

LUCOEX CONFERENCE OSKARSHAMN



FE/LUCOEX: QA/QC

during granulated bentonite material
production and emplacement

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Bentonite Raw material production, drying, pelletization (Cebo, Rettenmaier)

- Water content of raw material and of different fractions on granulated material
- Density on different fractions of granulated material
- Grain size distribution of raw material and of granulated material
- Back up sampling of raw material and of granulated material

On-site (300 Samples)

- Water Content on different fractions of granulated bentonite material
- Density on different fractions of granulated material
- Back up sampling of emplaced granulated material

Laboratory of ETH Zürich (Switzerland) and BGR (Germany) (30 Samples)

- Mineralogy of natural sodium bentonite (X-Ray Diffraction) esp. Smectite content
- Chemistry of bentonite (X-Ray Fluorescence)
- Water Content on different fractions of granulated bentonite material
- Density on different fractions of granulated material
- CEC - Cation Exchange Capacity (Copper Method)
- Grain size distribution of granulated material
- Water uptake / free swelling (Ensslin Neff method)
- Drop density min (dropping) / max (plus shaker)

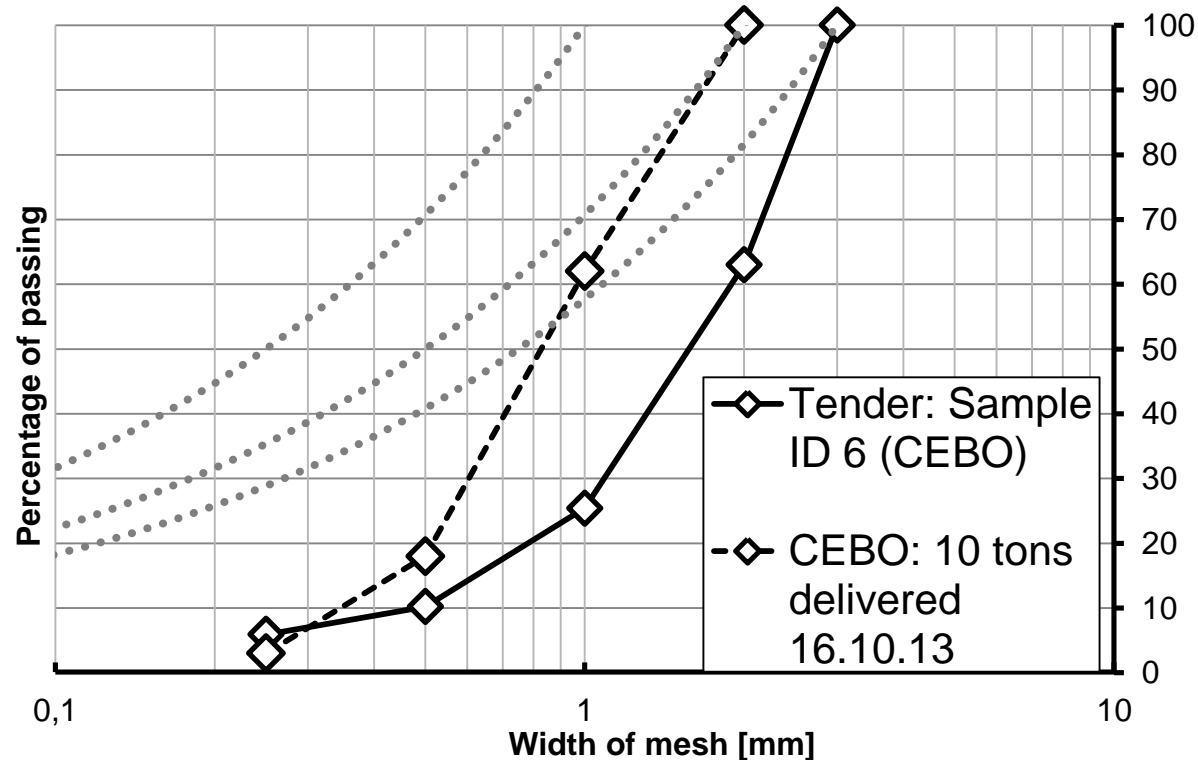
Water content
civil engineering

$$w = \frac{m \cdot m_d}{m_d} \cdot 100$$

Criterion	Description
Material	Natural (non-activated) sodium bentonite
Smectite content measured by X-ray diffraction and Rietveld analysis	>75%
Additives (such as Magnetite, Baryte, etc.) by X-ray diffraction	No additives allowed
CEC (Cation Exchange Capacity) by Cu(II)- triethylenetetramine method	>70meq/100g
Water content, measured according to the norm ASTM D2216 - 10	<14%
Pyrite content measured by X-ray diffraction	< 1%
Sulphur content measured by LECO or mass spectroscopy	< 0.5% (corresponds to approx. 1% of pyrite)
Organic carbon measured by LECO or mass spectroscopy	< 1%
Grain size distribution of the delivered raw material according to the norm ISO 3310-1, BS 410-1	Well distributed between very fine and maximum 2 mm

