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HygIRC benchmarking experimental work

Maref, W.

IRC-ORAL-478

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hyglIRC benchmarking experimental work

Presented by

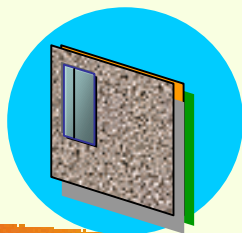
Wahid Maref

On behalf of

MEWS Research Team

Institute for Research in Construction, Ottawa, Canada

February 05, 2003



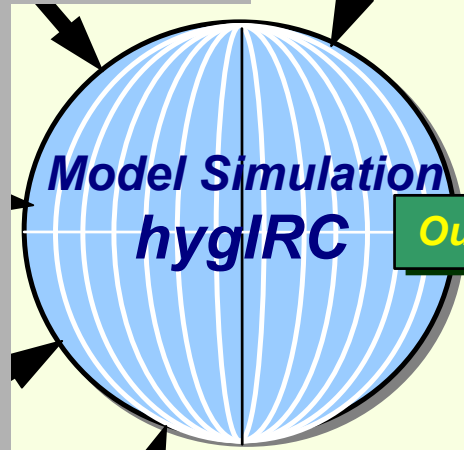
Research Team

Team Work

- ***Daniel Booth***
- ***Mike Lacasse***
- ***Wahid Meref***
- ***Mike Nicholls***
- ***Daniel Perrier***
- ***Yvon Tardif***

Benchmarking

Benchmarking





Outline

- Objectives - approach
- Small-, mid- and full-scale
- Simulations
- Experiments
- Results
- Summary

Objectives - approach

- Evaluate drying process of wood-based components in wood-frame construction
- Benchmark model (*hyglRC*) prediction of drying rate of wood-based components

Approach -

- Establish drying rates for OSB sheathing board - alone - and wrapped in sheathing membrane
- Monitor total Moisture Content over time
- Subject specimens to nominally steady-state conditions



Benchmarking criteria

If the agreement between the experimental and simulated drying curves is around 5% in terms of drying times as well as the shape of the drying curves derived from the experiments, it is acceptable for practical purposes

Starting point for the experiments

How to conduct a full scale Moisture response of wall assemblies experiments?



Thermal Properties ?

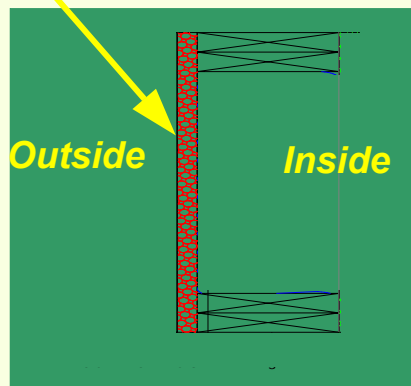
Moisture Content ?

*And.. ?
?????*

Moisture Transport ?

