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Community Research

ESDRED

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*Practical Aspects of Deep Radioactive Waste Disposal*

**Session 3 - Paper N°14**

# The Surface Mock-up KENTEX: On the Thermal-Hydro-Mechanical Behaviors in the Buffer of Korean HLW Repository

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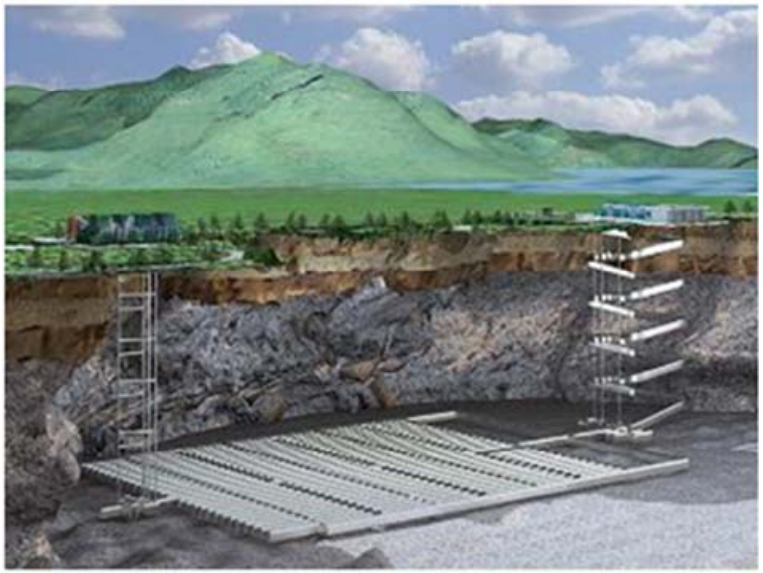
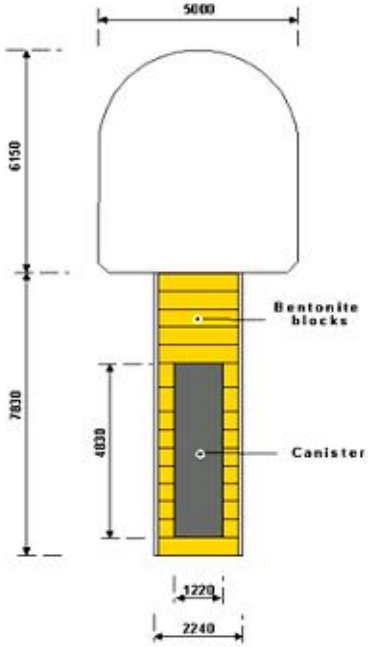
# PRESENTATION OUTLINE

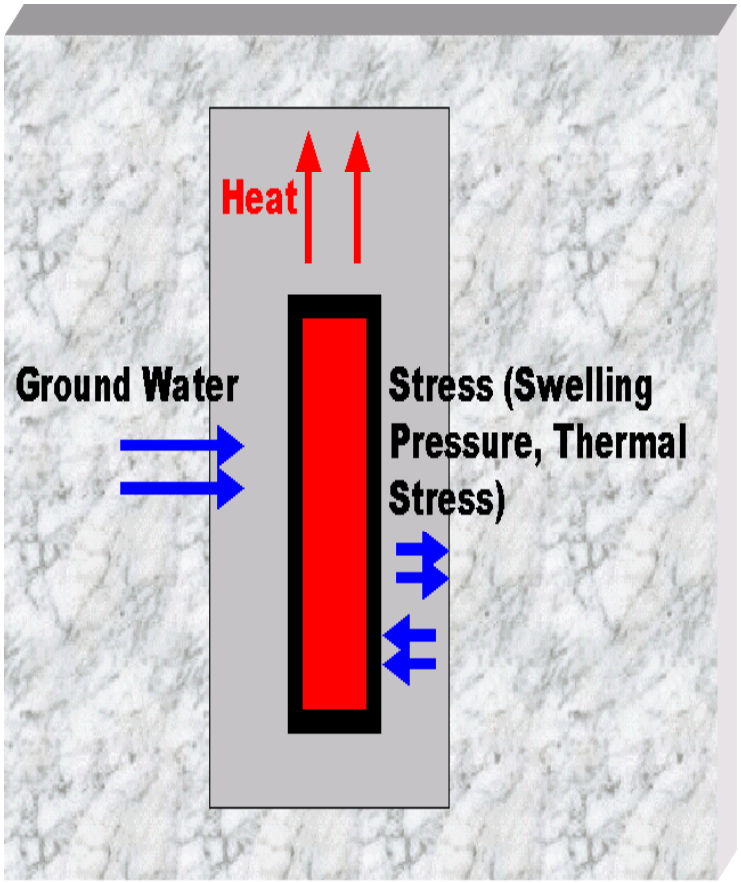
- ✓ Introduction
- ✓ Surface Mock-up KENTEX
- ✓ Operation and Experimental Results
- ✓ Hydro-Mechanical Modeling Using a Computer Code TOUGH2
- ✓ Conclusions

# Korean Referece Disposal System (KRS)





# Disp'l Conditions in Buffer

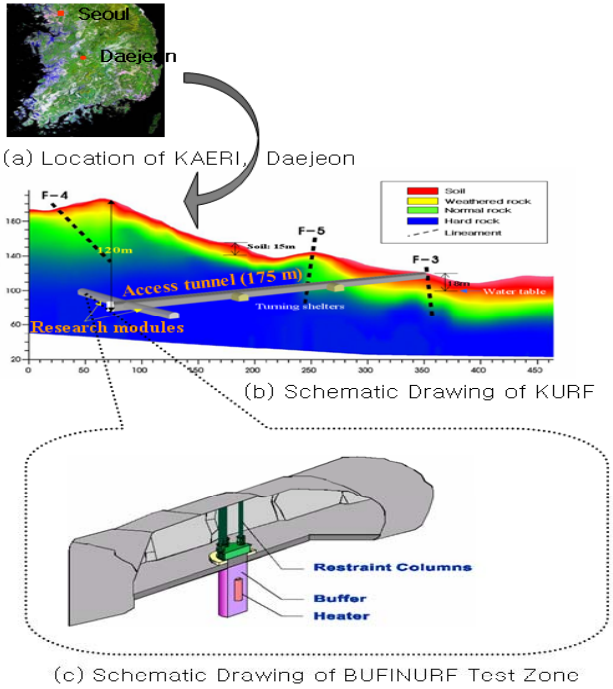



- Radioactive decay heat from HLWs
- Infiltration of gw from the surrounding host rock
- Swelling pressure of a buffer and thermal stress

➢ These processes may lead to complicated disp'l conditions in buffer and thus uncertainties in a performance assessment.

# Large-scale Buffer Test Programmes

- Intermediate-scale Surface Mock-up Test (KENTEX)
- Full Scale "in-situ" Test in KURT (under planning)



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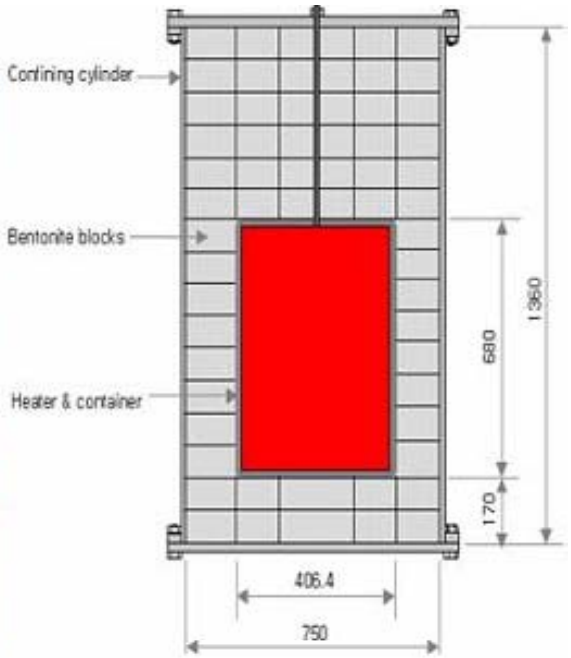
# Surface Mock-up KENTEX

✓ KAERI Engineering-scale THM Experiment for the EBS

✓ A third scale of the KRS




▶Major Components
- -Confining cylinder
- -Bentonite blocks
- -Container and heater
- -Hydration tank
- -DAS & heater control system

▶Test Conditions
- -Heaters: 1 kW x 3
- -Bentonite: 13% of water content, $\rho_d$=1.5 $cm^3/g$
- -Interface temp bet'n heater and bentonite block= 90 °C
- -Room temperature= 25 °C
- -Applied water pressure=5 atm

▶Measurement Parameters
- -Temperature (T)
- -Water content (θ)
- -Total pressure (P)

# Objectives of the KENTEX Test

- To provide information (on large-scale appratus, sensors, monitoring system etc.) needed for an in-situ test in KURT

- To develop a computer code for the T-H-M performance assessment of the buffer of the KRS

- To demonstrate the engineering feasibility of fabricating and emplacing the buffer of a HLW repository

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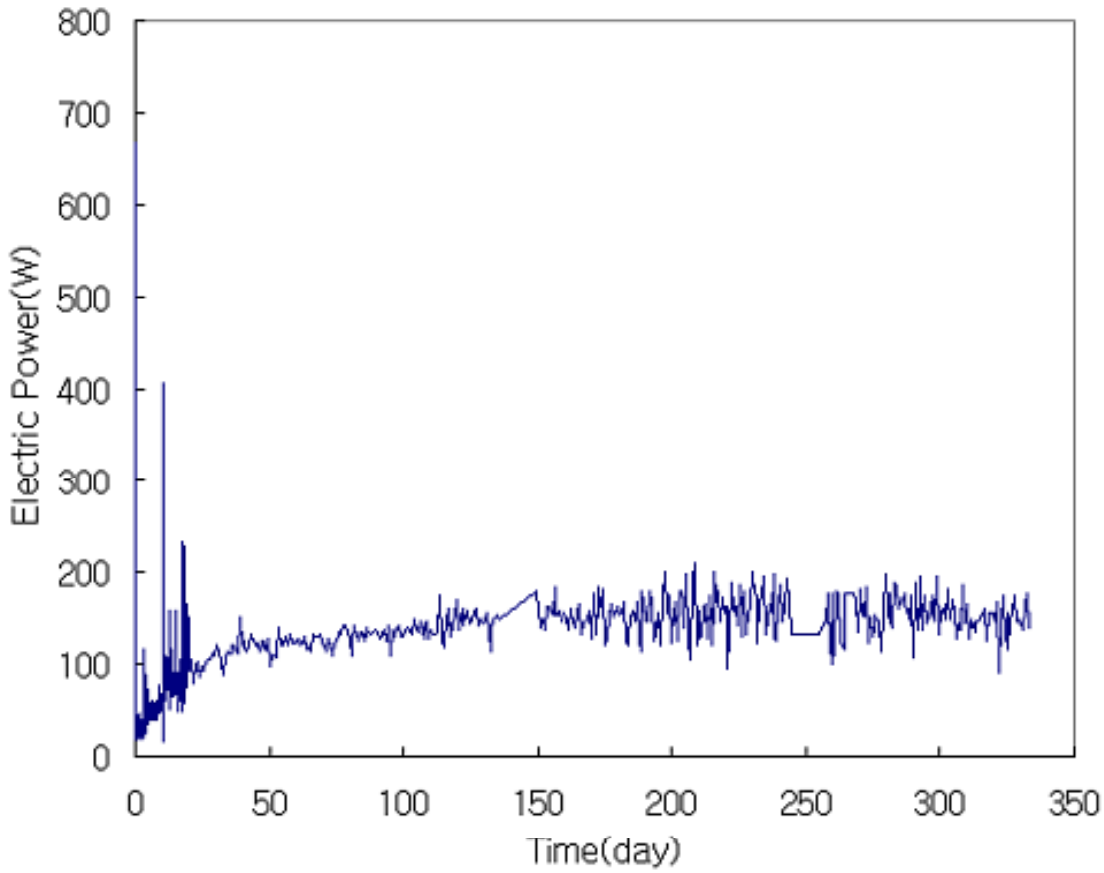
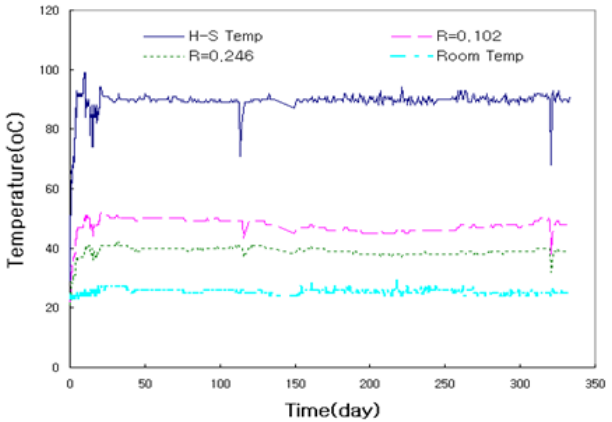
# System Component Performance

