BGE TECHNOLOGY NEWS

4
2023

Large-scale in-situ test for a drift seal in a salt formation, STROEFUN Project

BGE TECHNOLOGY GmbH

BGE TEC supports IAEA Working Group on development of RD&D programmes for DGR

Dear Readers,

I am glad to present you with our latest newsletter number 4/2023, which is also the last one for this year. Writing these lines was a little shock for me. It indicates that the year, slowly but surely, will come to an end, but there are still so many things to do or new things that want to be started. The following articles give a good overview of the things that have been or will be done. I am happy to introduce you to our exciting projects and our world of innovation.

Projects that come to an end are for example the screening of existing FEP databases and the development of scenarios for the Dutch HLW repository concept in preparation of a preliminary safety case. The engineering support in preparing the demonstration of deep borehole disposal can be highlighted as well.

Exciting innovation is for example represented by the work in the Pionier project, which made great progress during the year, and the goals are almost fully achieved. The project consisted of developing and implementing a new material model for claystone that incorporates the mechanical, thermal, and hydraulic behaviour of the rock. Together with the Institute of Engineering UNAM (IINGEN), a suitable constitutive model was implemented within the open-source computer code OpenGeoSys (OGS). The model incorporates a number of characteristic features of indurated clayey materials, including anisotropy and time-dependent deformations. Furthermore, the model was extended to temperature-dependent effects on the mechanical and hydraulical behaviour and couplings between them. Now, an advanced model is available that has demonstrated its capabilities in various benchmarks.

Parallel to this, new activities, like the further investigation of support structures in clay or the functional assessment and geo-mechanical and fluidic characterisation of properties of an MgO drift seal, have started. The first activity is represented by the follow-up project AGENT002. This project continues the successful cooperation with DMT GmbH & Co. KG. This time, the focus is on the crossings of mine openings, the design of their support systems, as well as on the interaction between the underground structures in an emplacement field. For the planned numerical simulations, the advanced clay model from the Pionier project will be very helpful as well. The second activity is represented by the project FUNGUS. It is a follow-up to the projects STROEFUN I to III. In FUNGUS, we seize the unique opportunity to further investigate the existing half-dam at the Teuschenthal mine.

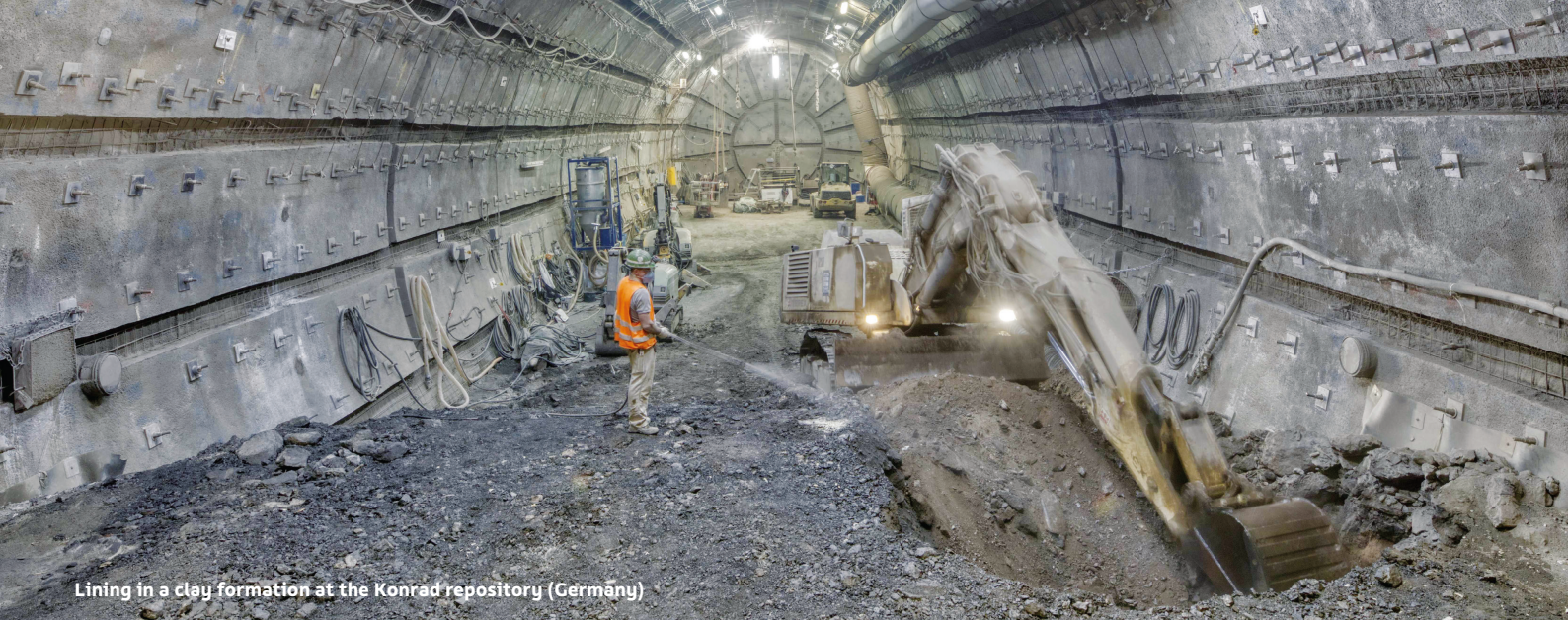
So, there are many good reasons to look positively into the future while the end of the year is approaching. Let the reading convince you! Enjoy and thank you for being part of our loyal readership!

