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### Review of full-scale test methodology for HAM benchmarking

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# ***Review of Full-Scale Test Methodology for HAM model Benchmarking***

Prepared by :

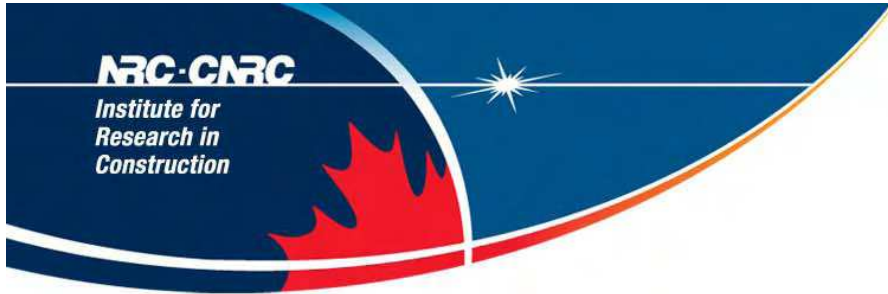
Dr. Wahid Maref & Madeleine Rousseau

For the  
**CIB W40 Seminar on Research in Building Physics**  
**Sep 5, 2006 (Syracuse University, NY, USA)**



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Council Canada

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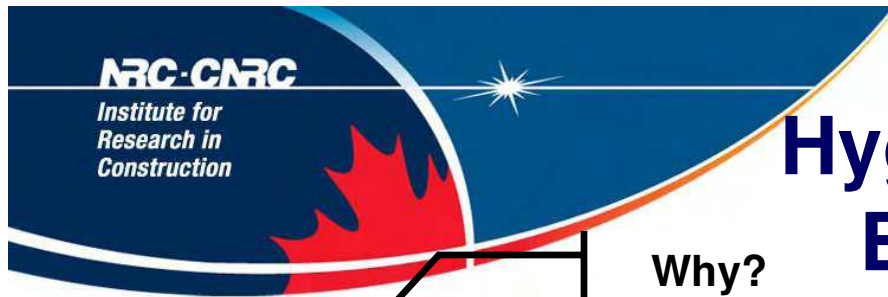
# Outline

- Hygrothermal Performance of BES
  - Modeling
  - Field Experiment
  - Laboratory experiments
- Conclusion



# Outline

- Hygrothermal Performance of BES
  - Modeling
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# Hygrothermal Performance of Building Envelope Systems

Why?  
How?  
Which?  
What?

## **MODELING**

(i.e. IRC's HAM Tools  
hygIRC 1D & 2D,  
WeatherSmart)

## **FIELD**

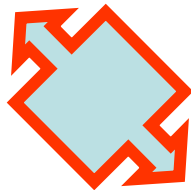
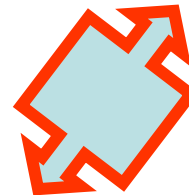
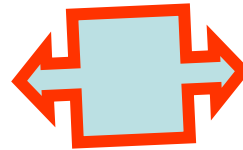
(i.e. IRC RHs, CCHT)

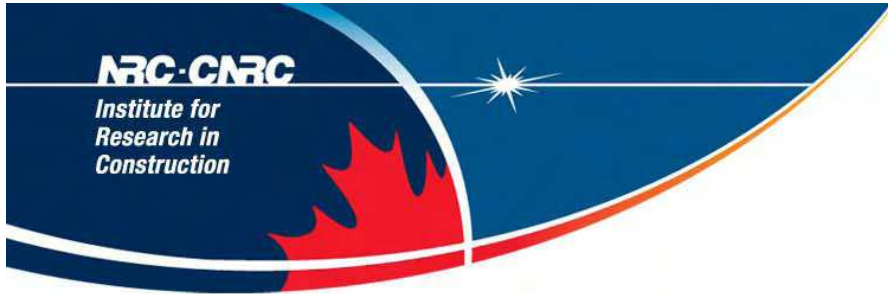
Why?  
How?  
Which?  
What

## **LABORATORY**

(i.e. DWTF, EEEF)

Why?  
How?  
Which?  
What?





# Outline

- Hygrothermal Performance of BES
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# Modeling

- Why to do modeling?
- How to model?
- Which model to use?
- What do you expect from modeling?



# Modeling: IRC's HAM Tools

- *hygIRC* 1-D V. 1.1 is a user-friendly, one-dimensional version of NRC-IRC's *hygIRC*, a state-of-the-art hygrothermal model.
  - ❑ 1-D *hygIRC* can be used for
    - parametric analysis: changing weather (locations), materials, for example

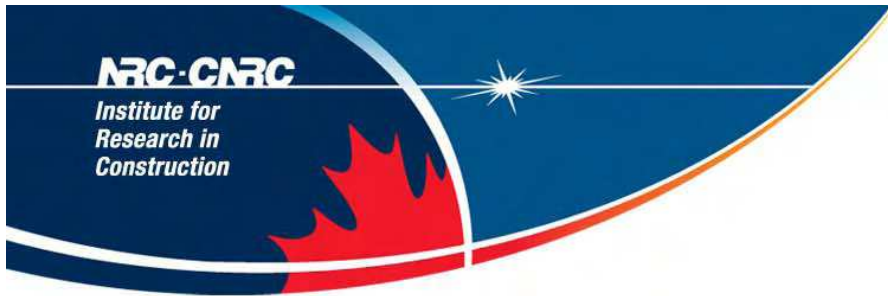
For more information please visit *hygIRC* Website:  
[http://irc.nrc-cnrc.gc.ca/bes/software/hygIRC/index\\_e.html](http://irc.nrc-cnrc.gc.ca/bes/software/hygIRC/index_e.html)
- *hygIRC* 2D is the Advanced hygrothermal models
  - ❑ Best handled by *hygIRC* 2-D
    - air leakage
    - water leaks
    - gravity effects
- *WeatherSmart*





# Outline

- Hygrothermal Performance of BES
  - Modeling
  - Field Experiment
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- Conclusion



# Field Experiments

- Why to do field experiment?
- How to do experiment?
- Which physical phenomena to investigate,..?
- What do you expect from experiments?



# Field Experiments

- IRC's Research Houses:
  - Research House #3 (IE/BES)
  - CCHT
  - Roof Top Garden, etc.

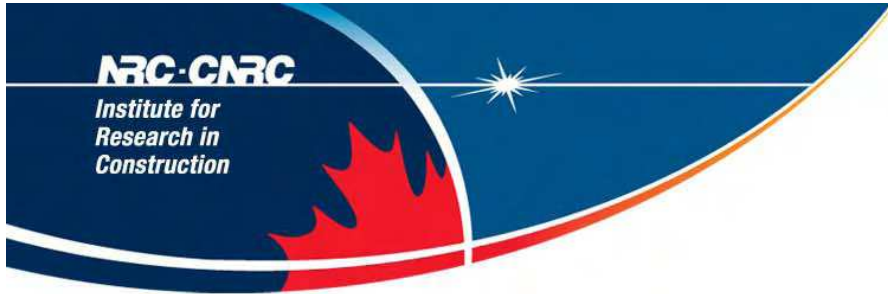




# IRC Field Exposure of Wall Facility (FEWF)



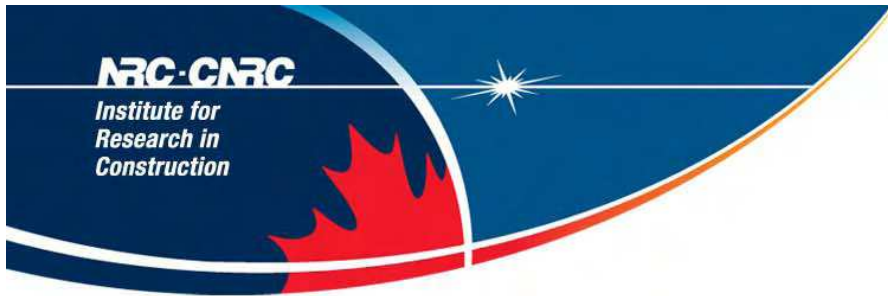
- **Background**
- **Objectives**
  - Compare performance of different side-by-side wall assemblies
  - improve understanding of HAM response of wall and window assemblies exposed to naturally occurring climate loads of Ottawa as well as to indoor environment loads of T, RH and P defined by occupancy and HVAC systems.
  - Research the interaction between the building envelope and the indoor environment
  - Complement IRC's controlled laboratory test and modeling simulations



# IRC Field Exposure of Wall Facility (FEWF)

- **Window Monitoring Objectives:**

- The cold weather monitoring will examine the potential for condensation and possibly mould growth at several locations of the windows and the wall adjacent to it, with blinds open and with blinds closed, and that for three orientations:
  - ☐ • Glass edge
  - ☐ • Window frame
  - ☐ • Indoor sill shelf
  - ☐ • Wall/window interface
  - ☐ • Drywall at thermal bridges and dead air pockets



# IRC Field Exposure of Wall Facility (FEWF)

## Windows Characteristics

- Triple glazed
- Double low-e coatings
- Argon-filled
- Insulating spacer
- Fiberglass box frame
- Combination of fixed and casement sashes



# IRC Field Exposure of Wall Facility (FEWF)

- **Experimental Approach**

- **Year 1 (2006-2007)** Commission the facility by monitoring three identical test specimens of traditional construction (2x6) through Fall, Winter and Spring.
- **Year 2 (2006-2007)** Investigate the performance of two to three wall specimens of different innovative designs based on industrial collaboration/partnership.
- **Year 3 and beyond** Expand the program in collaboration with Indoor Environment to examine whole house performance issues.





South facade



Inst  
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North facade



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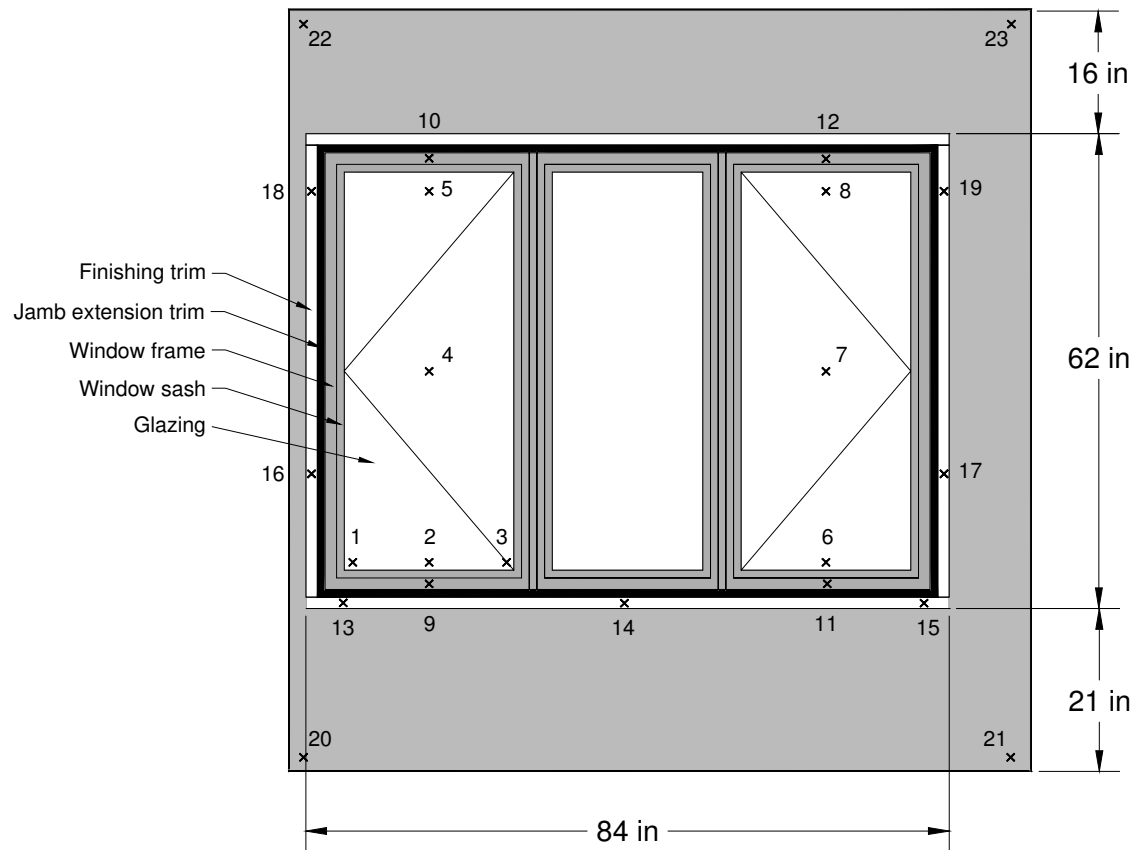
casing  
n