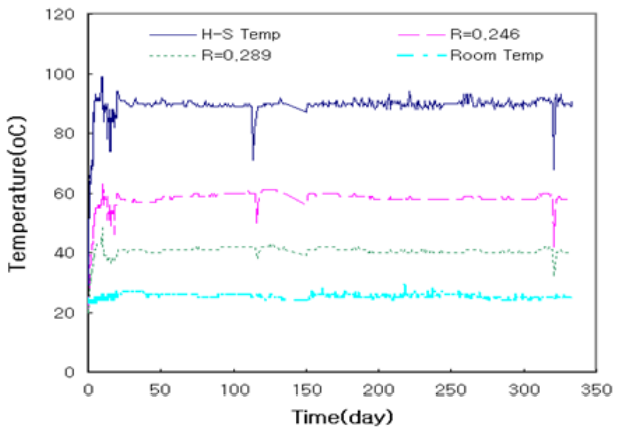
- The KENTEX has successfully operated since its start.
- The performance and
  except for the humidi
  - More than 99% of
    in operation.
  - For humidity sens
    malfunctioned.
- The performance of tl



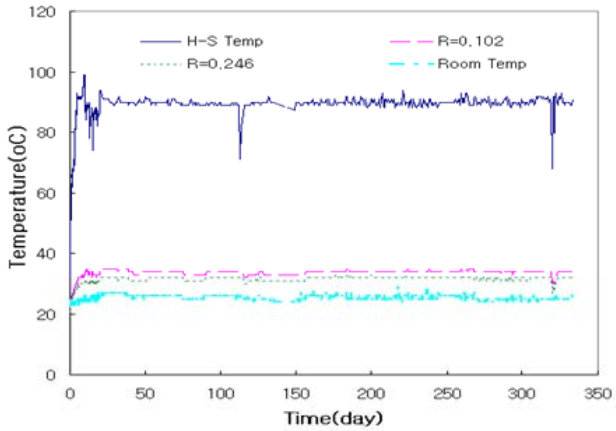
# Thermal Behaviour (Temperature) - 1/3



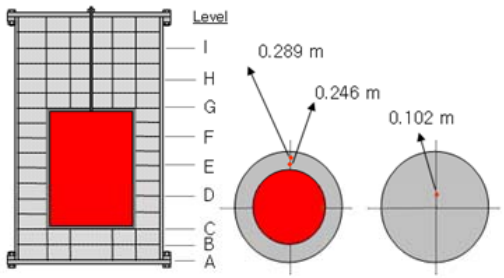

Level = B (0.085 m)




Level = F (0.680 m)

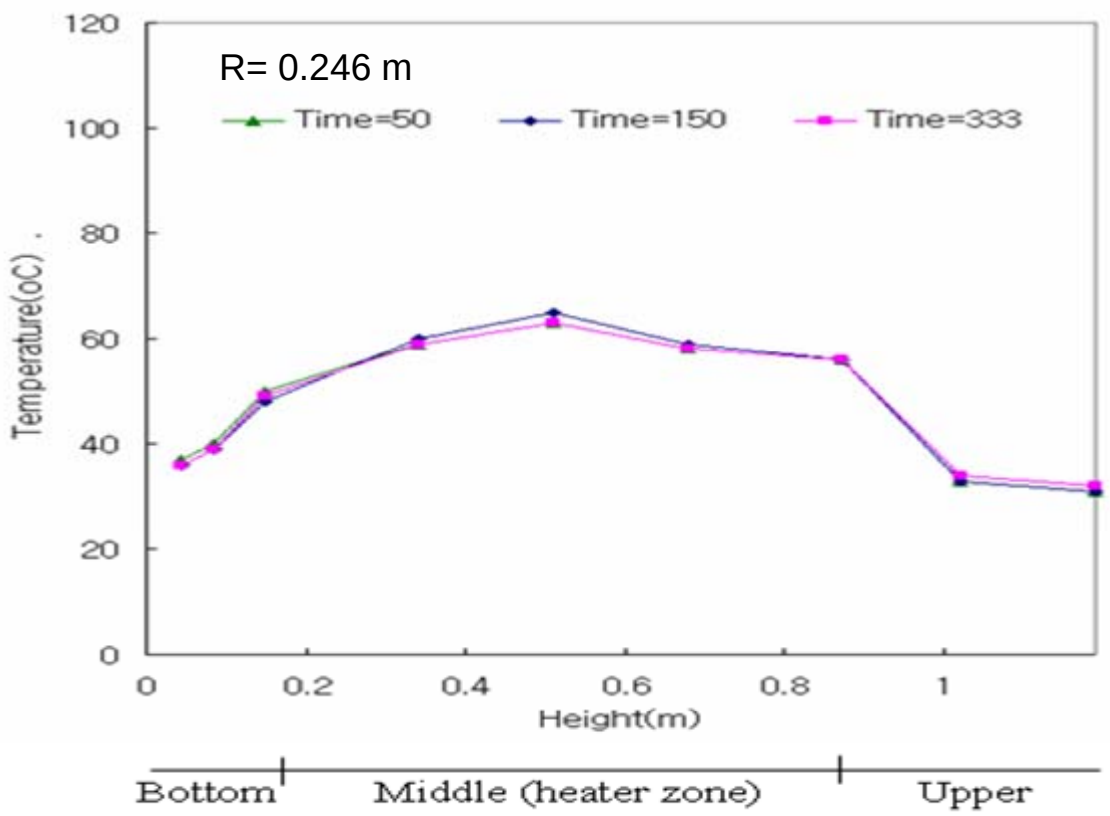



Level = H (1.190 m)