Happy Reading!
Philipp Herold

BGE TECHNOLOGY GmbH Supports COVRA in Their Generic Studies on the Dutch Salt Formations

The Dutch programme for analysing options for the disposal of radioactive waste in a deep geological repository in salt formations is at an early stage. For developing suitable disposal options and for evaluating their long-term safety, generic studies have to be carried out. To prepare a generic performance assessment, a FEP catalogue and scenario development are necessary. BGE TECHNOLOLGY GmbH has been commissioned by COVRA with the preparation of the corresponding documents for a repository in salt rock.

For preparing the required FEP catalogue, the NEA-IFEP-list and FEP catalogues from different German salt projects have been analysed and adapted to the Dutch inventory, geology, and repository design. The FEP catalogue includes FEP descriptions, indicates their relevance to performance and safety, identifies FEP interactions, and describes results of a FEP screening (plausibility check). The FEP catalogue includes all information necessary for scenario development. On this basis, the expected future system evolution (= base scenario) has been derived by applying the corresponding German methodology. Key issues of this method-



Lining in a clay formation at the Konrad repository (Germany)

ology are the evolution of the engineered barrier system (EBS) and the radionuclide mobilisation and transport. Additionally, specific assumptions on future climate evolution, the functionality of the EBS, and on undetected geological properties have to be made.

Furthermore, seven representative alternative scenarios with a low probability of occurrence have been defined. They address the failure of different components of the EBS and less probable radionuclide mobilisation and transport. Additionally, three potentially relevant "inadvertent human action scenarios" have been identified.

The study provides the fundamentals for COVRA's generic safety assessments.

Support Structures for a GDF in Claystone

Within the R&D project AGEnT (the German acronym for support structures for mine openings in HLW repositories in claystone), BGE TECHNOLOGY GmbH together with DMT GmbH & Co. KG already started the development of such structures. As of this summer, the project is being continued in a follow-up project. The project is sponsored by the Project Management Agency Karlsruhe (PTKA), on behalf of the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection. The title and the general topic changed slightly. In the new project called AGEnT002, long-living main drifts and their crossings are in the focus. The plan is to further develop the support structure concept of AGENT for long-living drifts by means of in-depth planning of the proposed wedge block lining and its individual elements. This also includes compressible elements outside of or in between the wedge blocks. Furthermore, the development and dimensioning of the crossings between long-living drifts will be carried out. In the context of a German HLW/SF repository, this is the very first time that such an in-depth investigation of the crossings is done. The crossings are exposed to complex stress conditions, which places special demands on their design and the individual (intermediate) construction steps during installation. The support structures developed will finally be analysed in a global model of a full emplacement field. With the help of hydro-mechanically-coupled models, desaturation and damage processes in the near-contour area will be analysed. The models thus allow a better process understanding of the interactions between the types of support structures and the mine openings and the influence of the different rock properties.

Functional Assessment of Geomechanical and Fluid Engineering Properties of an MgO Drift Seal

In the past year, the project STROEFUN III was finalised. The measuring system to determine the hydraulic properties of the contact zone developed within this project was tested successfully in situ. It is installed in the Teutschenthal half-dam, which was erected for the purpose of testing. As the measuring system operates non-destructively and the half dam is still accessible, further measurements can be taken. The time-dependent sealing of the contact zone is of major interest for the safe containment of radioactive waste. Up to now, this time-dependent process has not been observed in situ directly but solely indirectly or on a laboratory scale. This time-dependent process takes place at every rock salt location due to convergence-induced pressure build-up. Due to its relevance for demonstrating the safe containment of radioactive waste in rock salt, our parent company BGE took over responsibility for continuing the measurements and contracted BGE TECHNOLOGY GmbH to establish a follow-up project in order to support the closure of the Morsleben repository (ERAM). The currently starting project – called FUNGUS (Functional Assessment of Geomechanical and Fluid Engineering Properties of an MgO Drift Seal – Interactions with Salt Formations and Mine Atmosphere) – focuses on the hydraulic and mechanical properties of the contact zone between the salt formation and the sealing body made of Sorel concrete and their evolution with time.