West facade

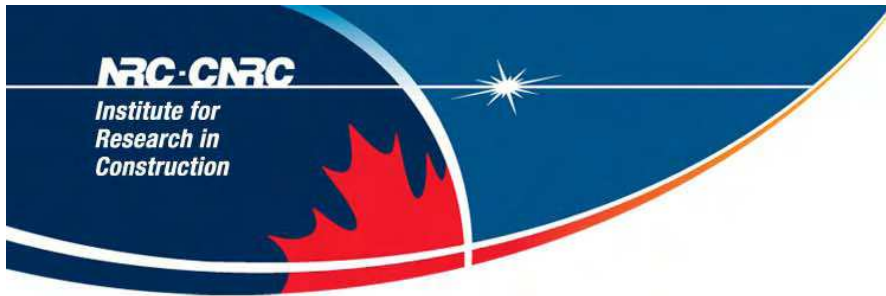




# IRC Field Exposure of Wall Facility (FEWF)



## Window Monitoring

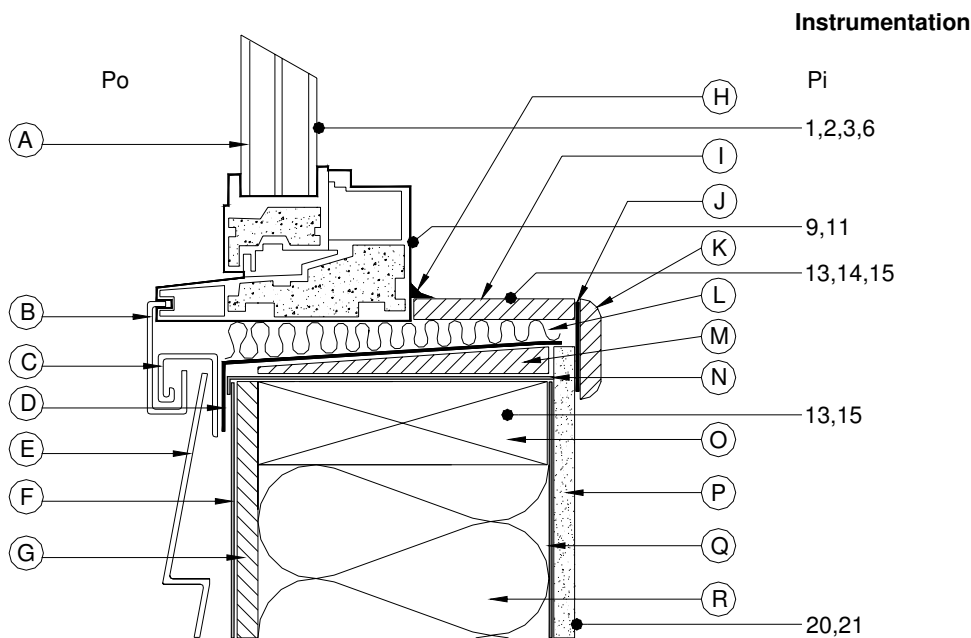


# IRC Field Exposure of Wall Facility (FEWF)

Exterior

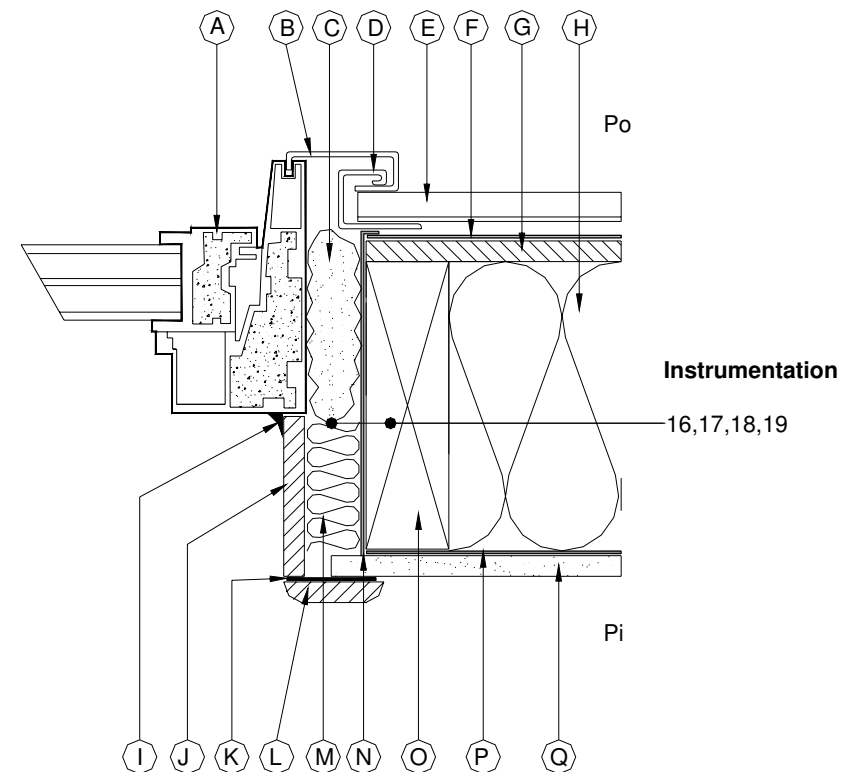
Exterior

Interior



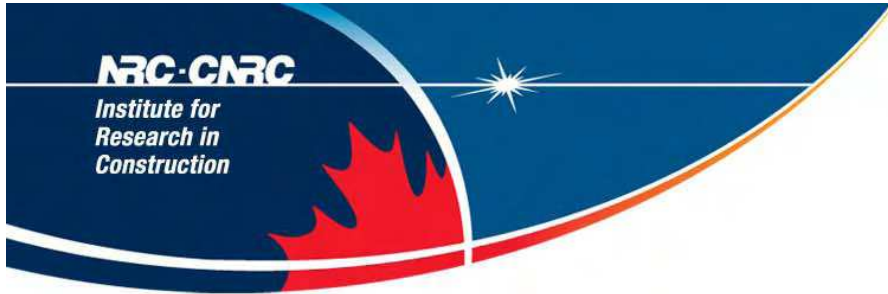
**Sill Detail**

**Window Monitoring**



Interior

**Jamb Detail**



# IRC Field Exposure of Wall Facility (FEWF)



**West facade**

# IRC Field Exposure of Wall Facility (FEWF)

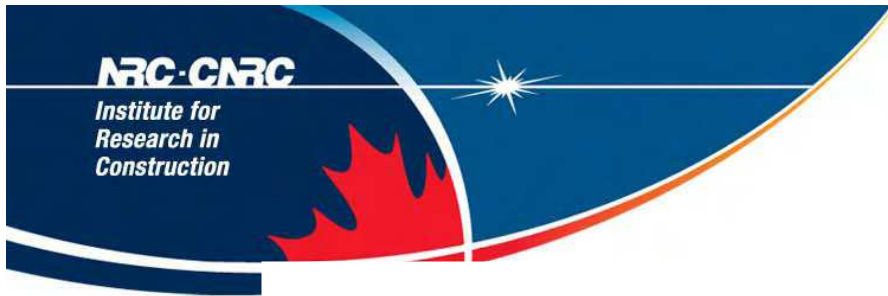




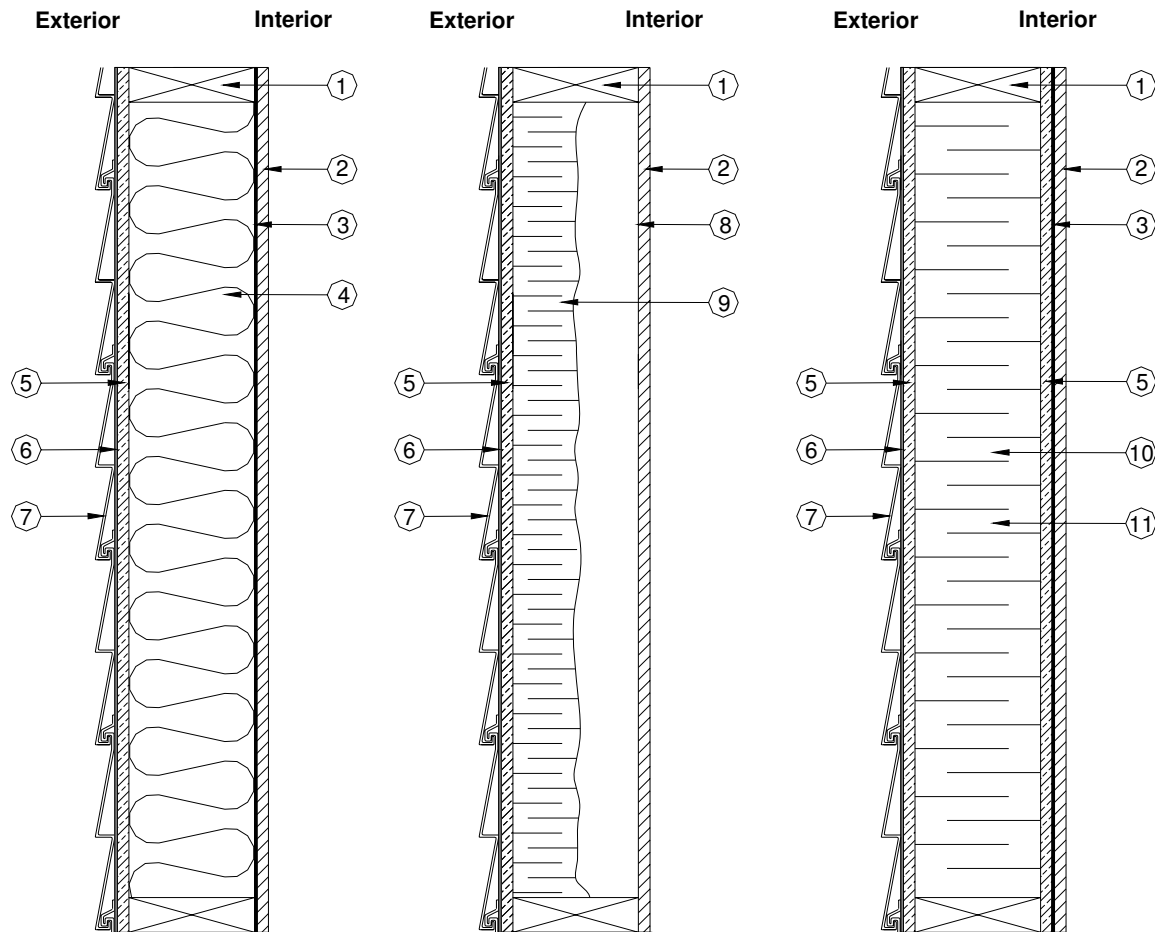
# IRC Field Exposure of Wall Facility (FEWF)



