Initial Plug and Seal Design for the Dutch Repository Concept (PPT)

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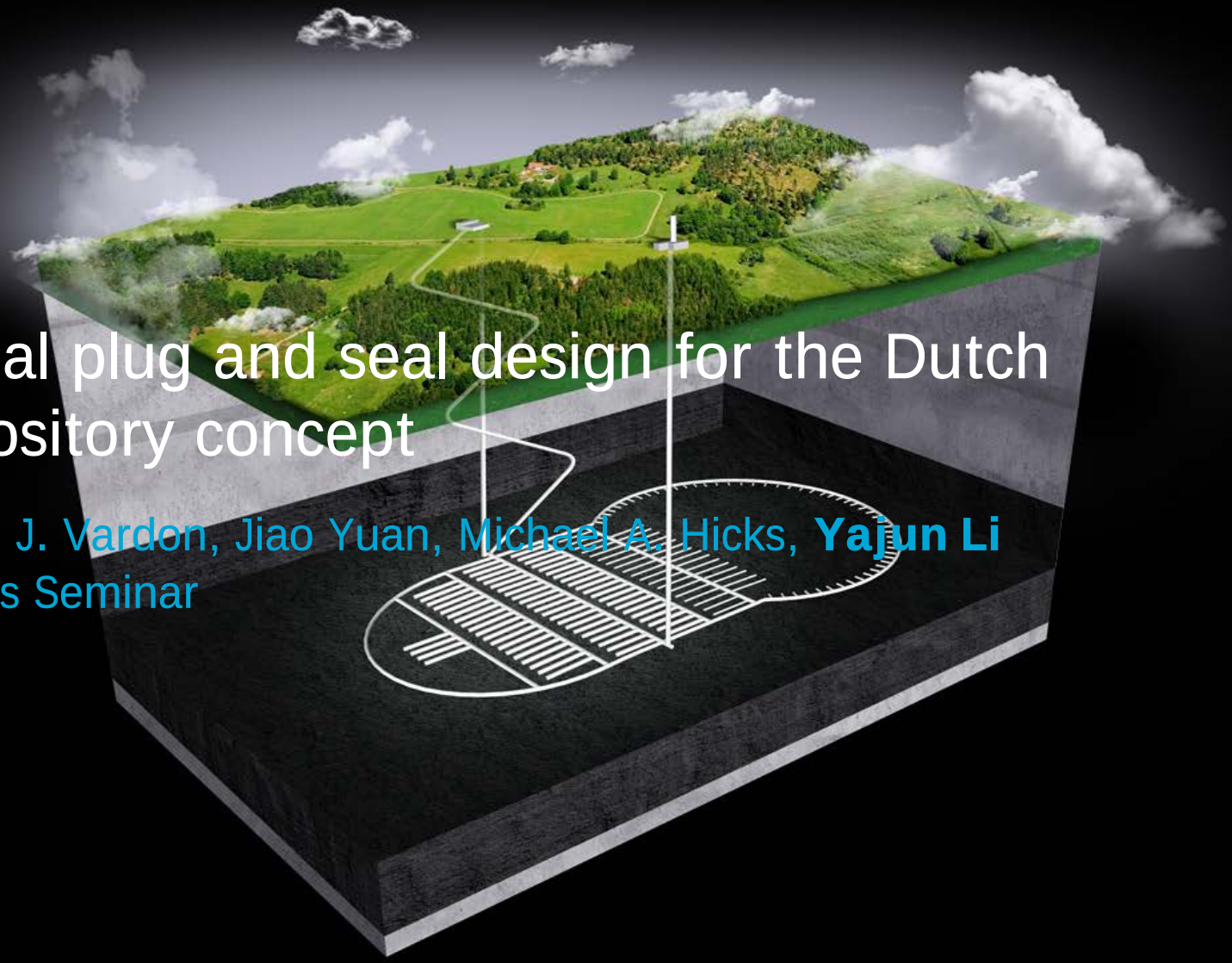

Initial plug and seal design for the Dutch repository concept

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PERSONAL INFORMATION

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EDUCATION & BACKGROUND

- Jan. 2016 - present, Postdoc in the Section of Geo-Engineering, Delft University of Technology, Delft, The Netherlands.

- Sep. 2011 - present, PhD student in the Section of Geo-Engineering, Delft University of Technology, Delft, The Netherlands.

Contents

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- Repository outline
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- Plug system design
- Requirements and design scenarios
- Mechanical stability
- Hydraulic seal

