INFLUENCE OF REGIONAL FLOW ON FLUID FLOW IN BENTONITE-BASED DRIFT SEALING SYSTEM

Victoria Burlaka, Michael Jobmann

BGE TECHNOLOGY GmbH, 31224 Peine, Germany

8TH INTERNATIONAL CONFERENCE

13-16 June 2022 - Nancy (France)

ON CLAYS IN NATURAL AND ENGINEERED BARRIERS FOR RADIOACTIVE WASTE CONFINEMENT

Introduction

Within the framework of the R&D project "Development of a safety and verification concept for a repository for heat-generating radioactive waste in crystalline rock in Germany" (CHRISTA-II), BGE TECHNOLOGY GmbH has developed a conceptual design for drift seals. The conceptual design includes main sealing elements made of bentonite and concrete-based abutments (Fig. 1). Regional flow can have a strong impact on radionuclide transport and hence, on the long-term safety of a repository. In the present study, the influence of three horizontal pressure gradients of 10 Pa/m, 100 Pa/m, and 1000 Pa/m on the water velocities in the bentonite based sealing elements was investigated. Furthermore, the robustness of bentonite-based drift seals in case of complete chemical degradation of asphalt elements after 10,000 years for the case of a pressure gradient of 100 Pa/m was analysed.

Methods and Materials

Three-dimensional simulations using TOUGH2 together with module EOS3 have been performed to simulate one-phase flow in the model.

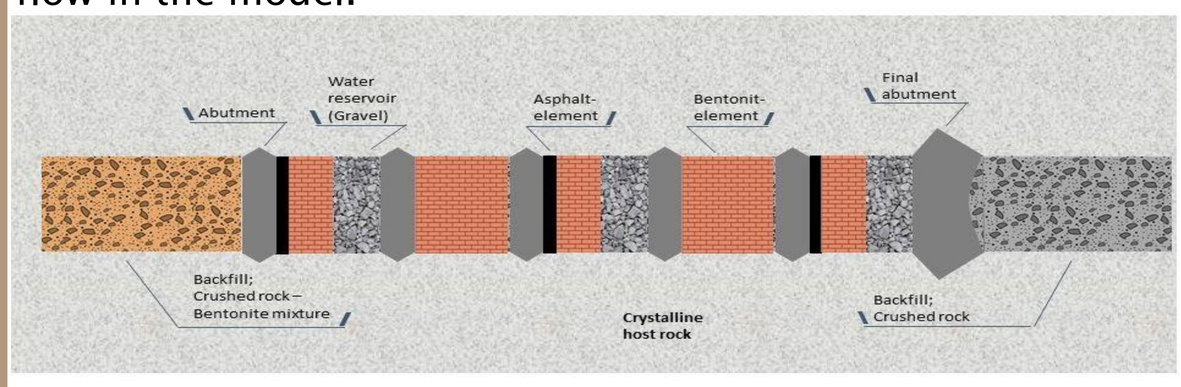

Fig. 1 Conceptional design of a bentonite-based drift seal in crystalline host rock

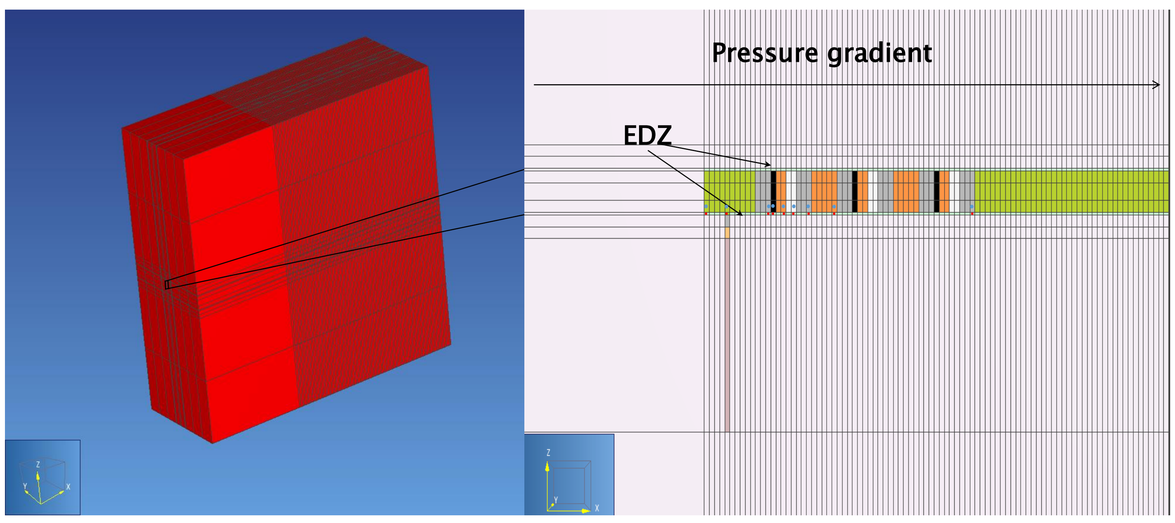

Fig. 2 3-D model and enlarged mesh of the drift seal area in the xz plane, blue points correspond to the observation points in the drift seal, red points correspond to the observation points in the EDZ elements

The drift has a length of 91 m and a cross-section of 49 m², EDZ has a thickness of 0.5 m in the model.