General approach

Single Panel - OSB Sheathing



Step 1

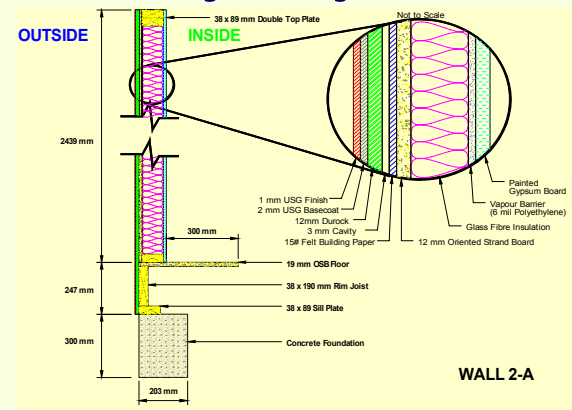
Step 2

Step 3

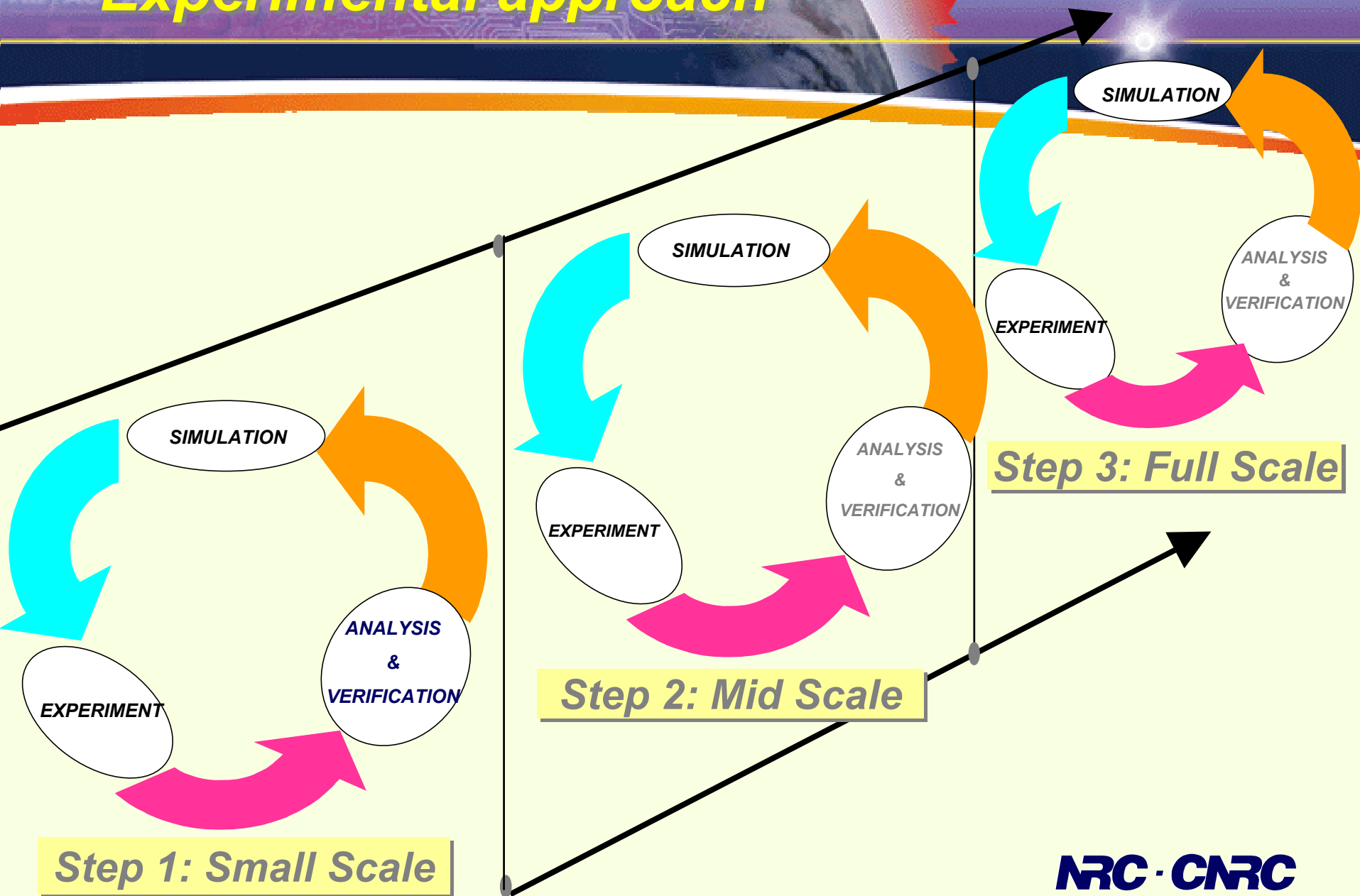
Step 4

Step n

Multi-layer System



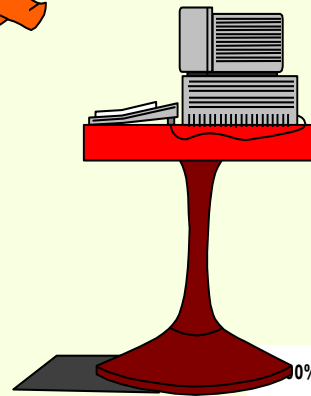
Experimental approach



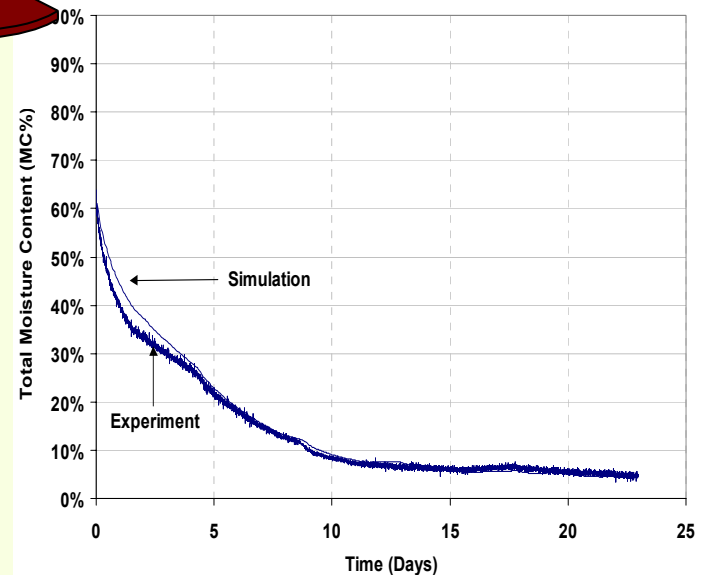


SIMULATION-hyglRC

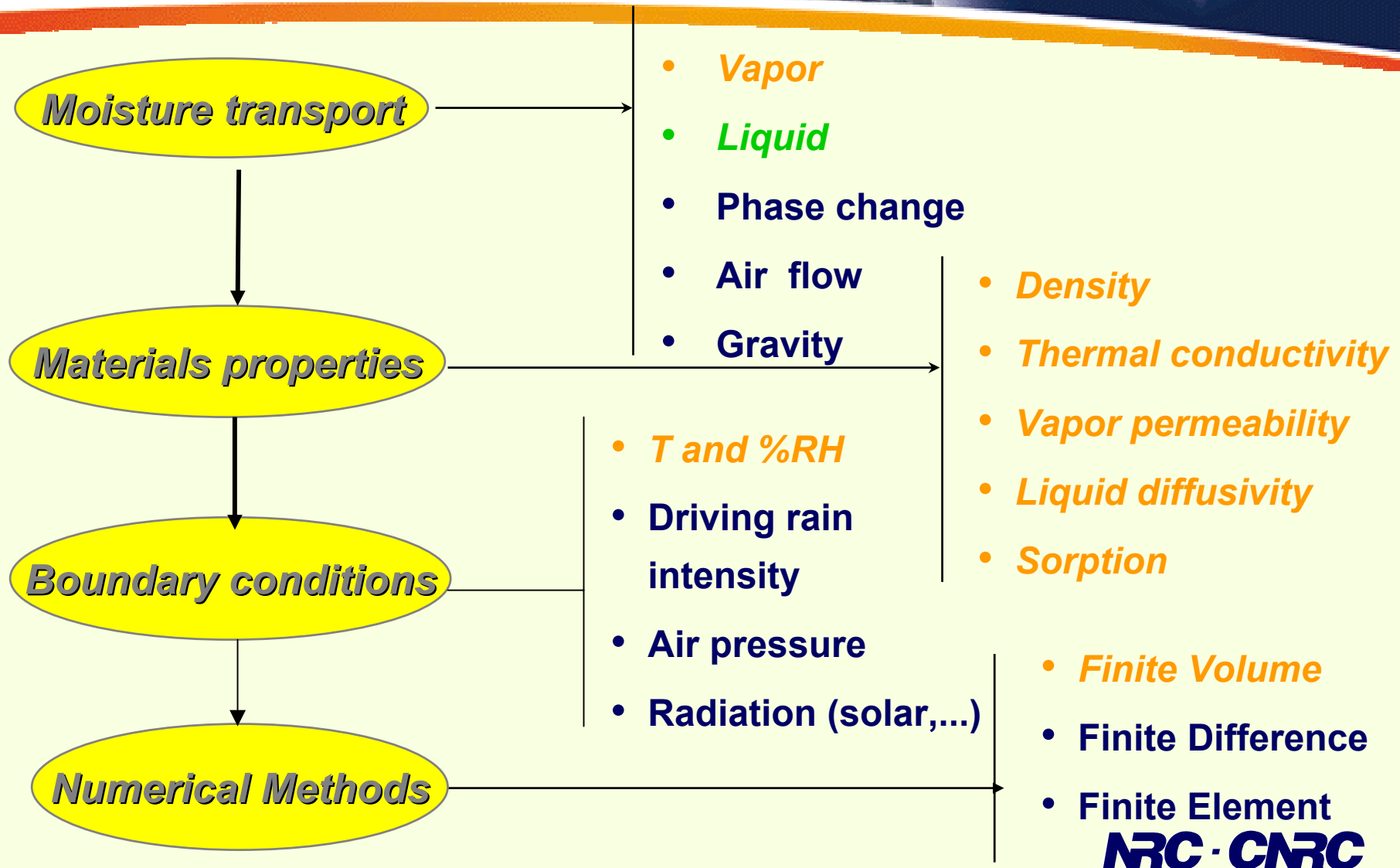
EXPERIMENT



ANALYSIS & VERIFICATION



Hygrothermal analysis





Simulations

- **Liquid transport through sheathing membrane not modeled**
- **Air movement not explicitly considered**
- **Contact between membrane and OSB sheathing was assumed to be perfect**
