Dear Readers,

By means of our sixth “Year Book”, we aim to provide you with a comprehensive overview of everything that happened at our two facilities in 2014 – at the Josef Facility and the Faculty Department in Prague. The main content of the work of the Centre of Experimental Geotechnics (CEG) staff members last year consisted of their involvement in research projects conducted principally at the Josef Underground Laboratory. Of course the teaching of, and contact with, students remains equally important to the CEG.

In situ work on the assembly of the Experimental Pressure and Sealing Plug (EPSP), one of four plugs being constructed as part of the pan-European DOPAS project, continued successfully during the year. In addition, through persistent hard work and special presentations on the Josef Underground Laboratory at the European level, the CEG is also involved in the preparation of other European projects.

During the year, the CEG chalked up a very special achievement outside the fields of research and teaching. After two years of hard work, we finally opened the so-called “underground cathedral”, a huge underground space created by experimental mining in the 1980s, to the general public.

Prof. Ing. Jaroslav Pacovský, CSc.
CEG Head
He graduated of the Faculty of Civil Engineering, Czech Technical University (CTU) in Prague, 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 the Theory of Building Structures and Materials.

It was he who came up with the idea of opening the abandoned Josef gold mine for teaching and research purposes and, subsequently, initiated the establishment of the “Josef URC” science and technology park. A two-year project concerning the opening of a vast underground cavern in the Čelina East section to the public was carried out under his direct supervision.

A graduate of the Faculty of Civil Engineering, CTU in Prague, in the branch of Structural and Transportation Engineering, he continued studying for his doctorate following graduation in 1999 in the branch of Physical and Material Engineering which he completed in 2004. While studying, he first worked for the CEG as a student and, subsequently, during his Ph.D. studies, on a part-time basis. In 2004 he was given a full-time employment contract. He is co-responsible for CEG research activities and represents the CEG in a number of international projects as a senior researcher.

A graduate of the Faculty of Civil Engineering, CTU in Prague, in the branch of Economics and Management in the Building Industry (1979), she is responsible for the day-to-day administrative and economic management of the Department and participates in the administration of research projects by providing both technical support and the management of project funding. She is also in charge of the HR agenda.
Ing. Danuše Nádherná
Assistant Professor

A graduate of the Faculty of Civil Engineering, CTU in Prague, in the branch of Economics and Management in the Building Industry (1981), she first became involved with the CEG in 2006, becoming a full-time member of staff in 2008. She is responsible for the provision of complete engineering services and is the health and safety inspector for the Josef Facility. She is also responsible for the management of the above-ground complex and participates in the preparation and administration of research projects. In addition, she is involved in activities concerned with the marketing of the Department and organises guided tours of the Josef complex for the general public.

Ing. Dana Pacovská
Assistant Professor

A graduate of the Faculty of Civil Engineering, CTU in Prague, in the branch of Economics and Management in the Building Industry (1979), she worked in cooperation with the CEG on a part-time basis from 2009, becoming a regular member of staff in 2014. She is responsible for the preparation and organisation of presentations concerning the various activities in which the Department is involved and assists in the preparation of research projects.

Ing. Radek Vašíček, Ph. D.
Assistant Professor

A graduate of the Faculty of Civil Engineering, CTU in Prague, in the branch of Structural and Transportation Engineering (2001), he completed his doctoral degree studies in the branch of Physical and Material Engineering in 2007. He first worked for the CEG as a student and became a full-time member of staff in 2007. In 2006, he attended an internship at the SKB Åspö Hard Rock Laboratory in Sweden. He is in charge of the CEG’s educational programme and the operation of the accredited geotechnical laboratory and is responsible for a range of research projects.
Ing. Lucie Hausmannová
Ph.D. Student

A Ph.D. student in the branch of Physical and Material Engineering, she has a part-time contract with the CEG and teaches courses in Soil Mechanics and at the Geotechnical Laboratory. She is co-responsible for the laboratory testing of materials intended for use in engineered barriers. She attended the International Interdisciplinary CCS Summer School in Spitzbergen in 2010, completed a three-month internship at the International Atomic Energy Agency in Vienna in 2013 and a further internship at the Mont Terri Rock Laboratory as part of the European LUCOEX project in 2014. She is also involved with the teaching of both international and domestic practical courses taught at the Josef Facility.

Ing. Markéta Levorová
Ph.D. Student

A Ph.D. student in the branch of Physical and Material Engineering, she has a part-time contract with the CEG and teaches a course in Soil Mechanics. She is co-responsible for laboratory testing and measurement. She attended the PETRUS II international training course which focused on the geological disposal of radioactive waste held at the Josef complex and Prague in 2011. In 2014 she completed a three-month internship at the University of Wollongong (Australia). She is involved with the teaching of both international and domestic practical courses taught at the Josef Facility.

Ing. Jan Smutek
Ph.D. Student

A Ph.D. student in the branch of Physical and Material Engineering, he is involved in the teaching of both international and domestic practical courses taught at the Josef Facility. His specialisation is the in situ pressure testing of rock massifs. He is currently working on a project related to the laboratory study of gas migration in bentonites. In autumn 2014 he attended a training course at the Mont Terri Rock Laboratory in Switzerland. The internship involved active participation in research related to the FE experiment (Full-scale Emplacement Experiment), which forms part of the wider European LUCOEX project.
A Ph.D. student in the branch of Physical and Material Engineering, he has a part-time contract with the CEG and teaches a course in Soil Mechanics. He is responsible for experiments involving the investigation of issues connected with sprayed-on buffers. In 2012 he attended a three-month internship at the International Atomic Energy Agency in Vienna. Under his supervision the “Bentonites 95” physical model was assembled and put into operation at the start of 2013, and he is currently the technical manager of this project. He is also responsible for the management of an in situ physical model representing a spent nuclear fuel repository.

