Scoping calculations for PRACLAY Seal design
Initial dry density of MX80 bentonite

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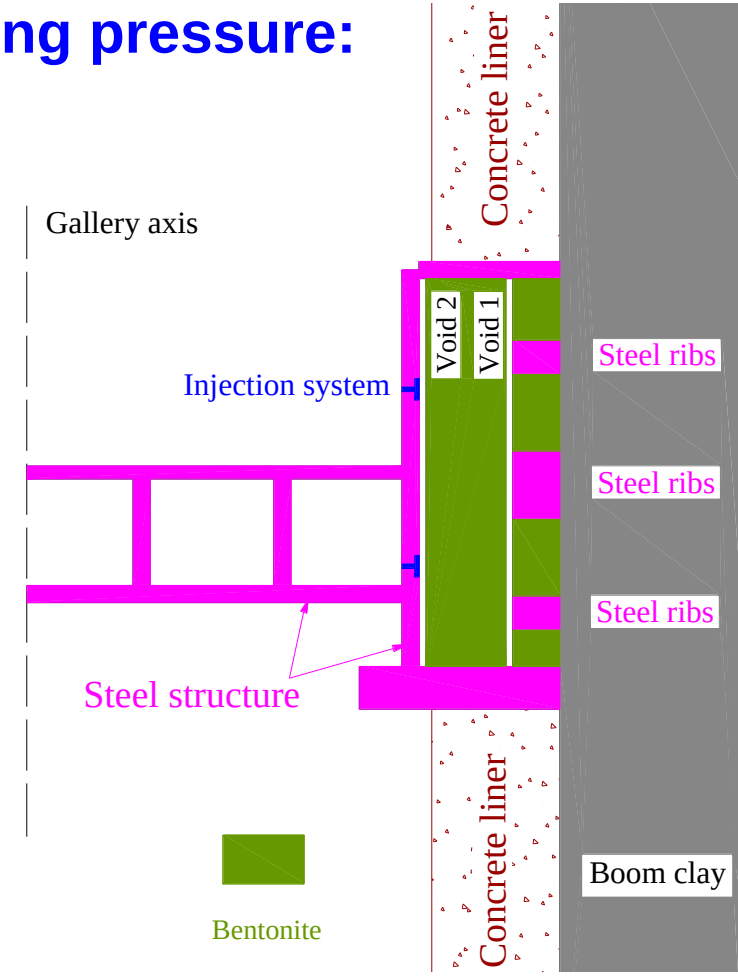
Main criteria to design the Seal:

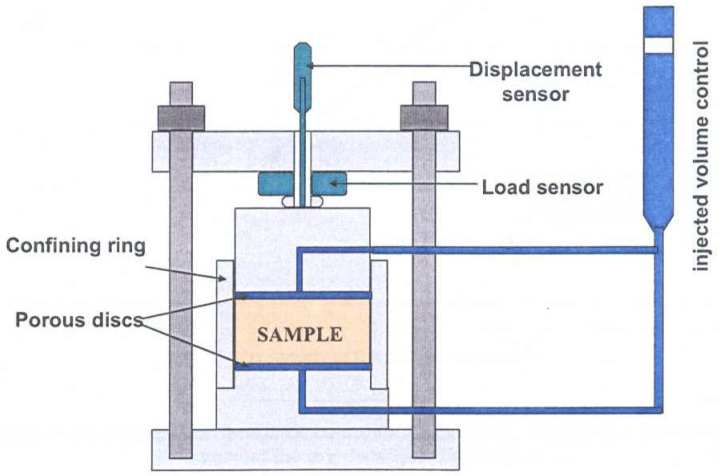
- Maximum swelling pressure: 4~5 MPa
- K_w: 1~2 orders lower than Boom clay

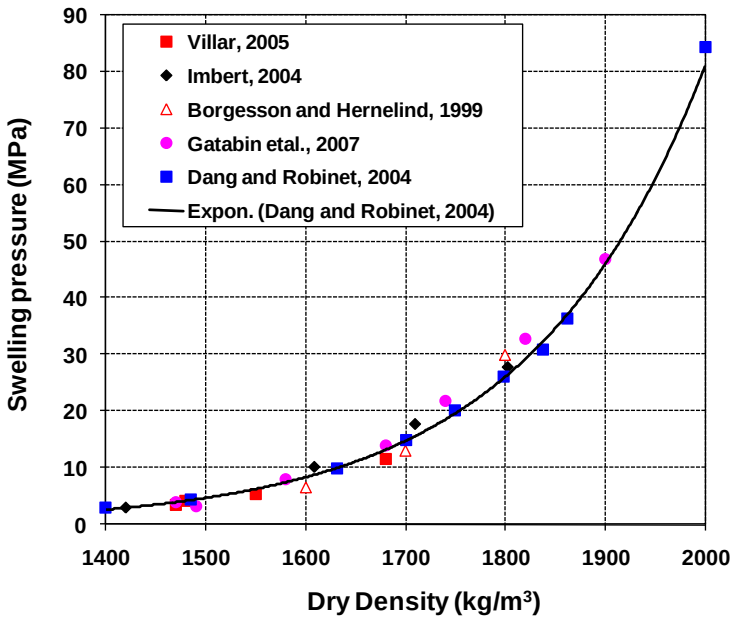
Main factors controlling swelling pressure:

- Initial dry density of MX80 bentonite
- Technological void ratio
- Boundary conditions
  - ✓ Boom clay
  - ✓ Steel cylinder