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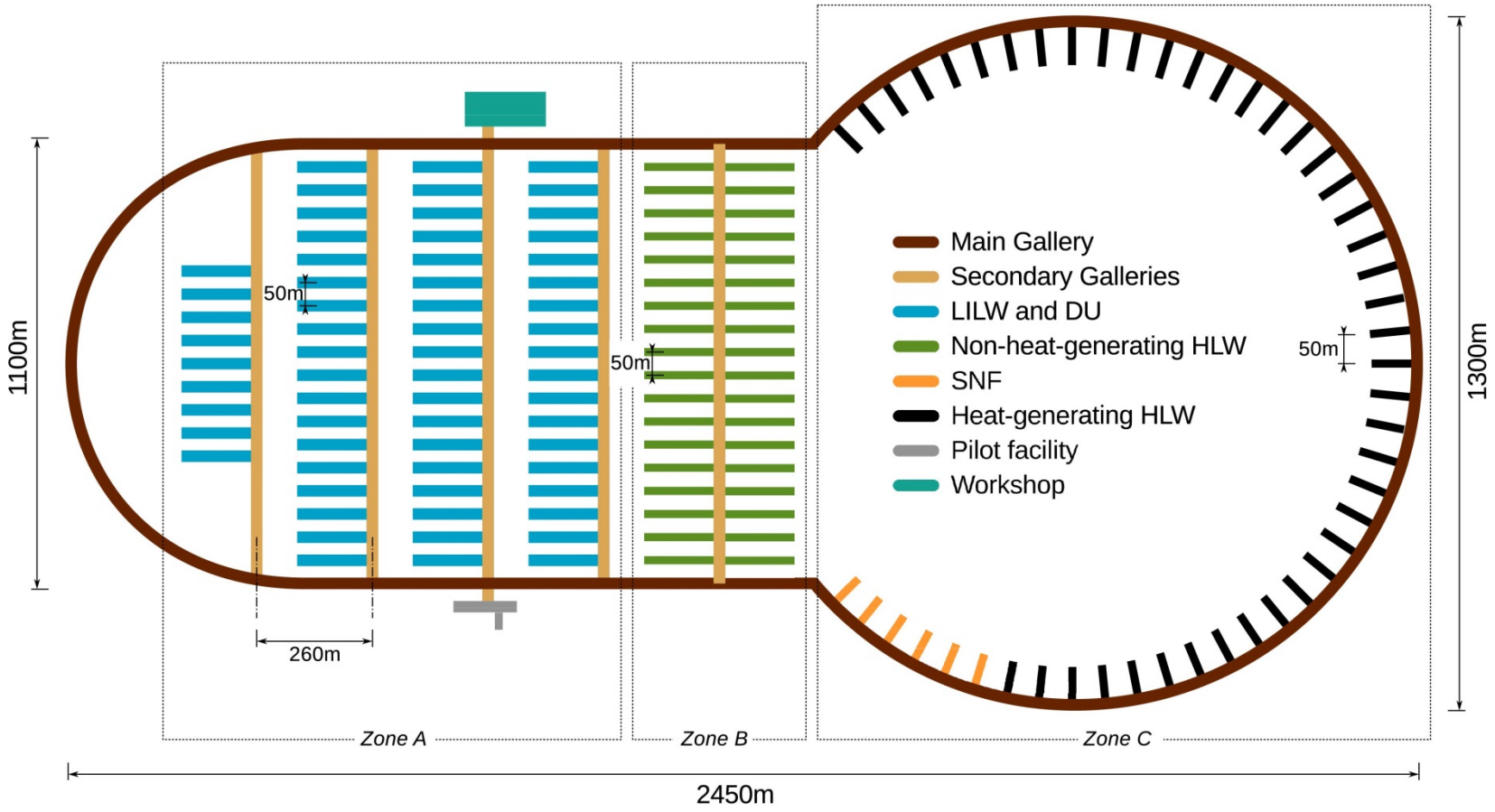
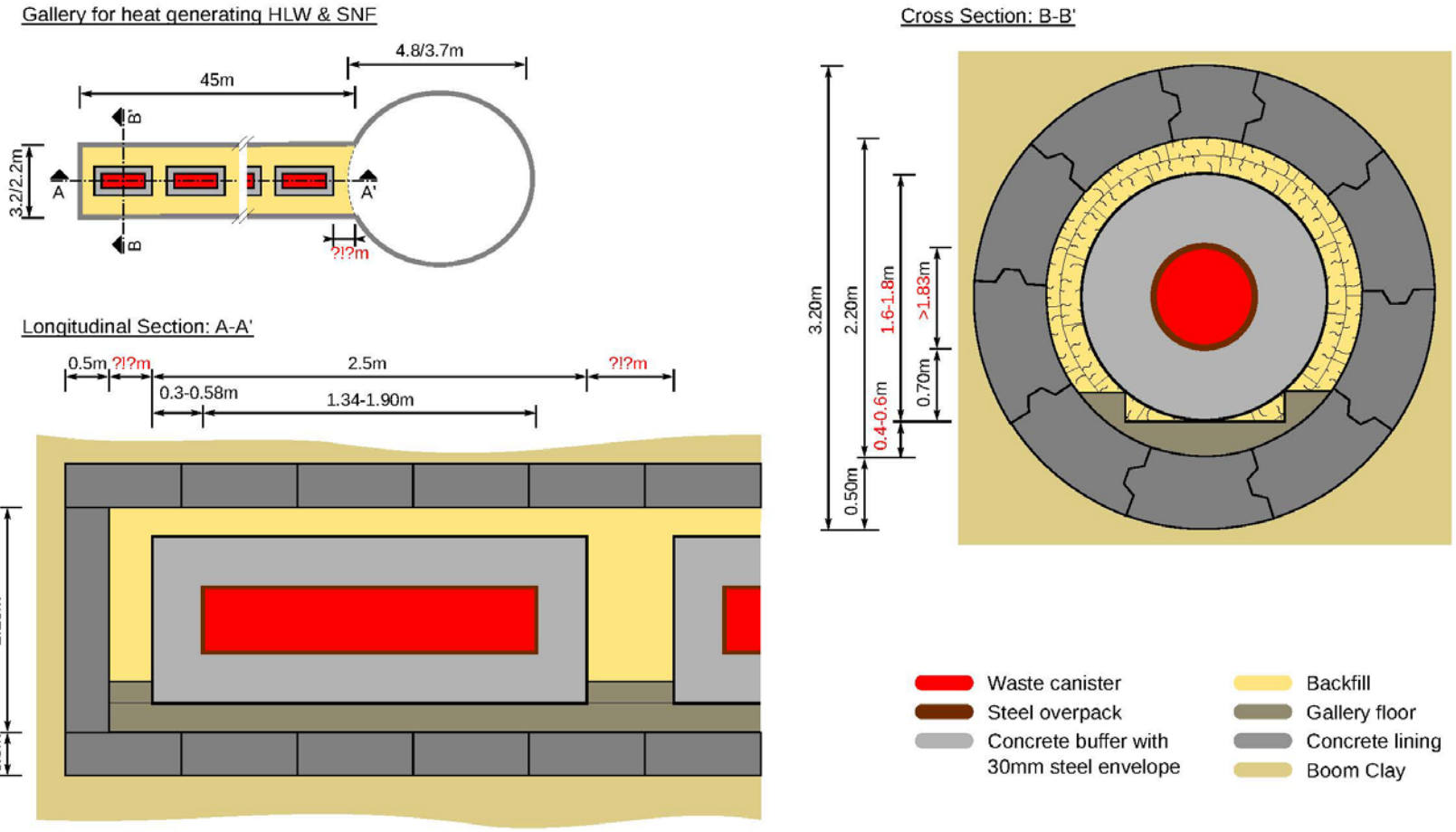
Conceptual outline