After completing her studies at the Commercial Academy in Příbram in 2010, she began working for the CEG in August 2011. She is involved in the day-to-day management of the underground complex, the Josef URC building and the various facilities which make up the above-ground area of the Josef Facility. She is also responsible for the security checking and registration of all persons entering the Josef Facility and particularly the underground complex.

A member of the CEG staff since 1998, he is primarily involved in the preparation and installation of measurement equipment for the conducting of experiments, is responsible for construction work during the physical assembly of experiments and provides and demonstrates the practical teaching to students. He is also involved in the ongoing reconstruction and opening up of new sections of the Josef underground complex.
Josef Kožíšek
Technician

A member of the technical staff at the CEG since January 2014, he is partly responsible for the maintenance and operation of the Josef Facility’s above-ground complex. He is also involved in providing technical support for teaching courses and research projects and the ongoing reconstruction and opening up of new sections of the Josef underground complex.

Josef Barták
Technician

A member of the CEG staff since 2010, he is in charge of maintenance and the day-to-day operation of the Josef Facility above-ground complex and the maintenance of machinery. He is also involved in providing technical support for teaching courses and the ongoing reconstruction of the Josef complex.

Petr Růžička
Technician

A member of staff since 2009, he is partly responsible for the maintenance and operation of the Josef Facility’s above-ground complex. He is also involved in providing technical support for teaching courses and the ongoing reconstruction and opening up of new sections of the Josef underground complex.

Josef Facility Security

Ing. Milan Štěrba

Lubor Stoulil
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/](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](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](http://www.igdtp.eu)
ABOUT THE DEPARTMENT

In 2014 the staff of the Centre of Experimental Geotechnics continued to devote most of their professional time and energy to the Josef Facility to which they are driven in the “company” Renault Traffic every morning. The offices and laboratory located at the Faculty of Civil Engineering building in Prague serve solely as the administrative support centre and, naturally, for the teaching activities of the Department’s assistant professors and Ph.D. students.

CEG

The Centre of Experimental Geotechnics (CEG) has been an autonomous Department of the Faculty of Civil Engineering CTU in Prague since 1998, and its educational activities are primarily oriented towards the practical teaching of students in laboratory testing and experimentation in the field of geotechnics, in situ testing and the taking of measurements related to foundation engineering and underground structures. The teaching of all the Department’s courses remained practically unchanged following the relocation of the majority of the CEG’s activities to the Josef Facility. All the equipment required for educational purposes remains at the FCE building in Dejvice, Prague, and only a small number of devices needed for research purposes were moved to the Josef Facility. Accredited laboratory testing concerned with the determination of soil and rock properties is conducted in new laboratories situated within the Josef URC building.

For many years, the bulk of the work of the CEG has consisted of research and experimentation which are currently mostly conducted at the Josef Underground Laboratory. Recent research projects have, to a great extent, focused on radioactive waste (RAW) disposal in deep geological repositories and related topics.
The Josef Underground Laboratory forms the focus for the various professional activities conducted at the Josef Facility. The more than 5 km of underground space presently available provides a unique background for the regular teaching of students, project research, training courses, field trips for both the professional and general public and for presentations from our various partners.

Faculty of Civil Engineering bachelor and master’s degree courses on underground construction are taught at the facility and students are encouraged to work there on their experimentally-oriented bachelor and diploma theses and dissertations. Teachers and students concerned with the branch of Geodesy and Cartography at the FCE also regularly make use of the Josef Facility which, in addition, hosts students from a number of other universities including ICT Prague, TU Liberec, MU Brno and CU in Prague.

Nevertheless, the conducting of research projects represents the main function of the Josef Underground Laboratory (for more information on individual projects, see the special chapter devoted to this theme) and as a component part of the URF (Underground Research Facility) network, it has gained international renown in the relatively short time since it opened. The underground areas are continuously being adapted and extended so as to create capacity for additional future research projects.

In 2014, the Josef Facility hosted several international events including, in May, the regular workshop of a group of experts dealing with research into bentonite (ABM – Alternative Buffer Material) involving the participation of 17 experts from a total of 7 European countries. In addition, interest was expressed during the year in future research cooperation at the Josef complex following a visit from scientific colleagues from St. Petersburg and even from as far away as Singapore. As part of the European PETRUS III project, and in cooperation with the CEG’s long-term scientific partners – SÚRAO and ÚJV Řež, a training course was held at the facility for international students specialising in issues surrounding radioactive waste disposal.

The annual “Josef Gallery Day” was aimed in 2014 at awakening the interest in the study of technical disciplines of school children in the upper years of three local primary schools.
Money from the “CTU Fund for the Support of All-University Activities 2014” was used to finance the presentation of the Department and a tour of the underground facility in which the children were introduced to both practical teaching in the in situ environment of the underground laboratory and a number of ongoing research projects.

One of the Department’s principal priorities is to open the Josef Facility to the general public in connection with which staff hosted during the year, for example, a group of interested geodets, primary and secondary school students, participants of the International Gold Panning Championship of the Czech Republic, a pensioners’ club from the local town of Příbram, etc. The construction of a staircase in an area previously accessible by means of a stiff climb was completed in February thus allowing a safe ascent from base level up to a level of +20m and finally to +40m, the exiting of the underground complex by means of a ventilation shaft at the bottom of Koňský vrch (Horse Hill) and descent following a footpath back to the Josef complex. The opening of this route significantly enhanced the selection of paths accessible to visitors to the facility. Guided tours for the general public run from May to October (http://ceg.fsv.cvut.cz). A total of nearly 1500 people visited the complex during the 2014 season.