Furthermore, when erecting the half dam, a number of unexpected matters occurred, e.g. interruptions during the concreting process. It is intended to investigate the resulting joints between different layers of concrete in more detail with respect to their hydraulic properties. Based on the results, it should be evaluated whether construction joints can be tolerated or must be avoided. A further research objective is the investigation of the foam development observed during the construction of the half-dam in STROEFUN III. The foam composition and development will be investigated. Potential causes of this foam development need to be identified in order to be able to give recommendations on how to avoid or at least minimise the development of foam in the future.

As in the previous project, a number of partners will be involved in FUNGUS and support BGE TECHNOLOGY GmbH with their expertise. While in STROEFUN III, the project lead was in hand of Technical University Clausthal, BGE TECHNOLOGY GmbH has now taken over this part. Other than these two institutions, IBeWa, K-UTEC, and the Helmholtz Zentrum Dresden Rossendorf will participate in the scientific work, while TS Bau will carry out the required drilling and con-

Stand of BGE and BGE TECHNOLOGY GmbH at the KONTEC 2023 in Dresden (Germany)

struction work in the mine. GTS will continue to support as a local partner and will provide the location and the necessary means of transport on site.

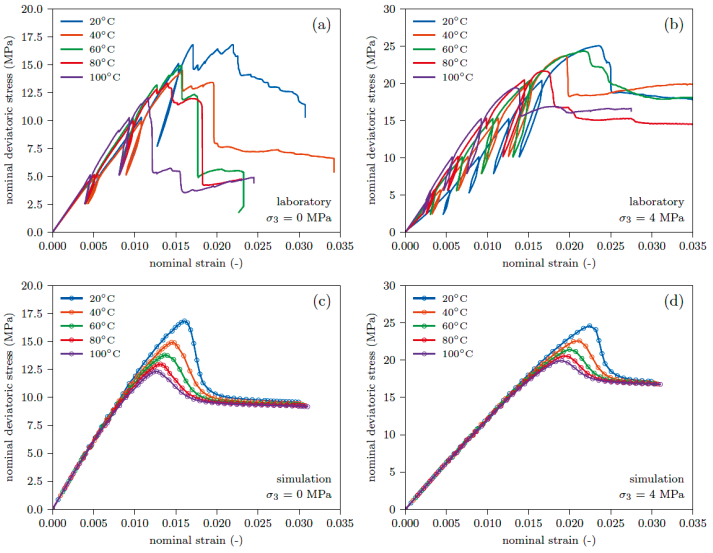
Development and Validation of a THM Model for Claystone

BGE TECHNOLOGY GmbH was commissioned by BGE with the project PIONIER to develop constitutive material models for claystone with the aim to support BGE's activities in the work package HITEC of the European Joint Programme on Radioactive Waste Management (EURAD). The new material model will incorporate the mechanical, thermal, and hydraulic behaviour of the claystones. Together with the Institute of Engineering (IINGEN, Mexico City) a constitutive model was implemented into the open-source computer code OpenGeoSys (OGS). The model incorporates characteristic features of indurated clayey materials like anisotropy and time-dependent deformations. The model enables a simulation of localised deformations through a non-local regularisation. The final objective is the simulation of the thermo-hydro-mechanical behaviour of stiff argillaceous formations in the context of deep geological disposal of nuclear waste within the OGS modelling platform.

For the implementation of the model, the basic version of the model was implemented first. In a second task, the model was further developed to incorporate thermal effects according to recent approaches in literature and to results coming out of the HITEC project.

Concerning the thermal enhancement of the model, two main phenomena have been addressed: (1) the continuous variation of mechanical properties (e.g. shear strength) with temperature and (2) the temperature-induced reversible expansive strains followed by irreversible contractive strains.

After implementation, simulations of a series of temperature-controlled triaxial compression tests on Callovo-Oxfordian argillite (COx) samples have been carried out for model validation. Although the laboratory data shows significant scattering, the simulations were able to reflect the behaviour of the clay. For instance, a higher strength loss was obtained for the unconfined simulations. The highest peak deviatoric stress is attained for the lowest temperature (20°C), and it reduces as the temperature is increased up to 100°C. Overall, a very good agreement can be identified, demonstrating the capability of the model to reproduce the effect of temperature on the strength of the COx claystone.



Deviatoric stress vs. axial nominal strain (a,b) from laboratory data and (c,d) from simulation results

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