BGE TECHNOLOGY NEWS

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BGE TECHNOLOGY GmbH

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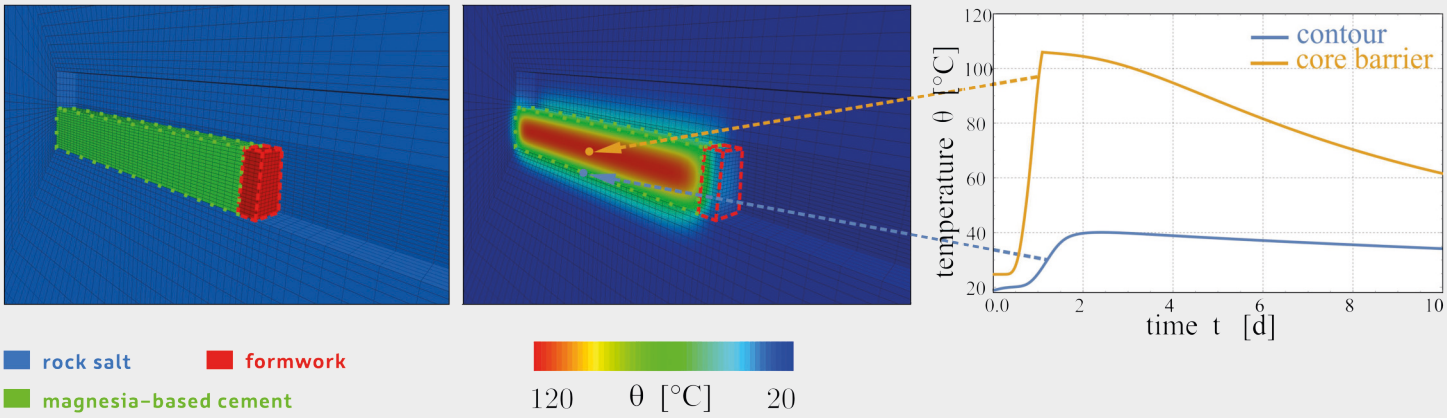
- TRANSPORT AND EMPLACEMENT TECHNOLOGY



Temperature evolution of magnesia-based cements during the hydration process

Dear Readers,

Yet another year has passed – but what a year it was!

Being active in the area of radioactive waste management, we are naturally used to building our activities and our thinking around the health and safety of people. However, already at the beginning of the year, Covid-19 took control of the whole world and we, like so many others, had to learn how to cope with a completely new situation. Personally, we have been driven by the concerns and worries about our families and friends, our neighbours, colleagues, and partners. Professionally, we were determined to perform our work at the quality level we always have been committed to while complying with all restrictions caused by the pandemic – be they required by law or owed to common sense. In essence, we faced a more digital life, fewer personal meetings, and more commingling and higher coordination of our private and professional lives.

Despite all challenges, we succeeded in several aspects in 2020. "We", that is our parent company, BGE, and us, BGE TECHNOLOGY GmbH.

BGE achieved a major milestone in the site selection process for a high-level radioactive waste repository by publishing the sub-area interim report. Transformation of the Konrad mine into a repository for low- and intermediate-level radioactive waste progressed, and the concept for the retrieval of waste from the Asse mine was published and discussed with important Stakeholders. In addition, knowledge about the site's geology was raised to a new level through extensive characterisation from the surface and from underground.

At BGE TECHNOLOGY GmbH, we successfully established our own, tailor-made quality management system, so that we were able to get it certified in July. But most importantly, we were able to move our projects forward. To demonstrate how versatile our work is, we present to you the R&D project STROEFUN, which aims at developing a concept for demonstrating the effectiveness of a sealing structure in a drift including a large-scale test. In the R&D project TREND, existing transport and emplacement technology is being developed further. Carrying the knowledge gained in R&D projects into reality can be seen in our projects dealing with designing support systems in the Konrad mine or with the refurbishment of the hoisting system for shaft 1 of the Mol URL in Belgium.

In any case, we hope to meet you in person again next year, and to discuss our projects maybe in more detail face-to-face. Until then, I say thank you to all our clients and partners for their loyalty and for the constructive ways of moving through the current times, and especially to all colleagues, who ensured this year's achievements through their high level of commitment.

