Experiences from an In-Situ Test Site for a Sealing Element in Shafts and Vertical Excavations in Rock Salt

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The repository for radioactive waste at Morsleben (ERAM) in Germany containing low-level and medium-level wastes is under licensing for decommissioning. The decommissioning concept includes the sealing of the two shafts and one vertical seal. These seals consist of sealing elements containing gravel and bitumen and/or asphalt. Both components, gravel and bitumen, have been tried and tested as single elements in the closing of shafts. A combination of both elements is used for the first time. Therefore, several tests have to be carried out. After laboratory and large-scale tests at the surface, an in-situ test underground as an experimental set-up comparable to the future sealing elements has been performed.

The test has been carried out in a vertical excavation with a nearly square base area of about 12 m^2. The height of the sealing element built of gravel and asphalt is about 6 m. The filling success is assessed by the measured pressure and by calculating the remaining pore volume between gravel grains and bitumen based on the masses of the materials used and the measured volume of the excavation. To assess the influence of hot bitumen on the rock mass, temperature measurements are carried out.

This paper gives an overview of the results from the surveying measurements and focuses on the construction process taking into account the difficulties of working underground but meeting the quality requirements of a long-term sealing structure.

1 Introduction

The radioactive waste repository Morsleben (ERAM) serves as a repository for low and intermediate level radioactive waste. It is located in Saxony-Anhalt, Germany. Currently, the repository is in the phase of decommissioning. The shafts Bartensleben and Marie were excavated at the beginning of the last century and are connected on the 1st and 3rd level. Due to the former mining for the production of potash and rock salt, the excavation ratio is very high.

Overall, in the period from 1971-1991 and from 1994-1998, 37.000 m³ of radioactive waste were emplaced. The storage areas are in the mine Bartensleben in the northern, eastern, southern and western fields and also, to a smaller extent, in the central part (Fig. 1).

The decommissioning concept consists of an extensive backfilling of cavities, drifts and sealing of the two shafts. Additionally, one vertical and several horizontal sealing elements to separate the emplacement areas from the other mine areas will be built. All these sealing structures will constrain possible infiltration of brine and the migration of radionuclides into the biosphere.

The shafts will be sealed with a combination of various sealing elements consisting of gravel, asphalt and/or bitumen and clay. The sealing concept using gravel and asphalt and/or bitumen will also be used in one vertical excavation that connects several horizontal drifts /1/2/.