Swelling pressure is a function of dry density

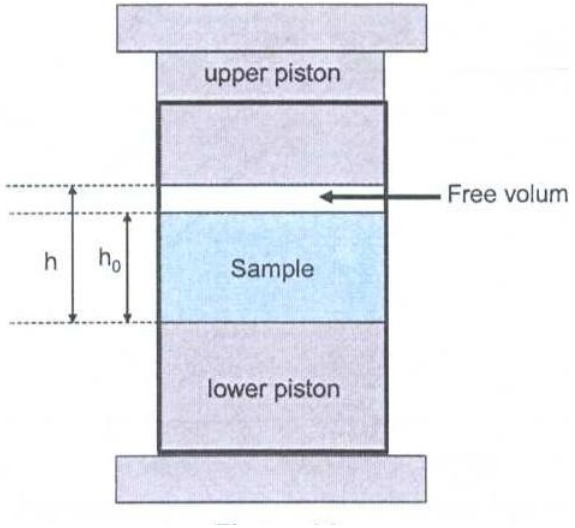


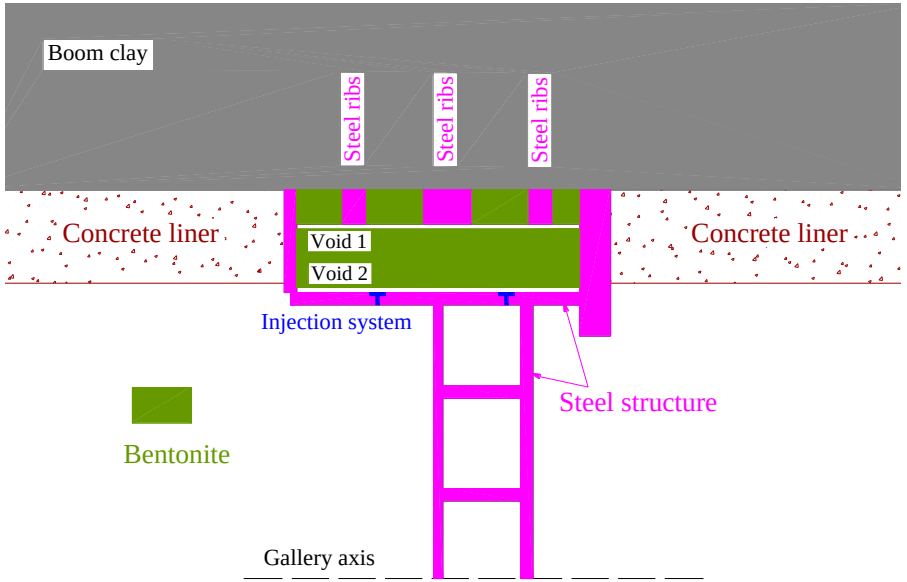


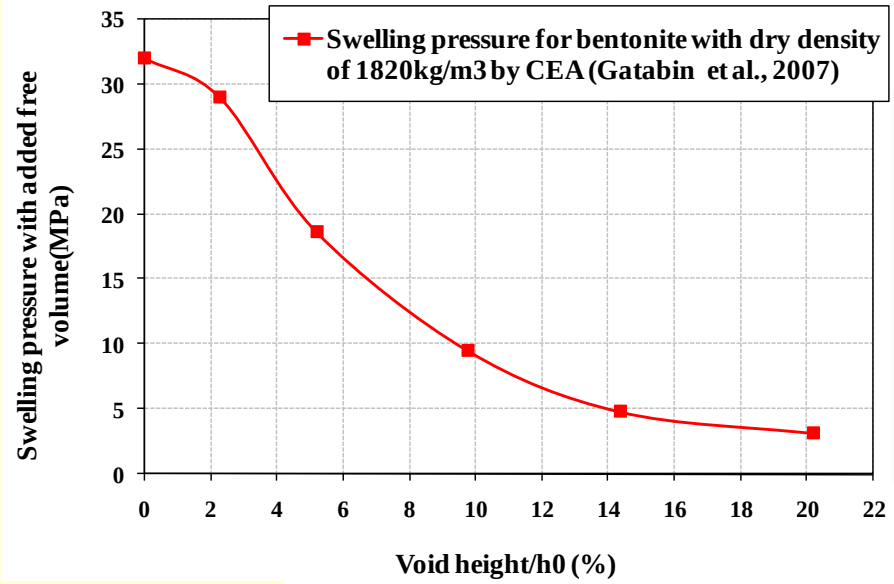
(Under constant volume)

- For dry density 1700kg/m^3: 14~15 MPa
- For dry density 1800kg/m^3: 29~30 MPa

Swelling pressure is a function of technological void ratio and boundary condition