OPERA deep geological underground disposal facility in Boom Clay



Supercontainer for HLW and SNF disposal



Objective

- Study the overall technical feasibility of the proposed repository.
  - Mechanical stability of tunnel system, tunnel crossings, THM behaviour, host rock variability.
  - See http://www.covra.nl/cms-file/get/iFileId/2844 for first report.
- For plugs and seals – initial specification and sizing (not detailed design).

Requirements of plug system

Plugs are proposed to be used to hydraulically seal off the disposal drift (and shafts and ramp) after emplacement of waste packages and to restrict movement of backfill.

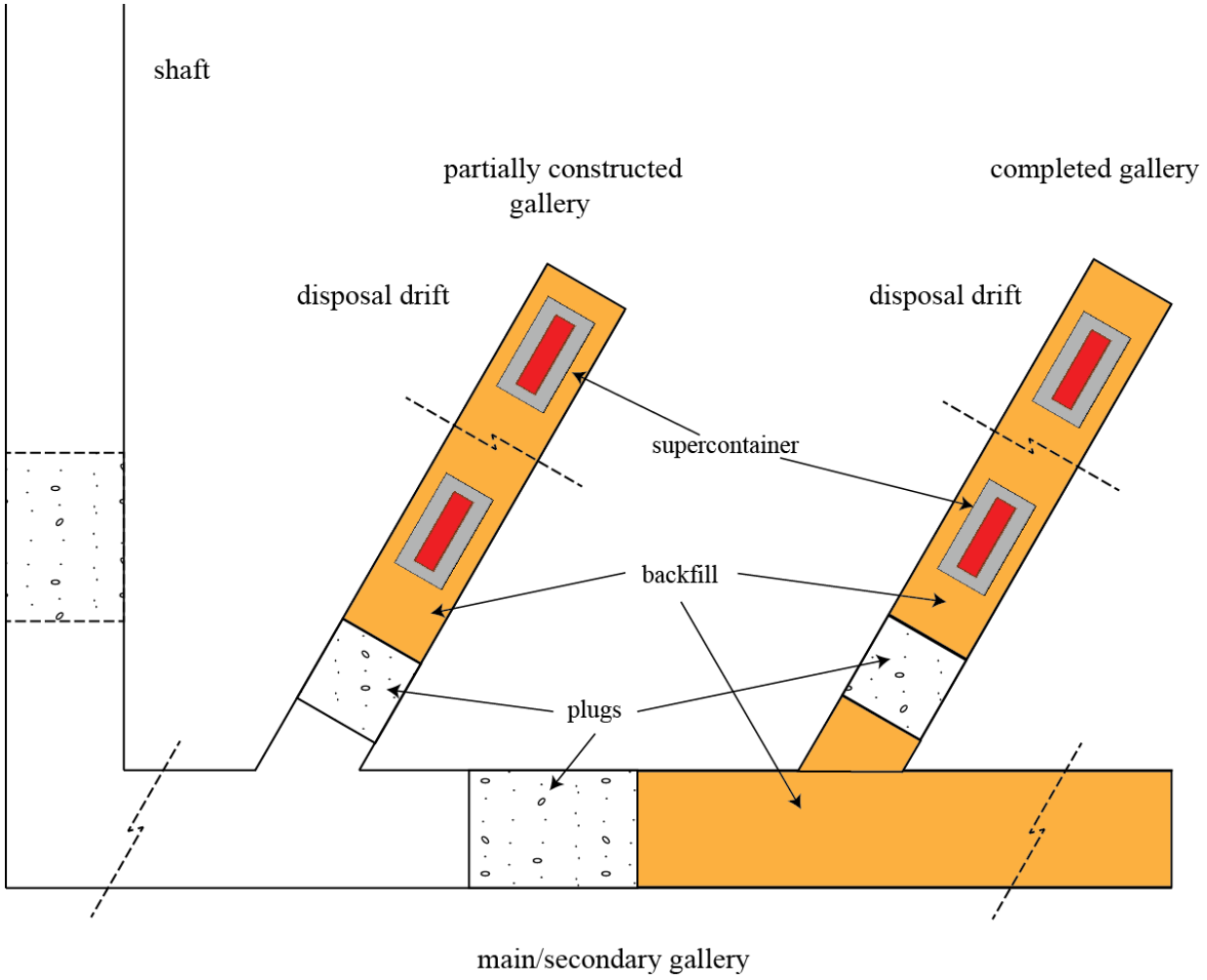
Functions are:

1. Keep the backfill in place;
2. Be a watertight barrier preventing axial water flow and erosion of backfill from the deposition tunnel.