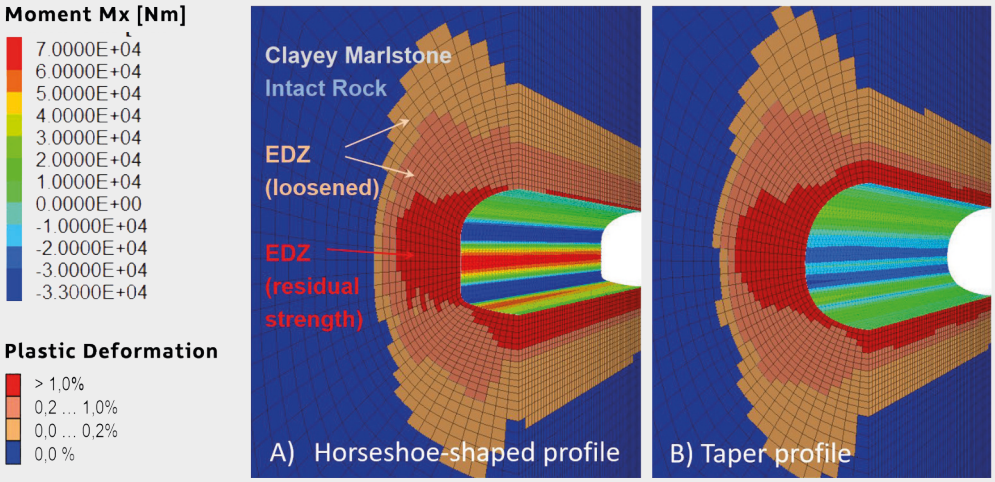
Happy reading.

Take care and stay healthy!
Thilo Berlepsch

Improving the Contact Zone of Geotechnical Barriers

To guarantee the safe containment of radioactive waste in a containment providing rock zone (CRZ), drift seals – in addition to the geologic barrier – play a fundamental role as they are to seal the access routes into the emplacement areas. Drift seals consist of a seal/abutment body made of magnesia-based concrete, the excavation damaged zone (EDZ) close to the drift contour, and the contact zone between the seal's body and the drift contour. Regarding the functionality of the drift seal, these three components act in parallel. Thus, the component with the lowest hydraulic resistance is decisive for the drift seal´s effectiveness.

The functionality of the sealing body can be demonstrated by testing. The contact zone is influenced by constraint stresses that arise from the thermomechanical impact during concreting as well as from the different stress-strain relations of the rock salt and the sealing body. If the rock salt and the sealing body undergo equal deformation in the contact zone, constraint stresses arise and may lead to micro-cracks. Consequently, the permeability increases, which can be detected by permeability measurements. Typically, pointwise measuring results are available from permeability tests in boreholes. Within the joint R&D project STROEFUN, a method to test the permeability of the contact zone along the entire contour of a sealing cross-section has been developed. Furthermore, the hydraulic conductivity of the contact zone will be reduced by injection measures. To test this method, a pilot test will be carried out in



Result of mechanical modelling for a drift in the Konrad repository

the Teutschenthal salt mine. Currently, the concreting of the pilot test is being prepared. During the in-situ test phase, it is planned to measure the evolution of the permeability of the contact zone and the improvement of the contact zone due to injections.

The R&D project STROEFUN is funded by the Project Management Agency Karlsruhe on behalf of the Federal Ministry for Economic Affairs and Energy and managed by the technical university of Clausthal. BGE TECHNOLOGY GmbH is involved as subcontractor.

Drift Design and Support Load Determination for the KONRAD repository

The Konrad mine is currently being converted into an LILW repository. The corresponding work includes extensive excavations for building the infrastructure rooms, enlargement of existing drifts, and installation of support systems in the control area of the future repository near shaft 2 and in the monitoring area as well. As support, an adaptable anchor-/shotcrete system is chosen, based on sliding anchors or fully glued steel, or glass fibre (GFK)-anchors and one or two shotcrete layers as concrete lining. Depending on the geological and geomechanical requirements, the support varies between stiff and yielding during the early stages. Some of the support systems are designed to cover the entire operating phase of the repository, in particular infrastructure rooms and drifts used for a long time.