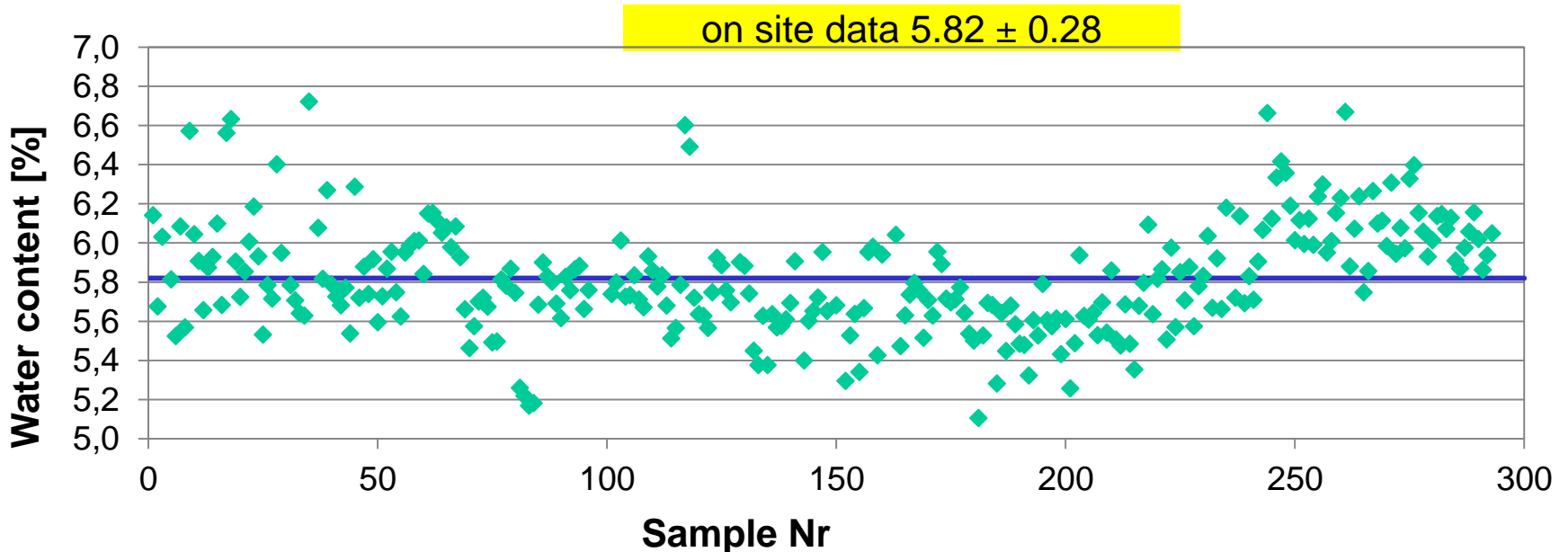
Minerals	Crude National Standard (%)	pellet fraction A (%)	pellet fraction C (%)
Smectite	89.0	88.9	88.5
Muscovite	0.4	0.4	0.4
Quartz	4.0	4.2	4.1
Feldspar	3.7	3.1	3.4
Gypsum	0.8	0.8	0.8
Pyrite	0.3	0.3	0.3
Calcite	0.1	0.5	0.5
Siderite	1.3	1.3	1.3
Cristobalite	0.3	0.4	0.6

Criterion	Description
Material	Natural (non-activated) sodium bentonite was confirmed by x-ray diffraction at different laboratories
Smectite content	Cebo 90%; BGR 88-89%; ETH 78%
CEC	94.3meq/100g ETH
Water Content	11.4% ETH
Grain size distribution	Measurements ETH, see Figure below.