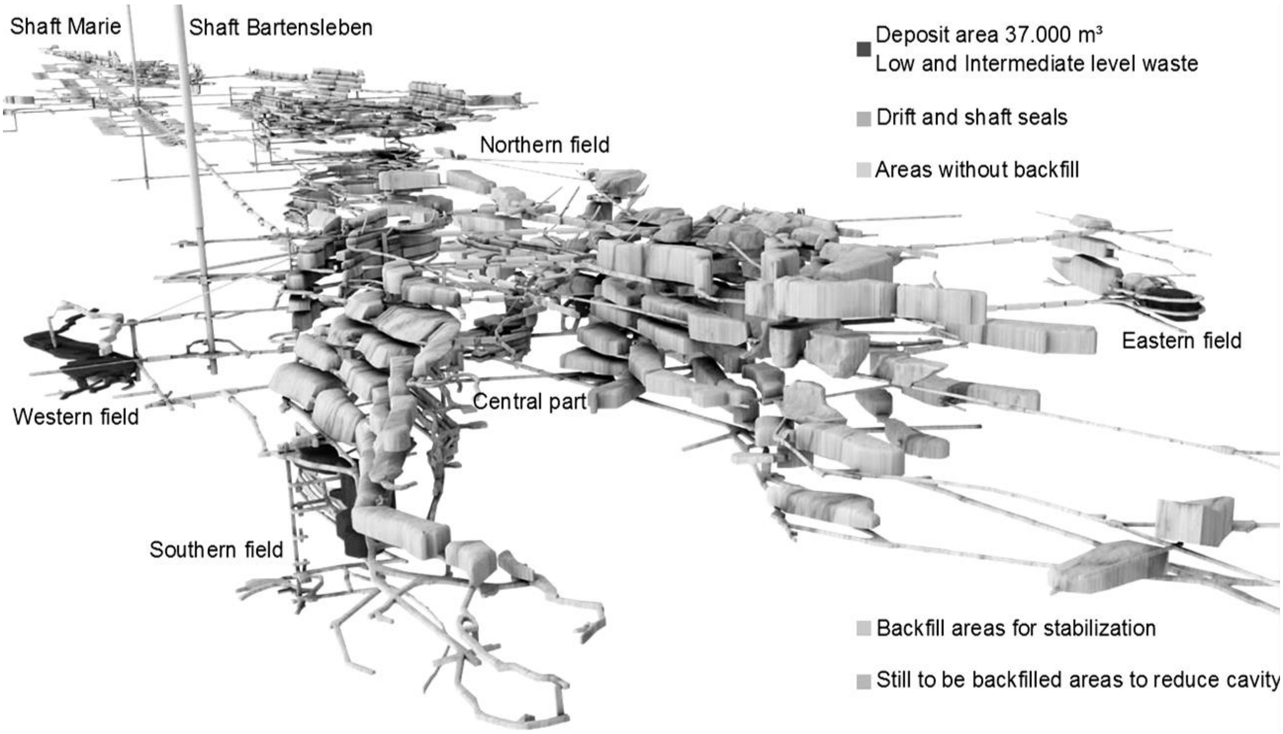

Fig. 1: Mine fields of Bartensleben with deposit areas (in foreground) and Marie (in background)

To show that these sealing elements can be constructed with the quality assumed in the safety assessments, several tests have been carried out. To demonstrate the material features and functionality of the combined abutment/sealing elements of gravel and bitumen and/or asphalt set out in the plans, several trials were executed.

In 2013, BfS tested the pouring of asphalt in gravel layers in a large-scale test at the surface. Based on monitoring data, the individual pouring tests were analyzed and their success was evaluated /3/-/6/. This way, important experiences could be gained for the large-scale test underground. In 2015, an in-situ test as an experimental set-up comparable to the future sealing elements was performed.

2 Scope and Objectives

Starting from the concept and the assumption in the safety assessments for the future sealing elements, a test site was chosen at the ERAM. The main goal was to show the technical feasibility of building a plug consisting of gravel and asphalt related to the logistic constraints underground as well as to the health and safety aspects concerning working with about 190°C hot asphalt in a vertical excavation.

Additionally, the influence of the hot asphalt on the surrounding rock salt and the pressure resulting from the asphalt filling the pores between the grains of the gravel are measured. A principle sketch of the test set-up and the measurement system can be found in Fig. 2.