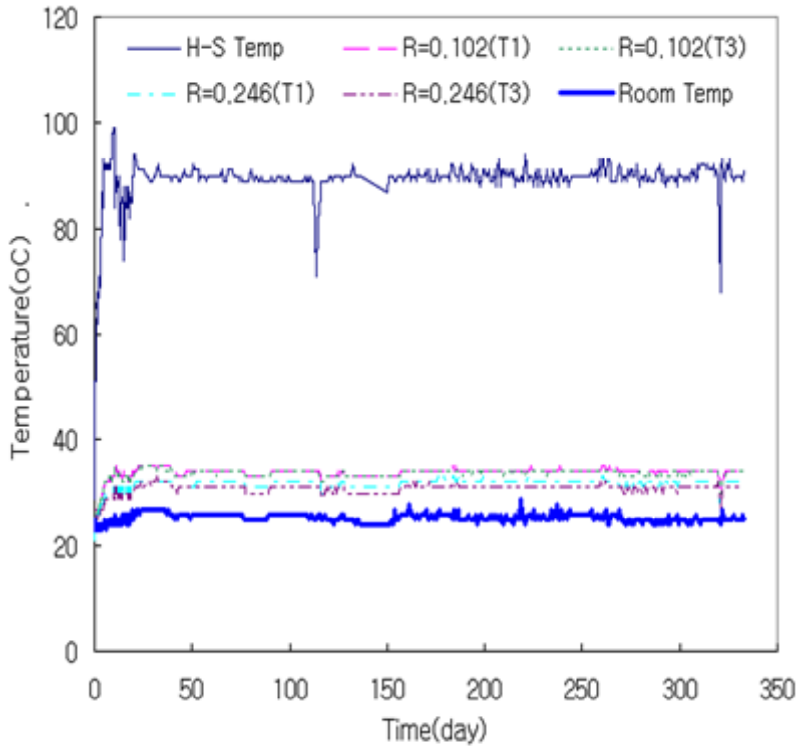


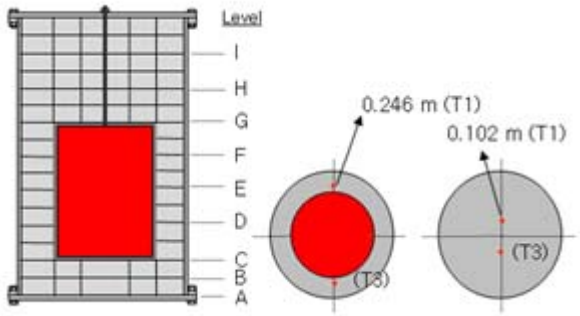

Location of the Sensor

# Thermal Behaviour (Temperature) -2/3

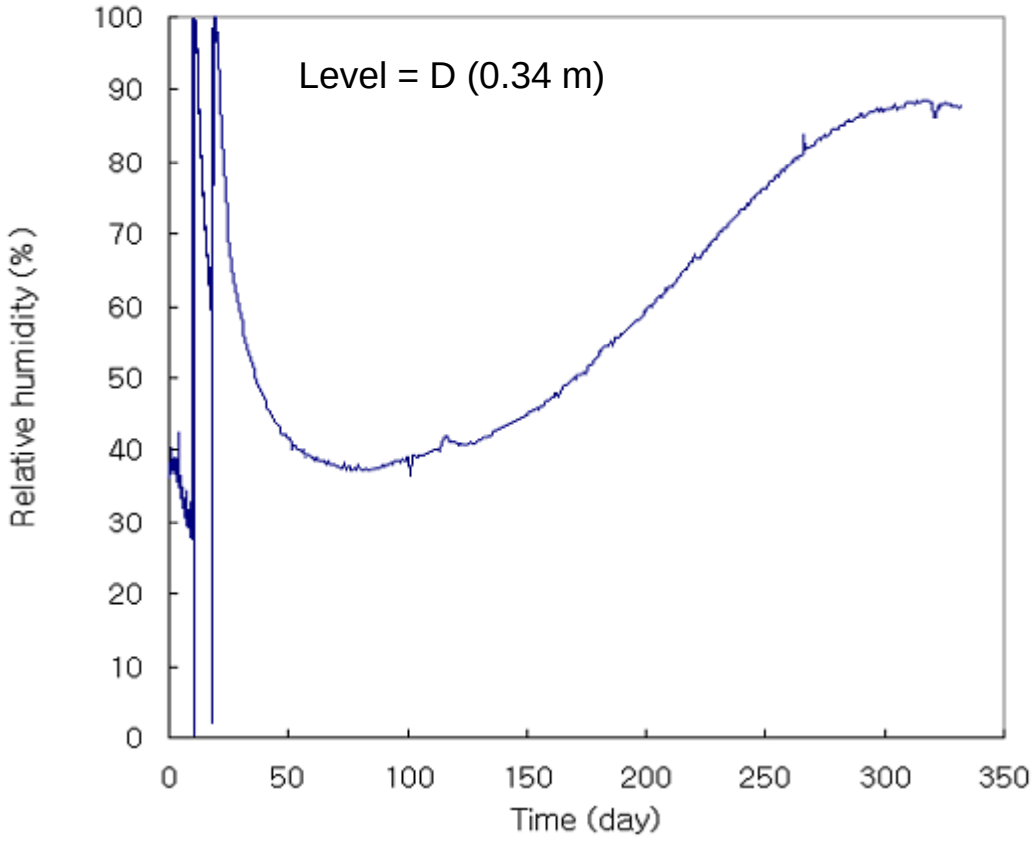


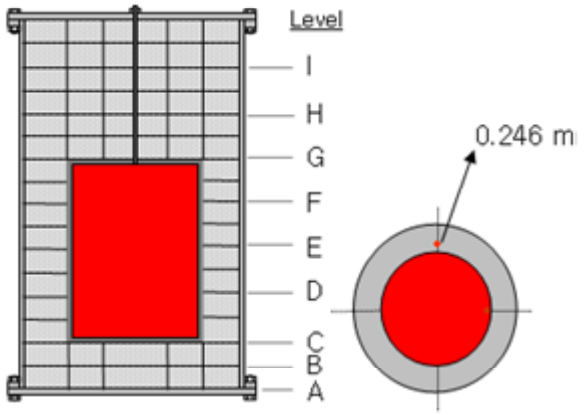
# Thermal Behaviour (Temperature) -3/3



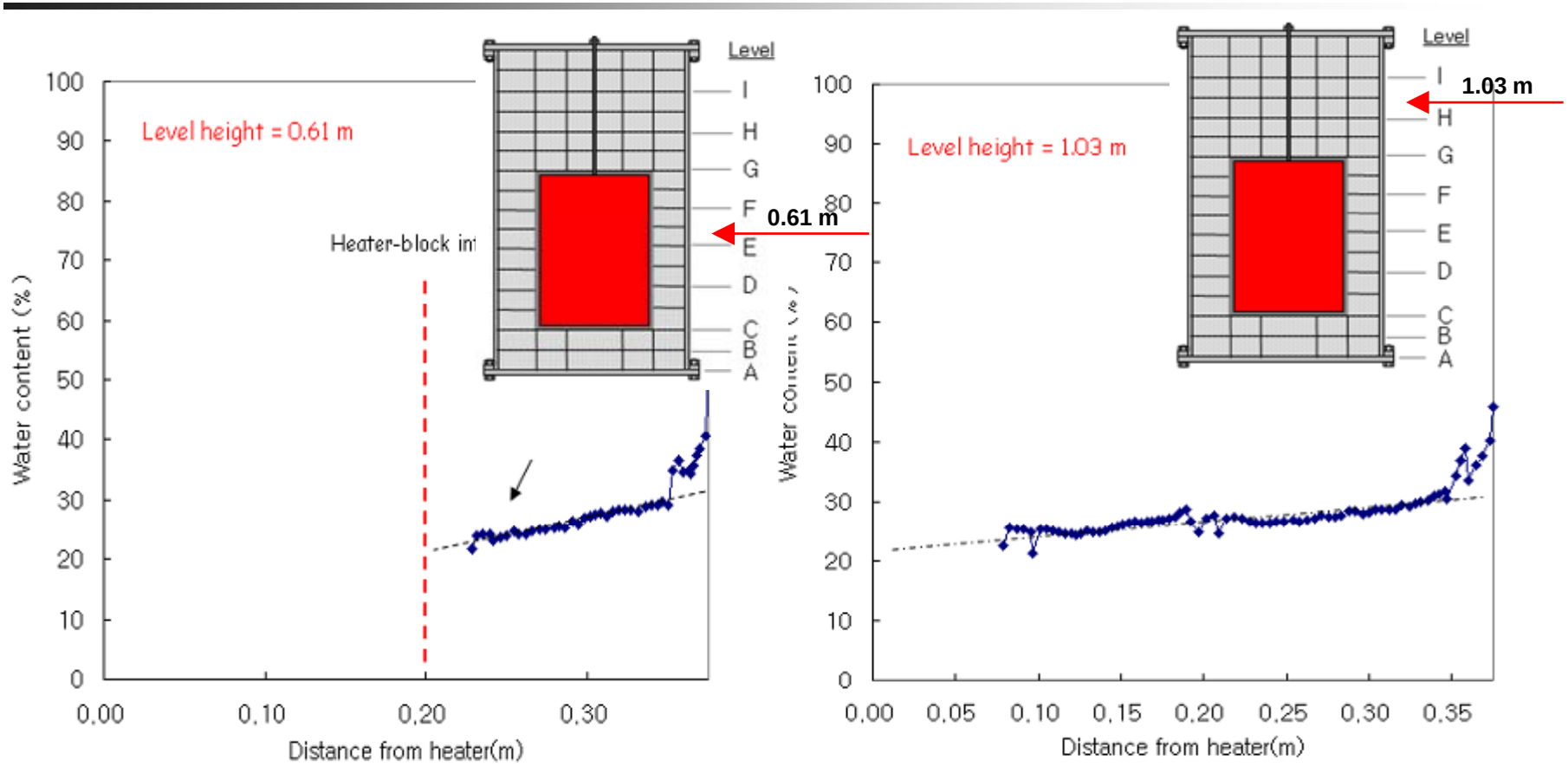
# Hydro Behaviour (RH) -1/2



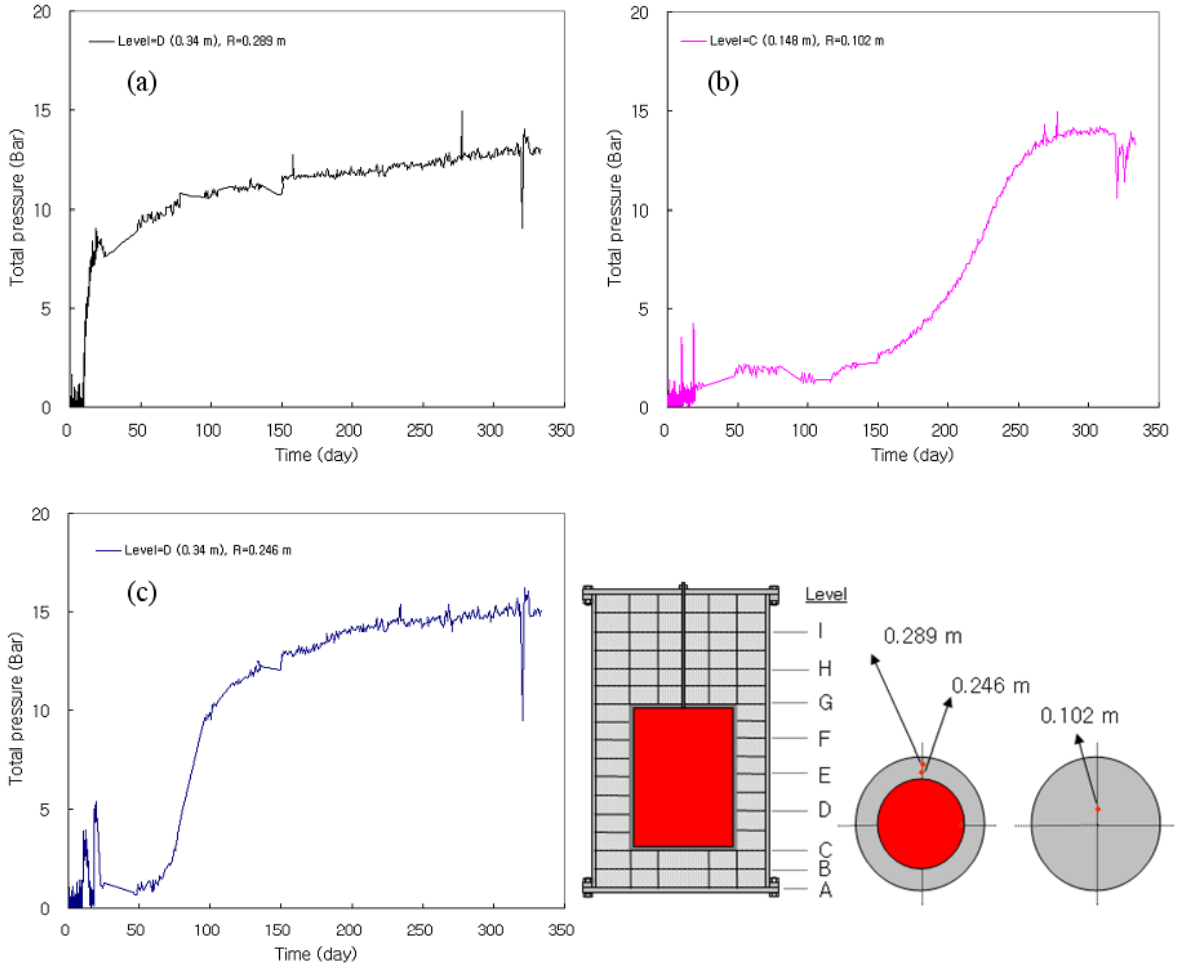




Location of the Sensor

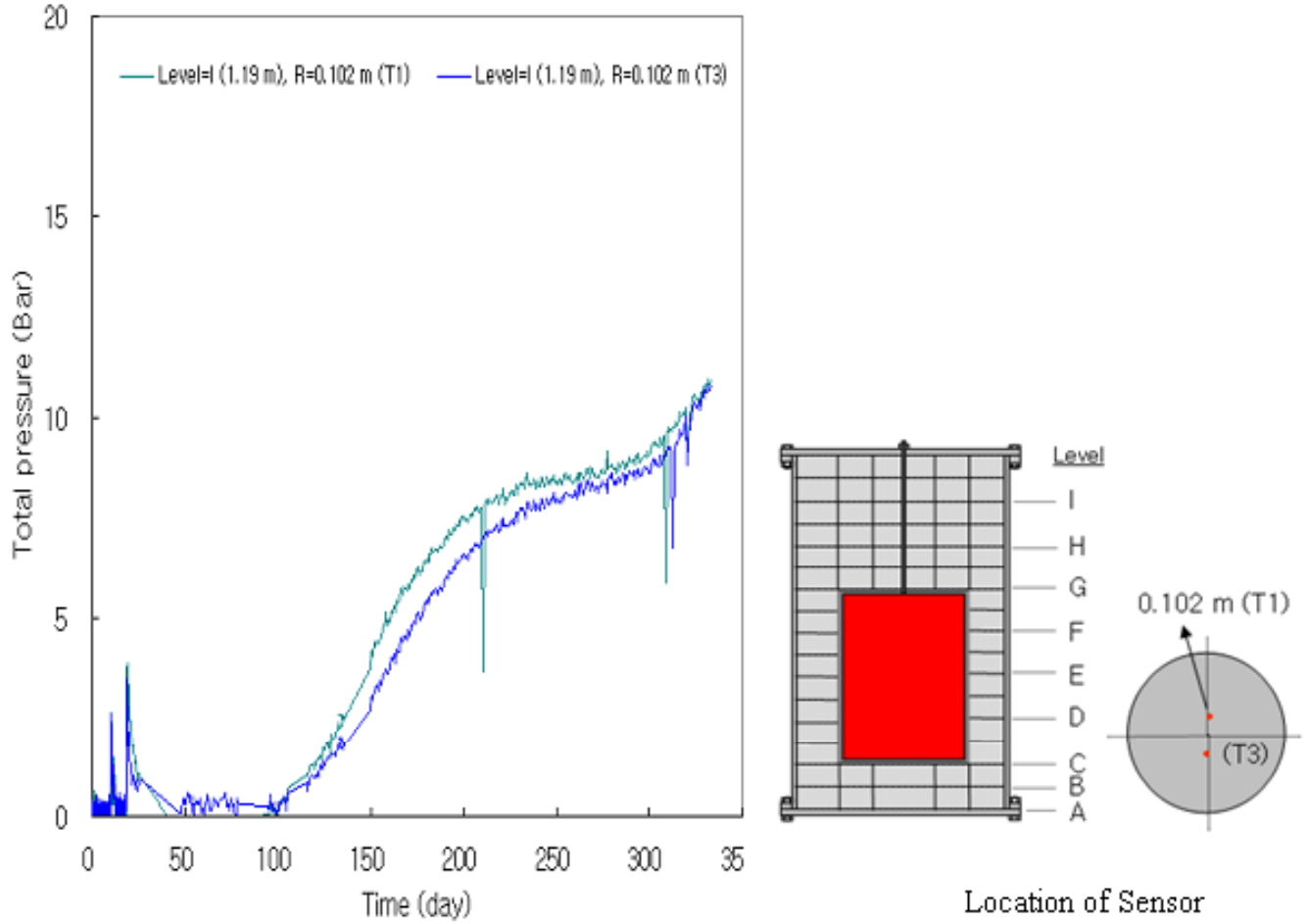
# Hydro Behaviour (Water Content) -2/2



# Mechanical Behaviour (Total pressure) -1/2



# Mechanical Behaviour (Total pressure) -2/2



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# TOHGH2 Code(Pruess at al., 1990)

- A general-purpose numerical simulation program for multi-dimensional fluid and heat flows of multiphase, multicomponent fluid mixture in unsaturated medium.
- Fluid advection is described with a mulitiphase extension of Darcy's law.
- Mass and energy balance equation:

$$\frac{d}{dt}\int_{V_n} M^k dV_n = \int_{\Gamma_n} F^k \cdot n d\Gamma_n + \int_{V_n} q^k dV_n$$

$M^k$ : mass accumualtion

$V_n$ : volume of arbitrary subdomain ($m^3$)

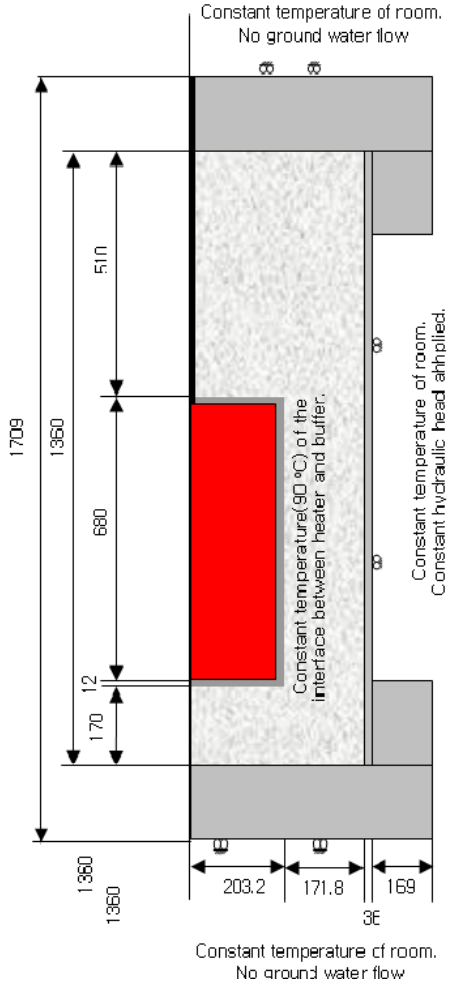
$\Gamma_n$ : closed surface ($m^2$)

$n$ : normal vector on surface element $d\Gamma_n$ pointing inward into $V_n$

$F^k$ : mass flux ($kg_m^{-3}s^{-1}$)

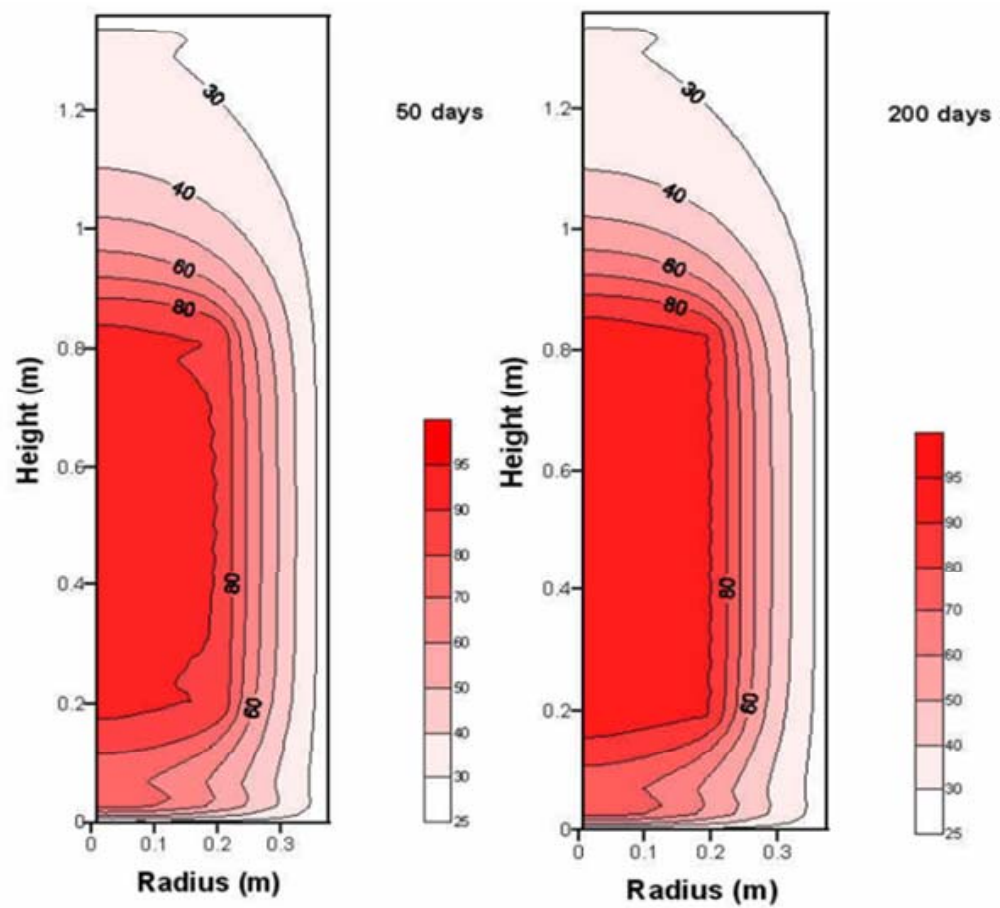
$q^k$ : specific mass source/sink ($kg_m^{-3}s^{-1}$)