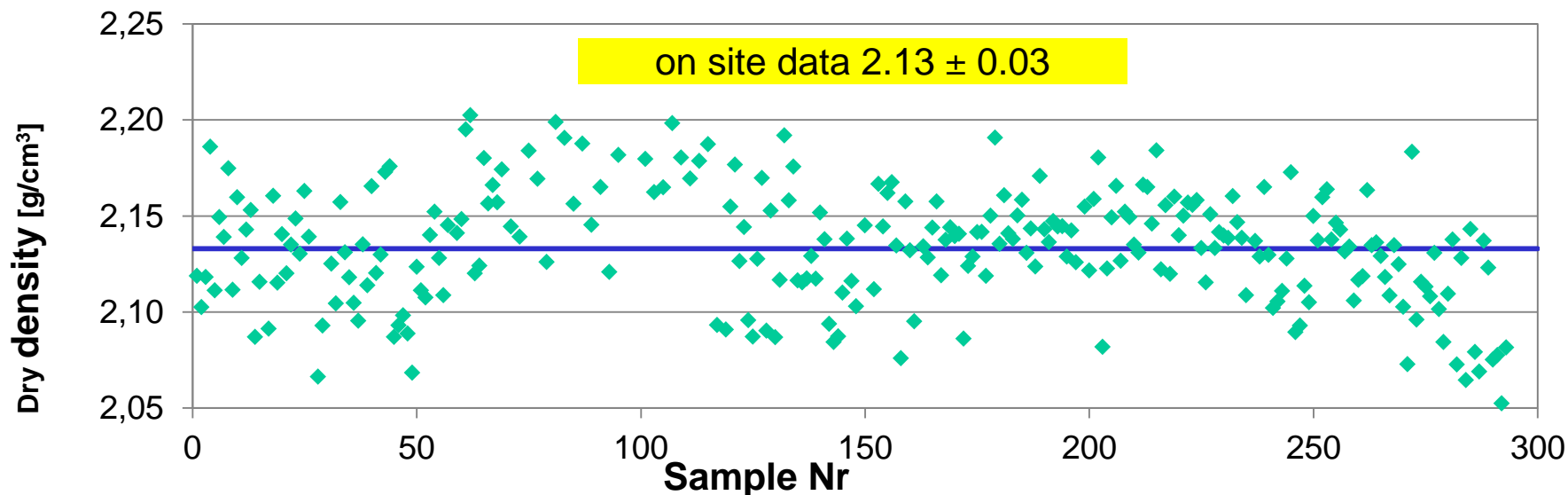
Determination Water Content of Pellets

Criterion	Description
Dry Density	2.15 ± 0.04% measurements ETH. A high pellet dry density could be reached.
Water Content	5.74 ± 0.5% measurements ETH. During the pelletization process the water content could be slightly reduced
Size of pellets	It was difficult to produce pellets larger than about 10mm diameter with an ideal shape close to spherical
Mechanical resistance	The produced pellets were mechanically quite stable