Test bay



# IRC Field Exposure of Wall Facility (FEWF)



Wall Cross-Section #1

Wall Cross-Section #2

Wall Cross-Section #3

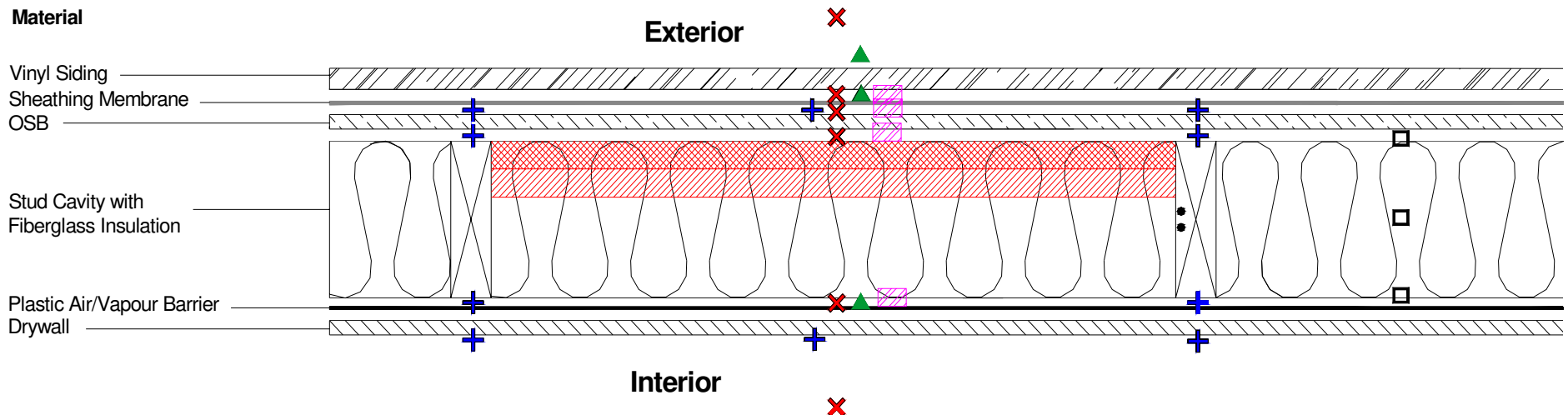
**Traditional/Reference**

**PUF**

**SIP**



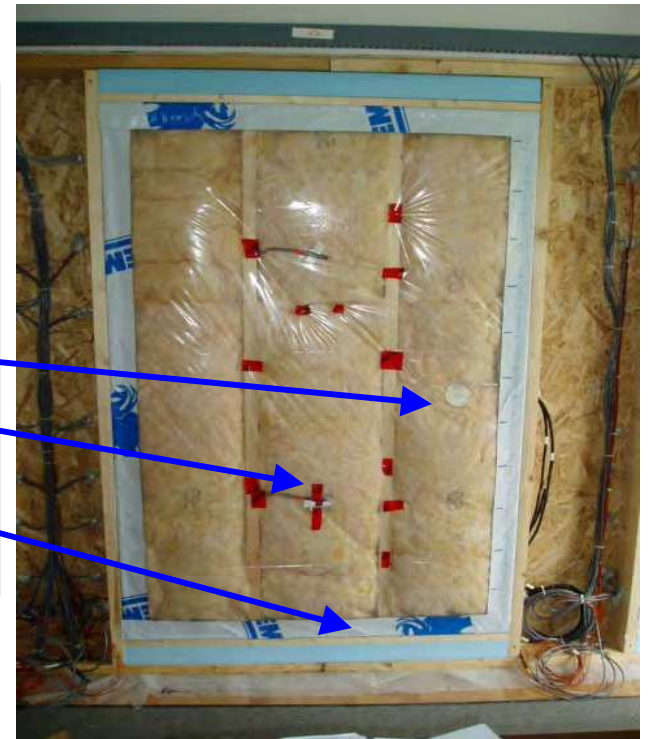
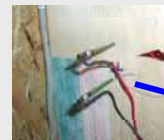
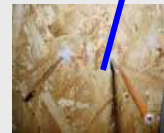
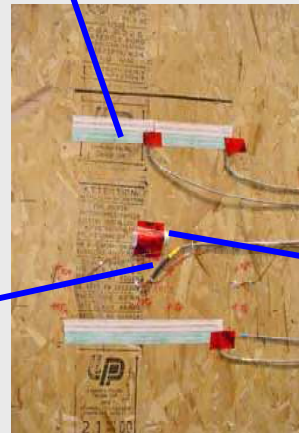
# IRC Field Exposure of Wall Facility (FEWF)



## Instrumentation - Plan View

- ✕ RH and T sensors
- ✚ T sensors
- ▲ Air Pressure sensor
- Moisture Pins
- ▨ Jeld-Wen Wireless RH&T Sensors
- Heat Flux Transducer (for W2 only)
- ▨ DETEC



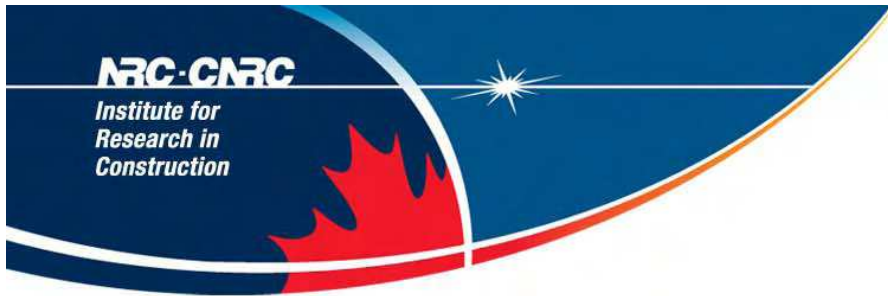






# Outline

- Hygrothermal Performance of BES
  - Modeling
  - Field Experiment
  - **Laboratory experiments**
- Conclusion



# Laboratory Experiments

- Why to do lab experiments?
- How to do experiment?
- Which physical phenomena to investigate,..?
- What do you expect from experiments?

# Experiments — Apparatus - EEEF



**- 47 to 48 ± 1 °C**  
**10 to 100% RH ± 3% RH**

*Specimens and  
weighing apparatus  
are placed in EEEF*

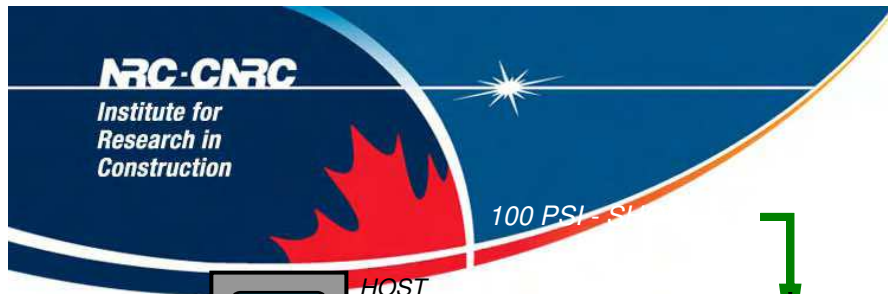
*EEEF maintains  
T and RH profile  
over course of  
experiment*

Environmental Exposure Envelope Facility

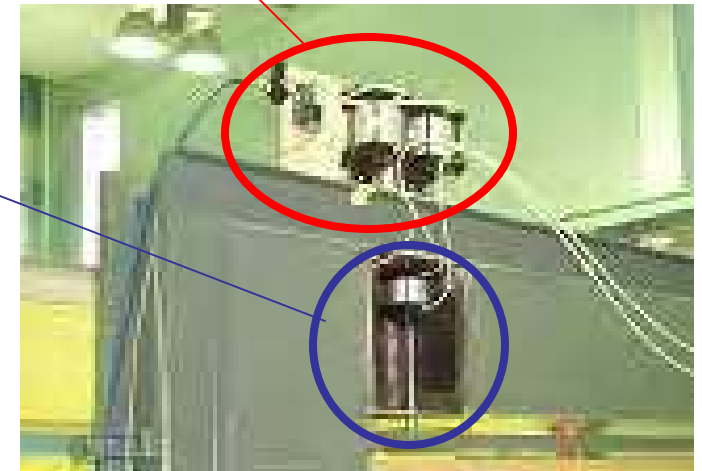
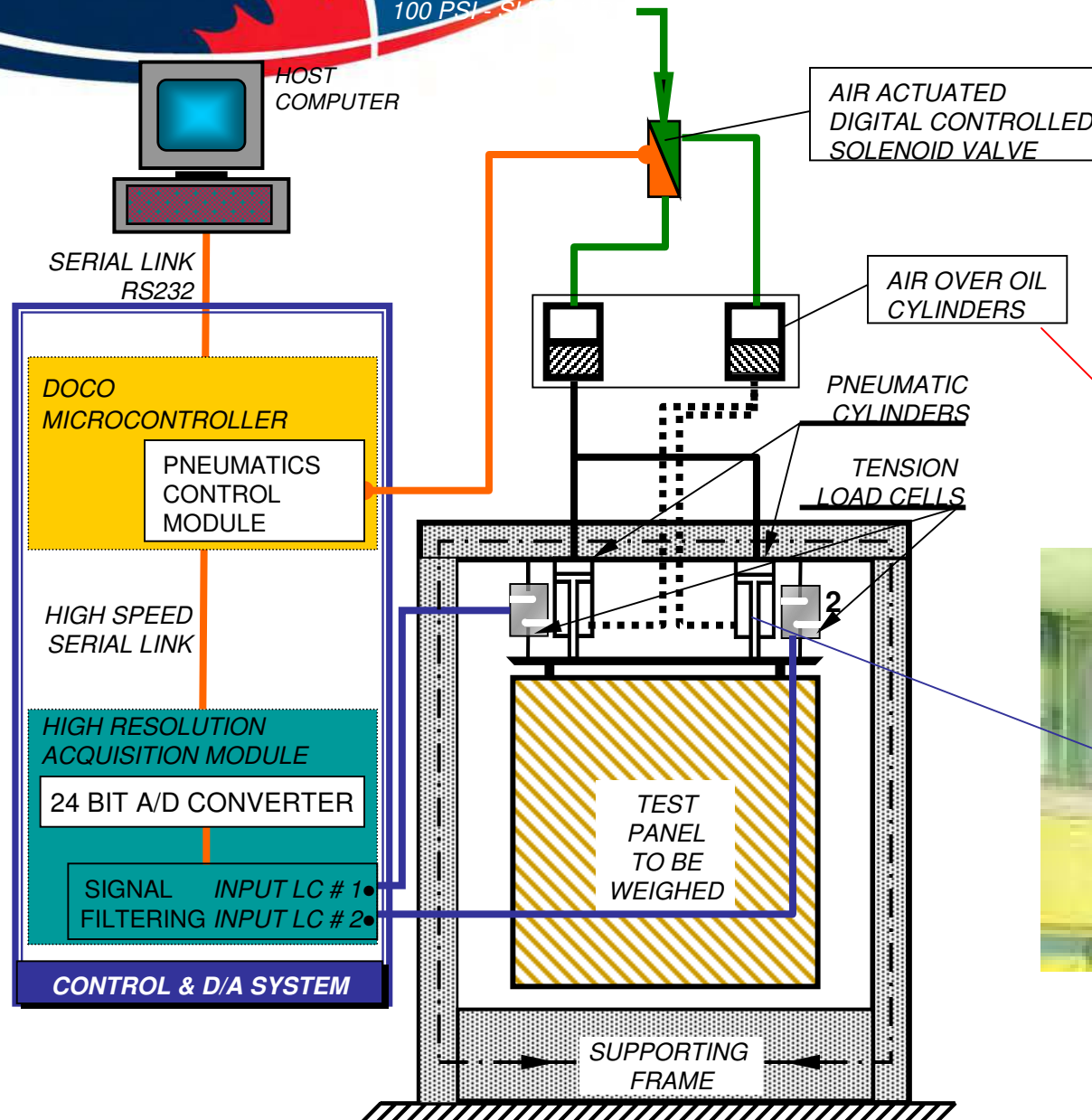