Representatives of the Society for the Protection of Bats conducted their third successive annual bat count in the main gallery which revealed a total of 29 of these fascinating flying mammals. The second annual “From the Gallery to the Gallery” cycle race organised for our sporting partners and CEG staff took place in May with, for the first time, international participation.

The Josef underground complex underwent a number of noticeable changes during 2014. The modular site containers were relocated and repainted, the “trains” were moved to a new position and the area in front of the tunnel portals was levelled and landscaped. Two new car parks were created during the year as well as extra storage space and an extensive yard for the storage of construction and other materials.
JOSEF URC

The “Josef Underground Research Centre” (Josef URC) which, together with the Josef Underground Laboratory, makes up a unique experimental and teaching complex, is rapidly winning the favour of the professional public.

The mission of the Josef URC Science and Technology Park is:

- technological development and innovation focused on new technologies and competitive products and services with regard to underground structures
- more rapid transfer of research results to practical applications
- training and requalification of workers in underground structures
- marketing activities, expert services and accredited testing

After completing their research projects, a number of lease-holders are leaving the complex; however, our aim for the future is to work hard to attract new, emerging and innovative companies to move into the vacated premises and to take advantage of the Josef URCs extensive support facilities.

The Josef URC is managed by CEG members of staff. There is no other facility of its type in the Czech Republic or indeed the rest of Europe which can provide the infrastructure, environment and services available at the Josef URC with its unique conditions for research, training and marketing in the field of underground structures.
Courses taught by CEG teaching staff are aimed primarily at students in the following branches: Structural and Transportation Engineering, Environmental Engineering and the Fire Safety of Constructions. These courses, all of which are closely related to experimental geotechnics, are taught both in the CEG’s laboratories and in the Josef Underground Laboratory. In addition, courses in geodesy and cartography are taught at the Josef Facility which is also used for the teaching of students from other universities (e.g. ICT Prague, TU Liberec, MU Brno).

BACHELOR DEGREE STUDIES

The Fire Protection Reliability of Underground Structures course is compulsory for the study of the Fire Safety of Constructions study programme. Students learn about the basic characteristics of underground structures, the risks involved in construction and operation and their prevention, mining regulations and other topics related to underground structures. The main emphasis of the course is on fire protection and safety issues.

Project 2 and Project D prepare students in the subjects Environmental Engineering and Structural and Transportation Engineering for the writing of Bachelor theses oriented towards experimental geotechnics. Students become familiar with professional literature and solve practical problems related to relevant issues, working both in the CEG laboratories and the in situ Josef Underground Laboratory. The course is completed with the design of a Bachelor thesis plan and a proposal on how to address the given issue.

The Bachelor Thesis offers students in the branches Structural and Transportation Engineering and Environmental Engineering an opportunity to write practically-oriented Bachelor theses focused on topical geotechnical issues. To this end, they are encouraged to use the above-ground geotechnical laboratories as well as the Josef underground complex.
FOLLOW-UP MASTER’S DEGREE STUDIES

Geotechnical Laboratory the content of the course consists of geotechnical in situ and laboratory tests used for the determination of rock and soil parameters. These parameters are of key importance for the performance of the subsequent geotechnical calculations and include mechanical, physical, hydrophysical and thermophysical characteristics and strength and deformation parameters.

Experimental Analysis of Structures – Geotechnical Part focuses on practical classes held in real conditions in the Josef Underground Laboratory. Students are trained in the monitoring of underground structures, the application and verification of the performance of clay sealing materials and the analysis of selected parameters of rock continua.

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

Diploma Thesis is designed for students in the Structural and Transportation Engineering and Environmental Engineering follow-up master’s courses who are required to produce Diploma theses with an emphasis on experimental geotechnics. The topics of such theses are usually closely related to ongoing research projects at the CEG. Students use both the CEG’s geotechnical laboratories and the Josef Underground Laboratory for research purposes.

Experimental Research of Radioactive Waste Disposal makes up 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, with physical modelling and related practical problems addressed at the Josef Underground Laboratory. This course is also taught in English.

Geotechnics at the Josef Underground Laboratory is an elective course offering practical classes in geotechnics to students of all branches. Teaching takes place at the Josef Underground Laboratory. Students are first familiarised with the facility, the rules of conduct underground and the respective codes of conduct. This is followed by all-day practical
classes based on geotechnical subject matter included in the “Experimental Analysis of Structures” course.

DOCTORAL DEGREE STUDIES

CEG teaching staff supervise students in the doctoral degree study of “Physical and Material Engineering”. A total of 4 students studied and prepared to defend their dissertations on this theme in 2014.

Markéta Levorová and Jiří Šťástka work under the supervision of prof. Jaroslav Pacovský and both of them are in the fifth year of their studies; the topics of their dissertations are “Stress redistribution in the rock massif due to thermal stresses” and “Physical modelling in the research of radioactive waste isolation issues” respectively. At the beginning of 2014, M. Levorová attended a compulsory three-month internship at the University of Wollongong (Australia).