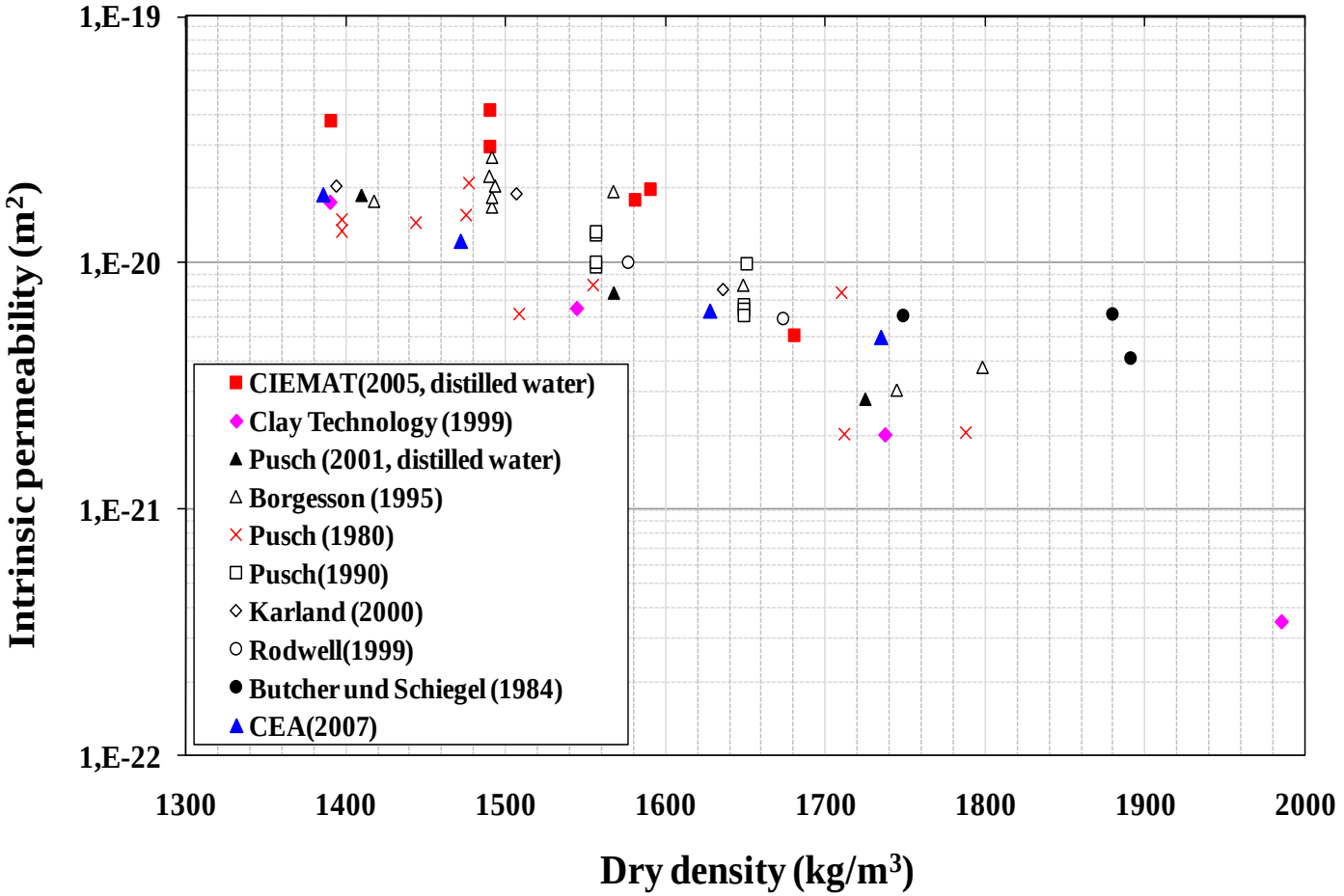






- Simple CEA test is designed to simulate Seal test
- Seal test is more complex:
  - ✓ Boom clay is an elastoplastic material
  - ✓ At least 2D problem
  - ✓ Steel ribs exist between bentonite & Boom clay
  - ✓ etc.

Intrinsic permeability is a function of dry density



For dry density 1800kg/m^3: 2 orders lower than Boom clay.

Modeling approach

- **Finite element method using code “Code_Bright”**
- **Bentonite/Boom clay are multi-phase and multi-species materials**
- **Many THM phenomena are considered**
  - Heat conduction, advection (T)
  - Water advection, vapor diffusion (H)
  - Thermal expansion, swelling of bentonite, elastoplasticity of Boom clay etc. (M)
  - THM coupling
- **Take into account interaction Boom clay/Bentonite/steel structure**
- **Follow the real test procedures as much as possible**
- **1D model, 2D axisymmetric model, & 2D plane strain model**
- **A large number of THM parameters and constitutive models are obtained and validated based on lab tests & in-situ tests.**