# Experiments — Apparatus - EEEF





# Experiments — Weighing System





# Benchmarking Trials: Test Frame installation



**NRC-CNRC**

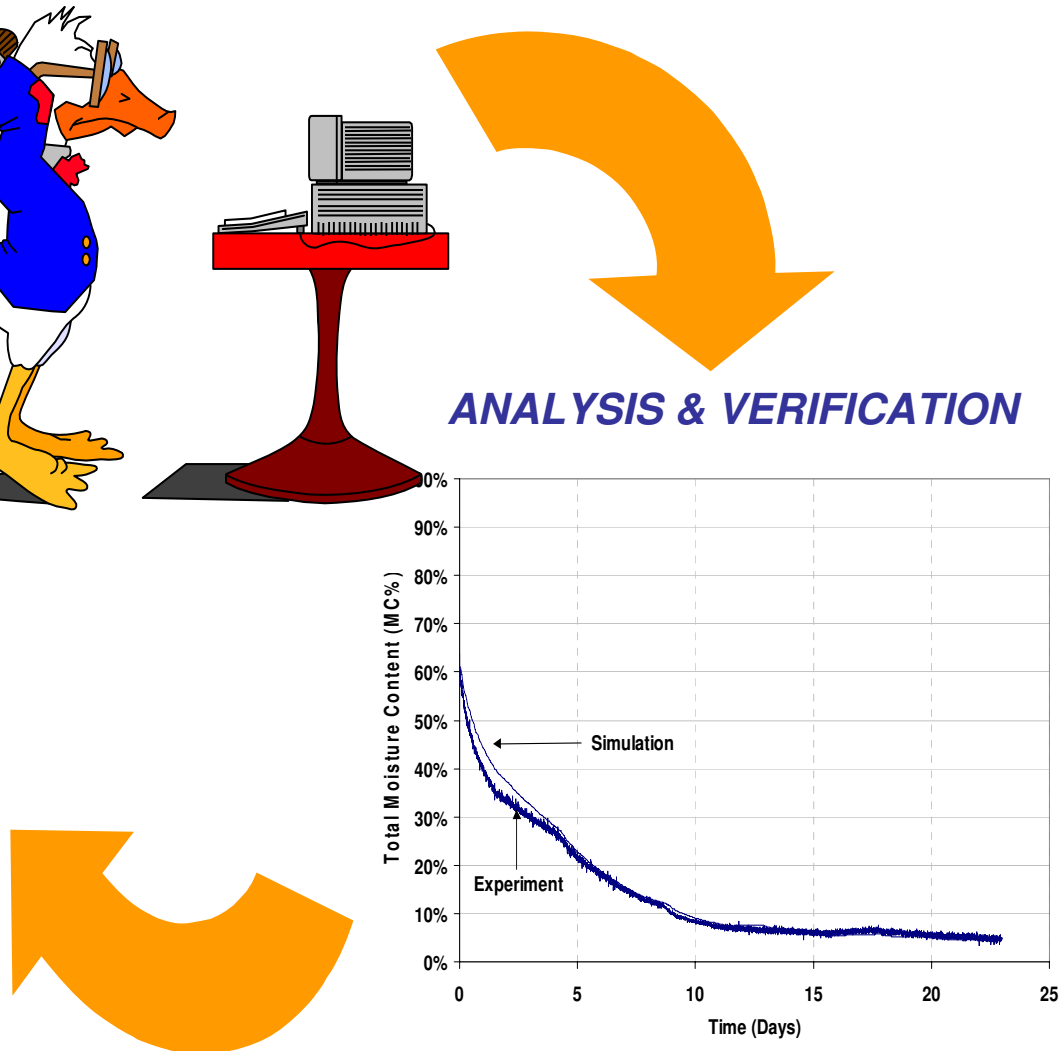
Institute for  
Research in  
Construction