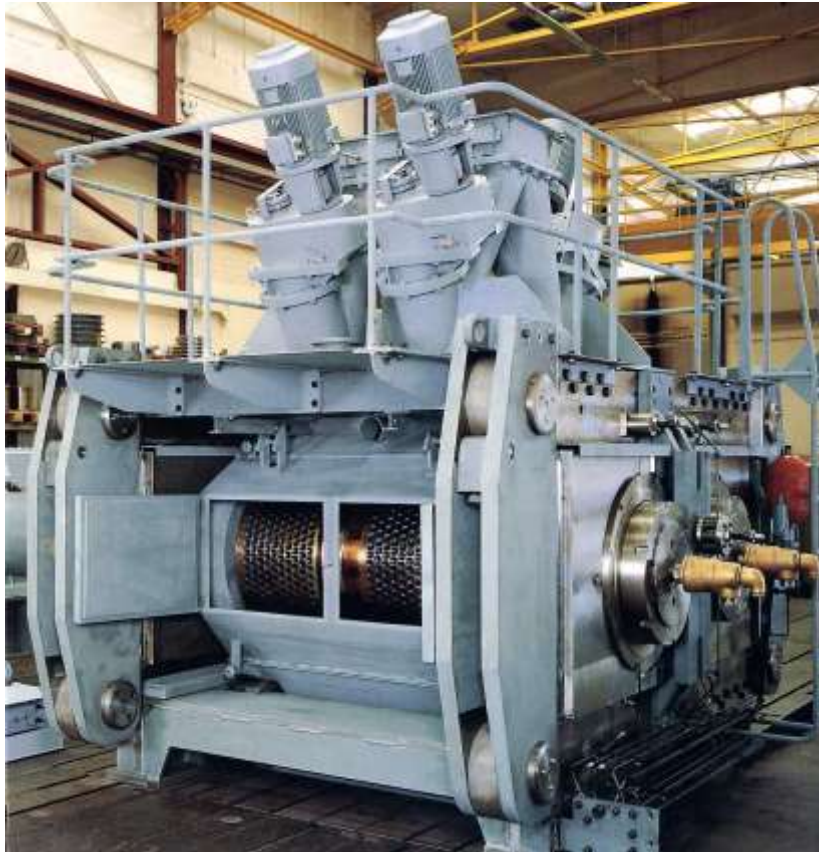


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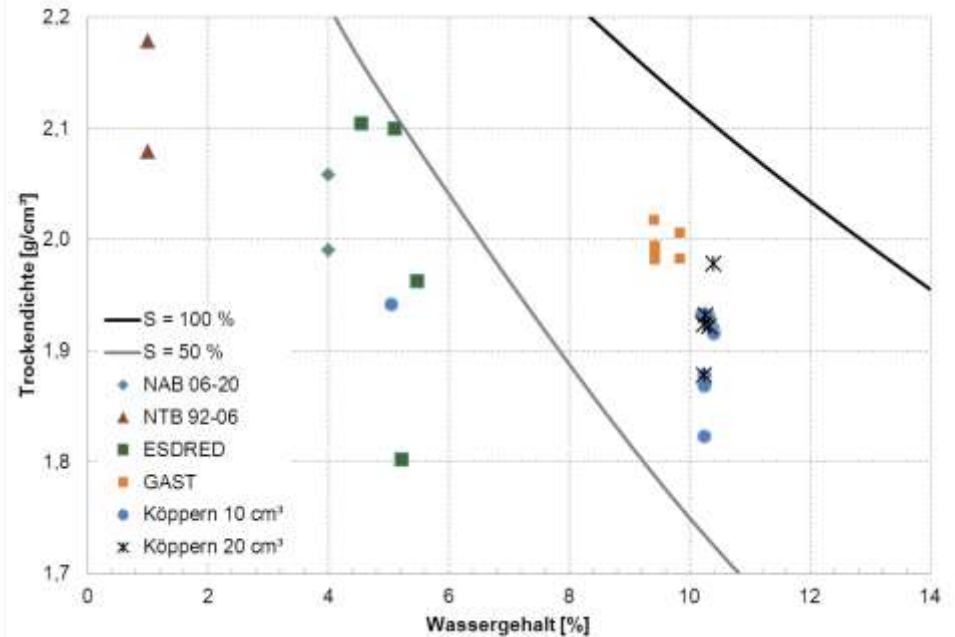


