM).

The analysis performed to date has revealed: a low rate of mineralogical change with respect to the in-situ experiments - the replacement of Na cations with Ca and Mg cations, measurable changes in hydraulic conductivity and swelling pressure and increased compressive strength; with respect to the heat-loaded laboratory materials - reduced compressive strength and elasticity and increased sulphate and calcium concentrations. The magnitudes of these changes differed depending on the cement used (OPC, RPM) and whether cement was used or not.

Duration: 2015-2019
Co-recipients: 28 organisations from Europe and Japan
Source of funding: Horizon 2020 EU programme

The European project partners consist of national organisations responsible for the construction of deep geological repositories (DGR) in their countries and research institutions involved in the development of DGR programmes. The project coordinator is ANDRA. The Czech Republic is represented in the project by the Faculty of Civil Engineering CTU in Prague, SÚRAO and the Technical University of Liberec (TUL).

The aim of the project is to develop and implement an effective and efficient DGR monitoring programme. The development of DGR monitoring requires a detailed definition of everything that has to be monitored so as to ensure the safety of the DGR and a knowledge of how the information obtained should be used. New technology is being developed for monitoring purposes - wireless data transmission, alternative power sources and new sensors and geophysical methods.

The project is being conducted in the six work packages (WP), of which the CEG is involved in WP3 (the research and development of monitoring techniques) and WP4 (the demonstration of implementation under in-situ conditions). Following the production of the first prototype of a multifunctional pressure cell in 2016 by the CEG and TUL, a second version was prepared based on the test results. Oil expansion issues were resolved, and the shape and size of certain components were optimised. The main advantage of the pressure cell consists of the simultaneous measurement of tension, pore pressure, relative humidity and temperature, integrated electronics with data recording.
The CEG also participated in other projects during the year. The four-year European Annette - Advanced Networking for Nuclear Education and the Training and Transfer of Expertise project, which follows on from previous projects concerned with radioactive waste disposal, continued in the context of the EU Horizon 2020 programme. The project, involving 25 European institutions, is being coordinated by the European Nuclear Education Network (ENEN). The CEG’s participation in the project includes the provision of practical laboratory and in-situ training at the Josef URC.

The CEG is active in the Research Infrastructure for Geothermal Energy (RINGEN) with concern to the research of the potential for geothermal energy utilisation in the Czech Republic as part of the Research, Development and Education operational programme. Infrastructure is being constructed in the former Jiříkov barracks complex in Litoměřice and the main objective is to develop a professional background for research into the effective use of deep geothermal energy.

The “Research support for the safety assessment of the deep geological repository” and “Research support for the design of the deep geological repository” reports were commissioned by the SÚRAO and were compiled in the form of so-called partial reports related to specific research areas. In 2018, CEG was involved in the compilation of the following partial reports: “Experimental evaluation of the gas permeability of deep geological repository engineered barriers”, “Site assessments”, “Transport 3”, “The behaviour of waste disposal packages for SNF and RAW / microbial corrosion” and a “Proposal for and production of a mixture of bentonite pellets”.

An in-situ polygon was constructed and operated in the Josef Underground Laboratory by CEG staff for the testing of tracers in connection with the “Multi-generational tracers” project conducted as part of the Enterprise and Innovation for Competitiveness operational programme by the companies PROGEO Ltd and WATRAD Ltd.
Čelina west

LEGEND
1. Prefabricated TOM lining (with convergence measurement sample)
2. Display of mining mechanised technology
3. 1:1 model of historical tunnel timering – 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

23 Projects included in the Annual Report
25 Others

Map of the underground area
Map of the underground area

Mokrsko west

Magmatites - Slapy granodiorite rocks
Jilové zone volcano – sedimentary rock

LEGEND

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. Multi-Generation Tracers project
We are doing our job better and better...

What else we accomplished this year
... and it is our pleasure!
Selected publications

Kruis, J.; Krejčí, T.; Koudelka, T.; Svoboda, J.
**Interakční fyzikální modely in-situ v PVP Bukov - Matematické modelování**

**Interakční fyzikální modely in-situ v PVP Bukov - Realizační projekt**

Svoboda, J.; Šťástka, J.; Pacovská, D.; Večerník, P.; Červinka, R.
**Interakční fyzikální modely in-situ v PVP Bukov - Rešerše obdobných experimentů, návrh případných úprav technického provedení**

Šťástka, J.; Pacovský, J.; Svoboda, J.; Vašíček, R.
**Výstavba, provozování a vyhodnocení demonstračního experimentu Mock-up-Josef - Závěrečná zpěva k projektu**

Šťástka, J.; David, V.; Černochová, K.
**Preparation for the Final Testing of the Sprayed Bentonite Sealing Layer of a Pond Dam**

Šťástka, J.; David, V.
**The Testing of a Sprayed Bentonite Sealing Layer**

**Interaction between cement and Czech bentonite under temperature load and in in-situ conditions: an overview of experimental program**