# Case Study 1- Benchmarking hygIRC

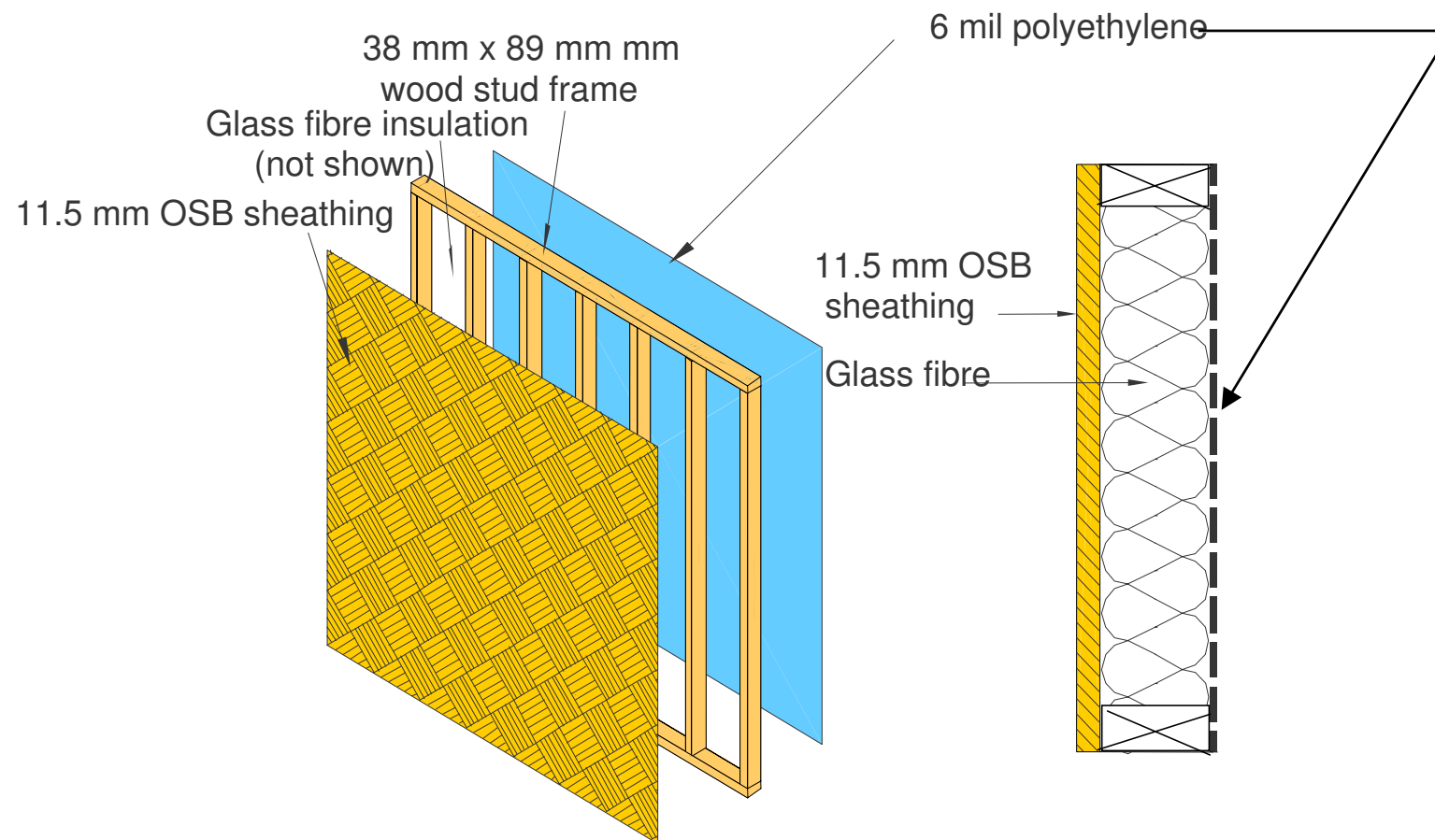
*SIMULATION-hygIRC*

*EXPERIMENT*

*ANALYSIS & VERIFICATION*

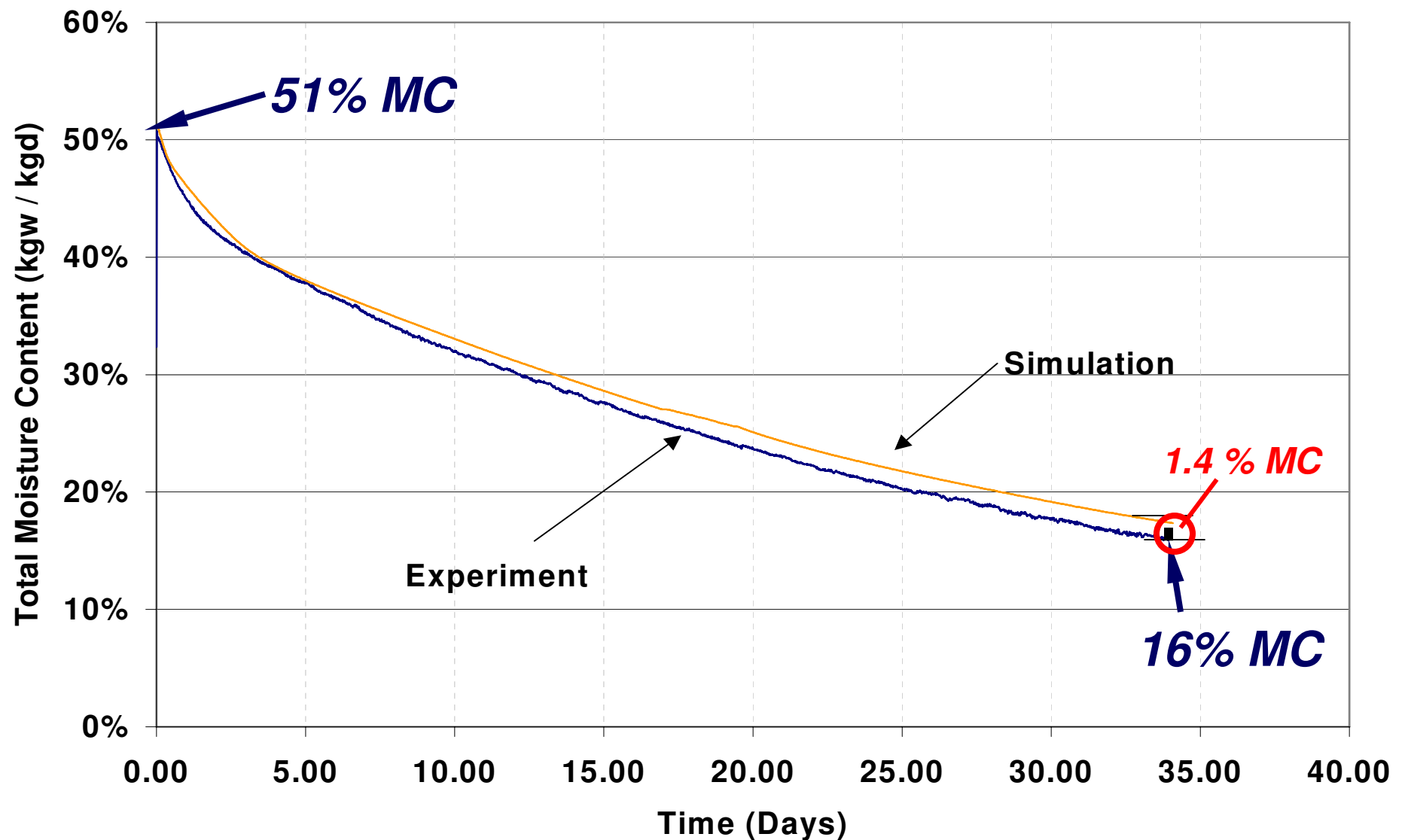


# Case Study 1 – Full-scale configuration

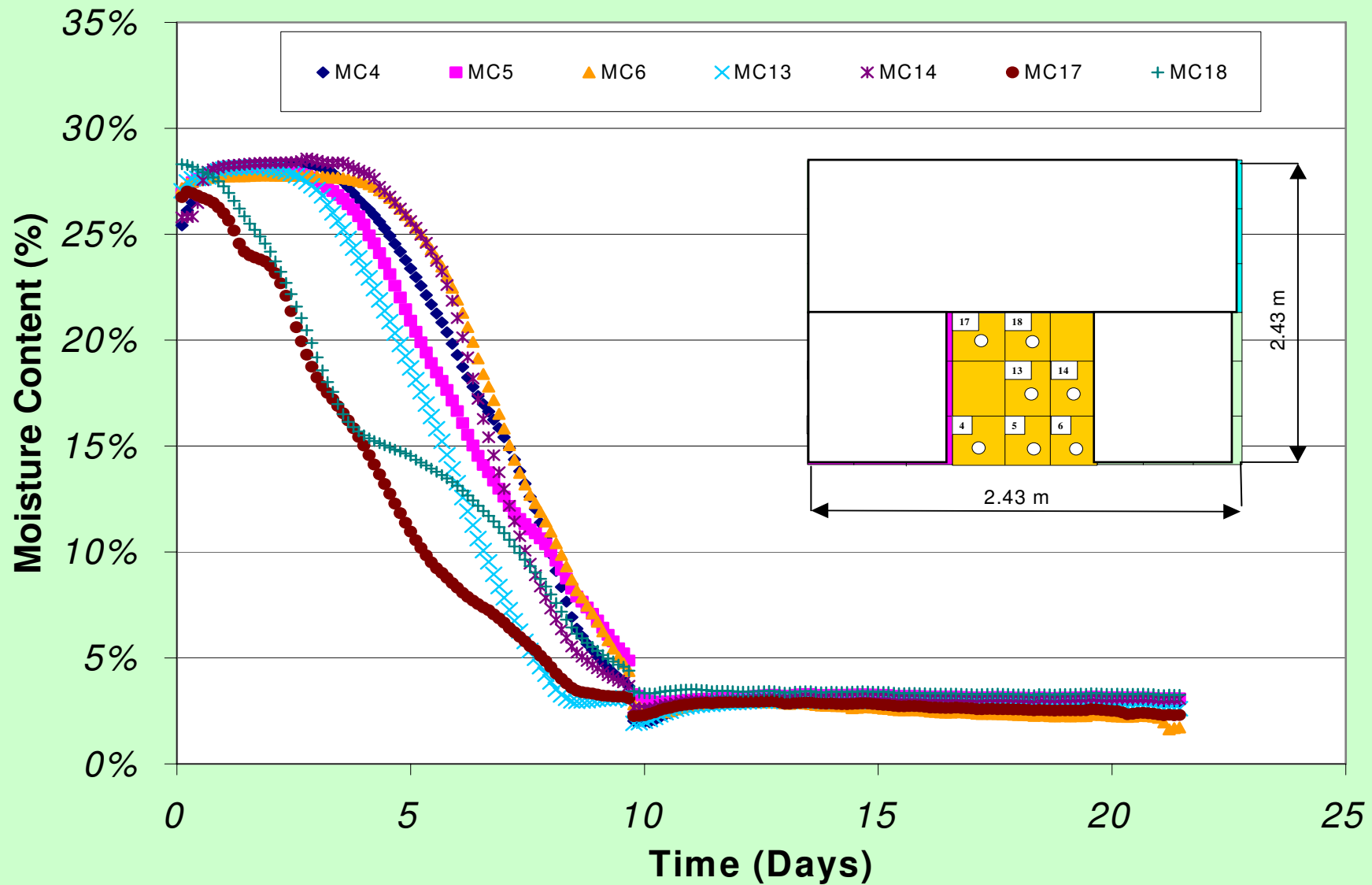




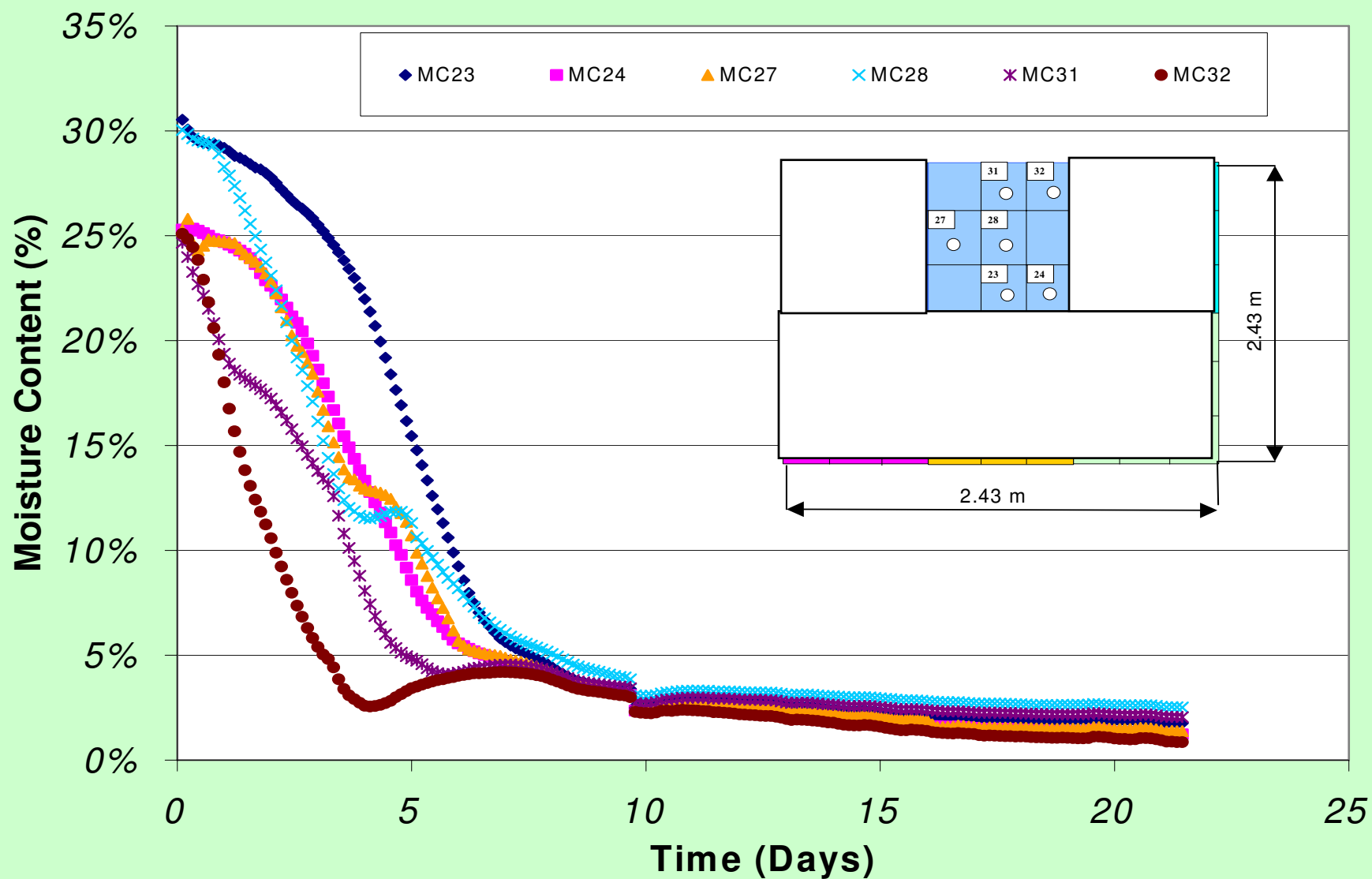