- **Initial moisture content of the membrane was set at 0%**

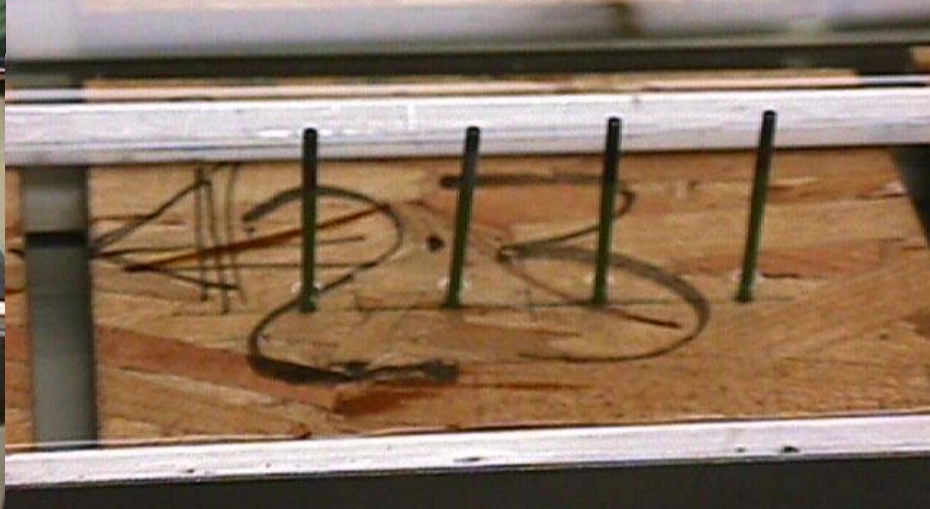
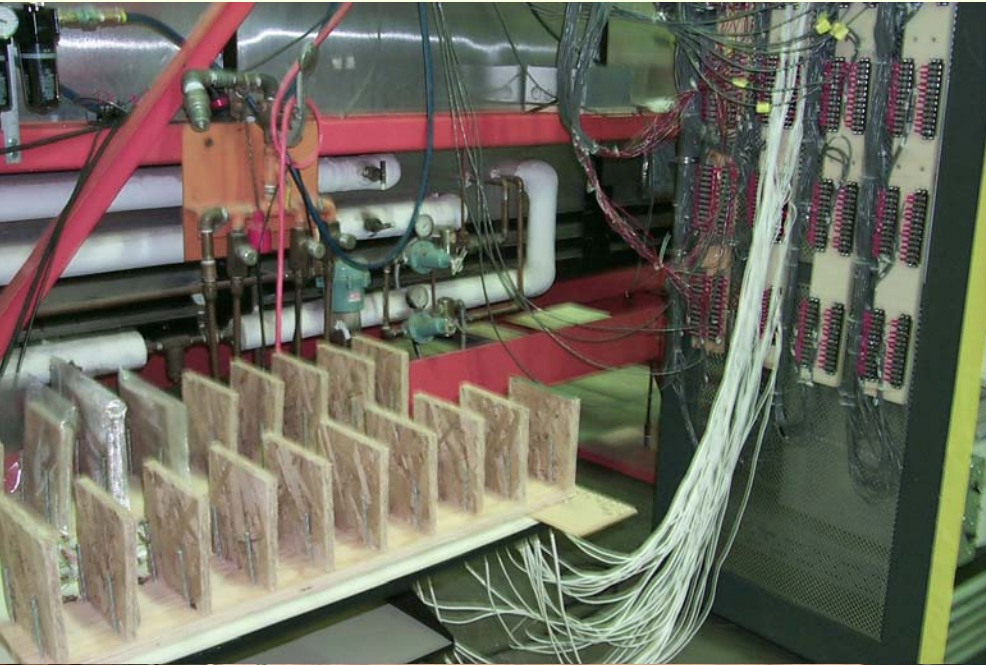
Experiments — approach / test parameters

- **Temperature and RH inside test chamber controlled**
- **Total weight of specimens obtained from periodic measurements using weighing system**
- **Moisture Content derived from dry weight measurement**
- **Moisture Content from moisture Pins (Delmhorst)**

Small-scale experiments

- ***Objectives***
 - ***Material properties (Task 3)***
 - ***Calibration of MP on OSB***
 - ***Technical information for the development of Mid & full-scale experiments.***

