The Josef Underground Educational Facility – a New Training Opportunity for Students of Geotechnics

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Abstract

The Josef Gallery, located in central Bohemia, Czech Republic, was excavated in 1981 as an exploration complex for the potential mining of gold. In 2007 the gallery was converted into a unique Czech Technical University in Prague (CTU in Prague) facility the main role of which is to provide an opportunity for practical education and research in the fields of underground structures, geotechnics, surveying and geology. Both the Centre of Experimental Geotechnics (CEG) geotechnical laboratory and the extensive underground tunnel network with widely varying geological conditions provide an ideal environment for practical training. Moreover, the broad range of research-oriented activities on offer provides a host of opportunities for students to be introduced to real problems in-situ, new methods, materials and technologies. Several domestic and international projects are currently underway at the facility (e.g. Thermal Impact on the Damaged Zone around a Radioactive Waste Disposal Vessel in Clay Host Rocks, the Fate of Repository Gases and Sprayed Clay Technology). Both government and private endusers are involved either as submitters or project partners in all of the projects. As a result, students participating in the various experiments gain real research and commercial experience and establish useful direct links with the industrial sector. This paper provides a detailed description of the facility, the studies currently underway at CTU in Prague as well as an outline of the activities of the Josef UEF.

Introduction

The Josef Underground Educational Facility (Josef UEF) is a new Faculty of Civil Engineering, Czech Technical University in Prague (CTU in Prague) facility which opened in June 2007 (Fig. 1, www.uef-josef.eu). The Josef UEF is employed primarily for the teaching of students from the CTU and other universities. Additional activities include research and cooperation on projects commissioned by the private business sector. The range of activities provided by the Josef facility is unique not only in the Czech Republic but throughout the whole of Europe. The construction of the facility was inspired by underground research and training centres in certain other European countries and the USA. Underground facilities run by universities provide a high level of practical education for students in real conditions and contribute towards closer cooperation between universities and the world of business.

Figure 1: The Josef UEF

The University and the Centre of Experimental Geotechnics

The Czech Technical University in Prague is the oldest technical university in Central Europe and one of the Czech Republic's foremost seats of technical learning with experience in education and research stretching back to 1707. Approximately 23500 students attend the university supported by roughly 3500 teaching and research staff. Students have a choice of seven faculties, covering the whole of the technical sciences spectrum i.e. the Faculty of Electrical Engineering, Faculty of Civil Engineering, Faculty of Mechanical Engineering, Faculty of Transportation Sciences, Faculty of Nuclear Sciences and Physical Engineering, Faculty of Architecture and Faculty of Biomedical Engineering (arranged in descending order according to the number of students). The Faculty of Civil Engineering (FCE) is one of the largest colleges of the CTU in Prague with approximately 6500 students and 400 teaching and research staff. Mathematics, architecture, material sciences, construction and ecology make up only a small number of the fields covered by the 29 departments and research centers of the FCE. The Centre of Experimental Geotechnics (CEG, http://ceg.fsv.cvut.cz) is a modern experimental FCE department concerned with both research and teaching activities (Fig. 2). The Centre employs a team of young specialists in experimental geotechnics. The CEG came up with the original idea of commissioning the Josef Underground Educational Facility (UEF) and is responsible for its operation. Research is conducted into both the technical and practical problems involved in soil and rock mechanics. The CEG cooperates extensively with industry and provides a range of professional services for construction companies. It assists in determining the geotechnical parameters of soil and rock environments and provides for the monitoring of special superstructures, underground structures (tunnels, underground storage) and so on (Vašíček, 2008). Special tasks being solved are connected to the research on high-level radioactive waste disposal and its physical modelling. Well known experiment Mock-Up-Cz is an example (Fig. 2 - middle, Svoboda & Vašíček, 2008).

Figure 2: Experimental projects underway at the CEG laboratory

Education and Geotechnics at the FCE

The Faculty of Civil Engineering provides education up to three academic levels (bachelor, master and doctoral degrees) via a wide range of different study programmes. The main teaching language is Czech but courses taught in English are also available. A summary of the study programmes available can be found in the table (Fig. 3).

