Granular bentonite production as buffer material for a Full-scale Emplacement ("FE") experiment

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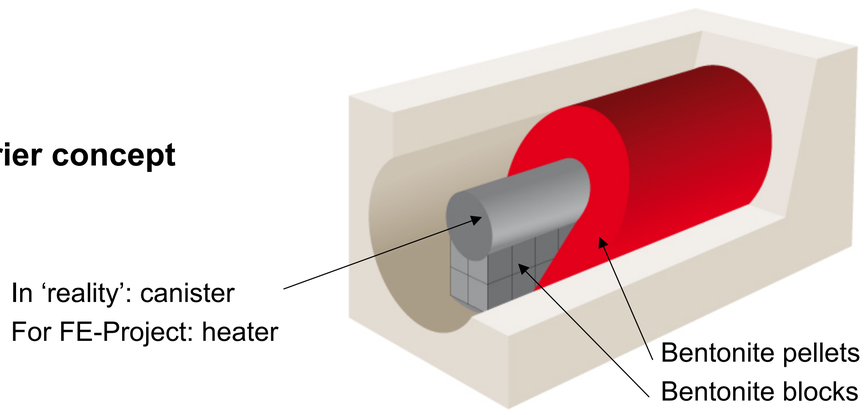
Introduction

In the Swiss repository concept for the disposal of spent fuel (SF) and high-level vitrified waste (HLW), the canisters are emplaced in galleries surrounded by a bentonite buffer which has the following functions:

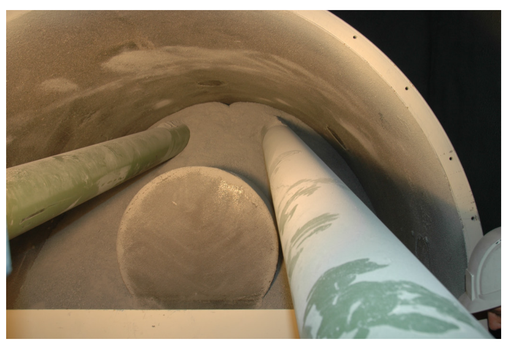
- keep the **canisters** in place and **protect** them by homogenising the stress field
- mechanically **stabilise** the space between the canisters and the geological barrier
- act as a **diffusion and sorption barrier for radionuclides**
- to **limit microbial activity**

NAGRA's HLW barrier concept



Bimodal granular bentonite production

Backfilling emplacement tests ESDRED project (2006)

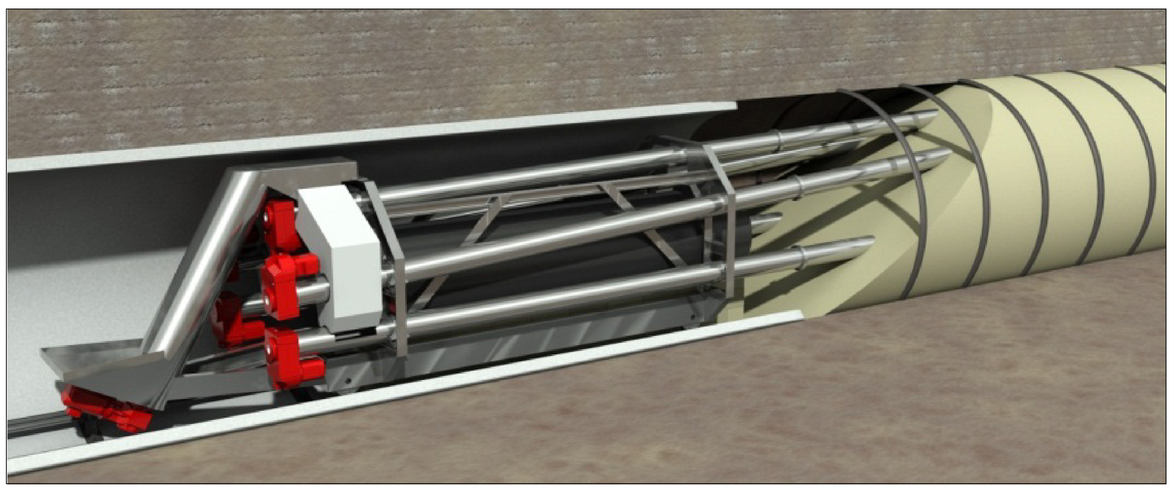


Objectives for the production of granular bentonite

The main objectives of manufacturing granular bentonite for the LUCOEX/FE project are as follows:

- production of a suitable bentonite grain size distribution in order to achieve a target emplacement **overall dry density of 1450 kg/m³** and a **homoge-neous distribution**
- **optimization of different parameters during the production process** (e.g. grain dry density, water content, grain size distribution and grain shape)
- evaluation of **suitable processes for the production of the granular material**
- development of **QA-measures** with regard to the requirements
  a) during production and
  b) during emplacement of the granular bentonite material.

