ASSESSMENT OF BACKFILL MATERIALS AND METHODS FOR DEPOSITION TUNNELS

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INTRODUCTION
The safety of a KBS-3 type of repository for spent nuclear fuel is based on a multiple barrier principle, meaning that a deficiency in one barrier shall not impair the safety of the repository. In a KBS-3V type of repository a copper canister containing the spent fuel is placed in a vertical disposal hole drilled in the floor of a deposition tunnel. The canister is embedded in a buffer material consisting of compacted bentonite blocks. The purpose of the bentonite buffer is to “maintain the integrity of the canisters for at least 100 000 years by protecting them from detrimental THMC processes, and to limit and retard the release of any radionuclides from the canisters” (Posiva 2006). After emplacement of the canisters and the bentonite buffer, the tunnels will be backfilled and sealed with a plug constructed at the entrance of the deposition tunnel. Regarding the long-term safety of the repository, the main requirements for backfilling are to maintain the safety functions of the bentonite buffer and to restrict advective transport along the deposition tunnels (Gunnarsson et al. 2006, Posiva 2006). In order to develop backfilling materials and methods that would fulfil the requirements set for the backfill in the expected repository conditions, a programme called “Backfilling and Closure of the Deep Repository”, Baclo, was launched as a joint SKB-Posiva programme in 2003 (Gunnarsson et al. 2004). The programme was divided into four different phases, of which the second one concentrated on laboratory experiments on various backfill material alternatives and analysis of two backfilling concepts selected during screening in phase 1 (Gunnarsson et al. 2004).

BREAKDOWN OF BACKFILLING REQUIREMENTS TO DRY DENSITY CRITERIA
In order to restrict advective transport along the deposition tunnels, the hydraulic conductivity of the backfill material should be less than \(10^{-10}\) m/s (Gunnarsson et al. 2006). This criterion is valid for the entire cross-section of the tunnel, including the contact zone between the backfill and the surrounding rock walls. Therefore, the backfill should have a swelling pressure of at least 0.1 MPa (Gunnarsson et al. 2006). Since it is very difficult to measure such a small swelling pressure in the laboratory, the criterion used in the laboratory studies was 0.2 MPa (Johannesson & Nilsson 2006). The backfill should also have low compressibility to be able to keep the buffer density within specified limits as the buffer saturates and develops a high swelling pressure. The criterion used in the analysis was that the saturated density of the buffer bentonite should not decrease below 1 950 kg/m\(^3\) at the level of the canister (Gunnarsson et al. 2006).

BACKFILLING CONCEPTS
The two backfilling concepts studied were 1) compaction of the backfill material “\textit{in situ}” in the tunnel, referred as the \textit{in situ} concept, and 2) placement of pre-compacted clay blocks and pellets (Gunnarsson et al. 2006). In the assessment presented in Gunnarsson et al. (2006) the dry densities estimated to be achievable with the two different installation methods were compared with the dry density criteria determined for different backfill materials.
BACKFILL MATERIALS AND INVESTIGATION METHODS
The backfill materials studied included two low-grade non-commercial bentonite clays (Asha 230 from India and Milos backfill from Greece), two mixed-layer clays (DJP from Czech republic and Friedland Clay from Germany), and mixtures of high-grade bentonite and ballast mixed in proportions of 30:70, 40:60 and 50:50 (Gunnarsson et al. 2006). The amount of swelling minerals within the pure clays studied varied between 25-60% (Johannesson & Nilsson 2006). The bentonites mixed with the ballasts had montmorillonite content between 80-85% (Johannesson & Nilsson 2006). The ballast materials studied were sand and two different types of crushed rock (Johannesson & Nilsson 2006).

The hydraulic conductivity and swelling pressure of the different materials were measured in oedometer tests with water salinities of 3.5% and 7%. The compressibility of the materials was studied with a different type of an oedometer test with a salinity of 3.5%. Based on the latter tests, analytical calculations were performed for evaluating the required dry density for the backfill in order to maintain the buffer density at an acceptable level (Johannesson & Nilsson 2006).

RESULTS
Based on the evaluation of the different combinations of backfill materials and methods, pre-compacted clay blocks result in high safety margins when comparing the achievable dry density with the dry density criteria (Gunnarsson et al. 2006). For alternatives based on the in situ concept the safety margins are significantly lower compared to the block concept (Gunnarsson et al. 2006). As a result of the assessment, the number of backfilling materials was narrowed to three (reference materials with varying amount of swelling minerals) and the block backfill concept was chosen as the main alternative for backfilling the deposition tunnels. The currently ongoing Baclo phase 3 focuses on studying different processes that can take place during the installation and saturation phase and how these processes will influence the design specifications for the block backfilling concept. In addition, the technique for installing blocks and pellets will be developed further.

References:

