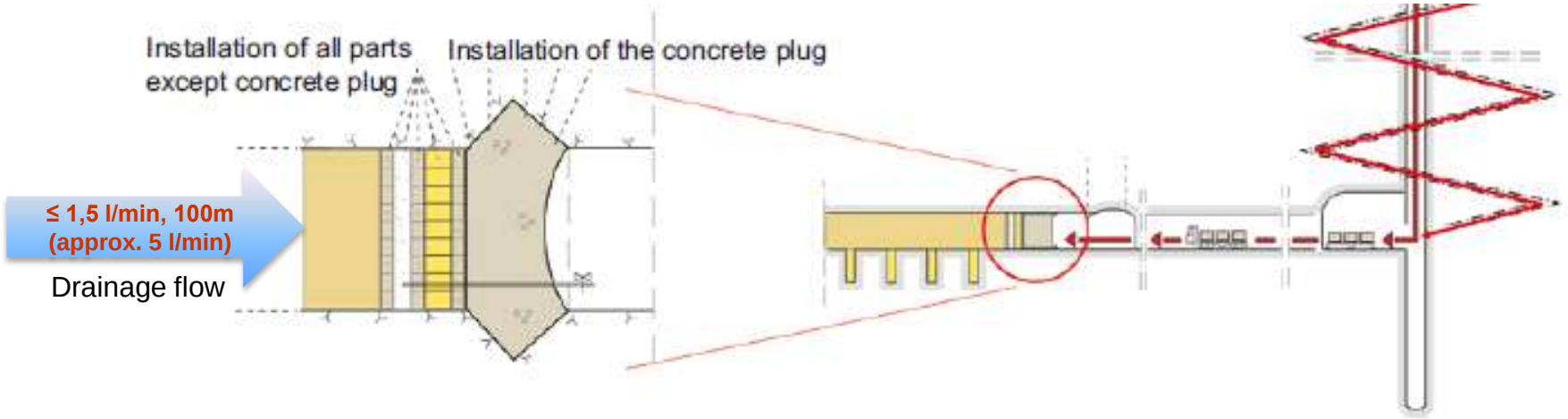
System Design of Plugs

Pär Grahm

SKB`s reference design (TR-10-16)

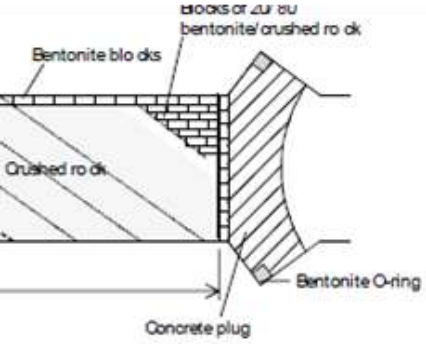
- Withstand the sum of hydrostatic pressure at repository depth (5 MPa) and the swelling pressure of the backfill (”2 MPa”) until the main tunnel is backfilled and saturated.
- Stop outflow of water passing the plug as soon as possible (investigation underway of acceptable loss of bentonite)
  - ”*Plugs should be as waterthight as possible*”



- The design working life is approx.100 years.
- High reliability (malfunction frequency <10^{-3})

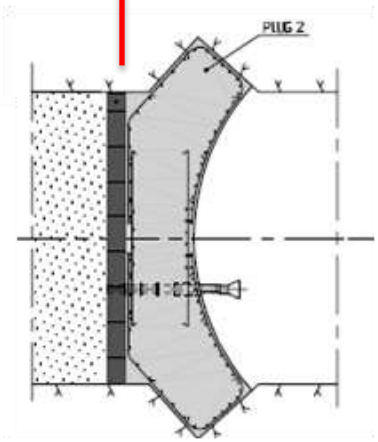
Design ”history” and demonstrations at Äspö HRL

1999
Backfill & Plug Test



2001
Prototype Repository Plug (inner section)

2003



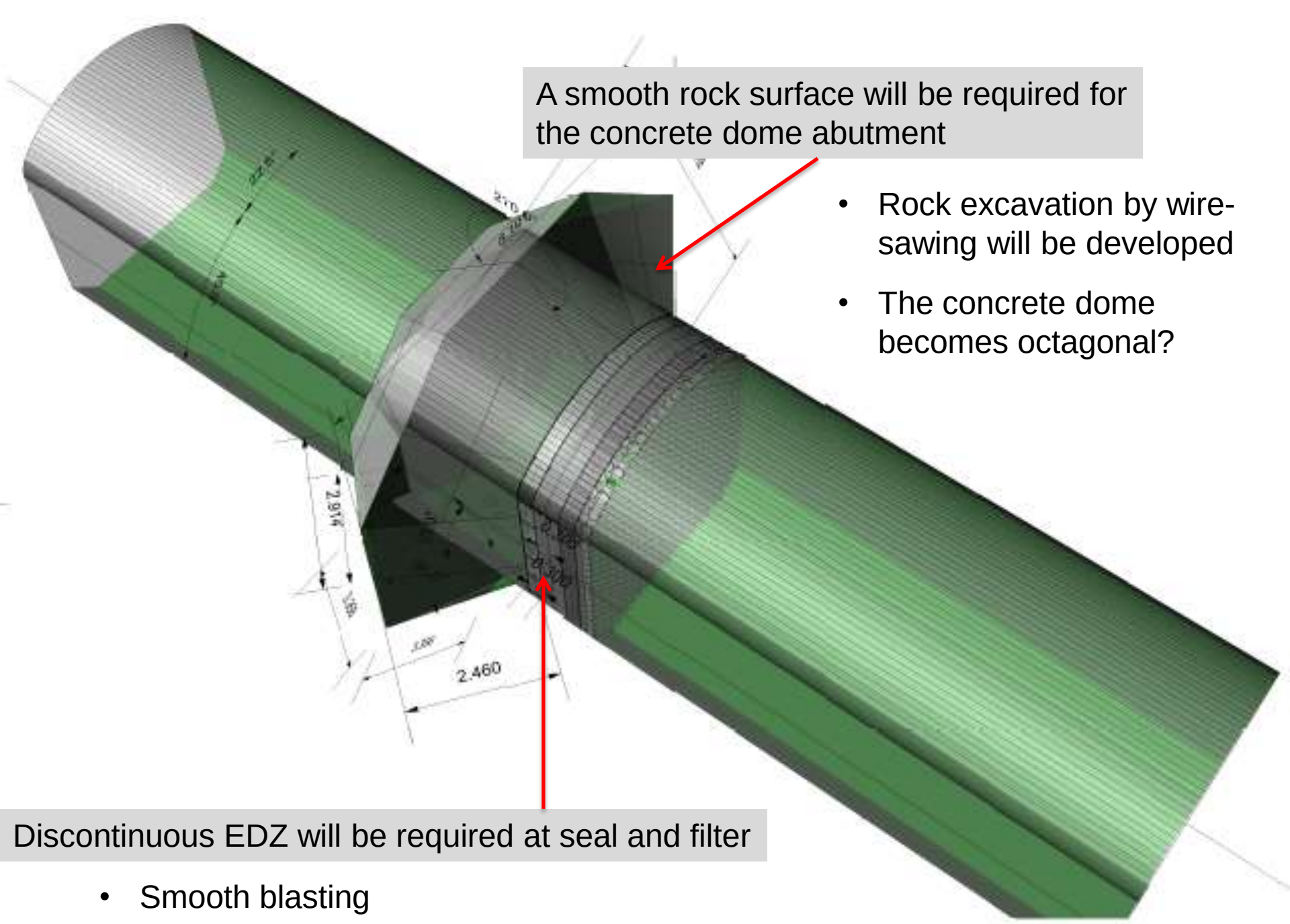
Prototype Repository ”Plug II” (outer section) *R-09-49*

2008
Development of low pH concrete (<pH 11) *R-09-47*

2009
Reference design including filter and clay seal, *TR-10-16* (concept for licensing KBS-3V)

2010
- KBS-3H Plug test
- Prototype Repository ”Plug II” dismantled
- System design starts for the KBS-3V Plug

2011
Reporting of the reference design Plug Development R-11-04

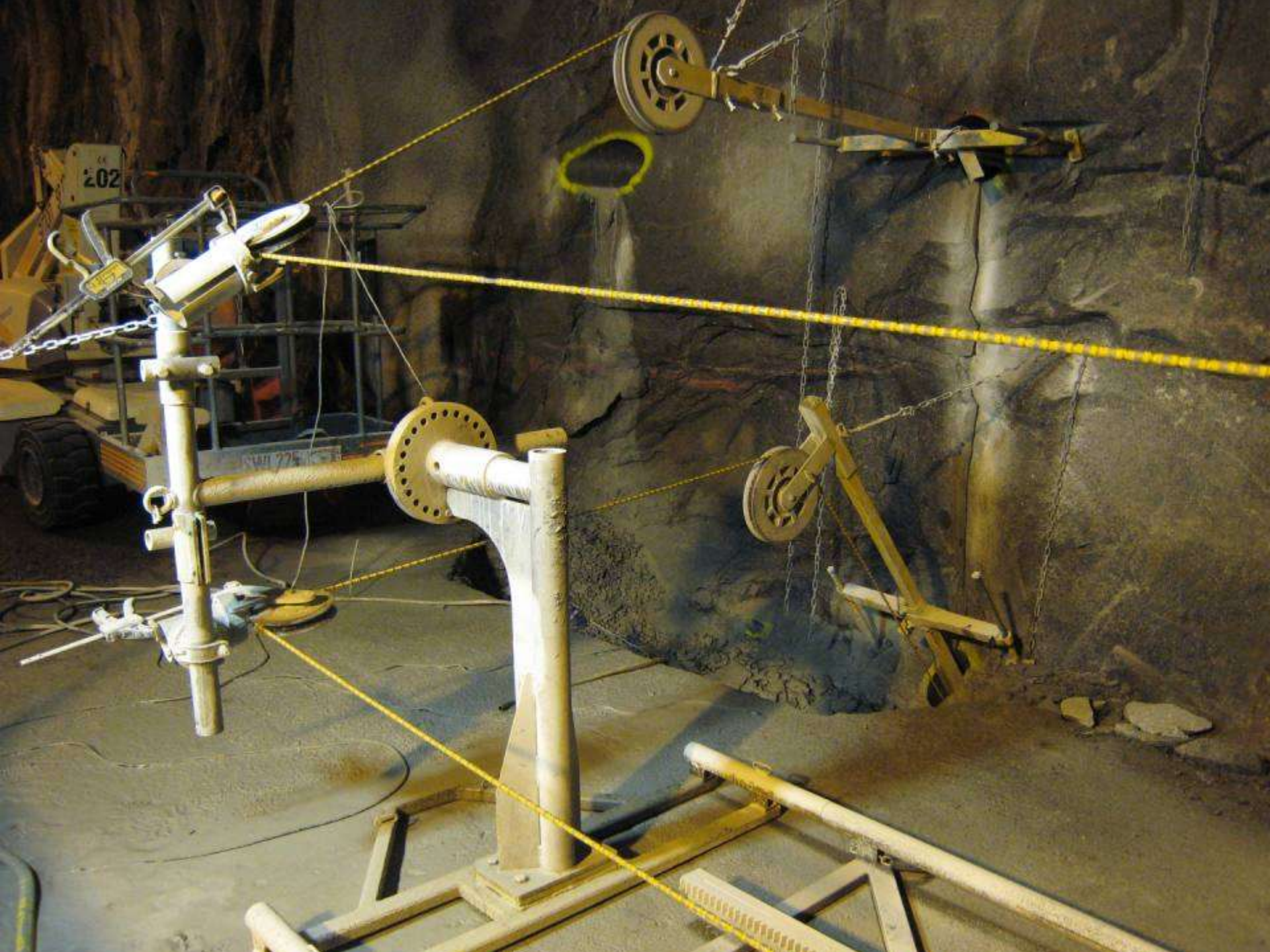


A smooth rock surface will be required for the concrete dome abutment

- Rock excavation by wire-sawing will be developed
- The concrete dome becomes octagonal?