# Case Study 1 – Results



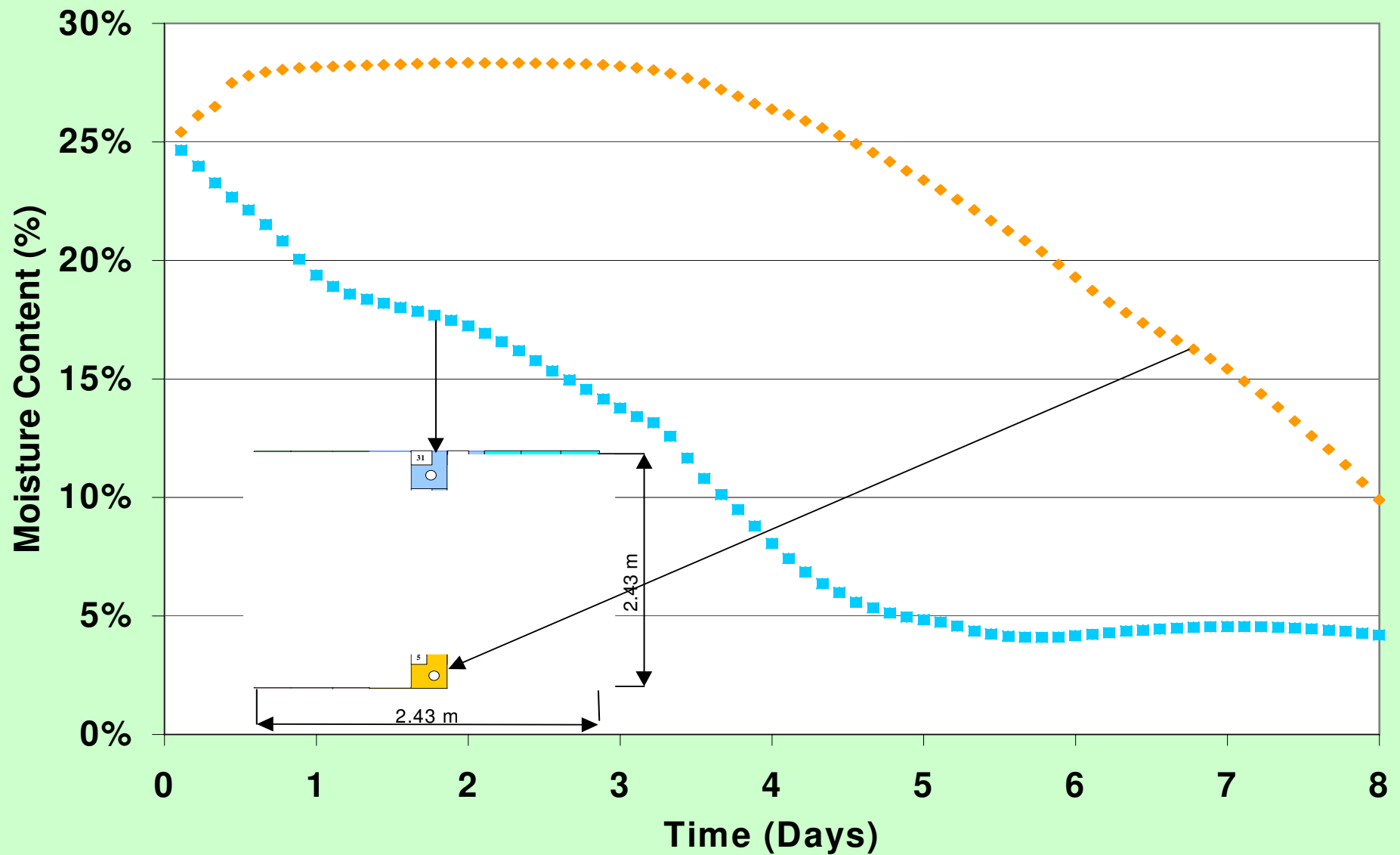
# Case Study 1 - Results



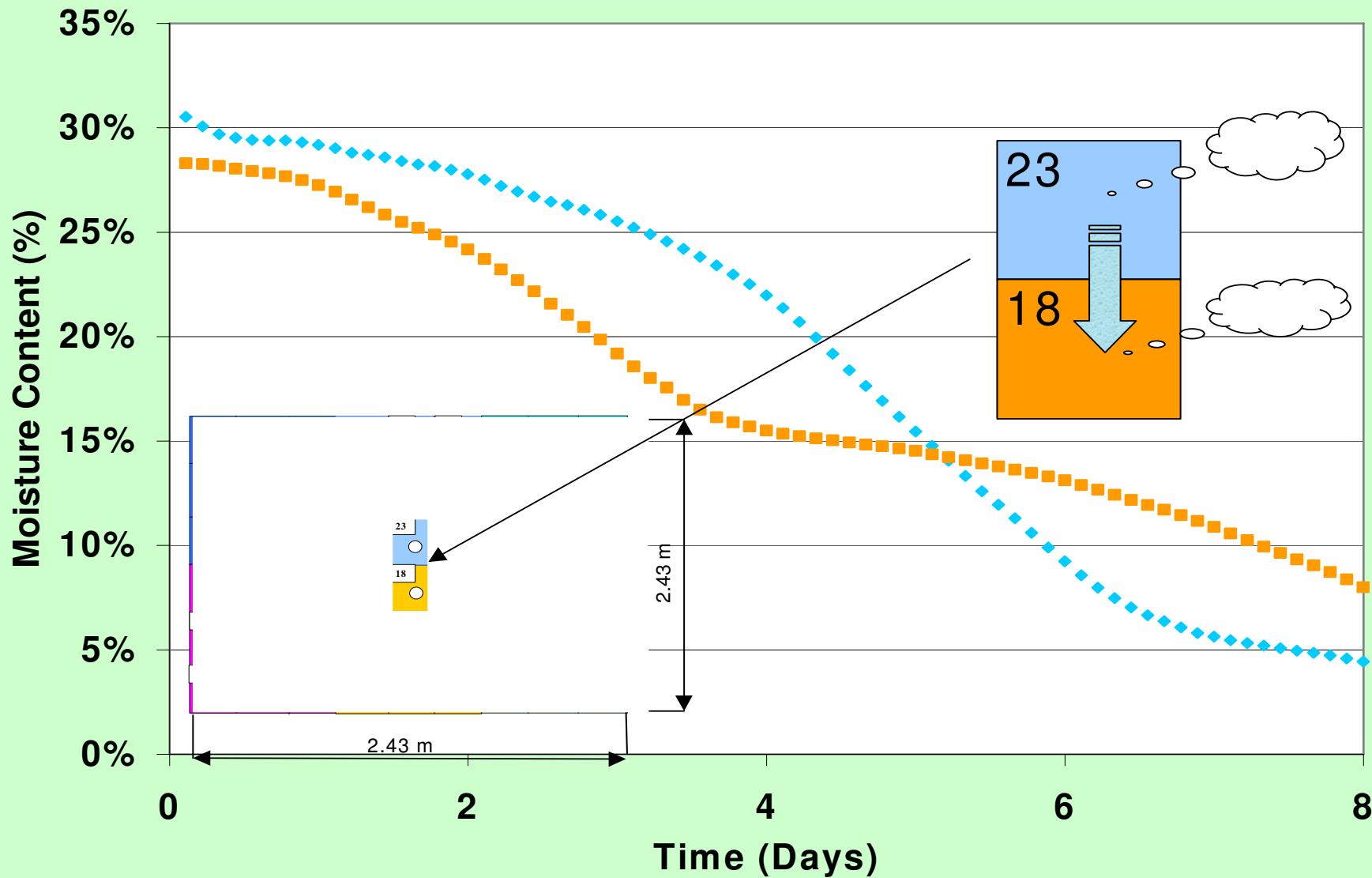
# Case Study 1 - Results



# Case Study 1 - Results



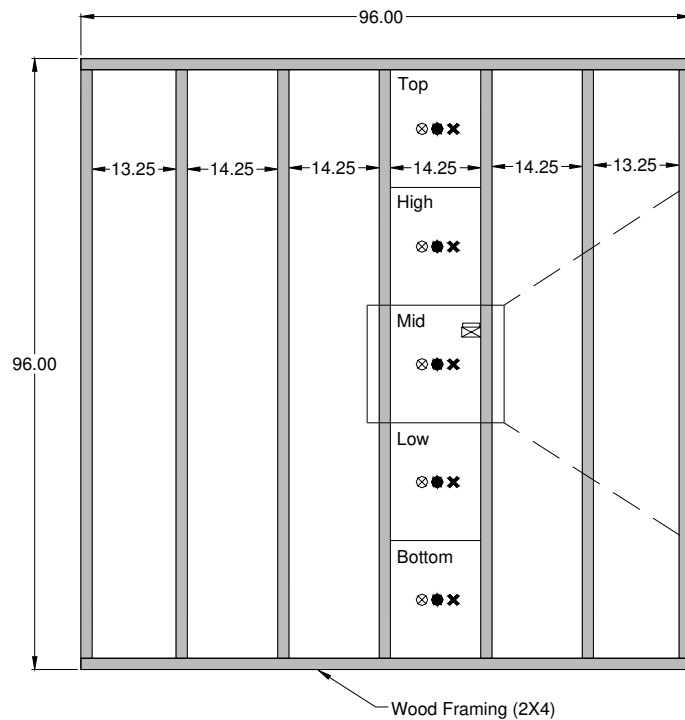
# Case Study 1 - Results



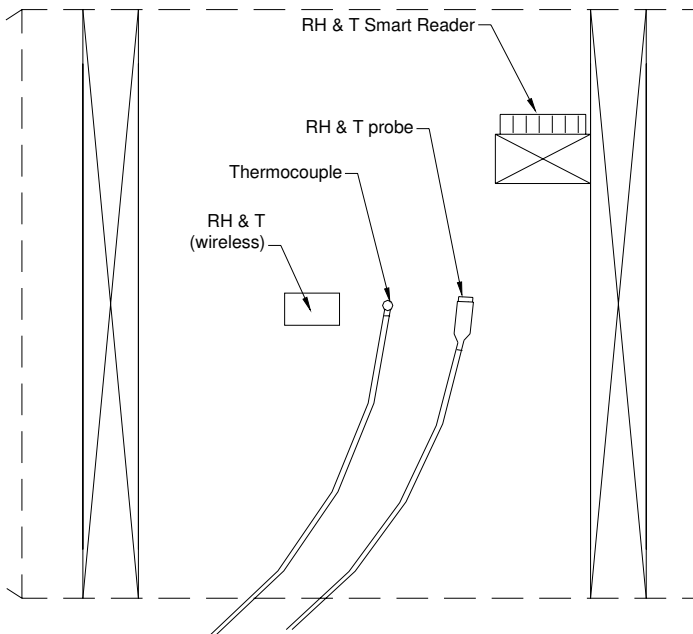
# Case Study 2- Solar Driven Inward Vapour Diffusion