Lucie Hausmannová completed her fourth year of study and is investigating the topic “Hydrophysical properties of smectitic clays in the conditions of a deep geological repository for nuclear waste” working under the supervision of Ing. Radek Vašíček. Jan Smutek, supervised in his fifth year by Ing. Jiří Svoboda, is writing his dissertation on the topic “Research of the gas permeability of a rock continuum based on experimental in situ measurements”. Both of them attended a two-week internship at the Mont-Terri Rock Laboratory as part of the European LUCOEX project in autumn 2014.

Student Grant Competition

The three-year student project, Research into the gas permeability of engineered and natural barriers, was completed in 2014. The student team was composed of Ph.D. students Ing. Markéta Levorová and Ing. Jan Smutek, and the project was managed by Ing. Jiří Svoboda, Ph.D. The project focused on research into the behaviour of Czech Ca-Mg bentonite in terms of gas permeability during different applications.

The project involved detailed in situ and large-scale laboratory tests focusing on research into the key characteristics of buffers – bentonite permeability and self-healing ability.
The in situ experiment represented an instrumented borehole filled with bentonite blocks through which passed a sensor for pressurizing the bentonite backfill with water and gas. Borehole testing involved both repeated saturation and the conducting of gas pressure tests. Large-scale testing was carried out in a steel chamber modified in order to allow the saturation and pressurizing of the bentonite backfill. The project was made up of a total of four experiments involving the manual testing of compacted granulated bentonite, sprayed-on granulated bentonite, a mixture of pellets and a mixture of crushed recycled bentonite. The results of the tests confirmed the theory concerning the opening of preferential flow paths in bentonite once swelling pressure has been exceeded and its ability to heal such flow paths following saturation.

A two-year student research project, the Hydrophysical properties of a bentonite-based non-homogeneous material, reached completion at the end of 2014. The applicant was Ing. Lucie Hausmannová and the research team was composed of Ing. Jiří Šťástka and Ing. Radek Vašíček, Ph.D. The objective of the project was to research the effect of the non-homogeneity of bentonite specimens, i.e. a mixture of pellets and crushed bentonite, on hydraulic conductivity and swelling pressure. The research was based on requirements concerning the characteristics of the bentonite that will be used for the construction of the buffer and/or backfill layer in the multi-barrier system of the future Czech deep geological repository for radioactive waste.

The second year of the project involved the taking of measurements in permeameters modified for the testing of large dimension non-homogeneous specimens. Each test lasted around 10 weeks. It was assumed that the specimen would become significantly homogenized during the course of the test. Once removed from the permeameter chamber, the specimen appeared to be uniform; however, following detailed investigation, non-homogenized pellet segments were identified in some places within the specimen.

The resulting values of swelling pressure and hydraulic conductivity were compared to values obtained for homogeneous compacted powder bentonite. Both materials exhibited the same swelling pressure values, whereas the hydraulic conductivity of a mixture of pellets and crushed bentonite was found to be lower than that of the compacted powder material.
DEFENDED BACHELOR AND DIPLOMA THESIS

Measurement of the hydraulic conductivity and swelling pressure of Czech bentonite at temperatures of up to 90°C
Jaroslav HLOUŠEK

The Bachelor thesis involved research into bentonite characteristics – swelling pressure and hydraulic conductivity, and the verification of their stability under thermal loading. It is supposed that bentonite will make up an important element of the geotechnical barrier system in the future Czech deep geological repository for spent nuclear fuel. The bentonite was tested in special devices called permeameters. The bentonite tested was of Czech origin (Červený vrch).

The permeameter chambers were modified so as to allow the heating of the bentonite specimens to a maximum temperature of 90°C by means of heating coils placed around the ring holding the specimen. The stability of the experiment was ensured via the fitting of insulation boxes around the permeameter chambers. In addition, the specimens were loaded with the pressure exerted by the chamber tightening screws and subsequently saturated with water so as to allow for the measurement of hydraulic conductivity.

The results of the research revealed that after heating the specimens to 90°C, swelling pressure fell by from 0.4 to 2.0MPa depending on the volume density of the specimen; hydraulic conductivity was found to be one order higher.

Analysis of THM processes in the Mock-Up-Josef in situ experiment
Václav PÁTEK

The Diploma thesis dealt with the construction of a finite-element-method computer model. The model simulates THM (thermal-hydraulic-mechanical) processes which it is assumed will occur within the bentonite barrier surrounding containers with spent nuclear fuel in a future deep geological repository.

The computer model was based on the Mock-up Josef in situ experiment which was
launched at the Josef Underground Laboratory on 14 December 2012. It is the first physical model in the Czech Republic to simulate the vertical emplacement of a container with spent nuclear fuel.

The content of the thesis consisted of a description of the simulation model created by means of the Code Bright programme and a detailed comparison of the outputs of the model with those of the Mock-Up Josef in situ experiment. The results consisted principally of information on the moisture pattern and its development over time and a description of swelling pressure development during the thermal loading of the barrier.

The comparison of the results of the computer model with those of the in situ experiment will contribute towards a better understanding of the behaviour of the bentonite barrier under loading with a temperature corresponding to conditions prevailing in a real deep geological repository.

Study of an alternative fire safety solution for a metro station
Tereza SYROTIUKOVÁ

The Diploma thesis addressed fire safety issues with concern to underground railway systems and included a design for an alternative fire safety solution for the Palmovka Station on Line B of the Prague metro system.

There is currently no legal regulation in force in the Czech Republic which deals in detail with the fire safety of underground railway systems. Although the probability of a major fire in the Prague metro system is low, concerning the potential number of people at risk imply that efforts should be made to tighten existing regulations, improve the standard of the fire prevention equipment and provide more information to passengers.