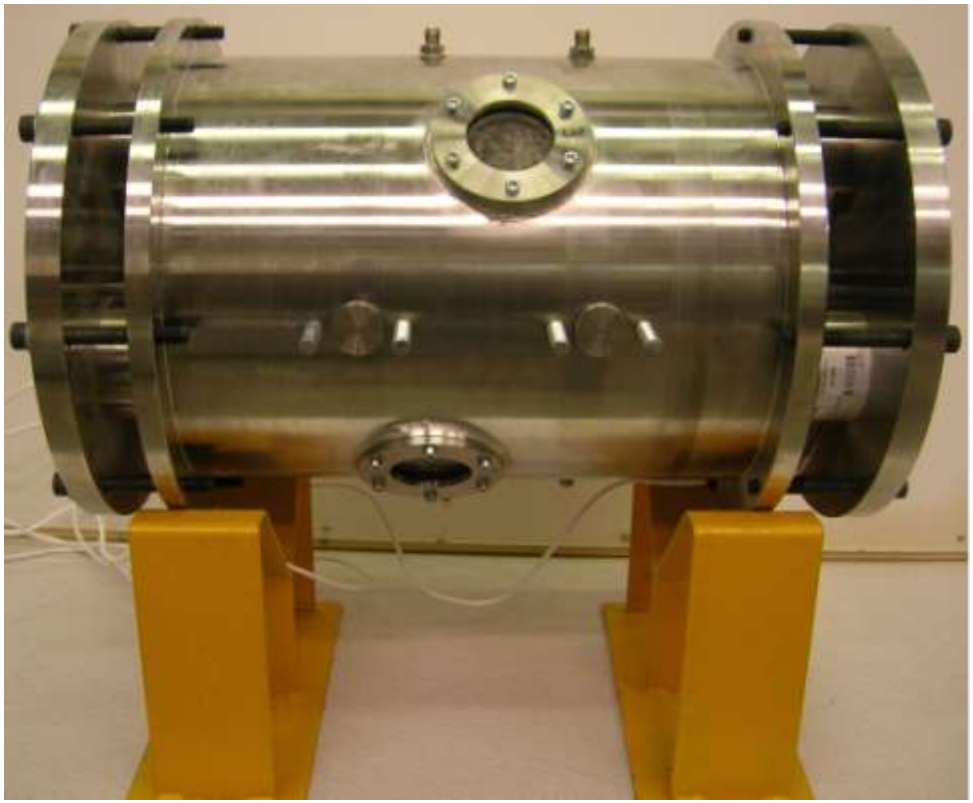
Discontinuous EDZ will be required at seal and filter

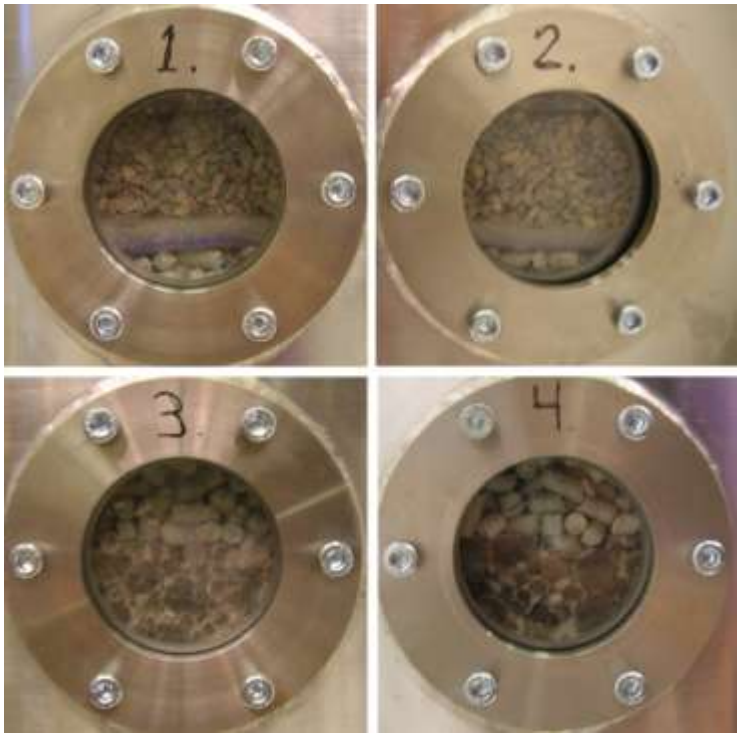
- Smooth blasting



Testing of plug performances in a Scale-model

- Laboratory at Clay Technlology
- Scale 1:20 / 1:10 lenght
  Ø = 25 cm / L = 50 cm