To dimension the support systems, numerical calculations that take into account the local geologic and tectonic settings, the excavation process, and the installation of the support system are carried out. BGE TECHNOLOGY GmbH currently carries out such calculations for a drift that is to be used in the long term and for a room that will be used as a workshop for an E-truck. In addition to the numerical analyses, BGE TECHNOLOGY GmbH conducts geotechnical assessments and provides results of the analyses, e.g. stress-resultants for BGE's subcontractor EDR GmbH.

To achieve an efficient and economic design, it was crucial to classify the support systems into "free of maintenance" and "free of refurbishment/recovery", depending on their future use and on aspects like permanent or temporary traffic, equipment installed, and the related mounting/dismounting effort.

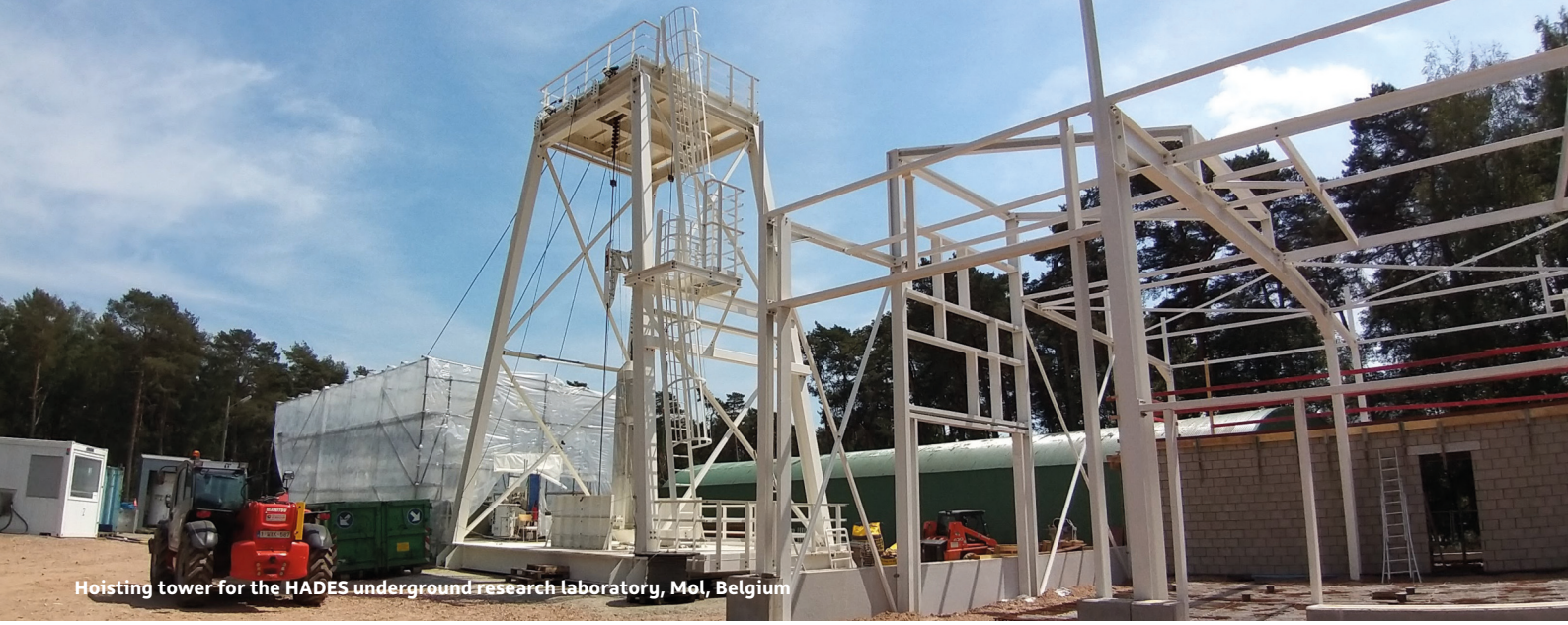
By accepting minor maintenance work during the operating phase, such as re-cutting of floor uplift, replacement of single anchors, minor shotcrete work, etc., it became possible to select a support system that comprises GFK-anchors and only one shotcrete shell. Despite the heterogeneous geology and local faults, long drift sections can be realised with a common horseshoe-shaped profile without floor retainment. Circular or taper cross-sections are only chosen where necessary. This way, an optimised and less complex and costly support system can be realised.