The “alternative design” was based on current legislation and a mathematical model concerned with the design of a system for the safe evacuation of passengers. The CFast simulation programme developed by the NIST Institute (National Institute of Standards and Technology, USA) was used for the simulation of a two-zone fire model. Subsequently, a series of modifications was designed to safeguard human life in such situations based on the simulation – e.g. protected escape routes, automatic ventilation systems, etc.
2014 proved to be a fruitful year in terms of the launch of new research projects at the Josef Underground Laboratory. The Centre of Experimental Geotechnics FCE CTU in Prague is a partner to no less than nine research teams involved in either newly submitted or launched projects.

Of the list of new projects, three are EU-related: Modern2020 (Development and Demonstration of Monitoring Strategies and Technologies for Geological Disposal), Cebama (Cement-based Materials, Properties, Evolution, Barrier Functions) and Price-lab (Controlled Permeable Fractured Rock in situ Experiments in a Geothermal Research Laboratory). In addition, 2014 also saw the approval of an international project to be conducted under the auspices of the Swiss-Czech Cooperation Programme “Partnership Fund”. Of the remaining five domestic projects, three are concerned with the expansion of teaching and experimental activities at the CTU, while the other two are being supported by the Technology Agency CR and the Czech Science Foundation.

Two five-year projects focused the capture and storage of geothermal energy reached their conclusion. The research teams are prepared to continue their research should they obtain new funding. 2014 also saw a series of detailed negotiations on potential cooperation with non-European partners; the Josef Facility hosted visits by colleagues from Russia and Singapore, and CEG staff members remain in close contact with Chinese and Korean experts.
DOPAS is a major pan-European project in which the Czech Republic is represented by the Faculty of Civil Engineering CTU in Prague, ÚJV Řež and SÚRAO. The goal of the Czech participation in the project is the assembly of an experimental pressure and sealing plug (EPSP – Experimental Pressure and Sealing Plug) in the granite massif in the Josef Gallery. Sealing plugs will form component parts of deep geological repositories (DGRs) for nuclear waste and their primary function consists of the separation of filled DGR disposal chambers from neighbouring unfilled capacity. The project assumes the assembly of a further three experimental plugs – in Finland, France and Sweden.

Now in its third year, the project continued with the laboratory testing of various component materials and in situ work related to plug assembly in the SP-63 niche in the Mokrsko West section. The niche profile was modified by means of ripping in order to attain the required shape. So as to prevent the leakage of the medium which will be used during the pressurisation of the plug, the rock around the niche within a distance of 5m was grouted. In addition, five boreholes were drilled to connect the experimental niche with an adjoining niche in which it is planned that the technological centre will be installed. Cables lead through the boreholes to sensors which will monitor stress-deformation, temperature and moisture changes within the body of the plug and the surrounding rock environment. The plug and its surroundings will be monitored by a total of over 250 sensors.

The pressure chamber has now been completed and the permanent formwork of the inside plug consisting of fibre-reinforced shotcrete, which was applied by means of spray technology, was installed at the beginning of November 2014.
The PETRUS III international project is a follow-up to the PETRUS II project the aim of which is to coordinate the efforts of European universities and educational and research institutes in terms of the joint education and training of Ph.D. students and experts in the field of radioactive waste disposal. The final objective is to design and implement an educational and training programme based on predefined graduate competencies. The principles and tools of the newly-introduced all-European system of professional education, ECVET will be employed for purposes of the programme.

The project is subdivided into six work packages (WPs). WP1 and WP2 are tasked with preparing a module for a master’s degree course and to implement it at a minimum of one of the universities involved in the programme. WP3 will focus on the preparation of multidisciplinary courses for Ph.D. students and on the organisation of international Ph.D. student workshops. The objective of WP4 and WP5 is to involve the cooperation of end users and the CMET (IGD-TP) working group in order to initiate the long-term development of PETRUS educational and training programmes. WP6 is tasked with coordinating the work of the other five WPs as well as the eventual communication and presentation of the results.

In September, CEG staff members conducted a 12-day international teaching course as part of the project involving students from France, the Czech Republic and Spain. The main part of the course took place at the Josef Facility where the students attended practical classes both in the laboratory and the underground complex. Study topics included the determination of the properties of shot-clay bentonite and rock characteristics.
On the basis of mutual visits, consultation and workshops, the objective of the project is to obtain the knowledge from foreign partners necessary for putting the first in situ underground laboratory with the potential application of active tracers into operation in the Czech Republic. As such research has not to date been conducted in the Czech Republic, it is essential to engage the involvement of foreign specialists. The participation of Swiss experts from the NAGRA organisation will allow the design and subsequent implementation of the experimental programme at the laboratory in order that the research and training processes are effective and to avoid the repetition of outdated experimental procedures and research topics. In addition to the CEG’s Josef Underground Laboratory, the ÚJV Řež has been invited to participate in the project due to its considerable experience in terms of the laboratory research of such issues.

The construction and operation of a specialised laboratory at the Josef Gallery will primarily enable training in a real in situ environment and the mastering of non-traditional experimental methodologies and research procedures. It will also further enhance the quality of the preparation of young experts at Czech universities in terms of research into transport processes.

Following the launch of the project in November 2014, a niche for the future laboratory was selected at the Josef Gallery and the modifications necessary prior to construction proper were carried out.
The project was launched in July 2014 and the objective is based on the necessity to reduce as far as possible the uncertainties caused by the transfer of the results of laboratory research and simulations to real in situ conditions with concern to migration processes in the rock continua housing deep geological repositories for nuclear waste. The research includes the participation of foreign experts within the Partnership Fund project (Czech Ministry of Finance).