Bentonite pellet production testing history

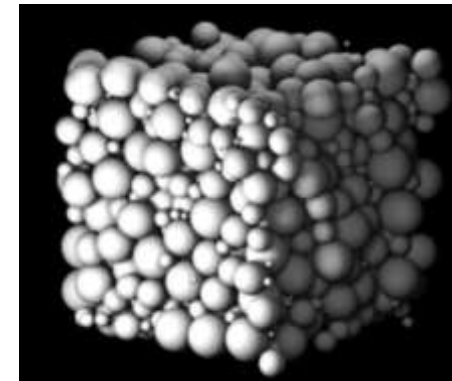


Testing with
a roller press
at Köppern
and TU
Freiberg,
Germany

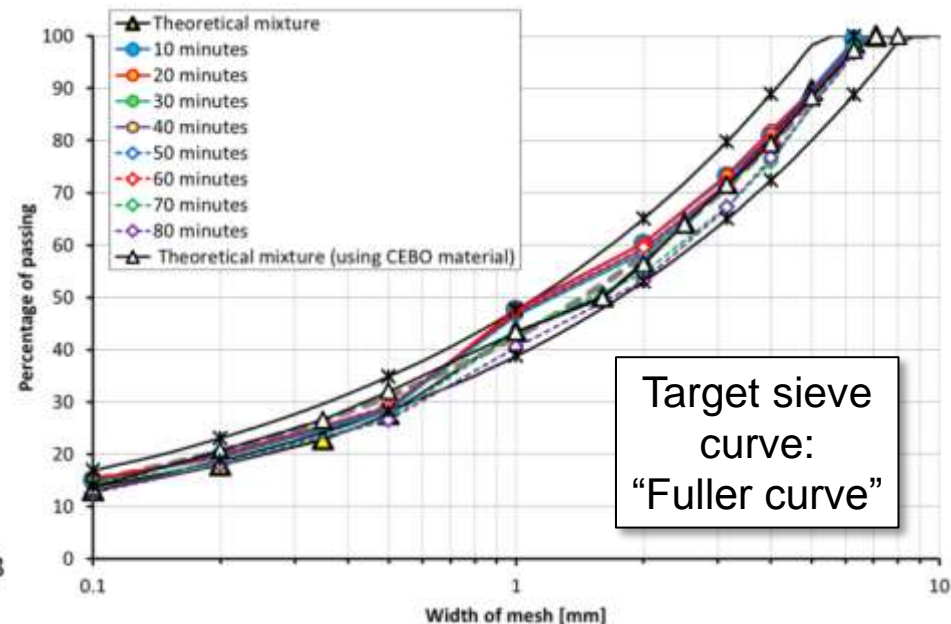
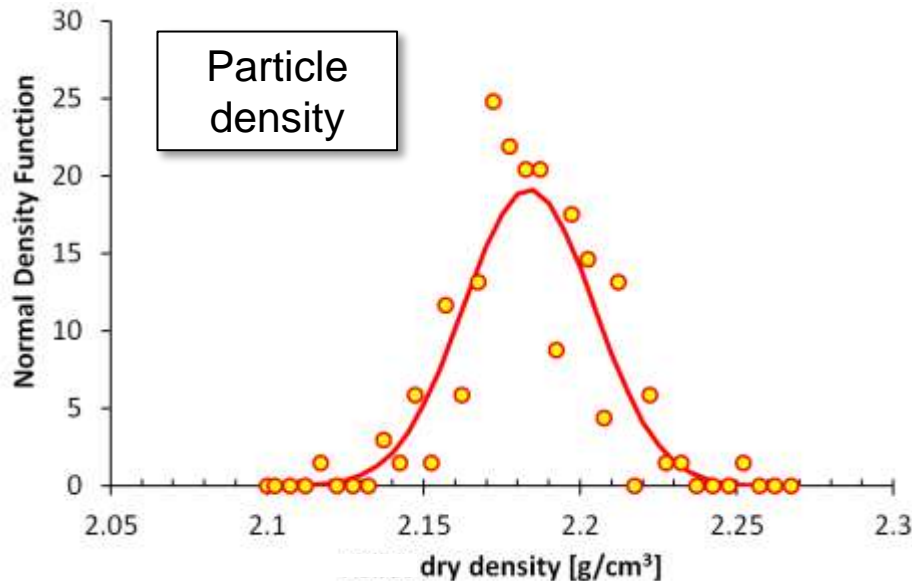
Water Ratio/
Dry Density-
Diagramme



- After public tender (acc. to WTO standards) (hc) **GBM** = (highly compacted) **granulated bentonite material** was ordered
 - approx. 100 tons for 1:1-scale pre-testing
 - another 250 tons for the FE tunnel @ MT
- Material: Non-activated sodium (Na) bentonite

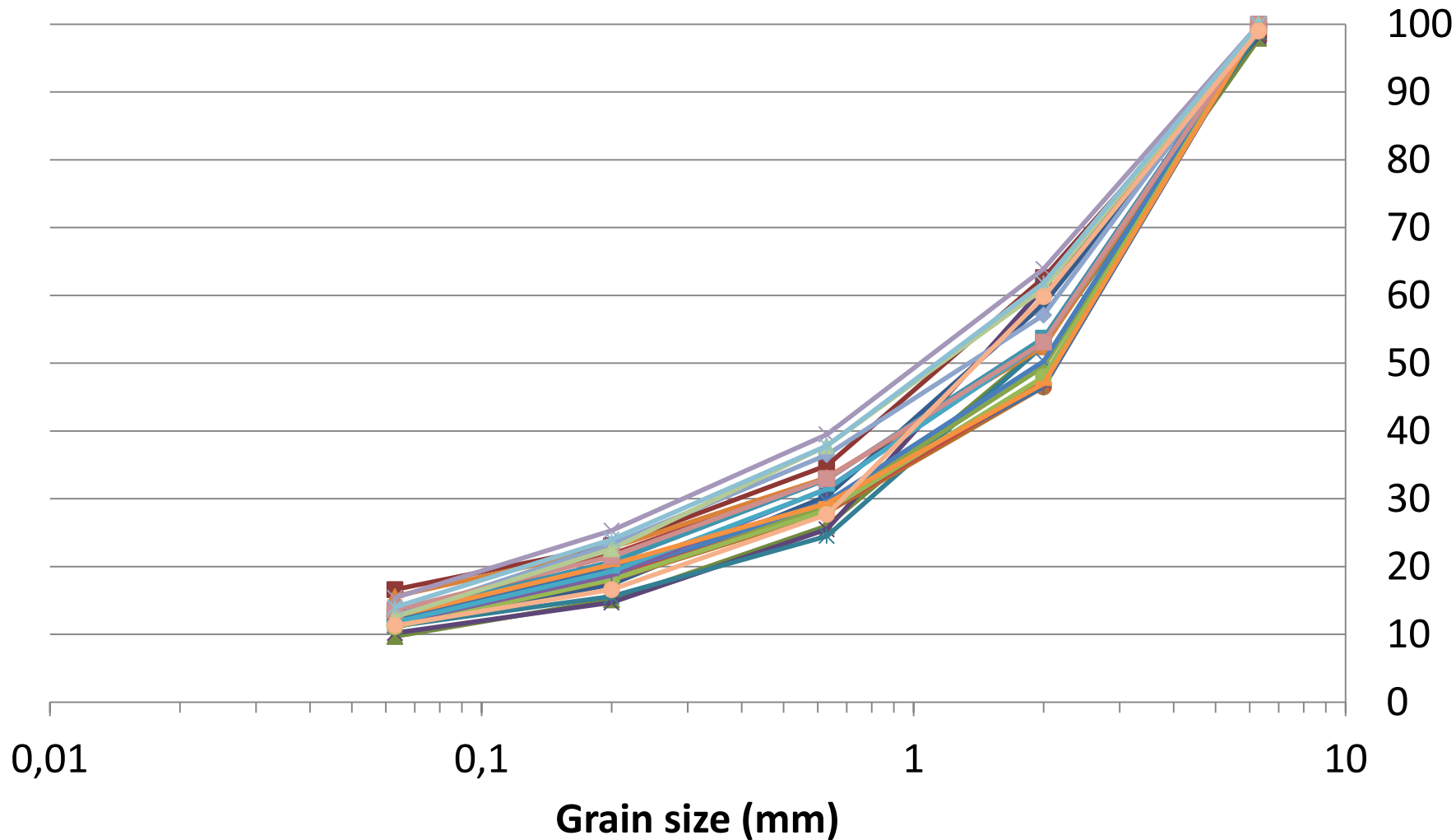


QC results (from 1st production):