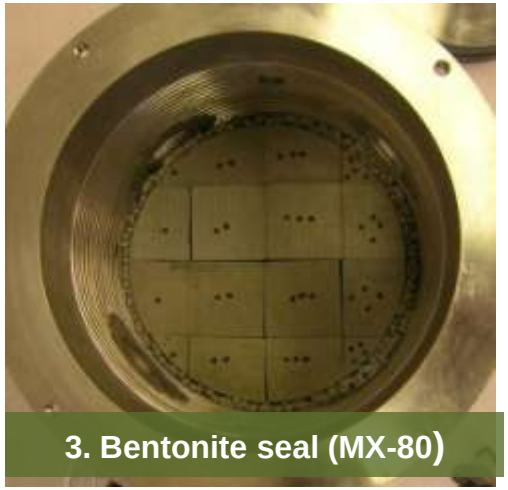




- 3-4 short time tests (~ 2 v)
- 1 long-term test until full saturation

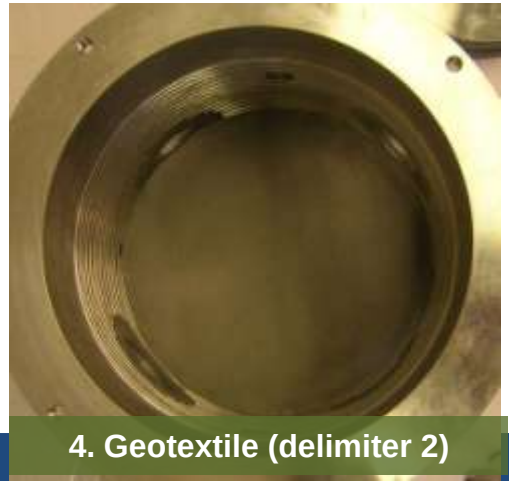
”Deposition tunnel”

2. Concrete beams (delimiter 3)



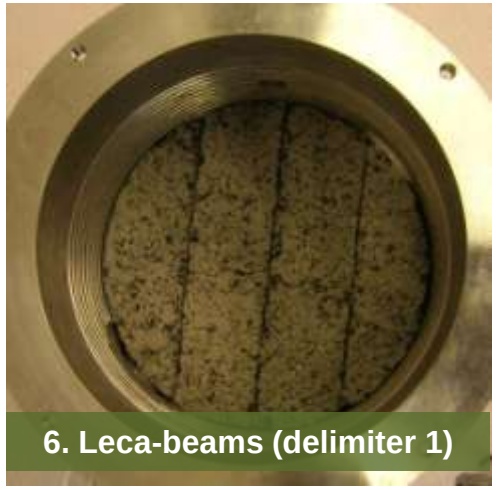
3. Bentonite seal (MX-80)

1. Bottom (Concrete dome)



4. Geotextile (delimiter 2)

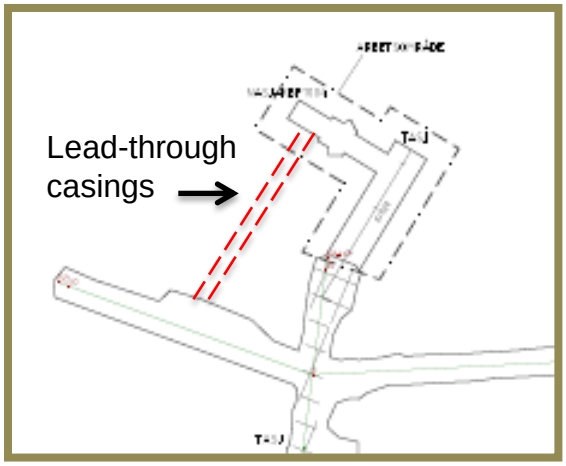
5. Macadam (2-4mm)