## EEEF WALL SPECIMEN - FRONT VIEW

Wall Specimen Framing



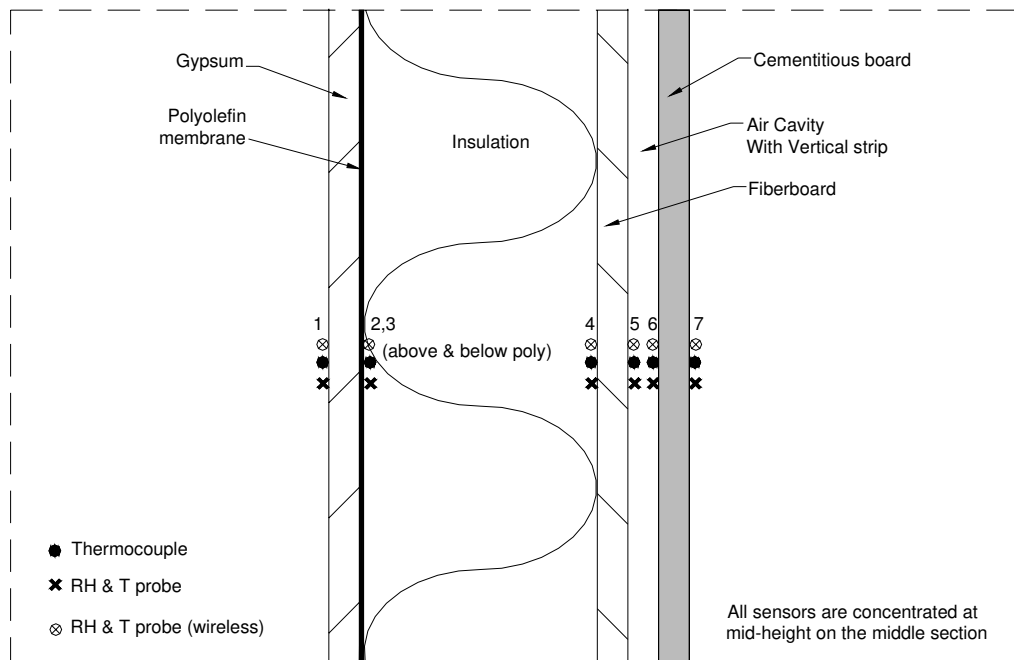
Closeup of RH & T Sensors



# Case Study 2- Solar Driven Inward Vapour Diffusion

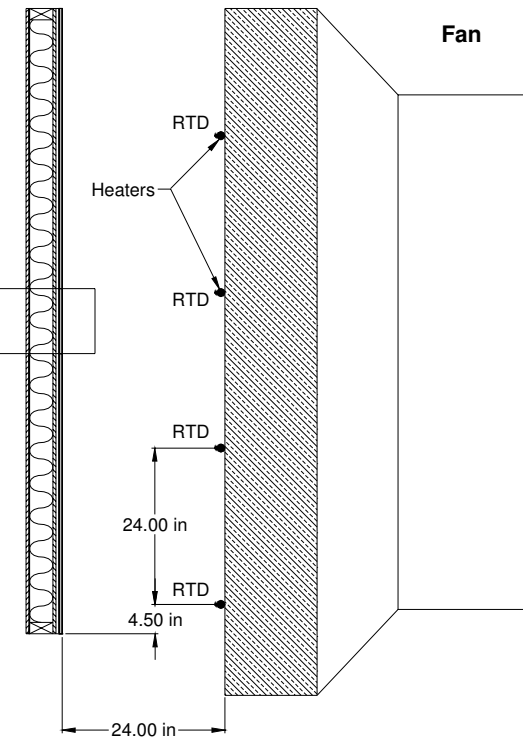
## EEEF WALL SPECIMEN - SIDE SECTION VIEW

Wall Specimen Closeup with Sensor Locations



Wall Specimen

Heater Panel



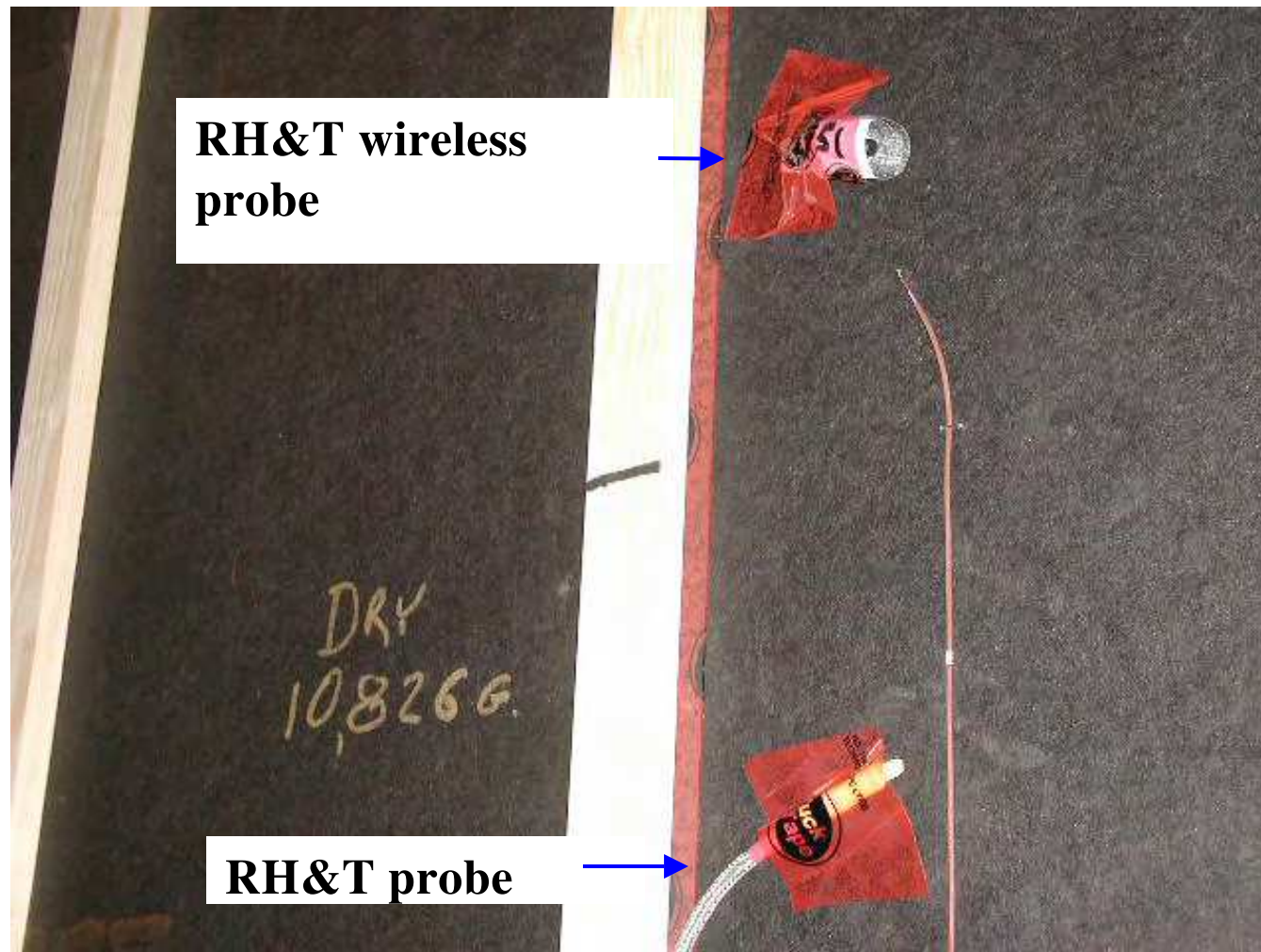


## Case Study 2





## Case Study 2- Solar Driven Inward Vapour Diffusion



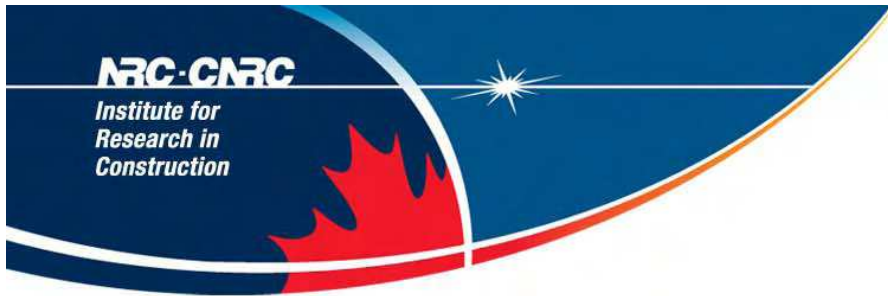
## Case Study 2- Solar Driven Inward Vapour Diffusion





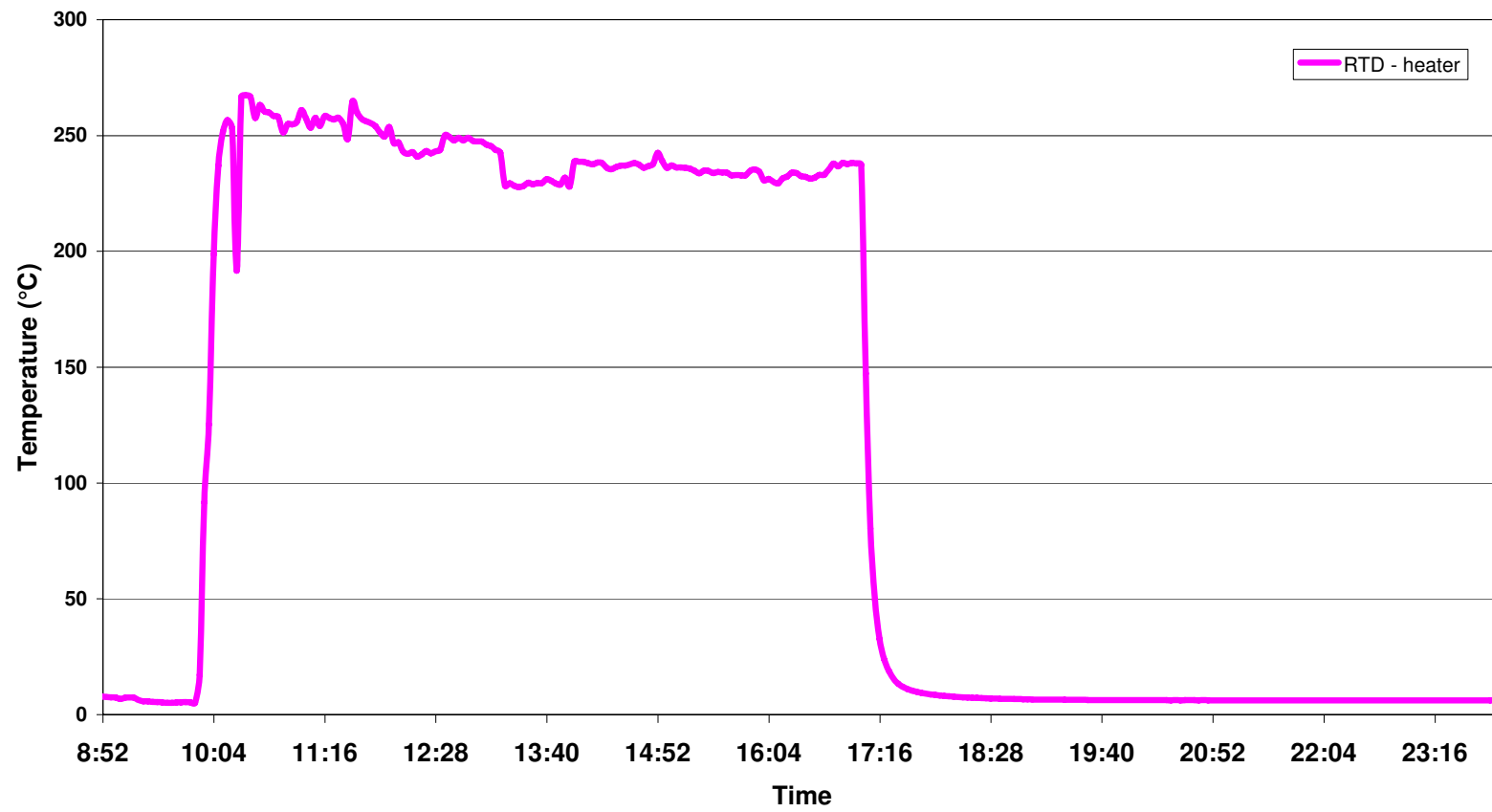
## Case Study 2- Solar Driven Inward Vapour Diffusion