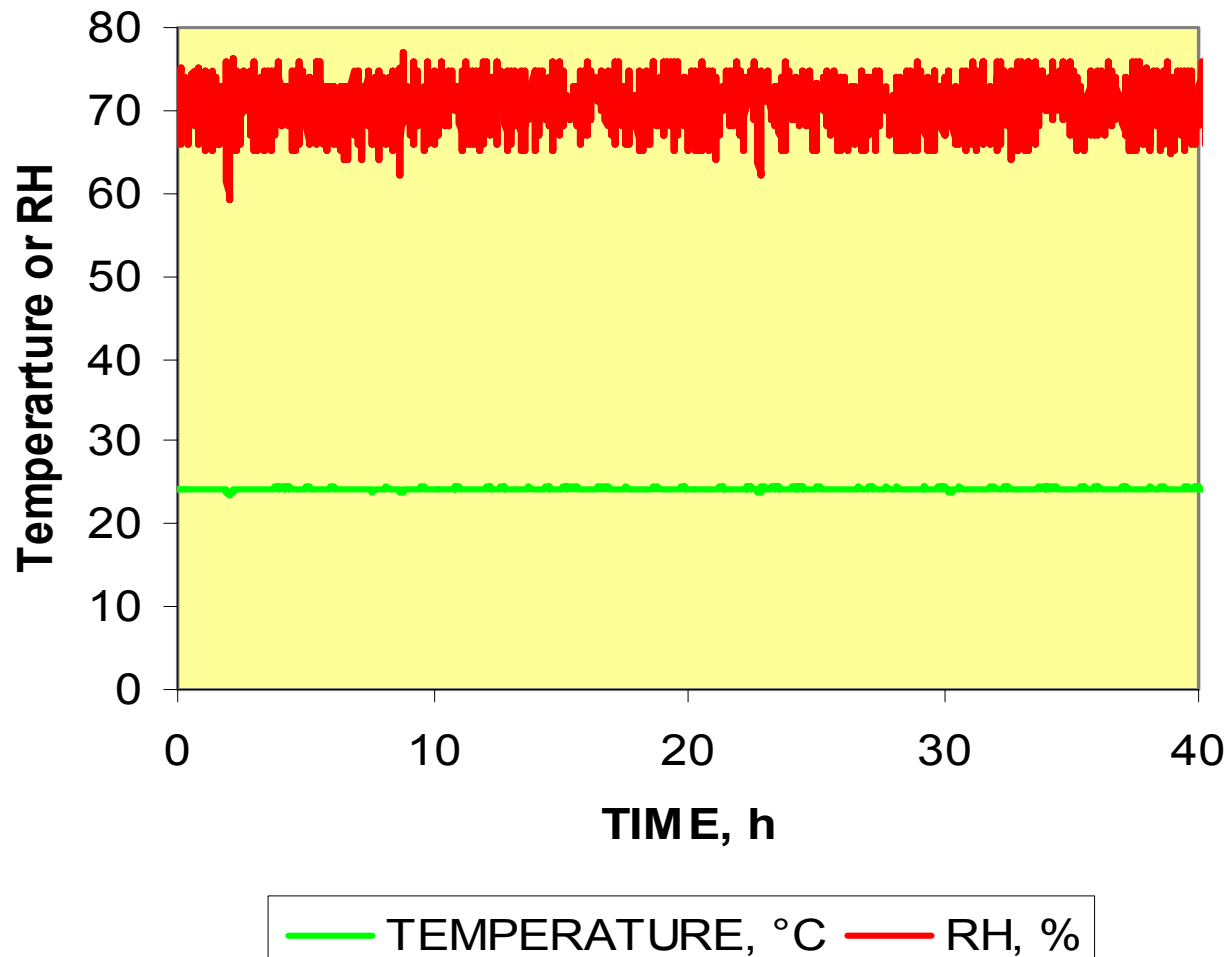
Small-scale experiments apparatus- Moisture pins calibration on OSB (150x150)



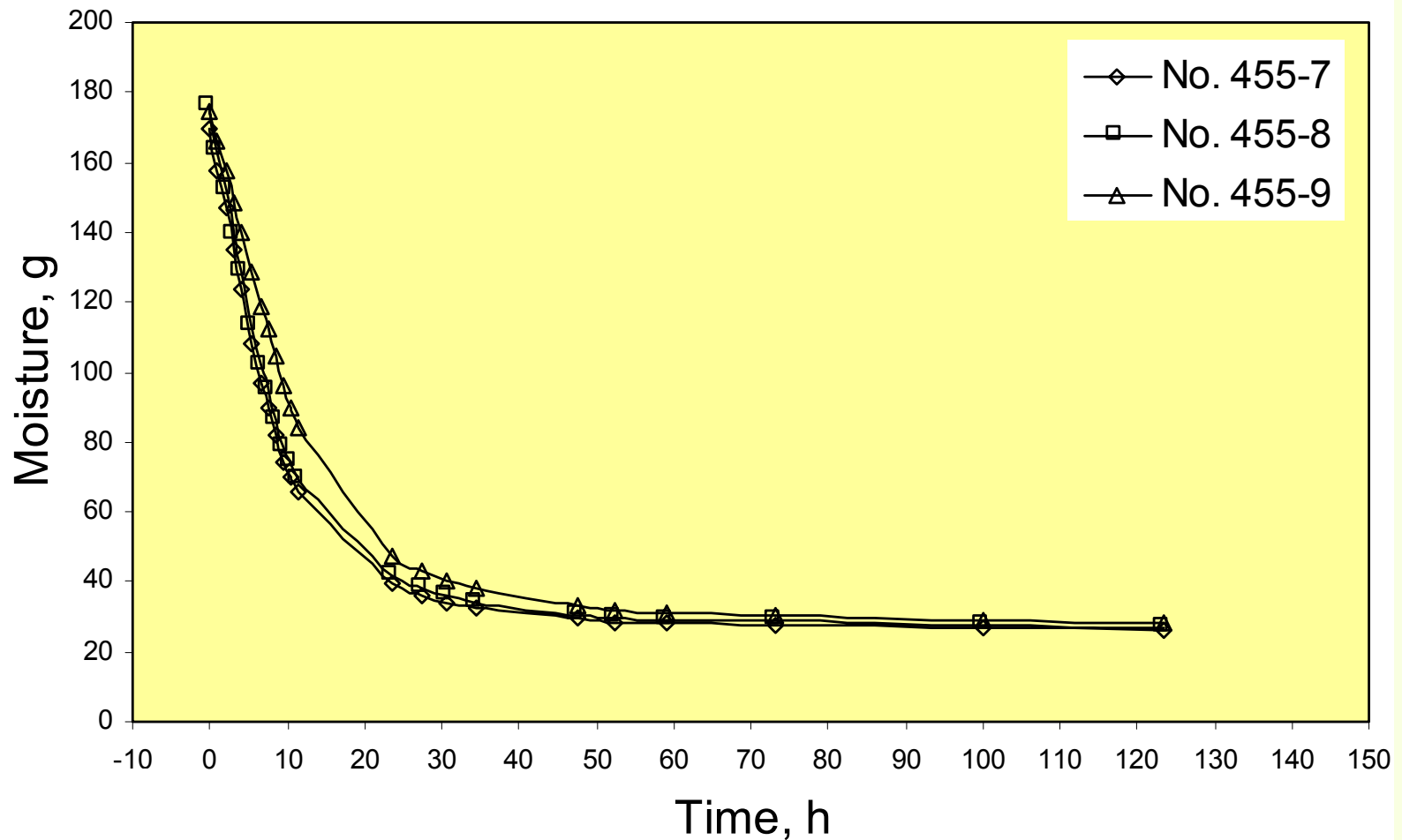
Small-scale experiments – Duracrete (300x300)

- Duracrete (All hygrothermal properties were determined for the specific product)- **3 specimens**
- Start with a high level of known moisture content (Total immersion in water for 24 to 36 h)
- Place in a chamber of constant Temperature, RH and air flow velocity and allow to dry through the major surfaces

Small-scale experiments – Boundary conditions



Small-scale experiments – Results

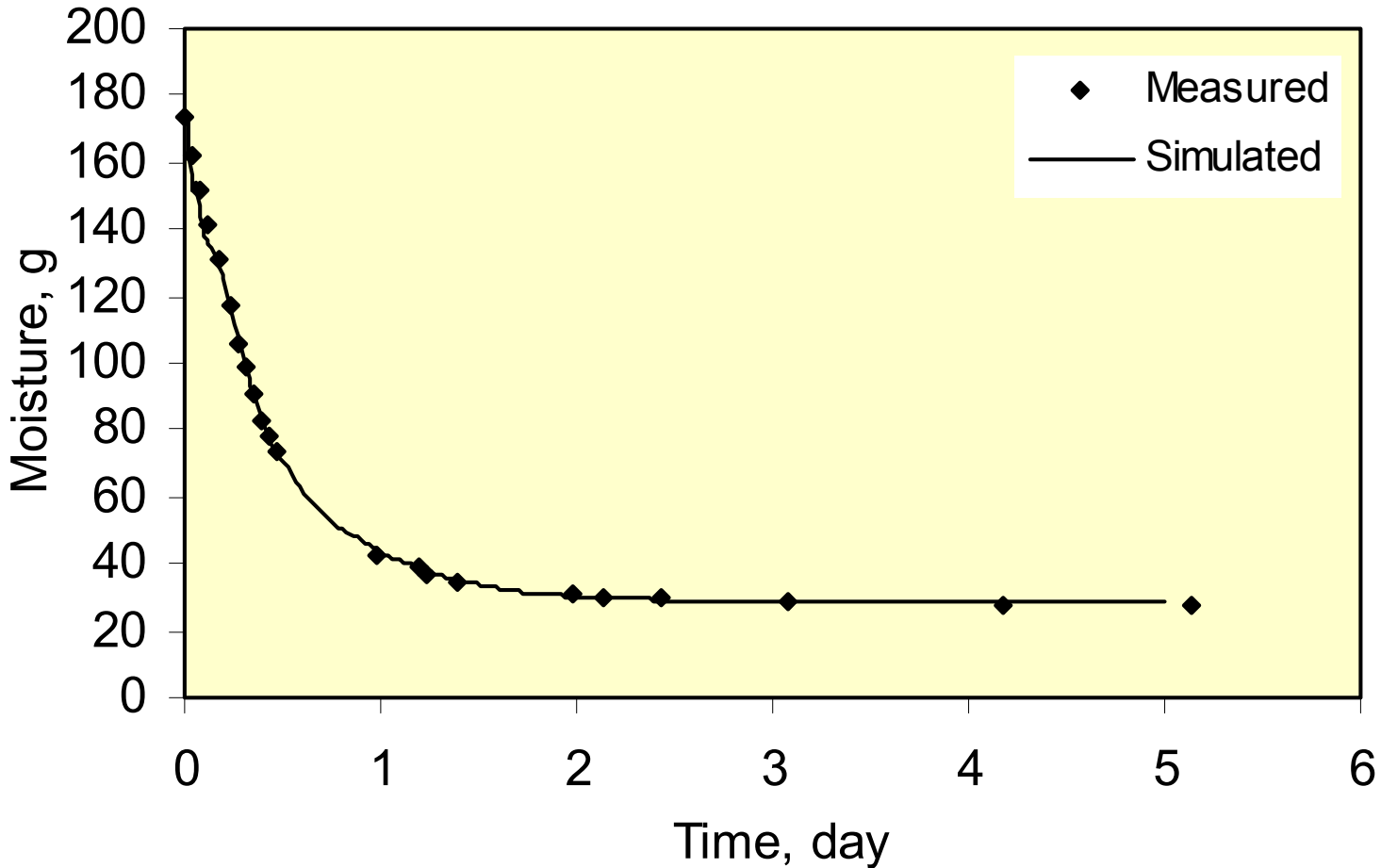




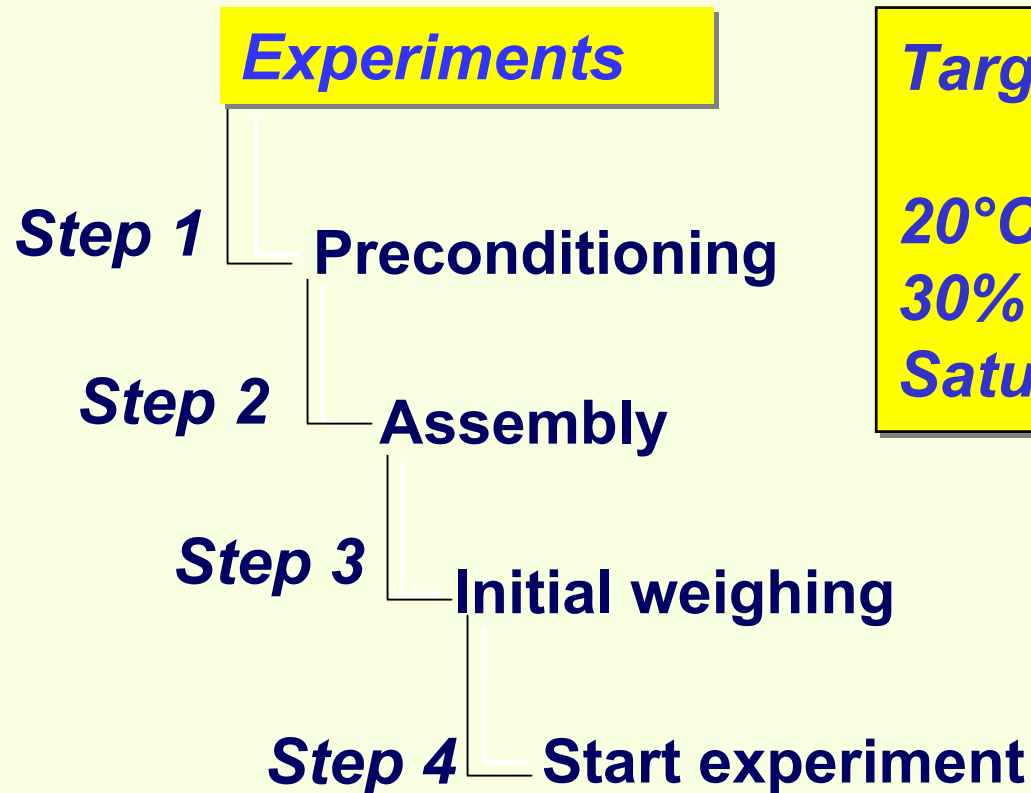
Simulations parameters

- **Measured Initial Conditions**
- **Measured Boundary Conditions**
- **Measured Air-Flow Rates**
- **Measured Properties for Duracrete**
- **Mass Transfer Coefficient from Literature (ASHRAE, Lewis' Relation)**

Small-scale experiments – Comparative results - Duracrete



Experimental steps – Mid & Full-scale



Target Boundary Conditions

20°C

30% RH

Saturated material

Apparatus - Climate chamber - EEEF

Specimens and weighing apparatus are placed in EEEF

EEEF maintains T and RH profile over course of experiment

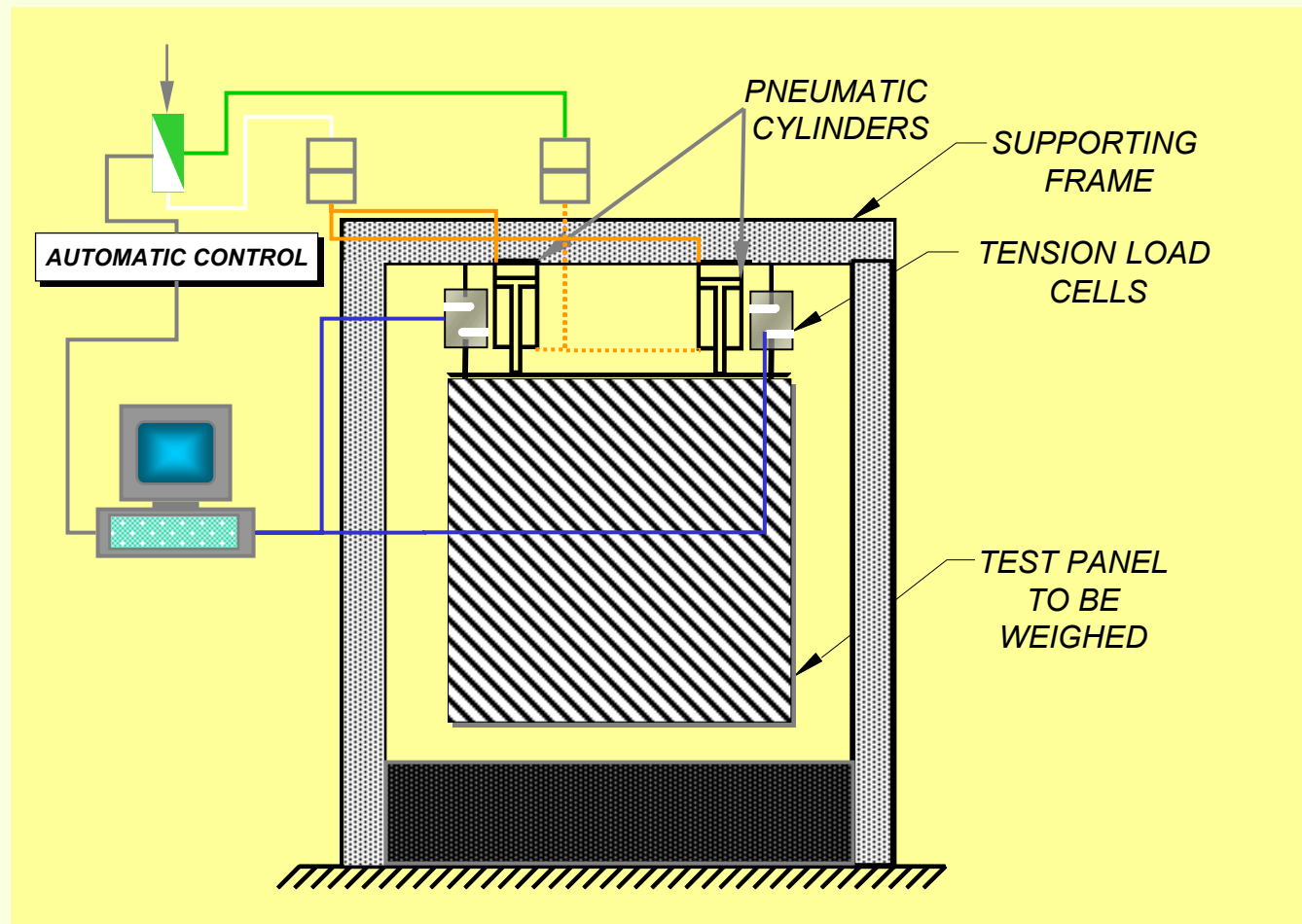
Smart reader (T , RH %)



**- 47 to 48 $\pm$ 1 $^{\circ}\text{C}$
10 to 100% RH $\pm$ 3% RH**

Environmental Exposure Envelope Facility

Apparatus – Full-Scale weighing system



Apparatus – Mid-Scale weighing system



Support beam

Load cells

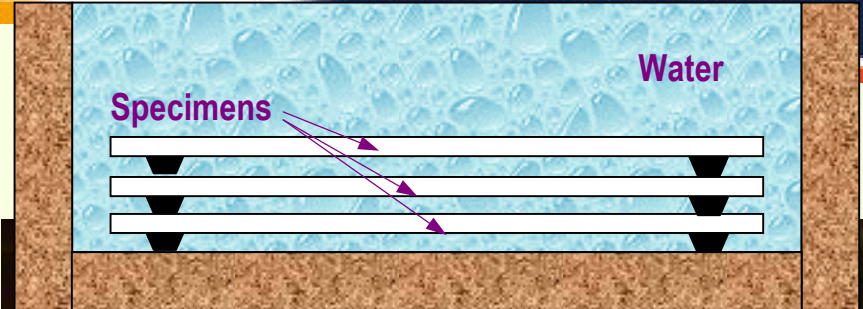
11/22/1999 16:24

Pneumatic piston

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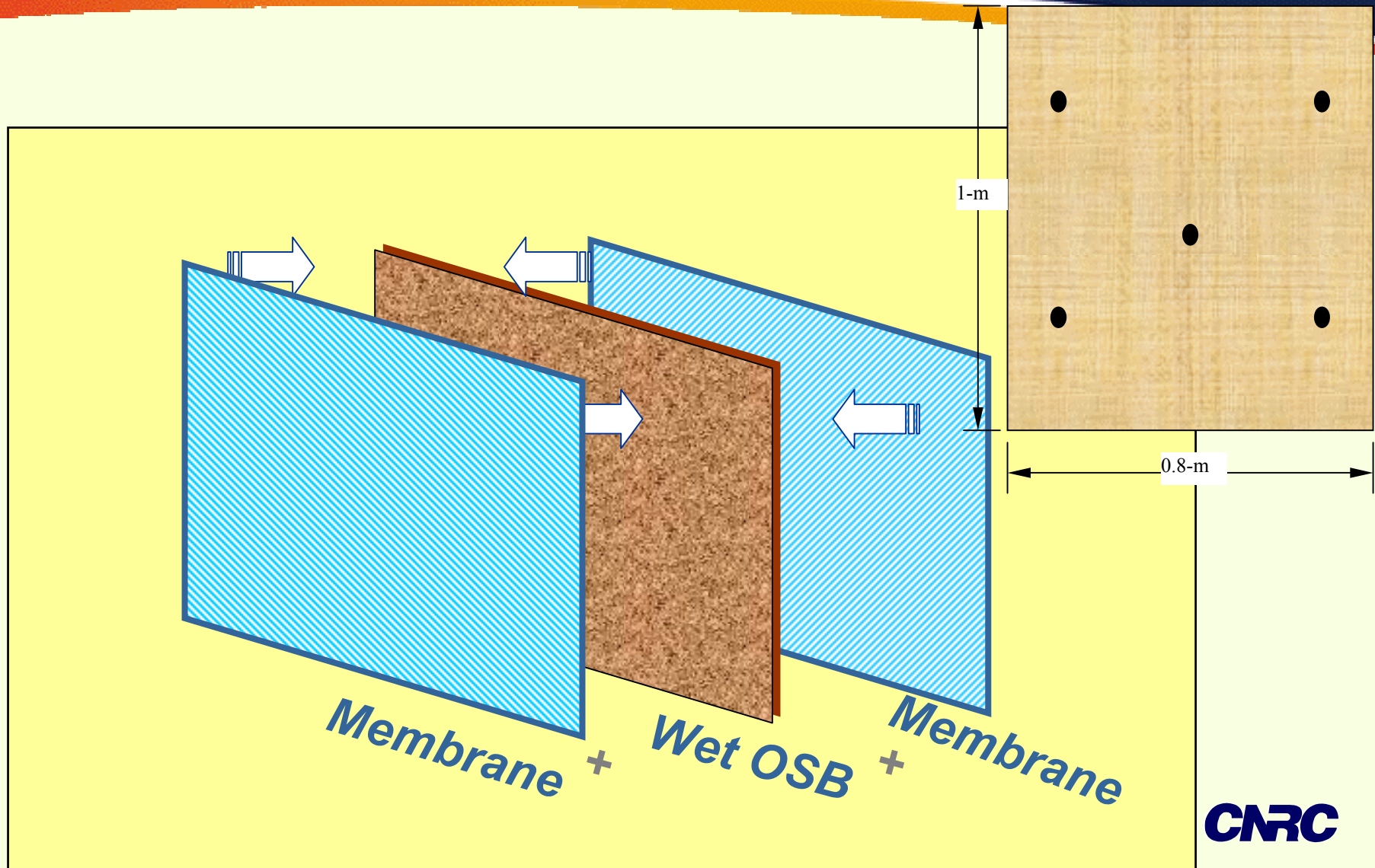
Mid-scale experiments- Preconditioning