The essential aim of the project, therefore, is to assess the potential for the transfer of the results of laboratory research into tracer transport processes to real conditions prevalent in granitic rocks (in situ experiments) and to models for the assessment of the diffusion of radionuclides into rock continua. At the same time, methodology will be designed which allows the transfer of information on rock properties and the processes from the micro to the real scale. In order to attain these objectives methodology will be devised related both to the use of special tracers (radionuclides) and modern analytical methods.

By the end 2014, an 80m-long niche had been prepared in granitic rock in the Josef Underground Laboratory to house the migration laboratory and for further in situ research requiring special safety conditions. The niche has been fitted with lighting, wiring and a forced air ventilation system and it has been partially concreted. A high-speed internet connection is planned for the next phase of construction.
The Mock-up Josef experiment consists of an in situ physical model, the first in the Czech Republic which simulates the vertical emplacement of a container with spent nuclear fuel. The experiment involves research into the effect of heat and groundwater on the bentonite sealing barrier, the so-called buffer, which will surround the spent nuclear fuel container.

In 2014 pressure, temperature and relative moisture, both in the bentonite barrier and the surrounding rock, were monitored continuously. The variables are measured in the bentonite barrier in intervals of ten minutes in five horizontal and one vertical profile. Metal samples have been placed within the barrier for the purpose of corrosion monitoring which will be investigated following the completion and subsequent dismantling of the experiment. The measuring system includes a web interface which provides an overview of developments within the experiment (http://uef-josef.uef-josef.eu/misc/mereni/).

In May 2014 the second sampling session of specimens from the bentonite blocks which make up the engineered barrier was conducted. The specimens were tested for the volume density of dry material, moisture content by weight, degree of saturation, hydraulic conductivity and swelling pressure. The values obtained were then compared to values determined from specimens taken in the first sampling session. The assessment of the samples suggested that the bentonite barrier has still not attained full saturation. Following discussions with the research proponent, it will be decided in 2015 whether the saturation and thermal loading of the barrier will continue in 2016 or whether the experiment will be dismantled and subjected to complex examination.
The project focuses on research into the gas permeability of smectitic clays in connection with the potential exploitation of their properties for the construction of sealing layers in landfill sites and in the construction of deep geological repositories for nuclear waste. Due to their very low permeability, clays and clay-based (mainly smectitic clay) materials are generally used as the buffer in a range of engineered structures, including the sealing of landfill sites for municipal and other solid waste and, in the future, the sealing of deep geological repositories for high-level nuclear waste. The generation of gases that might negatively affect the function and safety of such sealing layers is highly probable in the case of both landfill sites and deep geological repositories.

The objective of the project is the detailed research of the gas migration properties of Czech smectitic clays and the determination of their key characteristics in relation to the long-term safety of landfill sites and deep geological repositories for nuclear waste. The principal tasks involved in the project include the detection of the minimum gas pressure at which preferential flow paths are formed and the monitoring of the dynamics of this phenomenon, including self-healing ability. A further important objective concerns the determination of the effect of the non-homogeneity of the medium on the above phenomena.
The Bentonites 95 project is concerned with research into the chemical and physical interactive processes triggered by the emplacement of an experimental bentonite body into a saturated host rock medium (granodiorites in the Mokrsko West section of the Josef Gallery). These processes are being further accelerated by the application of thermal loading.

A fully-instrumented physical model, assembled at the Josef URC above-ground laboratory, was transported and sunk into a disposal well in the SP-51 niche situated in the Mokrsko West section. The technological joint between the model and the wall of the disposal well was then filled with water, the heating system which provides the thermal loading of the bentonite was switched on and the continuous data feed activated. The results provided by the measurement sensors are immediately displayed on website application.

Small physical models were prepared in 2013 for the continuous analysis of the bentonite during the course of the experiment. Three boreholes with a diameter of 57mm were drilled in the same niche as that housing the experiment. Models (bentonite cylinders with a diameter of 50mm and a height of 65mm) without a heat source were inserted into two of the boreholes, while the third borehole was fitted with a model with a heat source the purpose of which is to heat the bentonite backfill of the borehole. The small physical models were assessed in 2014 and preparations commenced for the dismantling of the large physical model.
RESEARCH OF THE THERMAL LOADING OF ROCKS – PERSPECTIVES FOR UNDERGROUND THERMAL ENERGY STORAGE

Duration: 2011-2014
Recipient: Czech Geological Survey
Partners: ISATech, s. r. o., Technical University Liberec, Institute of Rock Structure and Mechanics of the Czech Academy of Sciences, ARCADIS CZ a.s., Geotechnics Division
Grant provider: Ministry of Industry and Trade – Program TIP

2014 marked the final year of the project which concerned research into issues surrounding the storage of thermal energy in granitic rock media at relatively low temperatures (circa 90°C). The fourth and final phase of the project included principally field investigation and technical research concentrated in the SP-47 niche of the Josef underground complex. Research work involved the monitoring of the heating and cooling phases of the in situ experiment and the comparison of the results with those determined by means of numerical simulations.

Laboratory work included the completion of the detailed characterization of the rock medium in which the experiment is situated, the compilation of a detailed description of the behaviour of a thermally conductive polymer at the interface between the rock and water. An inseparable part of laboratory work was the investigation of pairs of heated and non-heated rock specimens with regard to their micro-structural and petrographic characteristics in connection with changes within the rock brought about by heating caused by thermal energy storage.