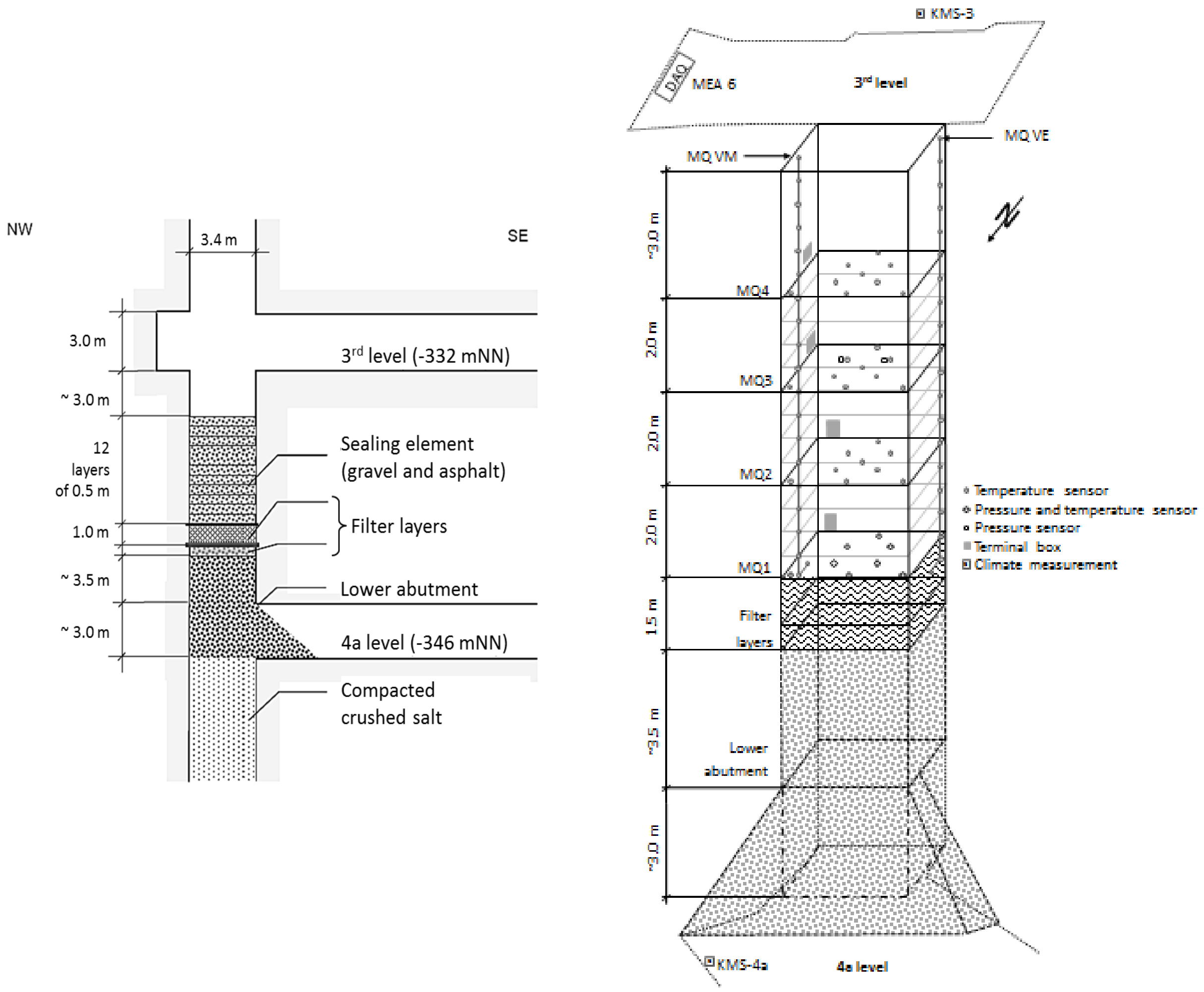

Fig. 2: Principle sketch of the test set-up and measurement system

3 Construction process

The test was carried out in a vertical excavation, the so-called IB blind shaft, with a nearly square base area of about 12 m^2. Among others, the construction site set-up included the following activities:

- The removal of existing equipment in the IB blind shaft,
- The installation of winches for person and material transportation required for the construction of the structure,
- The facilities mounting of the auxiliary ventilation of the working area,
- Mine survey of the blind shaft and marking of thickness of the gravel layers to be constructed.

After building an abutment of gravel and several filter layers, the sealing element with a total height of about 6 m was built. Above the last filter layer, pressure and temperature measurement instruments have been installed.

Before bringing in the gravel, two measuring chains with approx. 20 temperature sensors each were installed on the surrounding rock in the blind shaft. Furthermore, eight pressure sensors were installed on the filter layer at the bottom of the sealing element.

In the process of constructing the sealing element, further temperature sensors were placed in the gravel bed at a height of 2, 4 and 6 m. At a height of 4 m, two additional pressure sensors were placed. The temperature sensors measure the temperature changes in the gravel/asphalt-layers and on the rock surface. The pressure sensors measure the increasing pressure resulting from the filled-in asphalt.