Figure 3: Review of study programmes available at the FCE CTU in Prague

Type of study	**Number of Programmes/ Branches**	**Duration** (according to programme)	**Proportion of students**
Bachelor	5/ 14	4 years	60%
Master	8/ 20	1.5/2 years	30%
Doctoral	3/ 11	4 years	10%

The CTU adheres to the European Credit Transfer System according to the Bologna Declaration the aim of which

is to create a European forum for higher education in order to enhance the employability and mobility of citizens and to increase the international competitiveness of European higher education.

Geotechnics is introduced to students in a stage-by-stage manner consisting of basic courses on geology, soil mechanics and foundations which are included in all the bachelor degree programmes offered. Three of the twenty masters degree programmes offer detailed courses in rock mechanics, underground structures, advanced foundations, laboratory testing and field investigation methods. Courses are either compulsory or voluntary depending on the student's future planned study specialisation. CEG courses involve practical laboratory tests and experiments in soil and rock mechanics, as well as in-situ tests, building foundation measurement and underground structures. Students learn about and gain practical experience in geotechnical measurement while applying modern tunneling technologies and performing experimental research into the construction of underground repositories. Computer technology is used particularly in the continuous measurement of geotechnical parameters both in the laboratory and in the field. The education of doctoral students as well as undergraduate experimental diploma projects are conducted both in the CEG laboratories at the Prague site and at the Josef UEF under the supervision of experienced research staff.

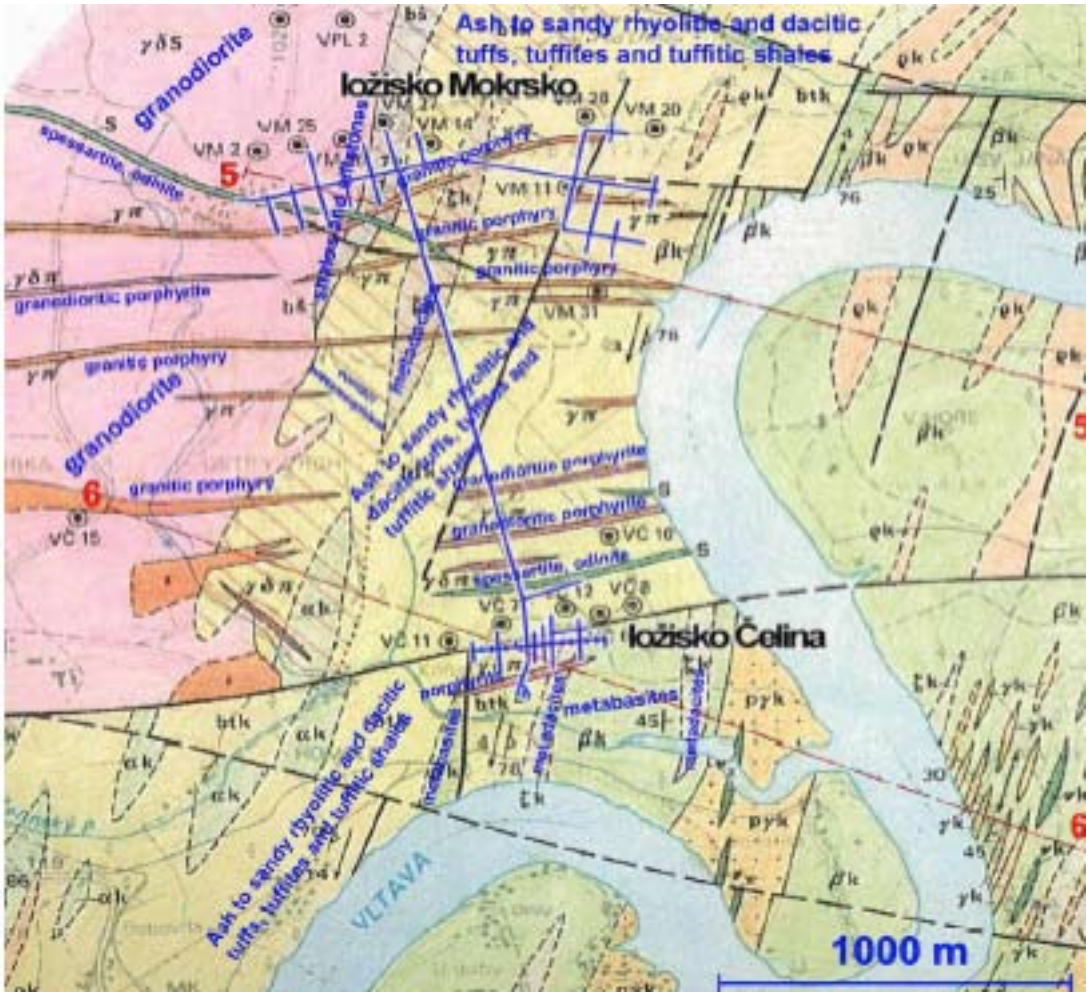
The Josef UEF plays a very important role in the respective study programmes. Half day excursions to the facility are provided as an introduction for first year students. The range of the student's study activities at the facility will depend subsequently on the specific study programme, the scientific branch chosen and the student's final specialisation.