Numerical modelling continued in the final phase of the project and the results were compared with results obtained from the in situ experiment. COMSOL software was used to simulate the temperature field pattern for five complete heating cycles. Further simulations concerned the representation of fissures in the stress state model.
ROCK MASSIF STIMULATION FOR CREATING A RESERVOIR FOR CAPTURING GEOTHERMAL ENERGY USING THE HOT-DRY ROCK SYSTEM

Duration: 2011-2014
Recipient: GEOMEDIA s.r.o
Partners: ISATech, s. r. o., Subterra a. s., ARCADIS CZ a.s., Geotechnics Division, Faculty of Civil Engineering CTU
Grant provider: Ministry of Industry and Trade – TIP Programme

The final phase of the project was devoted to processing and summarizing the information obtained during the research period. The outputs of this phase consisted of methodologies, compression test technology and information on the effect of the hydraulic fracturing method on the strength characteristics of selected rocks and concrete.

The hydraulic fracturing methodology involved the testing of micro and macro specimens and an in situ experiment employing both linear compression growth and fracturing with compression pulse generation. A total of 114 micro specimens from 10 rock types plus reference concrete and 58 macro specimens from 5 rock types plus reference concrete were tested. The methodology was verified in an in situ environment consisting of a horizontal borehole drilled into dacite rock at depths of from 4.4m to 7.8m. The methodology used for the hydrogeological modelling macro specimen tests and the in situ experiment was devised on the basis of the mathematical modelling of hydrodynamic conditions by means of Visual MODFLOW commercial software.

The device designed for the in situ fracturing of the rock massif by means of compression pulsing is considered to be a “functional model”, while the hydraulic fracturing technology in the pulse mode is considered the result of “verified technology”. A certificate concerning the granting of “utility model” status for the technical design of a hydraulic fracturing device was issued in May 2014.
Transport processes feature significantly in a host of topical geotechnical issues, e.g. with concern to underground energy storage (gas storage silos, excess energy storage in discontinuous rock media), the safe isolation of spent nuclear fuel in deep geological repositories (the study of the migration of radionuclides), etc.

An autonomous underground laboratory was constructed in one of the niches in the Mokrsko West section of the Josef Gallery for the purposes of the understanding and practical teaching of transport processes. Four separate work stations, all in in situ environments, will be used for the teaching of water and gas pressure testing and the long-term monitoring of migration processes and for the conducting of corrosion and diffusion experiments. The laboratory was put into operation in June 2014 following the MeziLab II project kick-off seminar at the Josef Facility which was attended by teachers and Ph.D. students from both of the universities involved.

The teaching of subjects focusing on transport process issues as part of existing courses commenced in the winter semester of the 2014/2015 academic year. The courses have been modified to suit the needs of individual schools. The MeziLab II project laboratory will be used by students for the collection of data for the writing of bachelor and diploma theses and dissertations.
DETERMINATION OF THE MIGRATION PARAMETERS OF ROCKS WITH FISSURE PERMEABILITY USING FLUORESCENT SOLUTIONS

Duration: 2013-2016
Recipient: ISATech, s.r.o
Partners: Faculty of Civil Engineering CTU, Geological Institute of AS CR, v.v.i., GEOMEDIA s.r.o.
Grant provider: Technology Agency of the Czech Republic – ALFA Programme

The project is concerned with the application of fluorescent substances for tracer testing purposes. These substances do not pose any threat to the environment; they are detectable using simple methods and allow the continuous recording of changes in tracer concentration which is important in terms of the identification of the migration parameters of rocks. The objective of the project is to determine the optimum composition of tracer solutions and to identify conditions for their use.

In the first year of the project, a dedicated laboratory was set up in the Čelina section of the Josef Gallery for the purposes of tracer experiments on macro specimens. The JP-17 niche in the Mokrsko West section was selected for the conducting of in situ tracer experiments.

In 2014 work concentrated on the laboratory testing of the inert backfilling of artificial fissures in macro specimens and on the preparation of a niche for in situ experiments. The inert material selected is so-called balotina in the form of industrially-produced micro beads. The basic properties of this material, i.e. apparent density (specific gravity), the bulk density of loose poured and packed material, grain size composition and hydraulic conductivity were identified by means of laboratory testing. Based on the results of geophysical measurements and geological mapping, it was decided to drill five roughly horizontal boreholes in the niche for in situ experimentation purposes. The boreholes were drilled and are now ready for the commencement of tracer experiments.
INFRASTRUCTURE IMPROVEMENT FOR THE TEACHING OF SURVEYING AT THE JOSEF GALLERY

Duration: 2014
Recipient: Faculty of Civil Engineering CTU
Grant provider: Ministry of Education, Youth and Sports

The objective of the project was the modernisation of the practical teaching of surveying assignments in study programme of the Geodesy and Cartography in underground spaces and involves the relocation of selected practical classes from the Faculty of Civil Engineering building in Prague to the Josef Underground Laboratory which offers an environment which closely resembles real conditions and includes the necessary support facilities.

For many years, practical assignments included in the “Geodesy in Underground Spaces” course were oriented solely towards basic classical mining surveying methods. This was the result primarily of the limited space available for the teaching of this course. The opening of the Josef Underground Laboratory finally presented the opportunity to teach this subject under virtually real conditions.