Fig. 3: Transportation of the gravel in the blind shaft

Before starting the construction process, the material properties of the gravel and the asphalt (bitumen with limestone powder as filler) were controlled. Then, building of the sealing element consisted of the following steps: A layer of about 0.5 m gravel was dumped in the excavation and compacted (Fig. 3). The gravel was weighted and the compaction was checked by measuring the volume and calculating the density.

Then, the hot asphalt could be filled in after being weighted as well (Fig. 4). For filling the compacted layer of gravel, the asphalt, which has been produced in an external facility, was heated above ground in an asphalt cooker up to the required temperature of 170 - 190 °C and transported underground.

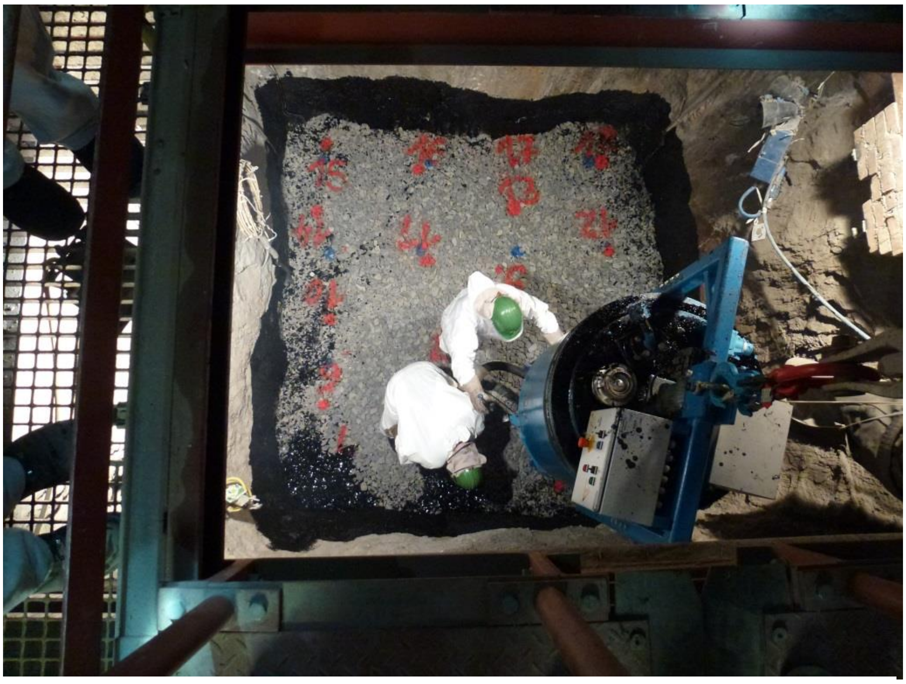

Fig. 4: Filling in the hot asphalt

After different waiting times ranging from about 12 hours to three days after filling, gravel for the next layer was dumped. Following the first layer of approx. 0.5 m thickness, two smaller layers of approx. 0.25 m thickness were built to improve the filling process. Then, 10 layers of approx. 0.5 m thickness were built, up to the planned height of the sealing element of approx. 6 m.

4 Results and Conclusions

The technical feasibility of building a vertical sealing element of gravel and hot asphalt has been shown. All quality requirements were met and all health and safety measures were implemented successfully. To check for potential air pollution during the work with hot asphalt, measurements were carried out by an external institution which stated that the permissible values were not exceeded.

For the temperature influence, see Fig. 5. The temperature in the filled-in asphalt reached about 160 °C just shortly, the temperature at the rock salt reached only about 45 °C at maximum. After some hours, the temperature decreased significantly. The initial surrounding temperature was reached after some weeks.