Description of the Josef Gallery

The Mokrsko-Čelina area in which the Josef Gallery is located is part of the Jílové gold bearing zone (Morávek, 1996). The Josef exploration gallery was excavated as part of renewed prospecting activities which commenced in 1981. It was decided, however, that mining operations would be discontinued since ore extraction and dressing would result in the devastation of an area of natural and recreational potential and consequently, in 1991, operations came to an end. In 2000, the entrance portals were plugged with concrete to prevent access to the underground areas.

The Josef exploration gallery is cut in a NNE direction across the Veselý hill rock massif. The total length of the main drift is 1700m, with a cross-section of 14-16m2. The overlying rock thickness is 90–110m. Two parallel tunnels lead from the entrance portals, each having a length of 40m and a cross-section of 40m2. The main exploration gallery is connected to various exploration workings by numerous insets, which follow ore formations and provide access to two further levels. The total length of the galleries is approximately 9km (in blue on Figure 4); 90% of the breakings are not fitted with linings. The end of the main gallery is connected to the ground surface by means of an unsupported 120m vent. The overburden consists of a volcanicsedimentary formation consisting mostly of tuffs, tuffitic shales and biotitic-amphibolic granodiorite of the Central Bohemian Pluton (Pacovský et. al., 2007).

Figure 4: Scheme and Geology of the Josef



The gold reserves in this area are some of the richest in Europe. According to recent estimates, local deposits contain up to 130t of the precious metal. The gold mineralisation is concentrated in quartz veins and is mostly very fine grained. The average gold content in the rock is no higher than 2g/t, which explains why the Mokrsko deposit escaped the notice of medieval miners; its potential was only fully recognised as late as in the nineteen eighties (Morávek, 1996).

At the end of the last century, the revival of gold mining in this area was seriously considered; however, the highest concentrations of gold occur at depths of up to 300m meaning that the gold would have to have been exploited by open-pit mining. Moreover, the separation of the gold would have required the use of the environmentally unfriendly cyanide process. Consequently, commercial gold exploitation is not currently envisaged and is not likely in the near future.

The Plan to Exploit the Josef Underground Gallery

The idea of exploiting the Josef underground gallery originated as early as in 2003. Following extensive discussions and consideration of the information available, the management of the CTU in Prague gave its support to the Faculty of Civil Engineering's scheme to establish the Josef UEF as a CTU in Prague multidisciplinary workplace. Unlike a number of foreign underground laboratories, the CTU workplace is not to be single topic-oriented; the size of the Josef underground gallery and its geological diversity allow the participation of a wide spectrum of those interested in experimental research. Since Josef is a university workplace, its primary mission is the education of young scientists – specialists in their respective branches.

A further use for Josef is in providing facilities for domestic and international single- as well as multi-disciplinary research projects; the Josef underground exploration gallery allows the performance of extensive experiments.