Two main components for a plug system in Boom Clay:

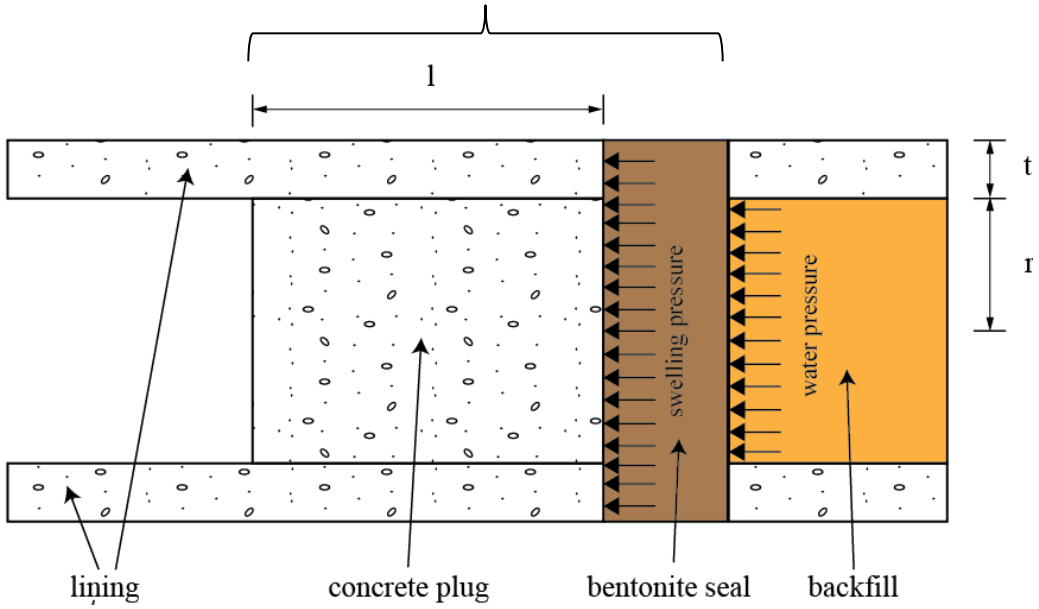
1. Concrete plug;
2. A bentonite seal.

Plug locations (schematic)



Outline design

Plug system



Mechanical stability

Hydraulic seal

Design scenarios

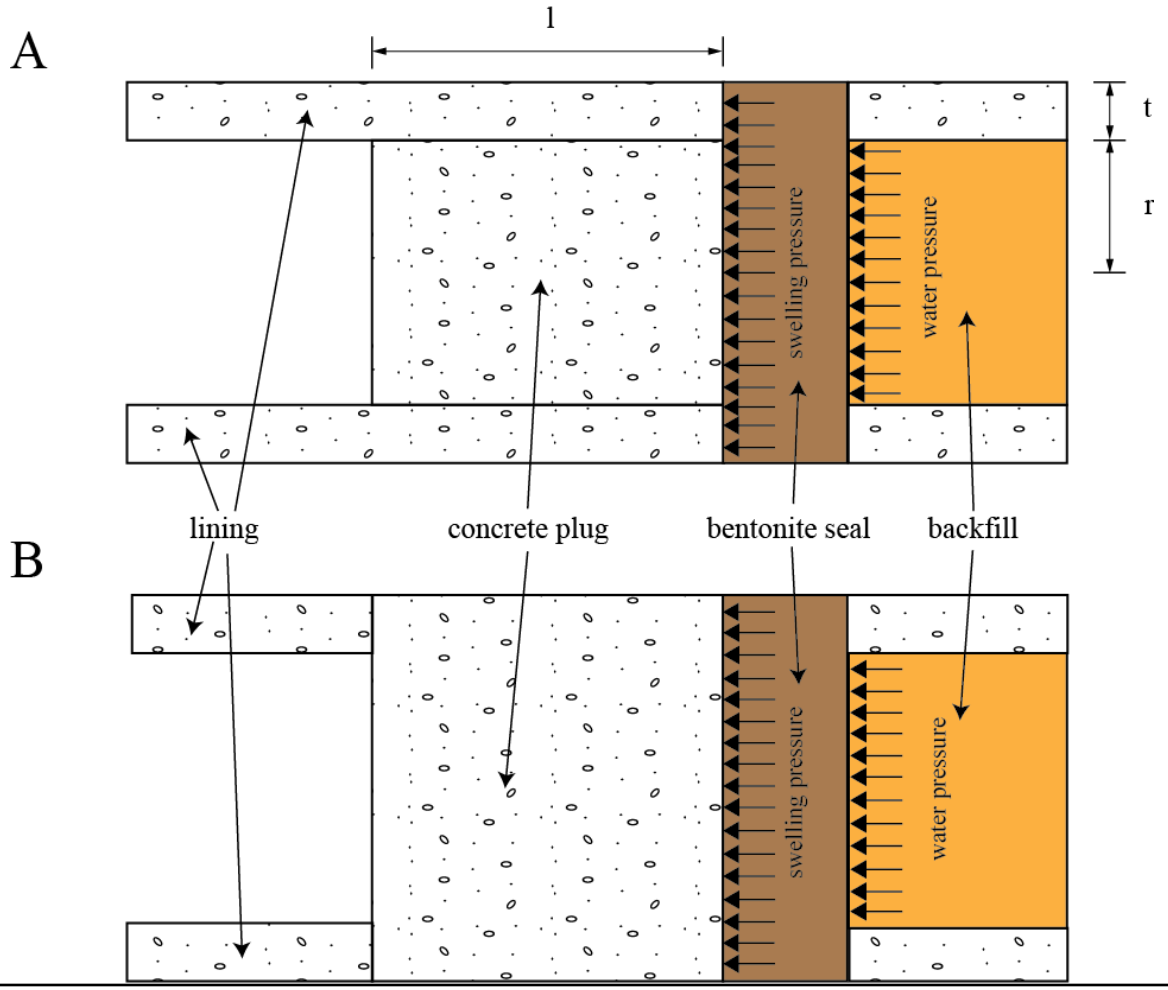
Three type of design scenarios are considered:

Scenarios	unbalance load	load ranges
Shaft flooding	hydrostatic pressure	0-5 MPa
Partially constructed	hydrostatic pressure + swelling pressure	0-7 MPa
Construction completed	no	0 MPa

Mechanical stability of the plug

The concrete plug should mechanically support the bentonite seal and backfill, and transfer the loads into the surrounding host rock.

Two types of conceptual plug design

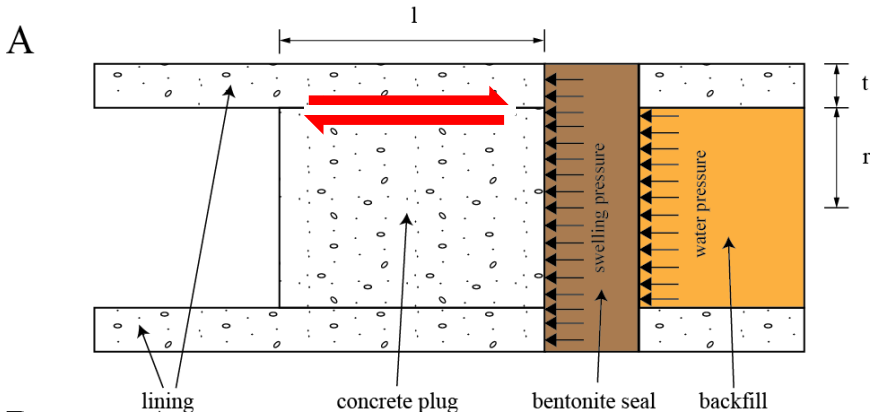


Design A

For design A, the failure of this parallel-sided plugs is governed by the interface shearing between concrete plug and lining.

$$p\pi r^2 <= 2\pi r l p_{pe}$$

$$l >= pr / 2p_{pe}$$



p is the intensity of applied pressure, r is the inside radius of the tunnel and p_{pe} is the permissible punching shear stress of the concrete interface.

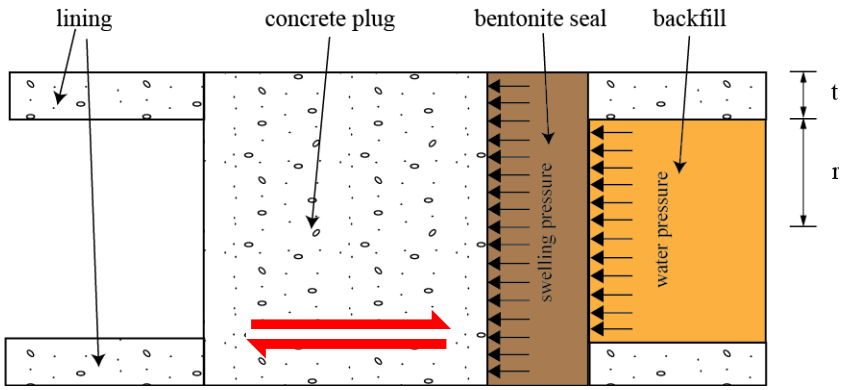
Design B

For design B, with lining thickness of 0.5 m, the concrete plug can be fully supported by the concrete lining. In this case, the failure of the plug is governed by the punching shear resistance of the concrete plug against the concrete lining

$$f_p = \frac{p\pi r^2}{2\pi rl} <= p_p$$

$$l >= pr / 2p_p$$

B



p_p is the permissible concrete punching shear stress.

Results

- Concrete permissible stresses based on Eurocode 2, EN1992-1-1 (**concrete class C55/67**).
  - Punching shear resistance, p_p = 3.873 MPa.
  - Shear resistance at the concrete to concrete interface, p_{pe}= 1.35 MPa.

- The max total stress p, is assumed to be 7 MPa.