Element	Permeability K [m²]	Porosity n [-]
Gravel	10^{-13}	0.4
Asphalt	10^{-23}	0.01
Abutment	$2 \cdot 10^{-17}$	0.2
Bentonite	10^{-17}	0.3
Host rock	10^{-19}	0.01
Backfill	10^{-16}	0.3
EDZ	10^{-18}	0.05

Table 1 Material properties used in simulations

Results

The average water velocities in the bentonite-based drift sealing system were calculated.
Under a pressure gradient of
10 Pa/m the average velocity is **$2.35 \cdot 10^{-12}$ m/s,**
100 Pa/m is **$2.35 \cdot 10^{-11}$ m/s**,
1000 Pa/m is **$2.35 \cdot 10^{-10}$ m/s.**
The water velocity (Fig. 3) is reduced by several orders of magnitude in the asphalt element. The water flows in the area of the asphalt element mostly through the EDZ, as the asphalt elements are impermeable.
In order to analyse the robustness of the drift seal even in case of degradation of the asphalt elements after 10,000 years, the velocities in the sealing elements for the case of pressure gradient of 100 Pa/m in the model without asphalt elements were determined.
The average velocity in the sealing system is
$2.35 \cdot 10^{-11}$ m/s **with asphalt** elements,
$8.25 \cdot 10^{-11}$ m/s **without asphalt** elements
The presence of **asphalt elements reduces the water velocity** within the bentonite-based sealing system **by at least half an order of magnitude.**

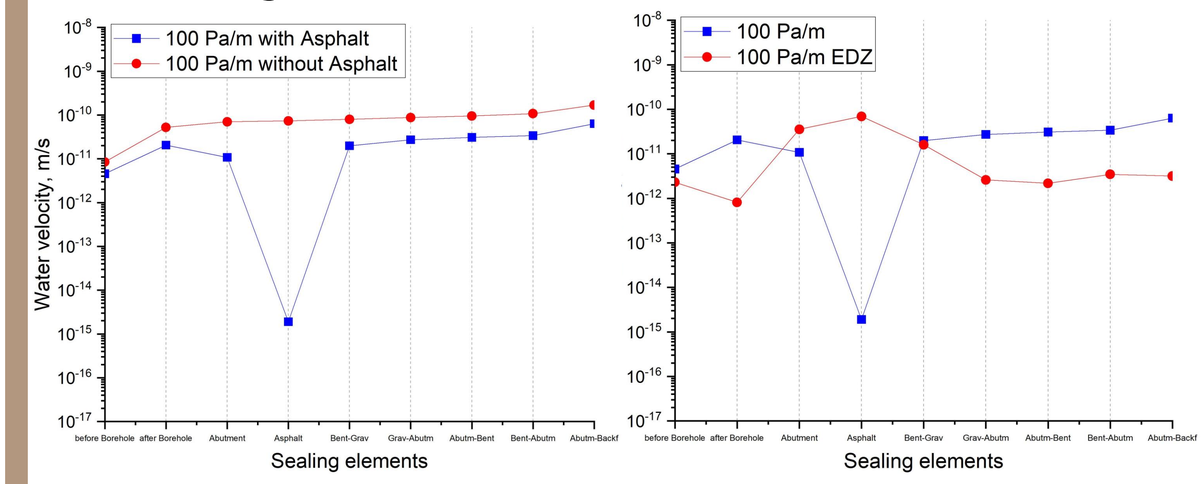

Fig. 3 Water velocities in the sealing elements in the models with and without asphalt elements under a pressure gradient of 100 Pa/m (left) and water velocities in the sealing elements and EDZ elements in the model with asphalt elements under a pressure gradient of 100 Pa/m (right)

Conclusions

It was demonstrated that regional flow has a great influence on the water velocities in the bentonite-based sealing system and hence, on the radionuclide transport in a repository. Asphalt elements reduce the water velocity in the sealing system. Assuming that asphalt elements will not last for the entire demonstration period, this is a positive effect that contributes to the robustness of the drift sealing system, at least during the initial phase of the demonstration period, especially in the period when the bentonite has not reached its full swelling pressure and thus its full sealing capability.

Acknowledgments

The R&D project “Development of a safety and verification concept for a repository for heat-generating radioactive waste in crystalline rock in Germany” (CHRISTA-II) was funded by the Federal Ministry for Economic Affairs and Energy (BMWi) and supervised by the Project Management Agency Karlsruhe (PTKA) of the Karlsruhe Institute of Technology (KIT).

BGE TECHNOLOGY GmbH

MANAGED BY PTKA Project Management Agency Karlsruhe Karlsruhe Institute of Technology

Supported by: Federal Ministry for Economic Affairs and Energy on the basis of a decision by the German Bundestag