Grain Size distribution emplaced material

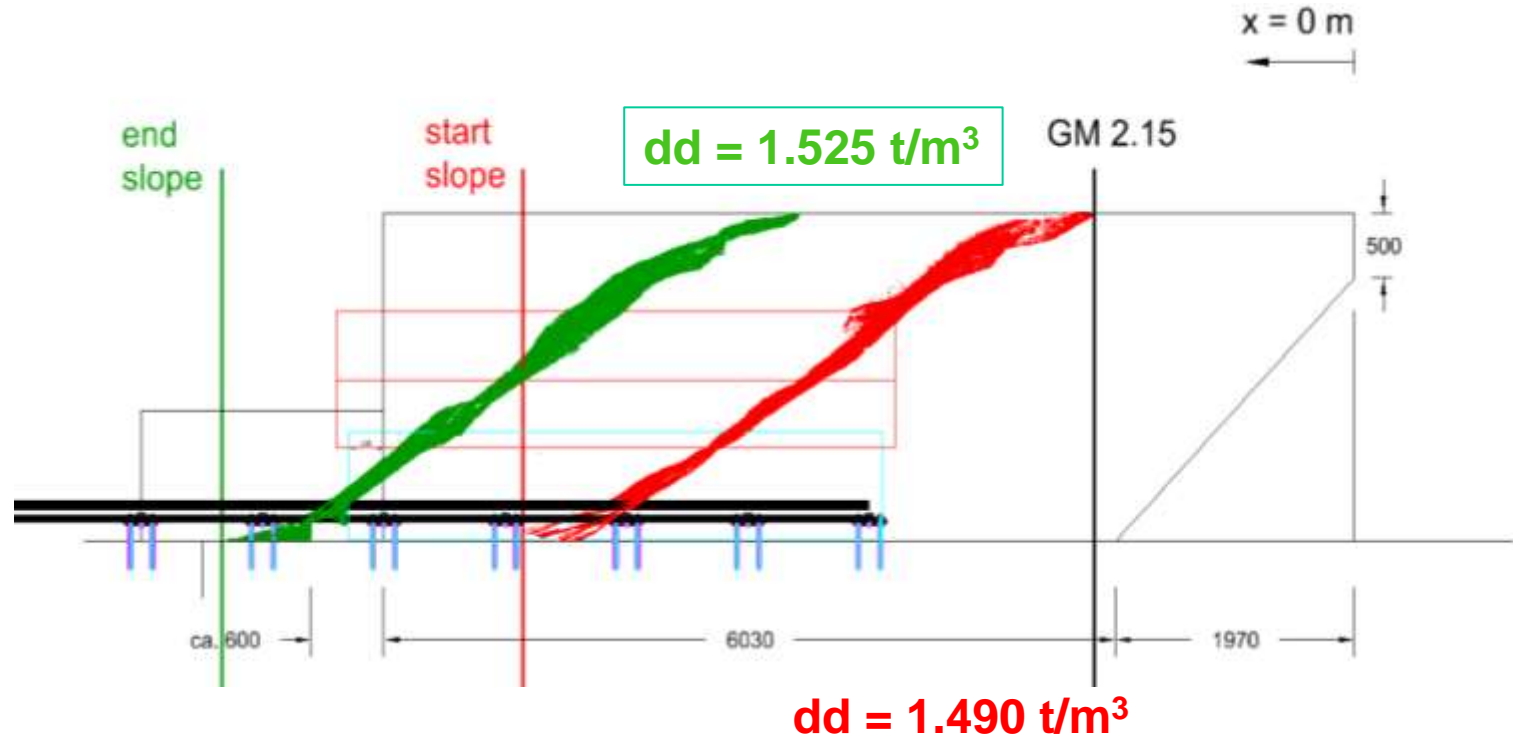
% passing





Test Production at Rettenmaier





Array of curves from scanning the "start slope" (red) and the "end slope" (green) for distinct volume and density determination behind and around the canister



Thank You for helping us:

Fabian Ammann (CH)

Berrak Firat (TUR/CH)

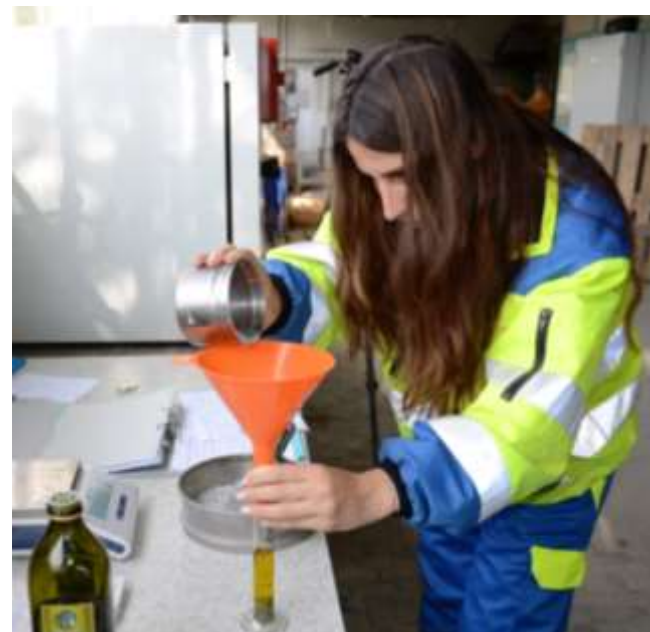
Lucie Hausmannova (CZE)

Mario Kälin (CH)

Acacia Naves (ESP)

Jan Smutek (CZE)

Holger Sprengel (DE)