In addition, the Laboratory has the potential for the practical teaching of other related subjects including modern tunnelling methods (automated measurements, laser scanning, etc.) which could not previously be taught despite the fact that such skills are often required of students. The main reason for relocation from Prague to a newly-opened part of the Čelina East section of the Josef Gallery is the intention to make use of a 40-metre high underground shaft which was previously used for connecting different floors of the experimental gold mine and which now connects 3 horizontal levels.
JOINT EXPERIMENTAL SUPPORT FACILITIES IN EXTERIOR AREAS OF THE CENTRE OF EXPERIMENTAL GEOTECHNICS, FACULTY OF CIVIL ENGINEERING FOR TESTING VEHICLE SYSTEMS AND THE CHARACTERISTICS OF ROAD BUILDING MATERIALS AND CONSTRUCTIONS

Duration: 2014
Recipient: Faculty of Civil Engineering CTU
Grant provider: Ministry of Education, Youth and Sports

This development project, involving two departments of the Faculty of Civil Engineering CTU, is a follow-up to a project conducted in 2013 which included the construction of the foundations of a circular track for vehicle testing under steady driving conditions. The continuation of the project has allowed the completion of the circular test track so that it complies with regulations governing the testing of vehicle fire resistance.

Since students using the Josef underground complex for practical instruction as part of various CTU study courses had no access to corresponding above-ground support facilities, a one-storey building has been constructed from modular containers and fitted with cloakrooms, restrooms and a meeting room with audiovisual equipment to serve the needs of students and teachers all the year round.

Project funds were used for the purchase of an LDD100 light dynamic plate and an ECM-Static load plate which are used for the determination of the load-bearing capacity of pavement and sub-base layers. The outputs provided consist of the modulus of deformation (static plate load test) and the dynamic modulus value (light dynamic plate test) which are used in the design and assessment of road constructions. Both devices can be used for the practical teaching of students and for research purposes.
Bird's eye view of the Josef Facility

ARCADIS staff members in the niche

Carmix concrete mixer truck
UNDERGROUND AREA - ČELINA WEST

LEGEND:
1. Prefabricated TOM lining (with convergence measurement sample)
2. Training wall - sprayed clays
3. Display of mining mechanised technology
4. 1:1 model of historical tunnel timering - Austrian system
5. Training wall - core boring
6. Contact stress measurement
7. Convergence measurement
8. Anchoring technology (ORICA)
9. Underground laboratory of “Tracers” project
10. Anchoring technology (HILTI Ltd)
11. Tank with processed water
12. Model of backfilling of a deep repository access gallery (BACKFILL)
13. Information centre for the BACKFILL project
14. EU TIMODAZ experiment
15. Information centre for the TIMODAZ project
16. Bore diagram and the teaching of destruction work
17. Bore diagram
18. Detection of critical areas geotechnical structures

Diagram of the Josef Gallery’s underground area

Projects included in the Annual Report
Others
UNDERGROUND AREA - MOKRSKO WEST

LEGEND:
20. Rescue chamber
21. Ventilation shaft
22. Tank with processed water
23. VITA Project
24. Bentonity 95 project
25. DOPAS technological centre
26. DOPAS project
27. Mock-Up Josef experiment
28. Inter-University underground laboratory (MeziLab)
29. TU Liberec migration experiment
30. Inter-University underground laboratory (MeziLab II)
31. SWISS project - active tracers
32. PAMIRe project
33. TACR „Tracers“ project
34. STIROMAS project

Diagram of the Josef Gallery’s underground area

Legend:
- Experiment, teaching point
- Accessible parts
- Inaccessible parts
- Projects included in the Annual Report
- Others
MÁŠ NA VÍC – DOSÁHNI NA Ph.D.

K220 – Centrum experimentální geotechniky

školící pracoviště doktorského studia oboru FMI - Fyzikální a materiálové inženýrství

Témata doktorských prací
specifické úlohy podzemního stavitelství a problématiky izolování vysokého radioaktivního odpadu v hlubinném úložišti

Těžiště práce
experimentální činnost v podzemní laboratoři Josef a povrchově akreditované geotechnické laboratoři

Konkrétní zadání – individuální dohoda studenta a školitele.

V současnosti řešená úloha doktorského studia:

- Problematika plynopropustnosti jílových bariér
  Ing. Markéta Levorová

- Vliv teploty na změnu napjatosti horniny;
  Ing. Jiří Šťástka

- Vývoj technologie nanášení bentonitových těsnění nástřikem
  Ing. Lucie Hausmannová

- Numerické modelování při řešení problematiky izolování radioaktivních odpadů
  Ing. Jan Smutek

- Vyhodnocení dat experimentu DOPAS (Experimental Pressure and Sealing Plug)
  Ing. Jan Smutek

- Výzkum plynopropustnosti horninového prostředí založený na experimentálním in situ měření
  Ing. Jan Smutek

Naše pracoviště nabízí...

V případě zájmu o praktický výzkum v podzemní laboratoři je možné během doktorského studia být zaměstnán v CEG na částečný úvazek.

Kontaktní osoba:
Ing. Radek Vašíček, PhD.
radek.vasicek@fsv.cvut.cz
tel.: 224 355 518

Přihláška do 29.5.2014
nástup v září 2014

WE ARE DOING OUR JOB BETTER AND BETTER...
...AND IT IS OUR PLEASURE!


Czech Technical University in Prague
Faculty of Civil Engineering
CENTRE OF EXPERIMENTAL GEOTECHNICS
Thákurova 7
166 29 Praha 6 - Dejvice

tel.: (+420) 224 355 507
e-mail: ceg@fsv.cvut.cz
web: http://ceg.fsv.cvut.cz

Czech Technical University in Prague
Faculty of Civil Engineering
REGIONAL UNDERGROUND RESEARCH CENTRE JOSEF URC
Chotilsko - Smilovice 93
263 01 Dobříš

http://ceg.fsv.cvut.cz