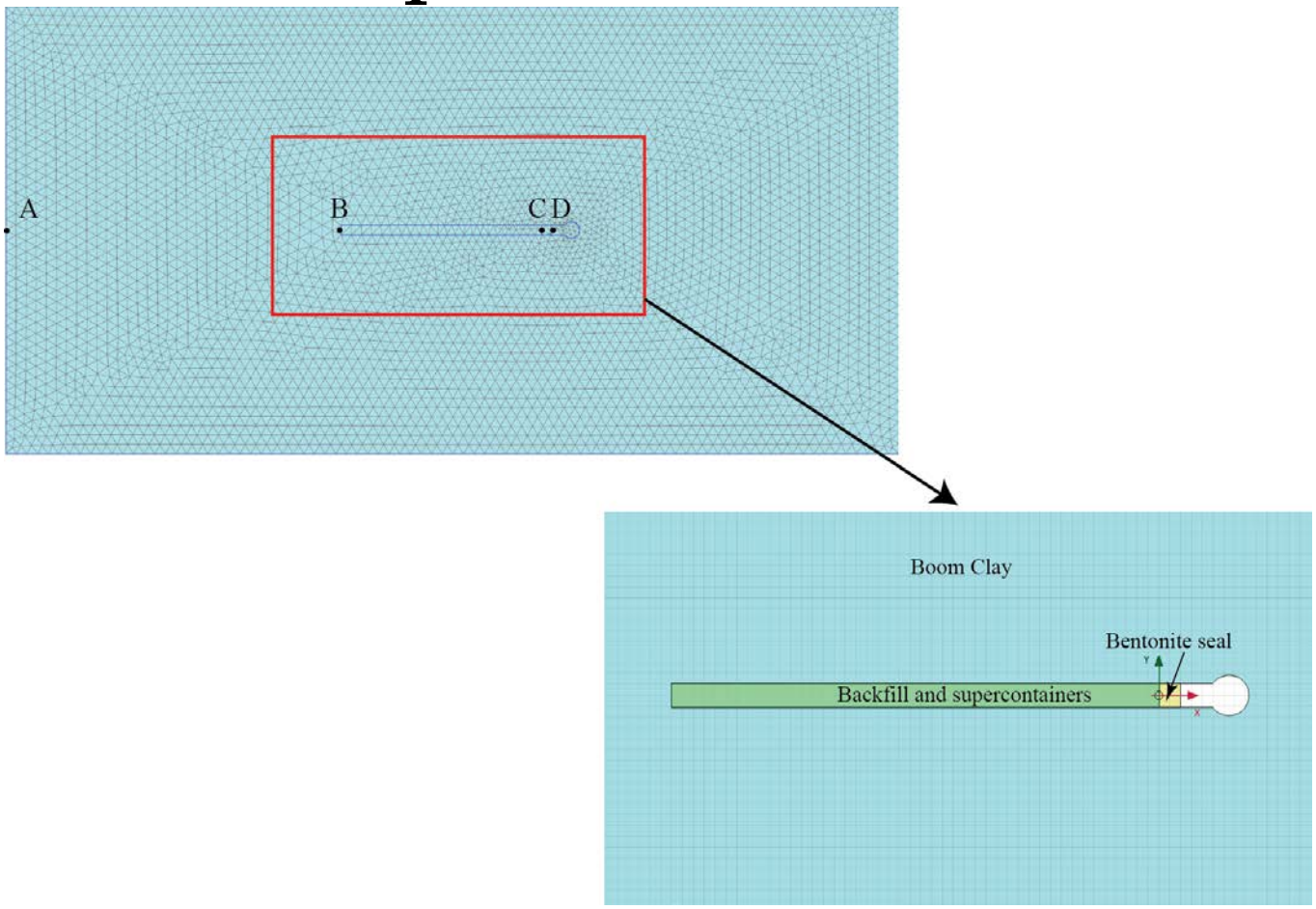
- Plug length:
  - Design A: plug length of 2.85-4.8 m (tunnel radius 1.1-1.85 m);
  - Design B: plug length of 0.99-1.67 m (radius 1.1-1.85 m).

Hydraulic seal of the plug

The bentonite seal is designed to have a low hydraulic conductivity, it must swell and seal all passages and it must be able to withstand a high hydraulic gradient.

Numerical simulations have been performed to study the hydraulic function and sealing length of the plug. The 2D plane strain analyses have been performed with PLAXIS 2D AE. The materials have been modelled here via a steady state Darcy flow equation.