Granular bentonite material produced in accordance with the requirements

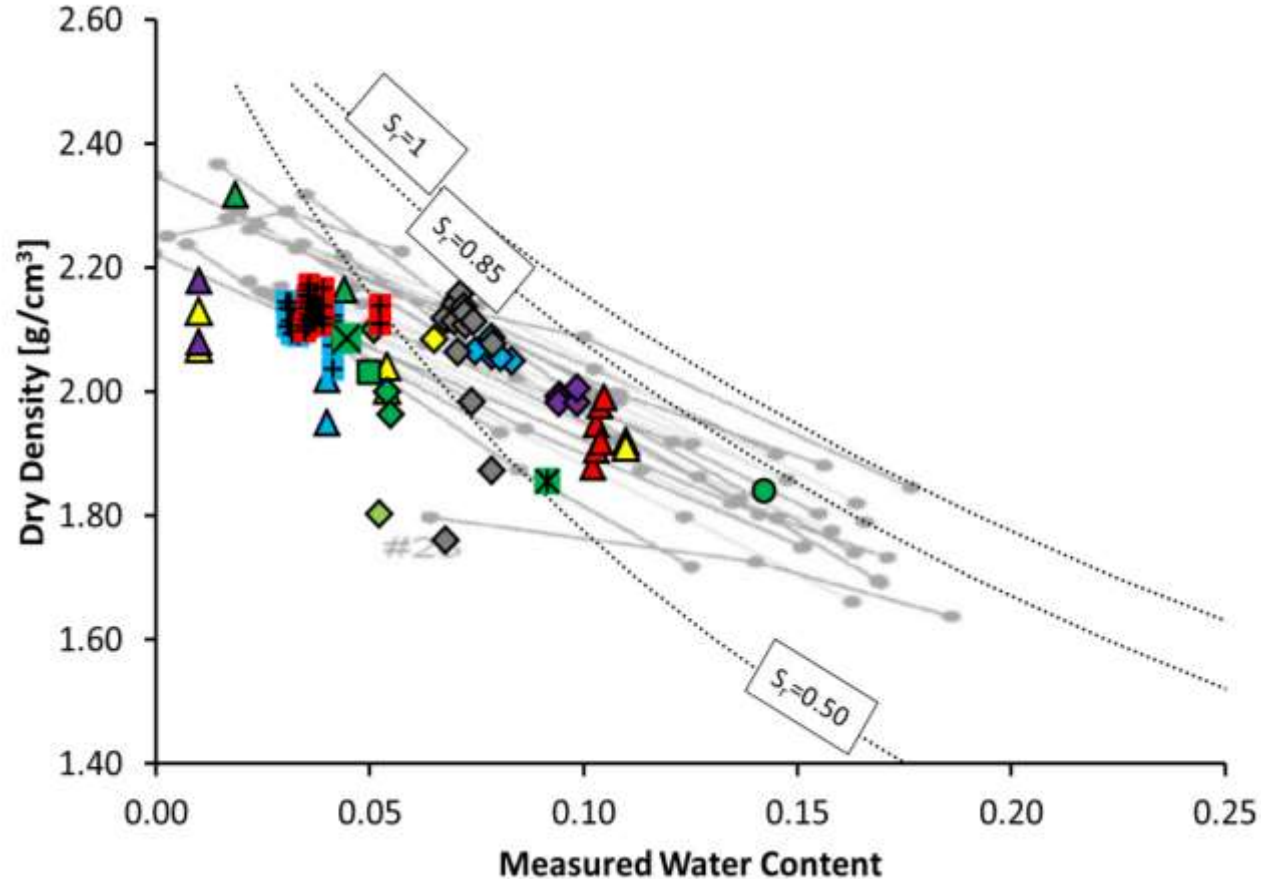
- QA/QC of water content, density and grain size distribution of raw material and of granulated material (pellets)
(300 measurements in on-site laboratory during emplacement at Mont Terri)

Laboratory measurements at ETH for verification of the on-site laboratory measurements

- QA/QC of water content, density , grain size distribution of raw material and of granulated material (on back up samples)
(30 measurements)
Plus: Mineralogy, Smectite content, Chemistry, CEC Cation Exchange Capacity, Water uptake and Drop density
- **High density granular bentonite material produced with a water content of ca. 5.8%**
- **Granular bentonite material (pellets) compacted to a dry density of ca. 2.15 t/m³**
- **Granular bentonite material emplaced in the FE Tunnel with a Fuller type grain size distribution and a dry density of ca. 1.50 t/m³**

**thank you
for your attention**

nagra.



Laboratory measurements on Wyoming natural sodium bentonite samples. Relation between initial water content and dry density reached after compaction.

«Aquarium»-Test @ VSH