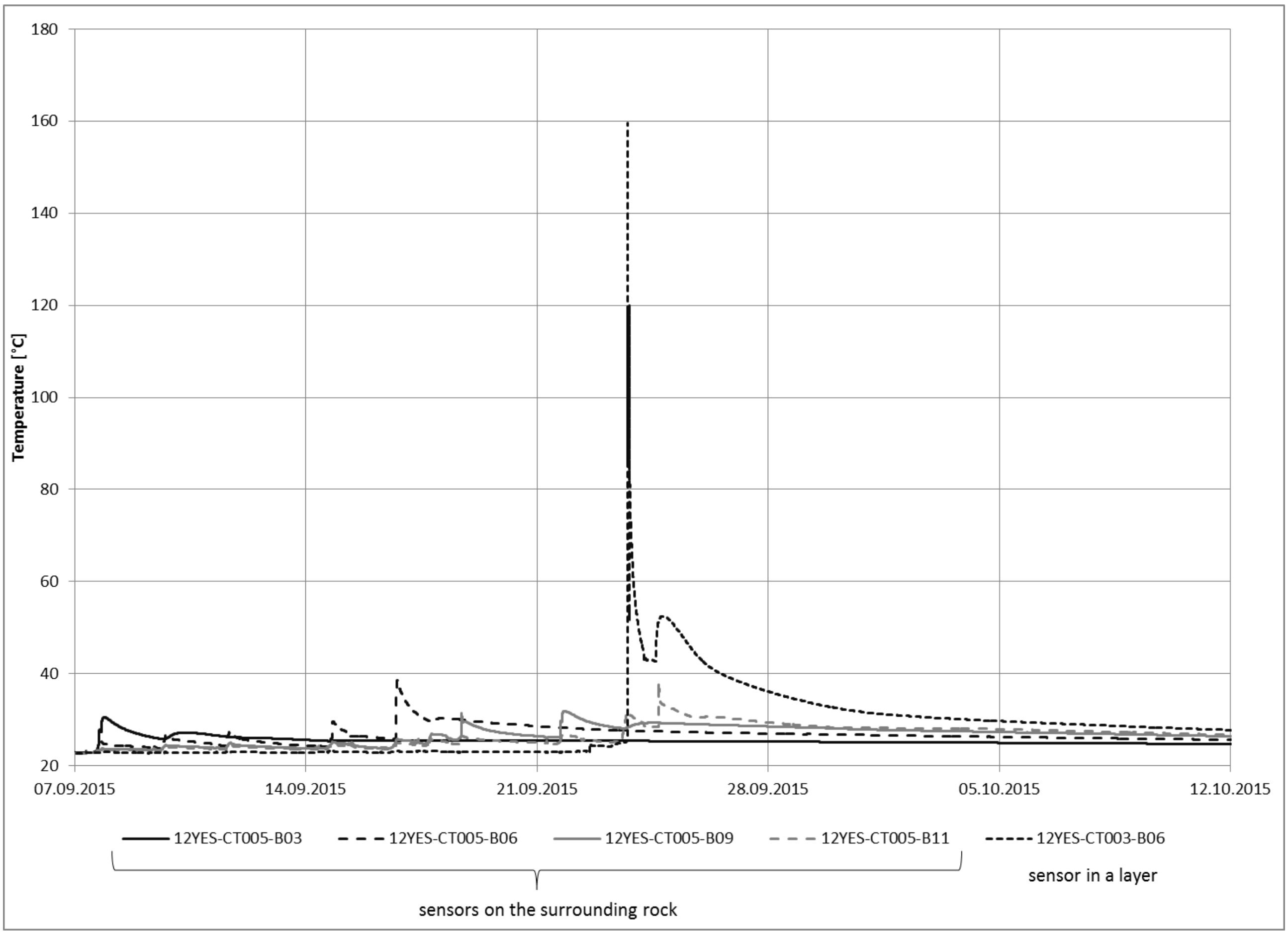

Fig. 5: Temperature in a layer and on the surrounding rock (representative sensors)

The filling success is assessed by the measured pressure, which is plotted in Fig. 6 for the sensors at 4 m height, and by calculating the remaining pore volume between gravel grains and asphalt based on the masses of the materials used and the measured volume of the excavation. For the latter, a remaining pore value of about 1.5% was calculated, which is below the target value of 3%. The pressure measurements prove that the asphalt acts like a liquid.