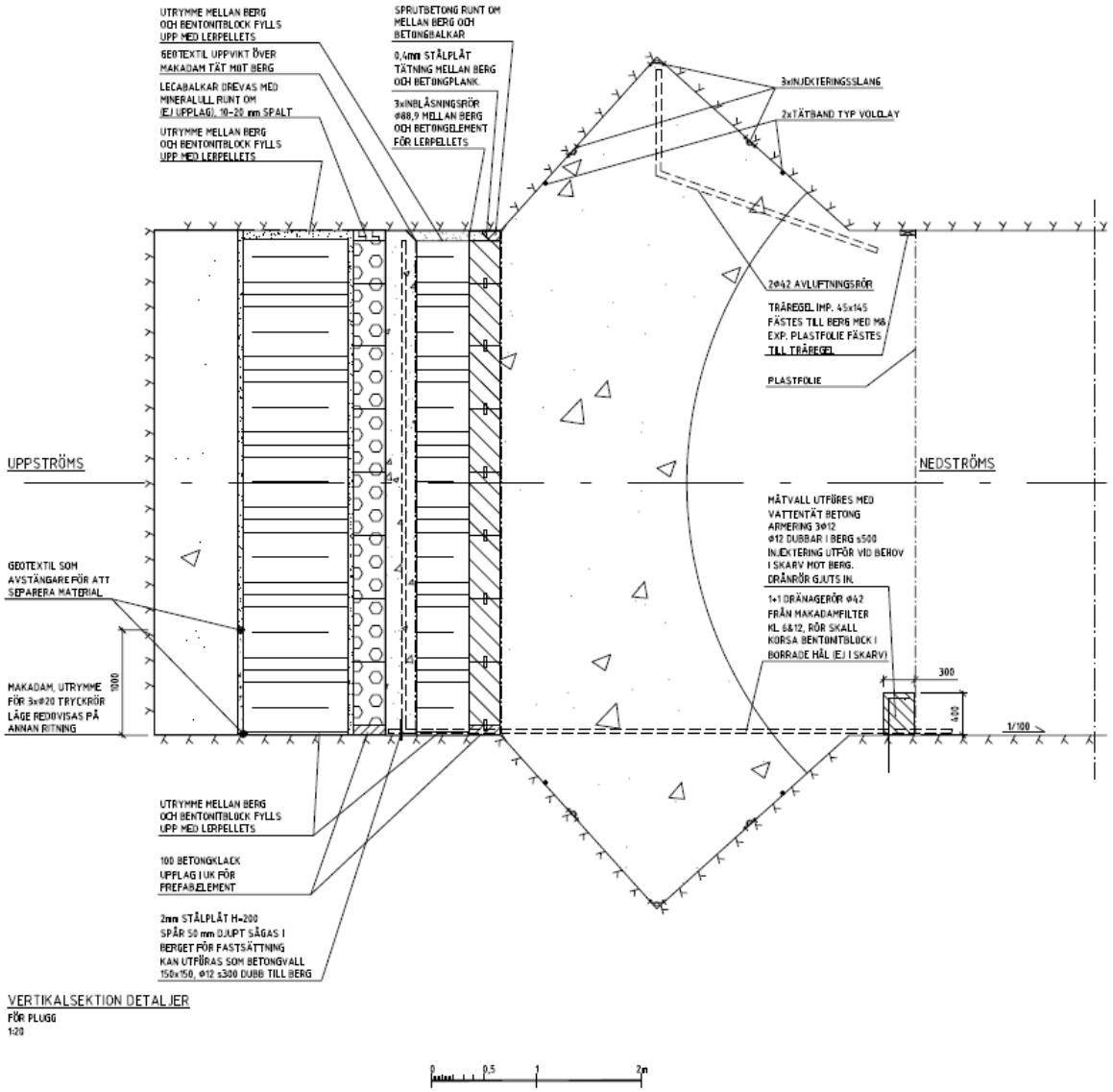


6. Leca-beams (delimiter 1)

7. Backfill blocks + pellets

Full scale test at Äspö HRL 2012





Monitoring of the concrete dome
= 36 sensors

Monitoring of bentonite seal, filter and backfill
= 45 sensors

What are we measuring?

- That the concrete dome shrinks and releases from the rock wall (joint meters) and that it is stress-free before grouting (strain gauges)
- The heat generation of concrete hydration and the effects of cooling (temperature sensors)
- The load acting on the concrete dome and on the rock abutment (pressure sensors) and the tensions that arise (strain gauges)
- Displacements of the concrete dome, the bentonite seal and the filter at different load levels (position sensors)
- The water saturation process in the bentonite seal and in the backfill transition zone (RH)
- The development of swelling pressure (total pressure sensors)
- Changes in water pressure at different parts of the plug system (pore pressure sensors)
- Leakage through the plug (weight/min)
- Turbidity in the leakage water (suspension)

Schedule - Full scale test at Äspö HRL

2012 March	Excavation of a new experimental tunnel at Äspö HRL
2012 April	Rock excavation (wire-sawing) for the plug abutment
2012 May	Installation of lead-throughs and casings etc.
2012 June	Installation and control of the pressurization system etc.
2012 Aug-Sept	Installation of backfill/filter/seal and instrumentation
2012 Oct	Start of test the programme (begins with simulating drainage from the tunnel), casting of Concrete dome
2013 Jan	Cooling of the dome and grouting of plug/rock interface
2013 Feb	Gradual pressurizing up to 5 MPa for homgenization
2013 March	Pressurizing up to 7 MPa for leakage test (8 months)
2013 Nov	Pressurizing up to 10 MPa with main purpose to test and evaluate the strenght of the dome
2014 Dec	Technical Report completed
2016	The experimental set-up is opened and retrieved

Thank you!