# Geometry, B.C., and Input Data

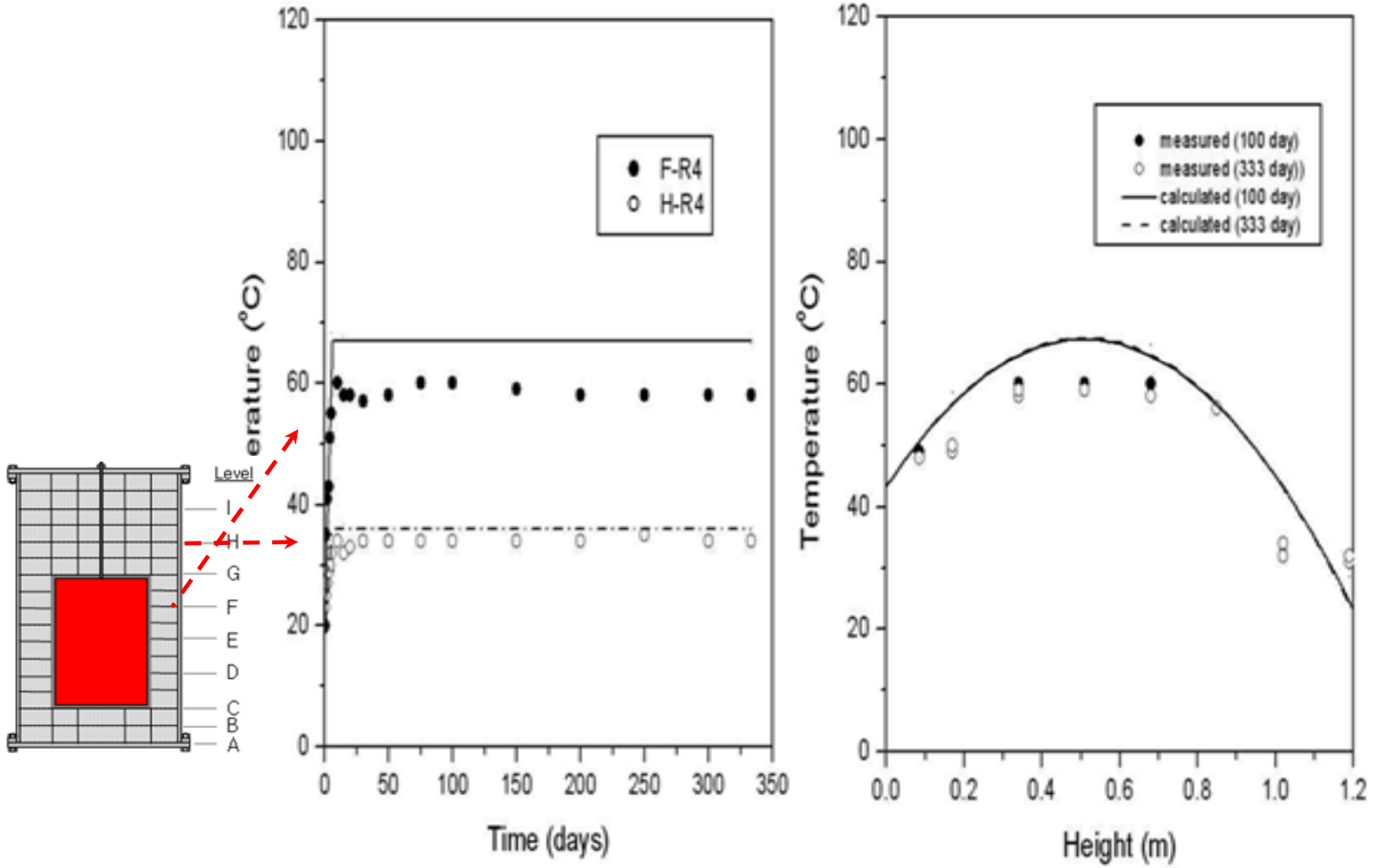



| Parameter | Value |
|---|---|
| Buffer | |
| > density (Kg/m$^3$) | 2700 (grain) |
| > porosity | 0.44 |
| > absolute permeability (m$^2$) | 6x10$^{-20}$ |
| > specific heat (J/kg℃) | 980.0 |
| > pore compressibility (Pa$^{-1}$) | 1.0x10$^{-8}$ |
| > pore expansivity (1/℃) | 1.0x10$^{-4}$ |
| Heater | |
| > density (Kg/m$^3$) | 4600 |
| > porosity | 0.20 |
| > specific heat (J/kg℃) | 590.0 |
| > pore compressibility (Pa$^{-1}$) | 0.00 |
| > pore expansivity (1/℃) | 3.5x10$^{-5}$ |
| Parameters in the van Genuchten function | |
| > α | 2.5493x10$^{-3}$ |
| > n | 1.4166 |

