Effects of early water inflow and water uptake in a deposition holes (EVA)

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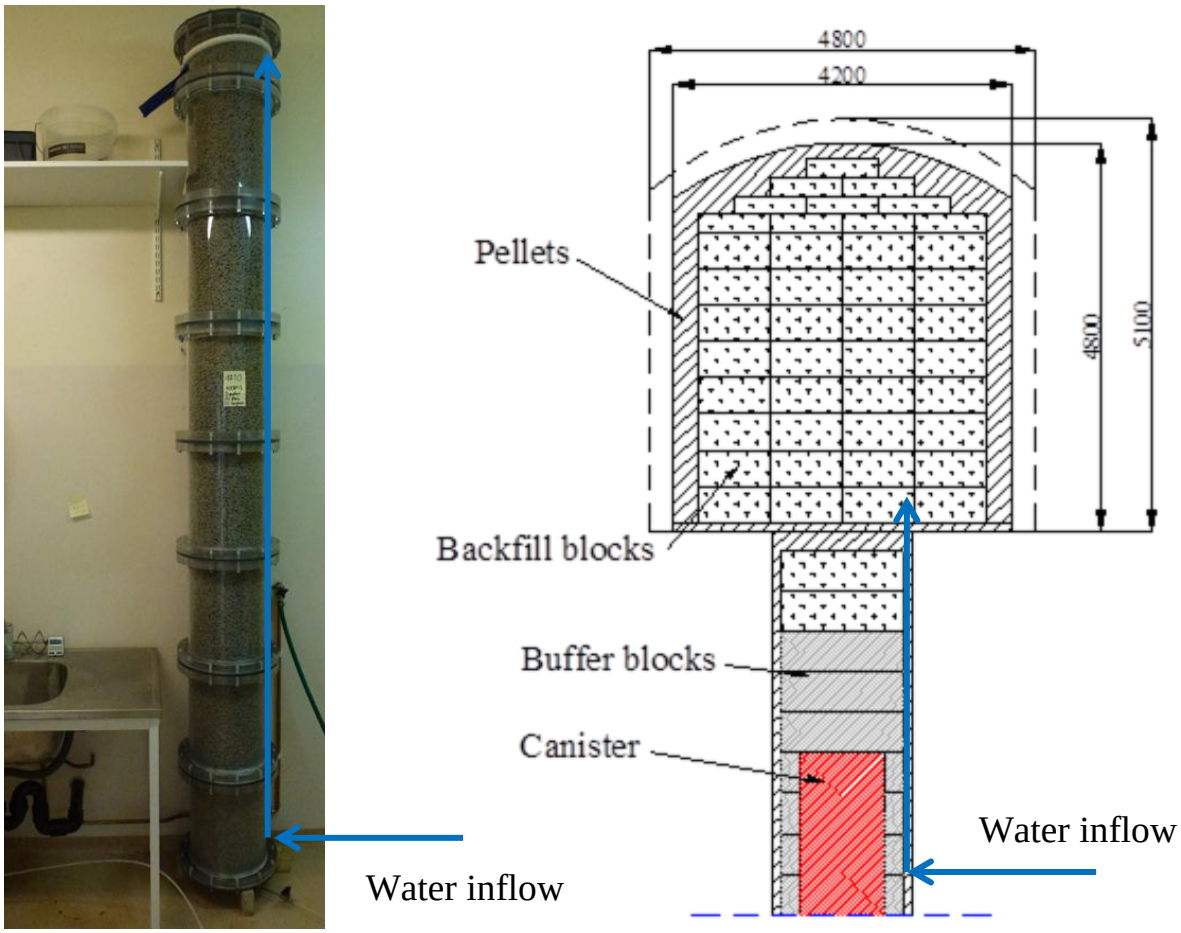

Simulation of water inflow into deposition holes for measuring erosion

Bentonite is an excellent sealing material after full water saturation when the high swelling pressure and low hydraulic conductivity can hinder water from flowing through the deposition holes. However, before the bentonite has produced a high swelling pressure that acts on the rock surface, which may take many years, it cannot prevent water inflow due to the very high water pressure that will be produced in the water bearing fracture at repository depth. If the water inflow is stopped the water pressure will rise in the fracture and since the pellet filling in the slots between the bentonite blocks and the rock cannot resist this pressure water will break the seal and force its way through the pellet filling.

The goals of the EVA- project have been to understand and develop models for critical processes at an early stage such as piping, erosion, water filling of pellets filled slots and early water absorption and to find bases for leakage criteria of the end plug in the deposition tunnel.

The project has only treated the processes up to the period when stagnant water flow situation has occurred and full water pressure has been applied on the plug. The water saturation phase afterwards and the homogenisation of slots and erosion damages have not been handled in the project with exception of the self-sealing of the erosion channels. The motivation for this exception is that the self-sealing of the erosion channels is tightly linked to the piping and erosion processes.

The project has included study of the following processes:

1. Erosion
2. Piping
3. Water flow in pellet filled slots
4. Ability to stop piping
5. Water absorption of the bentonite blocks
6. Formation of water or gel pockets in a pellet filled slot
7. Outflow of bentonite gel
8. Self-sealing of cracks by eroding water
9. Buffer swelling before placement of backfill
10. Self-sealing of erosion channels

In addition the study has included modelling. The following modelling work has been done:

1. Formulation of mathematical and conceptual models of some of the processes
2. Modelling of the expected inflow distribution in the Forsmark Repository
3. Modelling of water absorption of the buffer at different inflow situations

Finally a scenario description has been made. It has included the evolution of the hydraulic and mechanical processes in the bentonite in a deposition tunnel with deposition holes and an end plug in the time period from the installation until the end plug takes all the water pressure in the rock. All possible inflow combinations according to the inflow modelling have been considered.

The results have been used to compile bases for a decision on how tight the plug needs to be in order to prevent erosion from being damageable for the sealing ability of the buffer and the backfill.

The analyses have led to a number of preliminary conclusions regarding damages on the buffer and backfill. These conclusions have also been used as bases for the scenario analyses:

- The erosion follows Equation 3.2-1 with β=0.2 for the buffer and β=2.0 for the backfill as upper limits. The upper limits have been used in the analyses.
- Piping and subsequent erosion will occur and be maintained until the water pressure gradient is located at the plug and the flow rate out from the backfill is lower than 10^{-4} L/min. This flow rate is chosen since the process studies show that at lower flow rates the flow channels will be self-sealed and piping and erosion will stop. This means that

piping and erosion may continue at least during the life time of the plug i.e. 100 years, since the plug is not expected to have a lower leakage rate.

- Self-sealing of cracks in the plug or the rock will not occur. This is a pessimistic assumption based on that no real proof of sealing of cracks has been derived.
- Erosion channels with limited radial extension (1-2 cm) will be sufficiently healed, in order not to have a major influence on the hydraulic properties of the bentonite, when stagnant water pressure has been established.
- Formation of water or gel pockets may occur at low inflow rates but have not have not been considered in the scenario analyses

The following basic presumptions have been used in the scenario analyses:

- The analyses have considered the time span up to 100 years after closure of a deposition tunnel, except for the analyses of the effect of a malfunctioning plug where longer times also have been considered.
- The erosion damages have pessimistically been assumed to be located at the inflow point where all eroded material has been lost
- The following allowable loss of dry bentonite mass has been assumed:
    - Buffer: 100 kg
    - Backfill: 1 000 kg

Since a leakage through the plug and the rock is inevitable such scenarios have been studied.

Some scenarios with a non-functioning plug have been studied. The conclusions of these studies are that there may be no requirements on the plug tightness but that it depends largely on the time to fill up the repository with water.