Development of Long-term Stable Backfilling and Sealing Materials

In geological disposal facilities (GDF), sealing with engineered barriers (EBS) is carried out in order to ensure that no harmful quantities of radionuclides are released into the biosphere. The borehole, drift, and shaft seals are to restrict or prevent the flow of fluids. Backfill stabilises the cavities and thus prevents the generation of new flow paths. Therefore, requirements for strength, stiffness and, in the case of seals, the permeability of the structures and the building materials are defined. However, interactions with fluids may change EBS material properties and restrict their long-term function.

Due to the extraordinary importance of these processes, the working group Concrete Corrosion was founded by the German Association for Repository Research (DAEF). This association promotes research and development in the field of nuclear disposal by fostering cooperation. The working group gathers knowledge about corrosion, summarises the state-of-the-art technology in backfilling and sealing measures, identifies possibilities for optimisation, and the need for research.

An essential cornerstone for this work is the knowledge of BGE TECHNOLOGY GmbH on the corrosion behaviour of building materials, which has been gained in many national and international projects, and is a prerequisite for the development of optimal backfilling and sealing materials, the design of underground structures, and the implementation of technical demonstrations of their functionality. This way, BGE TECHNOLOGY GmbH can show efficient ways for a target-oriented development of long-term stable backfilling and sealing materials as a basis for the safe sealing of GDFs.



Hoisting tower for the HADES underground research laboratory, Mol, Belgium

Shaft 1 Renovation of HADES Undergound Research Laboratory

Since 2017, BGE TECHNOLOGY GmbH and their partner Tractebel Engie consult ESV EURIDICE GIE in the renovation of the shaft hoisting system of Shaft 1 of the underground research laboratory HADES in Belgium.

After developing specifications for the renovation work in close cooperation with the client, BGE TECHNOLOGY GmbH assisted in managing the tendering procedure for Lot 3 of the project (shaft equipment and hoist installations) and in selecting the contractor for detailed engineering and construction works. Construction started at the end of 2019. Using a temporary hoisting system, all former shaft installations have been removed. Since then, the concrete of the shaft has been inspected and repaired where necessary, and the new shaft equipment has been installed. The winches of the new hoisting system have been procured and are already on site. The major part of the remaining work is thus the erection of the final headframe and the concluding commissioning of the hoists with approval of an accredited expert for shaft hoists. The plan is to start hoist operation in Shaft 1 in April 2021. During the ongoing construction phase, BGE TECHNOLOGY GmbH consults Euridice with regard to a variety of technical questions and oversees the conformity of the works with the tender specifications.

Transport and Emplacement Technology

For approx. two years, BGE TECHNOLOGY GmbH has been tasked with the further development of the technology needed to transport and emplace high-level nuclear waste in the deep underground.

The aim of the R&D project TREND is to bring the existing concepts of transport and emplacement technology for various waste packages and different emplacement options to a comparable level of development. This has to be achieved across the various combinations of emplacement concepts, waste containers, and host rock formations, too.

The designs for the direct emplacement of transport and storage casks and for vertical borehole disposal were advanced taking into account the state of the art in technology and contemporary regulations. One major adjustment was equipping the emplacement device for vertical borehole disposal with a second hoisting rope. This decision was not driven so much by operational safety but by the requirement of retrievability of all waste containers during the operational phase of the repository. As a crash of a waste container into a vertical borehole would render retrieval extremely difficult, this risk was minimised by introducing a redundant second hoist rope. For emplacement in crystalline rock, a technical concept was developed to emplace waste containers in vertical boreholes without the need for a borehole cellar, as required in the former disposal concept. For horizontal borehole disposal, a completely new strategy, which relies on pressurised air, was investigated. This solution does not require mechanical or hydraulic means for pushing waste containers into the horizontal borehole, which can fail and result in radiological exposure problems. The update of the emplacement technology in drifts is still ongoing. All machines considered were modelled in 3D, and the most important operational processes were also animated.

The project is funded by the Federal Ministry for Economic Affairs and Energy (BMWi), represented by the Project Management Agency Karlsruhe (PTKA).

For further information, visit www.bge-technology.de or scan the QR code below.

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