Model set-up

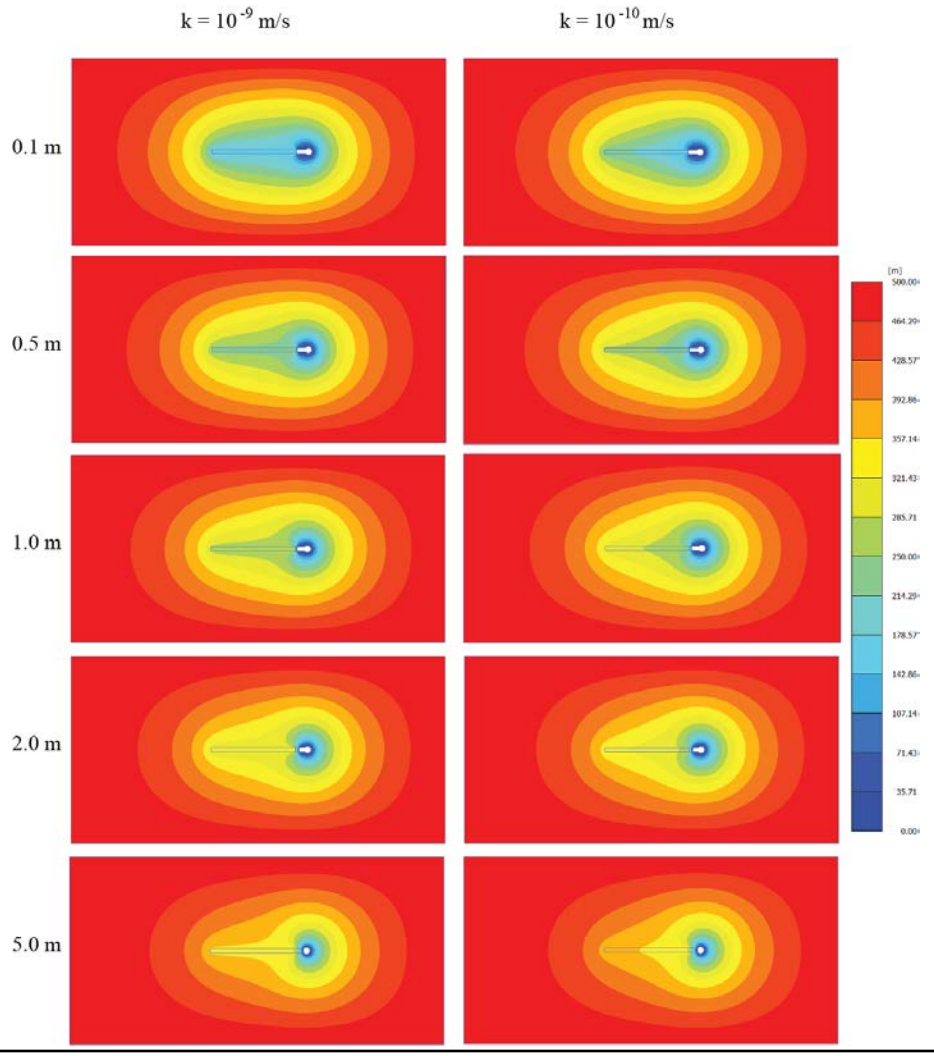


Details of the disposal tunnel and plug system used for the hydraulic simulation

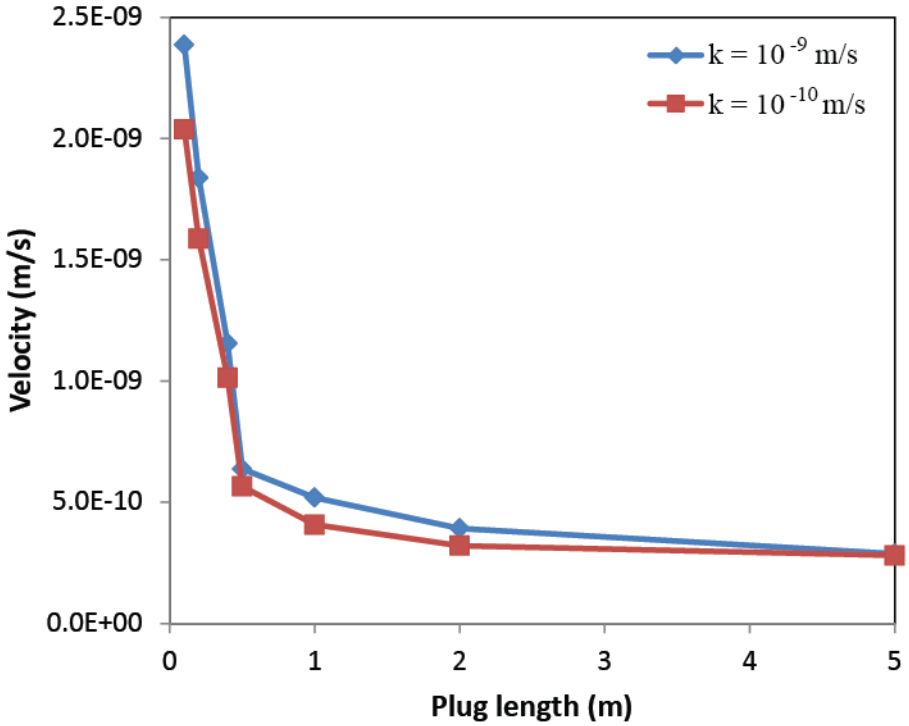
Hydraulic properties

Material	Hydraulic conductivity, k (m/s)
Backfill	10^{-9}, 10^{-10}
Bentonite seal	10^{-13}
Boom clay	10^{-12}