Teaching at the Josef UEF

Teaching programmes related to underground structures commenced at the Josef UEF at the beginning of the academic year 2007/2008. The courses are distinctively practically oriented, thus students have a unique opportunity to take real measurements and perform real experiments in an authentic environment (Fig. 5).
In order to support both the practical and theoretical elements of the various courses provided, several new teaching features have been introduced at the facility the most geotechnically important of which include:

- A convergence polygon where students have the opportunity to observe and practice the taking of measurements and learn about their role in the NATM method
- A contact stress measurement demonstration as part of the geotechnical monitoring process
- A number of blast hole patterns to show different blasting techniques
- Rock and soil bolting & nailing examples
- A replica of an old wooden tunnel support system (1:1 scale, Fig. 6)
- An exhibition of mining equipment (Fig. 6)
- TOM – a "cut and cover" prefabricated construction (surface feature)

Student visits to the Josef UEF are adapted according to the various study programmes offered and are organised at several levels. Typically the student visits the UEF as part of an organised tour to get a "feel" for and basic practical insight into soil and rock mechanic and underground structure issues.

Figure 5: Course of geology

Figure 6: Underground technologies

The student will then return to the UEF in the later part of his/her studies for further practical training as part of his/her specialised course at which time the number of students is limited which allows each participant the required amount of "quality" time and the resources with which to solve the various demanding tasks set (e.g. drilling etc.).

The Josef Gallery is particularly suitable for work on bachelor and diploma theses. Students are encouraged to actively participate in the various ongoing research projects at the Josef UEF.
Teaching programmes are provided by three departments of the Faculty of Civil Engineering, CTU - the Centre of Experimental Geotechnics and the Departments of Geotechnics and Specialised Geodesy (Fig. 7).

Figure 7: Practical teaching

Research in the Underground areas of the Josef Facility

Providing underground in-situ research is the most important role of the Josef UEF as well as an important long-term FCE priority. Currently the CEG/Josef UEF is involved in several projects including TIMODAZ (Thermal Impact on the Damaged Zone around a Radioactive Waste Disposal Vessel in Clay Host Rocks, EU FP6), FORGE (Fate of Repository Gases, EU FP7), PETRUS 2 (Towards a European Training Market and Professional Qualifications in Geological Disposal, EU FP7), An Evaluation of Saturation Media and Long Term Thermal Loading Impacts on Bentonite-Based Materials and the development of Sprayed Clay Backfill Technology.
The aim of the research connected with the TIMODAZ project is to investigate the effects of long-term thermal load on lining stability. The extreme long-term functioning of the lining around a disposal vessel is one of the premises for the potential safe removal of spent fuel canisters from the engineered barrier (Fig. 8 – left, Pacovský et. al., 2008).
FORGE is a pan-European project with links to international radioactive waste management organisations, regulators and academia, specifically designed to tackle the key research issues associated with the generation and movement of repository gases.
The aim of the PETRUS 2 project is to enable present and future professionals concerned with radioactive waste management in Europe, whatever their initial disciplinary background, to follow a training programme on geological disposal which will be widely recognised across Europe.
The Sprayed Clay Backfill Technology project is aimed at further developing the technology required for filling empty spaces in underground constructions (or between the construction and the rock milieu) using sprayed clay soils as the filling and sealing material.
The Evaluation of the Saturation Media and Long Term Thermal Loading Impacts on Bentonite- Based Materials project involves detailed research focused on the long-term stability of bentonite sealing materials under various conditions (Fig. 8 - right).
The results of experimental work in Josef are used for improvement of numerical models of disturbed rock mass. This includes using advanced statistical models for rock mass characterisation.

Figure 8: TIMODAZ experiment (left) and bentonite plugs sampling (right)

Conclusion

The importance of the Josef UEF to the standard of education provided by the FCE CTU, Prague lies in improving the attraction of the various courses offered for students as well as in the provision of practical experience and improved preparedness for the world of work. The huge potential of the underground area as well as the facility's surface area will be further utilised to gain the maximum benefit from this unique opportunity.

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