# Temperature profile of the heater

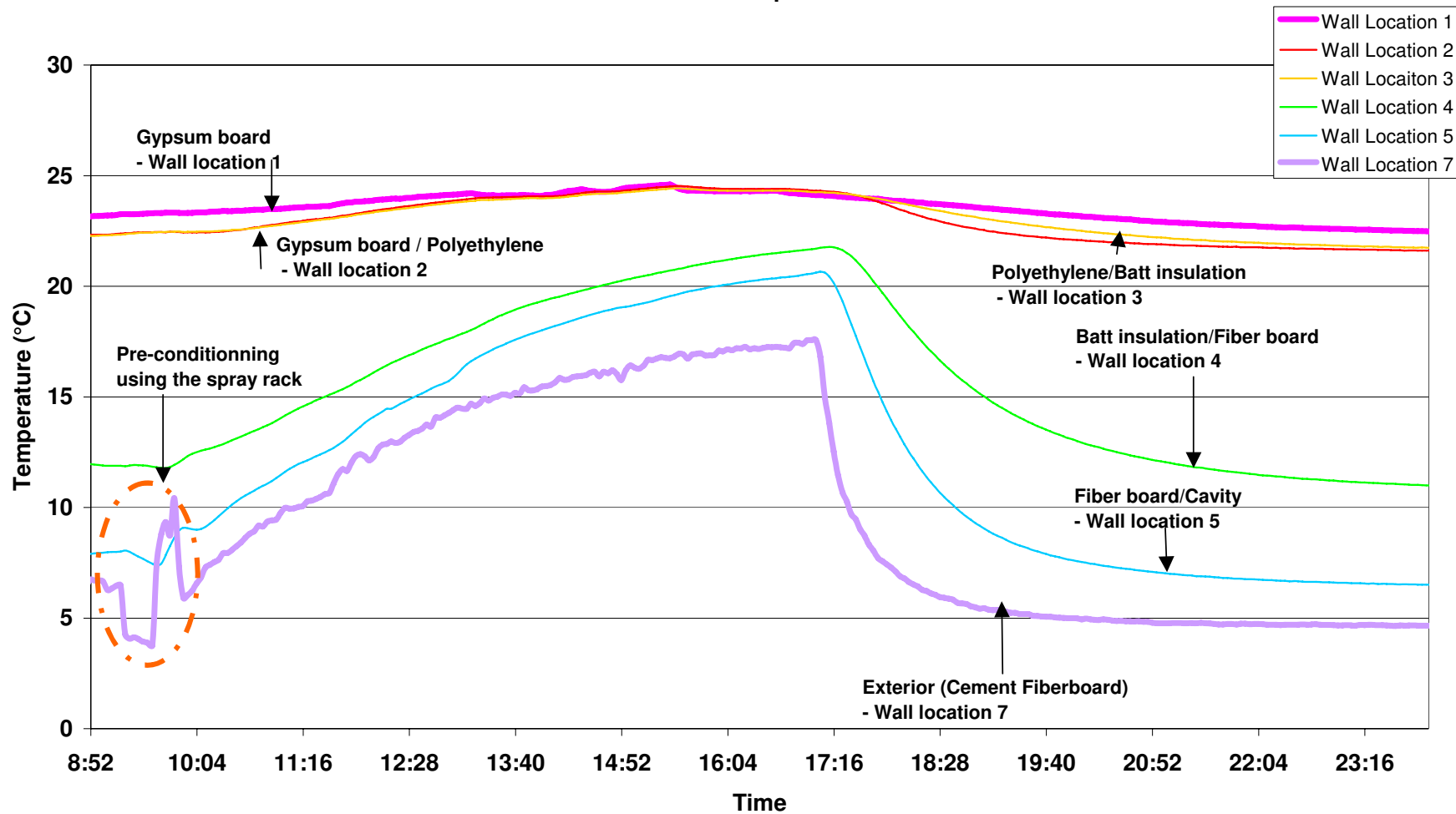
Heater Temperature (RTD)





# Temperature

Wall Cross-Section Temperatures - RHT

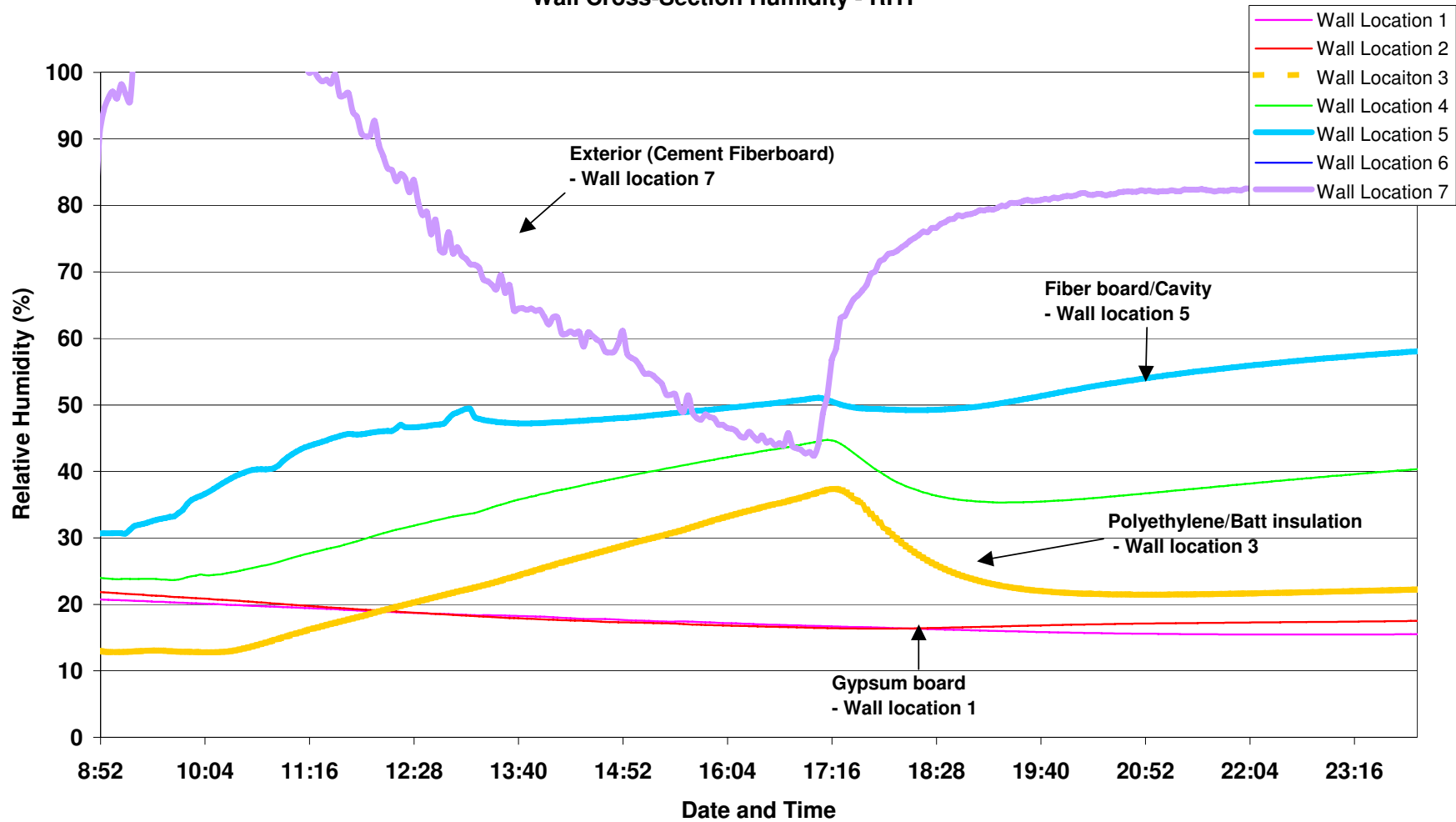


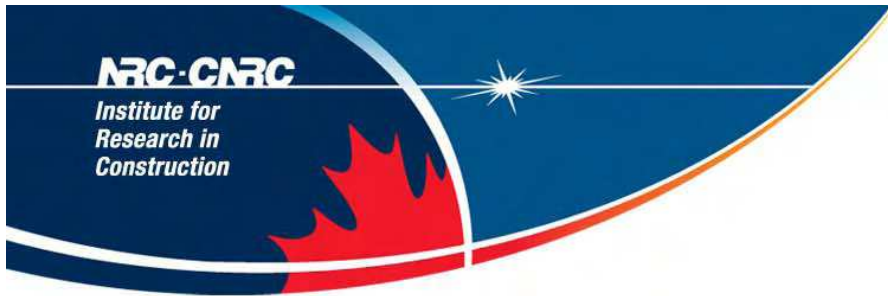




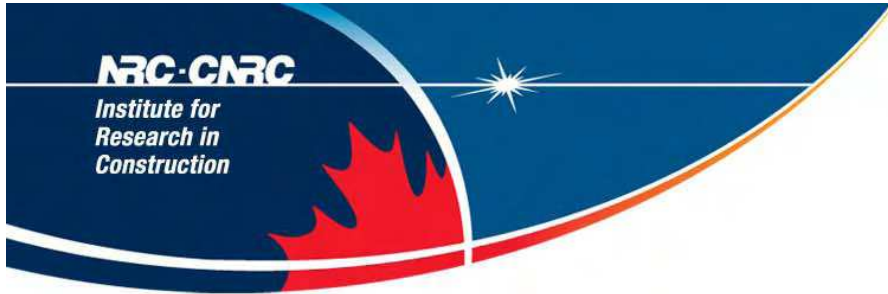
# Relative Humidity

Wall Cross-Section Humidity - RHT



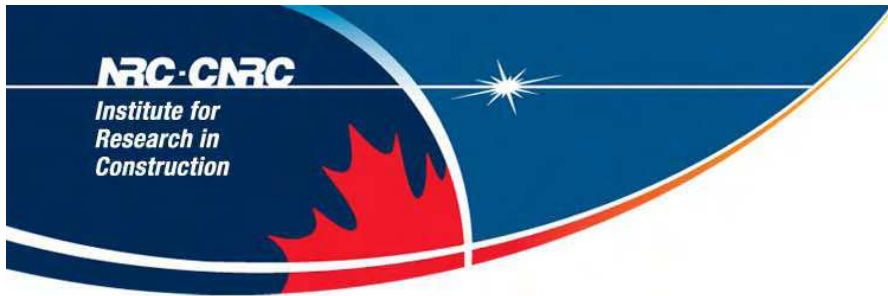


- Hygrothermal Performance of BES
- Modeling
- Field Experiment
- Laboratory experiments
- Concluding Remarks



## Concluding remarks

- **hygIRC** can adequately duplicate and help predict hygrothermal behaviour of wall components
- Tests that have been conducted in **EEEF** demonstrated the capabilities of IRC's facilities to carry out a series of experimental works to mimic the exterior conditions effect on the moisture transport.
- Lab and/or Field Experiments help to benchmark models
- Benchmarked models save time and money for doing parametric studies comparing to field and lab experiments
- Models, lab and field experiments complement each other



# Acknowledgments

- NRC for funding this cross program initiative between IRCs IE and BES programs
- IE/IAQ Group
- FEWF Team:
  - William Lei
  - Mike Nicholls
  - Marianne Manning
  - Roberts Berzins
  - Stacey Nunes
  - Khaled Abdulghani



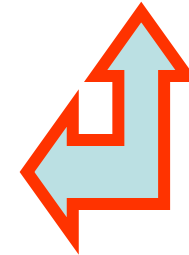
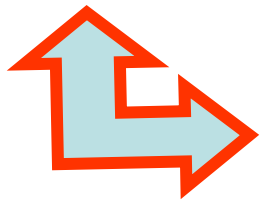
Lab-EEEF



Field-FEWF



HAM Model-hygIRC 1D



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**Tel. 1-613-993 5709**