Modeling procedure

- **Excavation & installation of liner**

  Nov. 2007

- **Drainage:**

  Nov. 2007~Feb. 2010

- **Remove wood**

  Jan. 2010

- **Install bentonite & steel**

  Feb. 2010

- **Inject water**

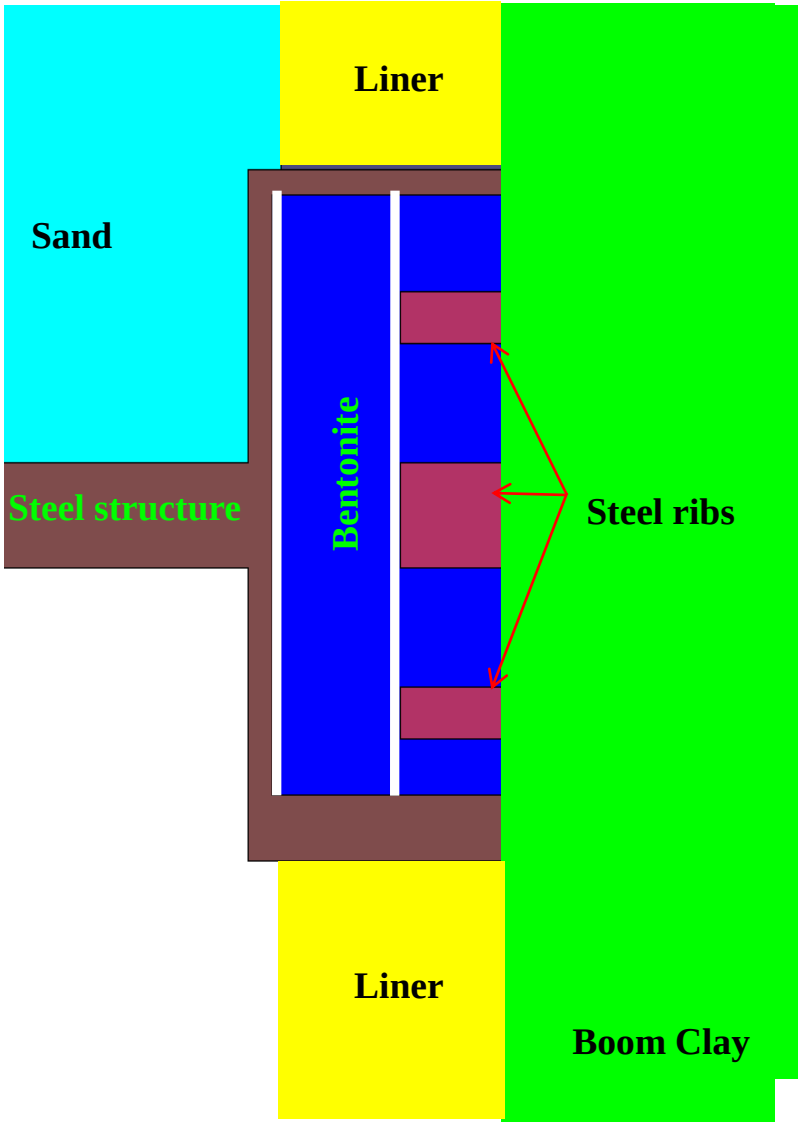
  Apr. 2010~Jan. 2011

- **Backfill & saturate sand in gallery**

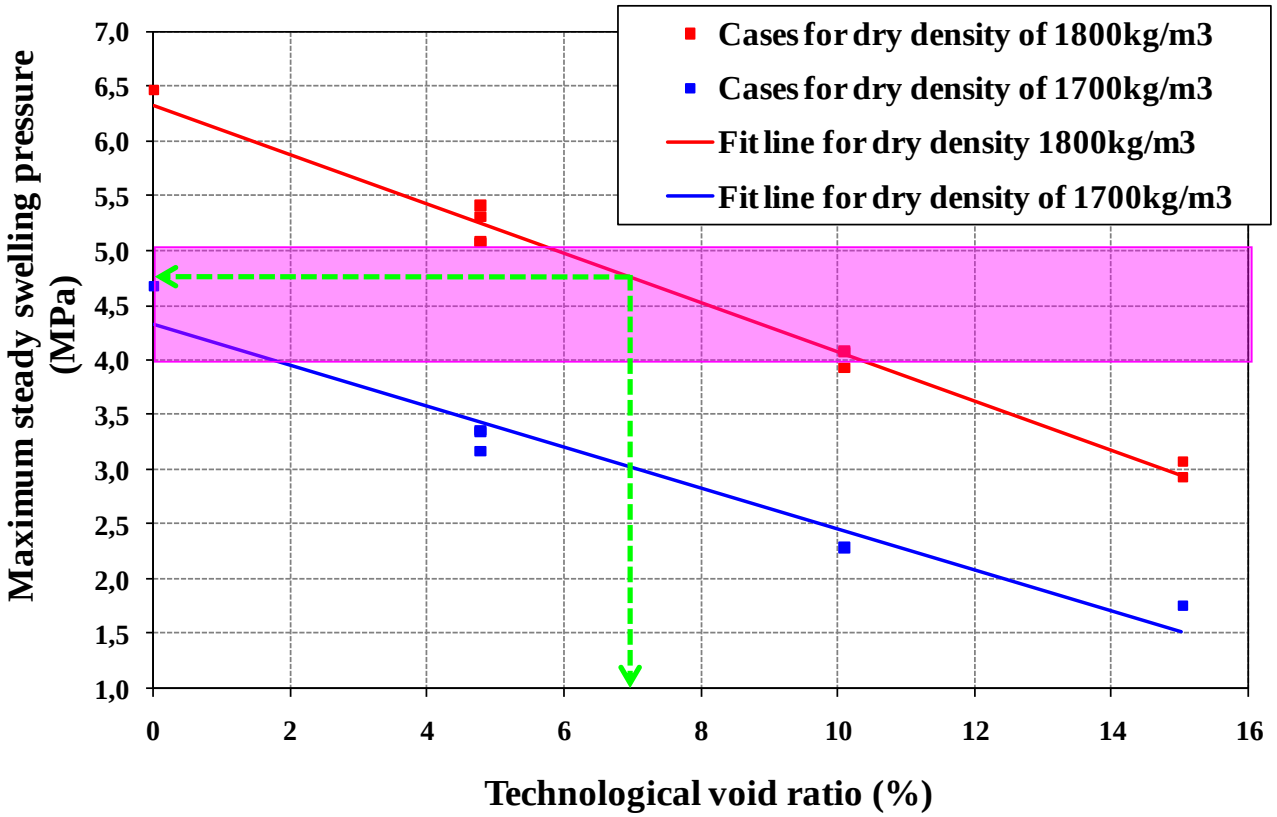
  Jan. 2011

- **Praclay heater test**

  Sept. 2011~Sept. 2021



Modeling results



steady swelling pressure ~ tech. void ratio, for different dry density

For initial dry density $\mathbf{r_d=1800kg/m^3}$, when technological void ratio: **6 ~10 %:**

=> swelling pressure : **4~5 MPa** (target swelling pressure)