Sketch of a multi-auger device which may be used in the repository for the emplacement of granular bentonite



Experience gained in previous projects

For the bentonite barrier in general:

- use natural **sodium-bentonite MX-80**
- during pelletization an **increase of bulk dry density** from 1.33 g/cm³ to 2.10 g/cm³ can be achieved (e.g. ESDRED and GAST projects)
- **rounded aggregates** lead to better pourability and avoid bridging effects

In ESDRED project:

- **rounding was carried out in situ by blowing** the granular bentonite under air pressure through a 200 m long steel pipe with conventional shotcrete equipment
- a side effect of this method was an **adjustment of the grain size distribution to the Fuller curve** and thus an optimisation in terms of **higher bulk dry density**
- large-scale emplacement tests with granular bentonite using a twin auger system showed that an **emplacement dry density of 1400 to 1500 kg/m³** could be reached

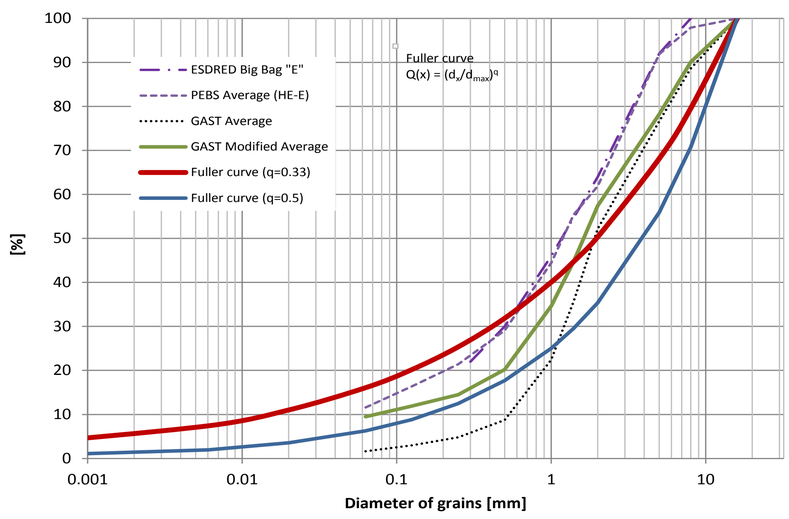
In ESDRED and PEBS projects:

- **water content** of the raw material was reduced to **5% by drying**
- granular bentonite which was produced for ESDRED in 2006 was re-used in the PEBS project after **5 years storage without significant water uptake** and a similar emplacement dry density was reached

In ESDRED, PEBS and GAST projects:

- **comparing the grain size distributions** of the granular bentonite used for each project with the Fuller curve allows for specific adjustments through the production process of granular bentonite needed for the FE experiment.

Grain size distribution: ESDRED/PEBS and GAST-projects

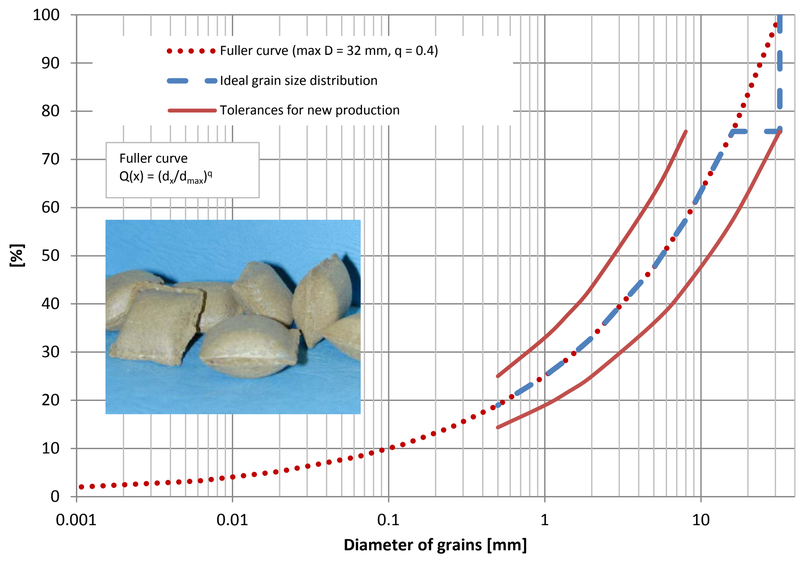


Future production of granular bentonite

Starting from the raw material delivered in big bags the production of granular bentonite can be described as follows:

- compaction of the raw material with the objective to obtain the **maximal grain density**
- **crushing, rounding and sieving** the product into 2 to 3 fractions;
- **mixing of the 2 to 3 fractions** to reach a final grain distribution as close as possible to the Fuller curve
- adding **25-35% of highly compacted briquettes** with diameter of 30 mm
- deliver the final product in **air tight big bags** to prevent water uptake through air humidity

Grain size distribution for FE - Project



The FE experiment ("Full-Scale Emplacement Experiment") at Mont Terri URL, which demonstrates on a 1:1 scale of the Swiss repository concept for disposal of SF and HLW in Opalinus Clay, is supported by the LUCOEX project (2011-2014), co-funded by the European Commission (EC) as part of the seventh Euratom research and training Framework Programme (FP7/2011-2014) under grant agreement n° 269905.