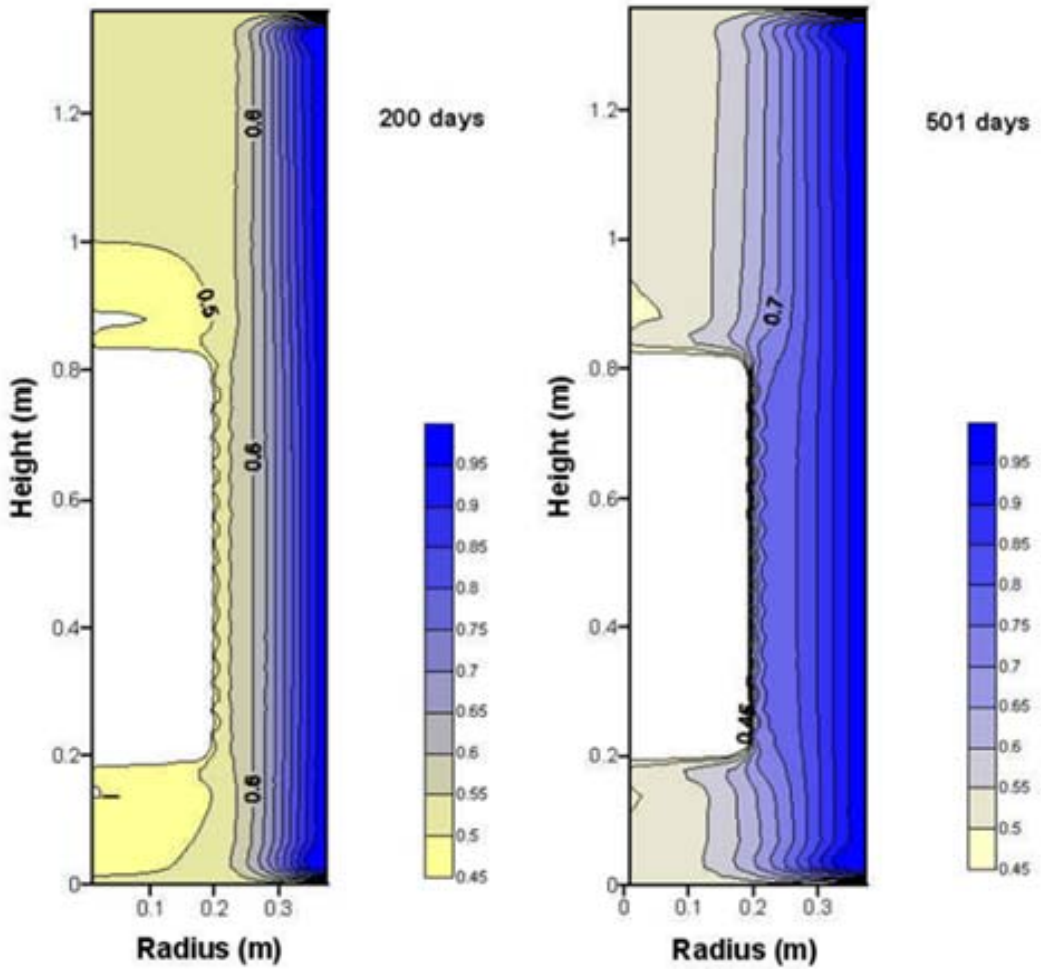
# Calculated Temperature Contours



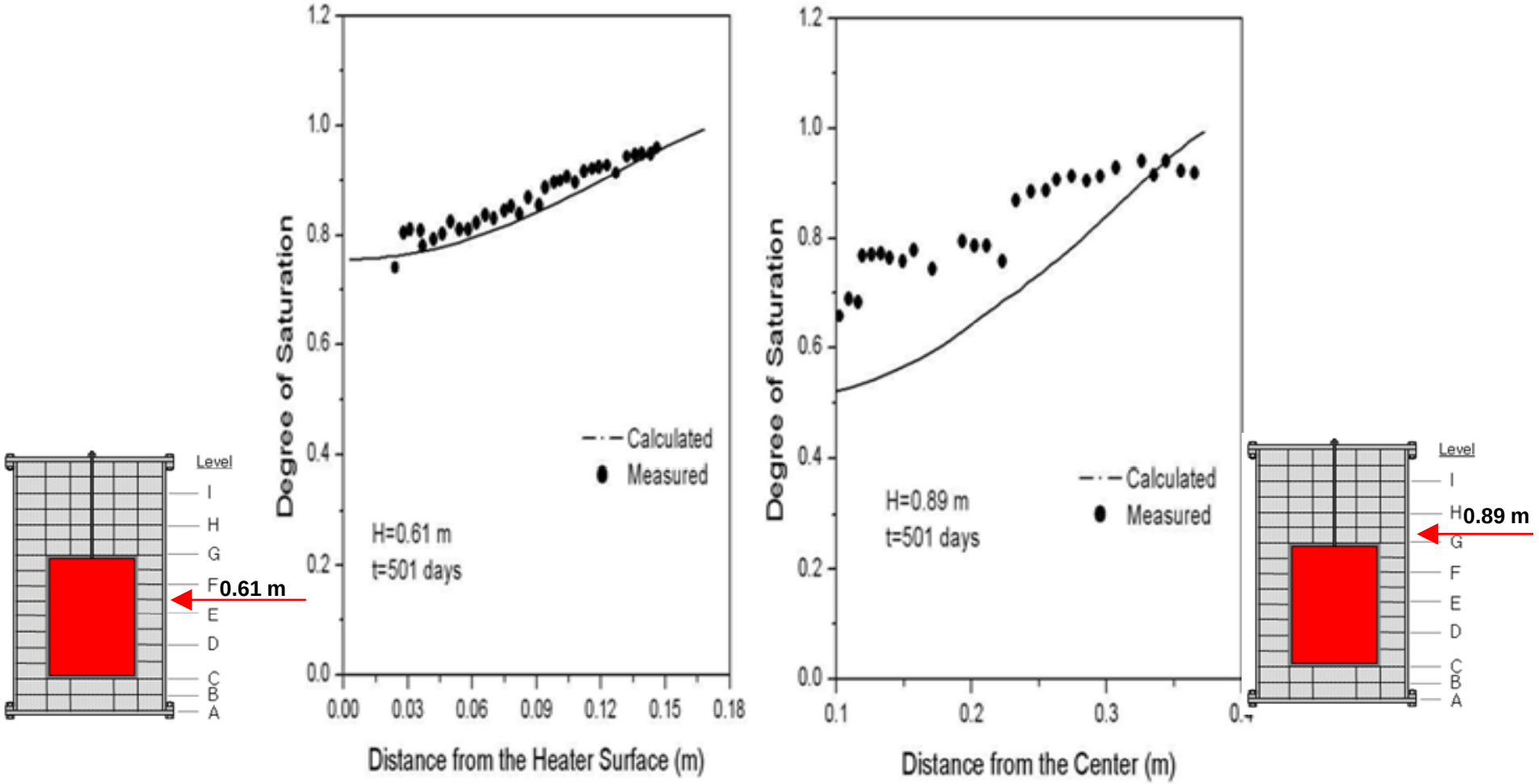
# Comparison of Calculated & Measured Temp. Distributions



# Calculated Water Distribution Contours



# Comparison of Calculated & Measured Water Content Distributions



# Conclusions

- The surface mock-up KENTEX has been operated successfully to date.
- The current T-H-M behaviour in the bentonite block allows us to draw preliminary and qualitative conclusions.
- Both the calculated and measured temperature and water content profiles agree well with each other, which suggest that the TOUGH2 code can simulate the coupled thermal-hydro behaviour of compacted bentonite block reasonably well.
- Further modelling work will be continued to analyze the fully coupled T-H-M behavior in the bentonite block.


국가 미래 에너지를 책임지는 연구원

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