- **Initial dry density of 1800kg/m^3 is selected, with**

  Water content: 16.5%

  Saturation degree: 83.8%

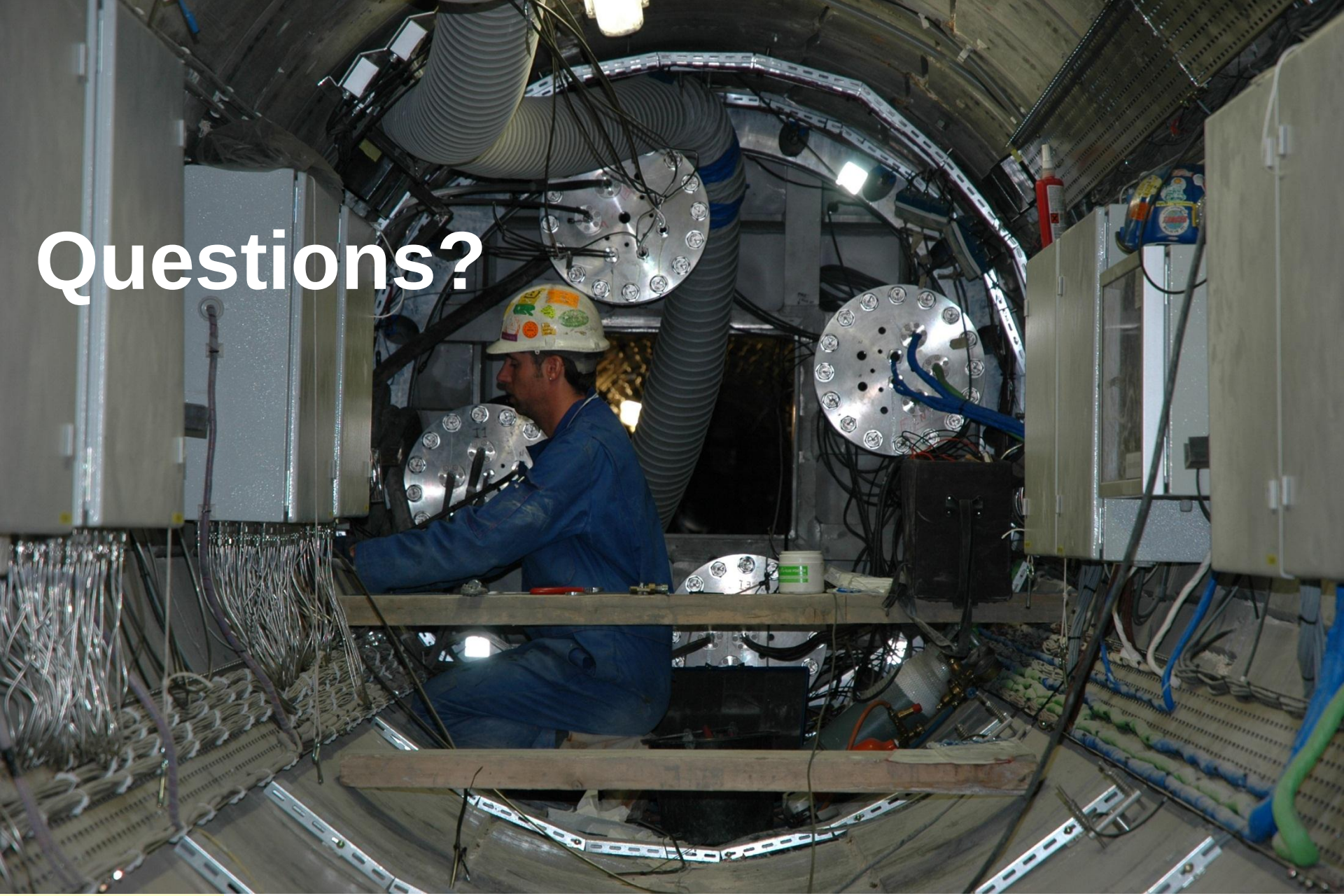
  Suction : 59 Mpa

- **Initial technological void ratio of 6.9% is obtained after installation**
- **At final state, the estimated intrinsic permeability: 6~10×10^{-21}m^2, nearly 2 orders lower than Boom clay**

Modeling also checks many other aspects:

- *Effect of artificial water injection on the saturation process*
- *Interaction between heater test and seal test*
- *Effect of non-saturation of Praclay gallery on the THM responses of Boom clay*
- *Influence of earlier backfilling in gallery on the seal saturation process*
- *Effect of unlocking the steel ribs on the homogeneity of swelling pressure*
- *Influence of upstream joint, downstream joint on the efficiency of the seal*
- *etc.*

Modeling keeps updating based on the measured data and real test conditions


Questions?