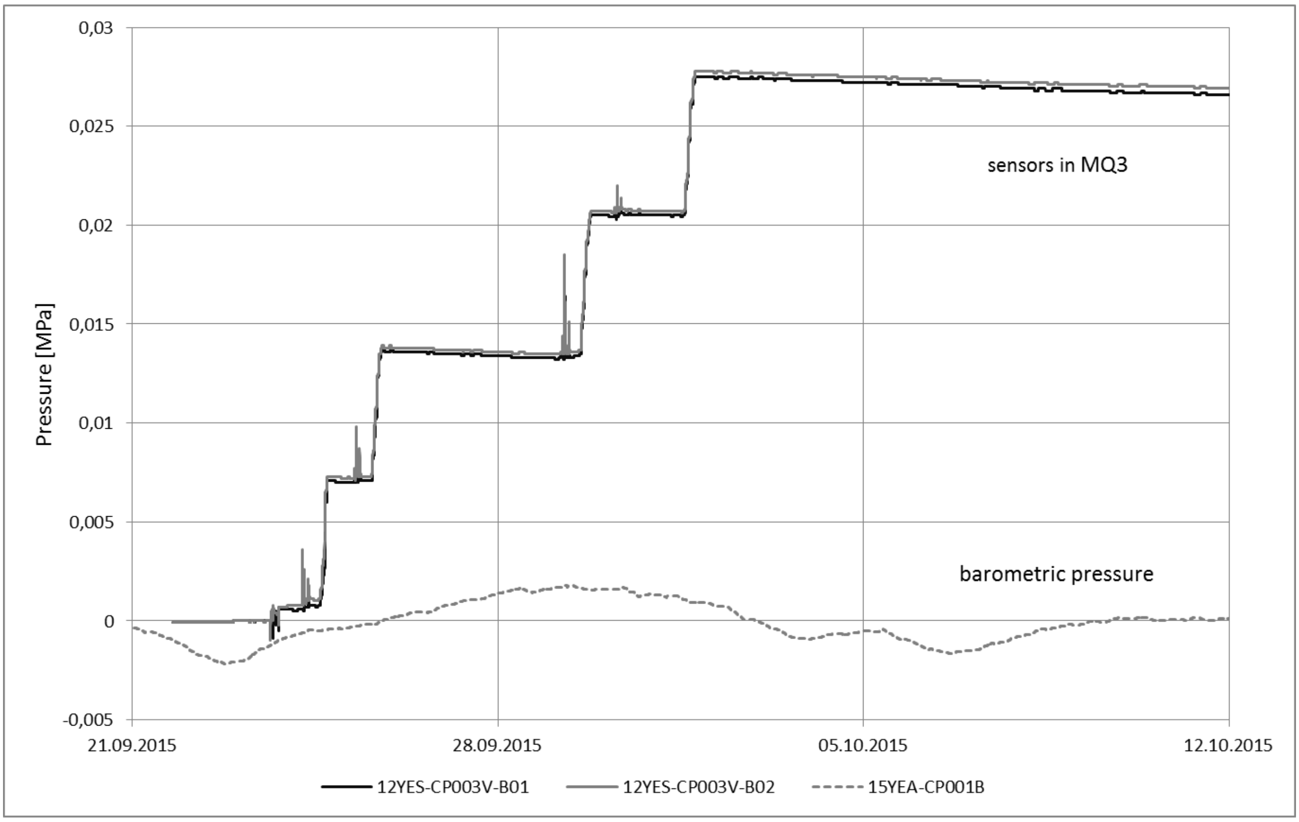

Fig. 6: Pressure at the sensors at 4 m height (MQ3)

The material properties were controlled by sample testing, and the construction process was monitored by quality measurements. The pressure measurements and the calculation of the remaining pore volume document the functionality of the sealing element. After extensive testing, it can be concluded that the vertical sealing elements can be built as assumed.

5 References

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