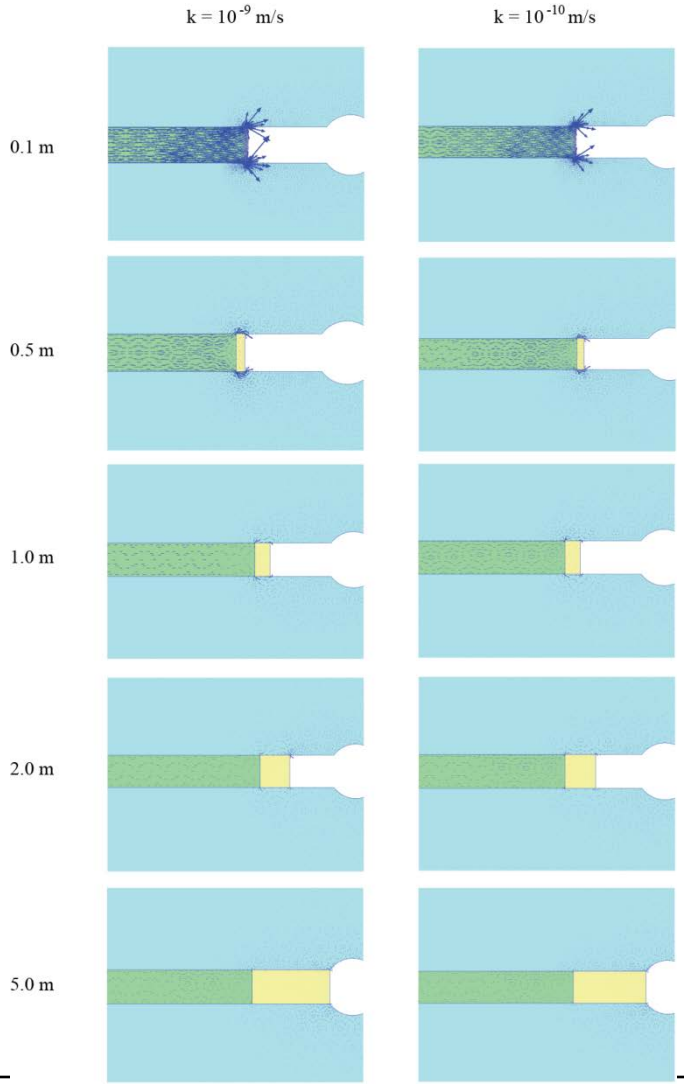
Water head distribution



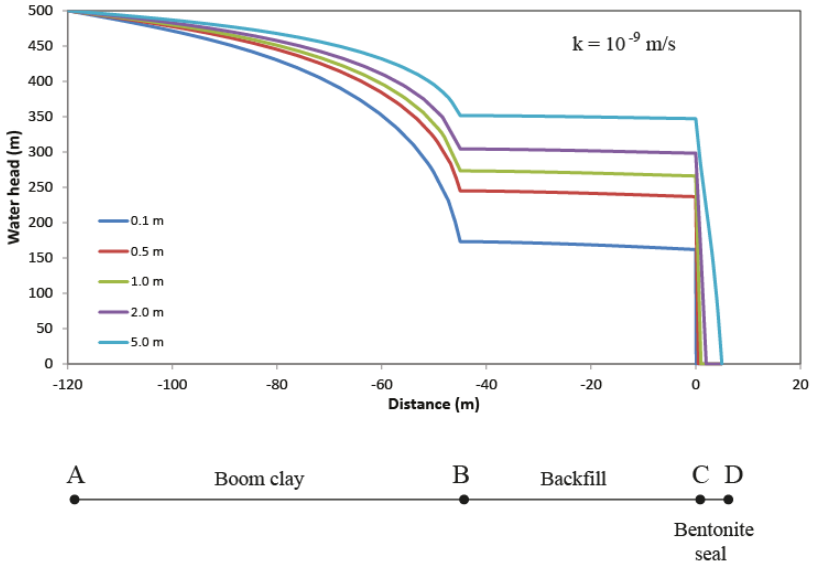
Maximum velocity versus sealing length

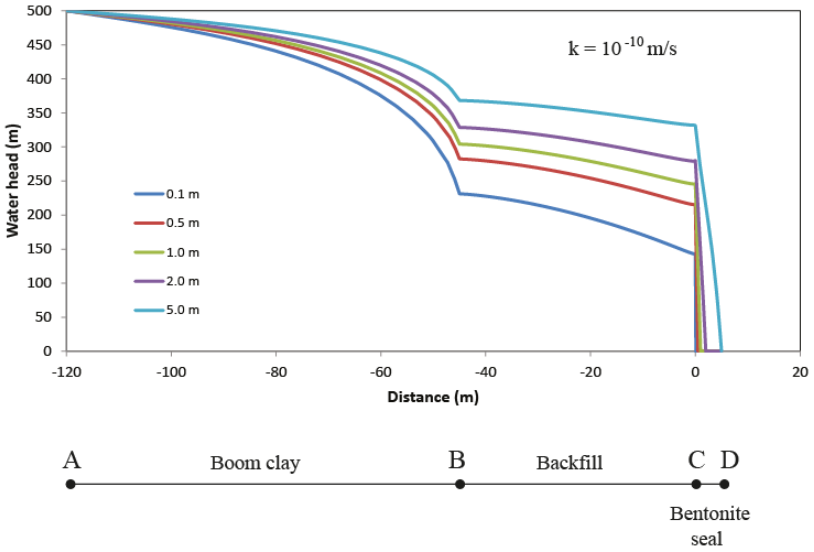


Velocity distribution



Water head distribution along the tunnel





Conclusions

Mechanical plug for stability:

- Design A: plug length of 2.85-4.8 m (tunnel radius 1.1-1.85 m);
- Design B: plug length of 0.99-1.67 m (tunnel radius 1.1-1.85 m).

Bentonite seal for hydraulic seal:

- Appropriate length between 0.5 and 1.0 m.

Two main requirements for the plug system for the Dutch geological repository have been distilled:
i) a plug that keeps the backfill in place and ii) a seal that prevents axial water flow. The system shall prevent erosion of backfill so that the backfill maintains its function.

Acknowledgements

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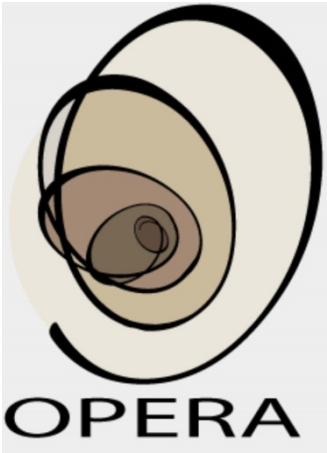

Thanks for your attention!