Immersed in bath for 5-d

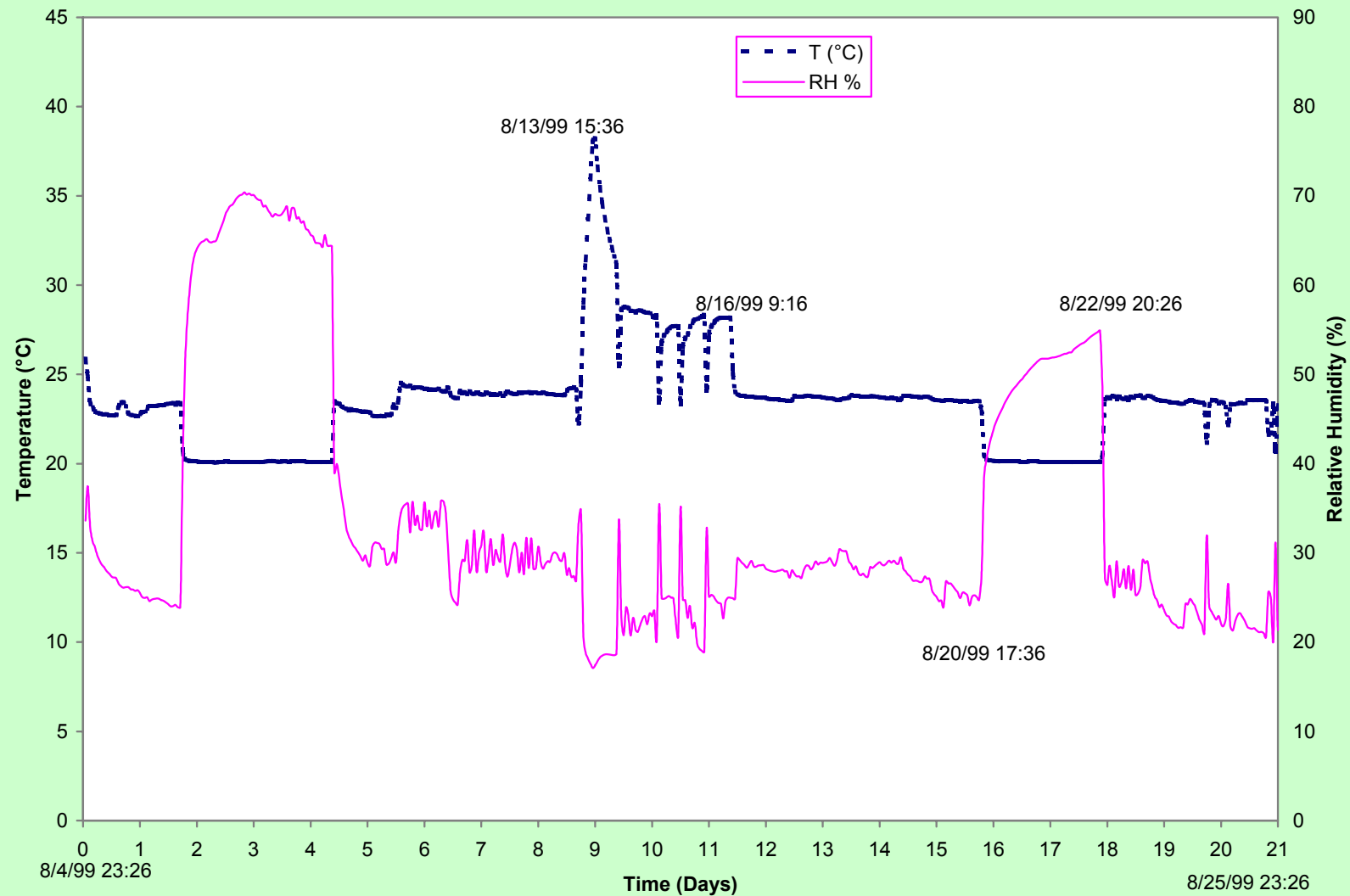


Remained in chamber for 2-d
NRC · CNRC

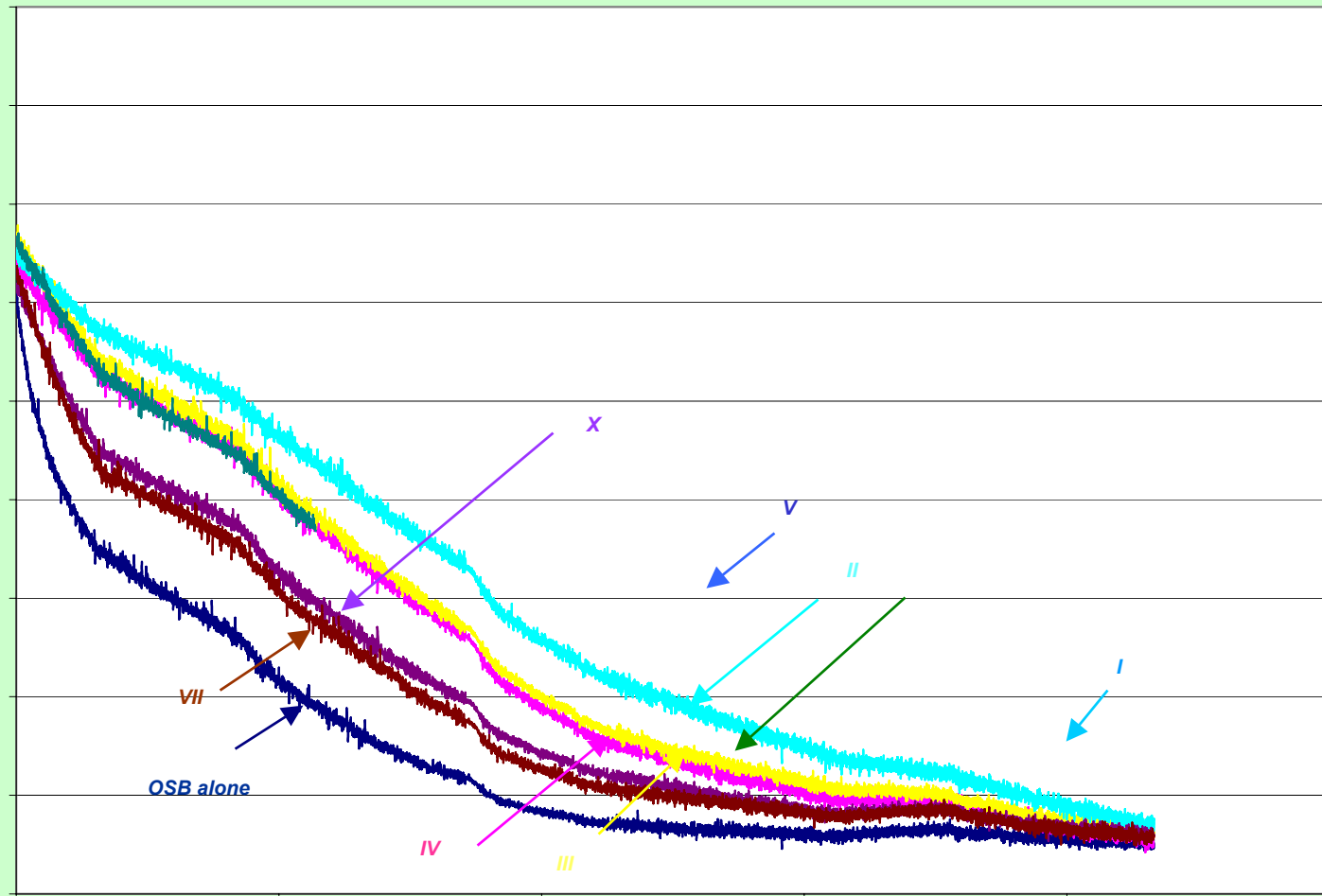
Mid-scale specimens: OSB + membranes



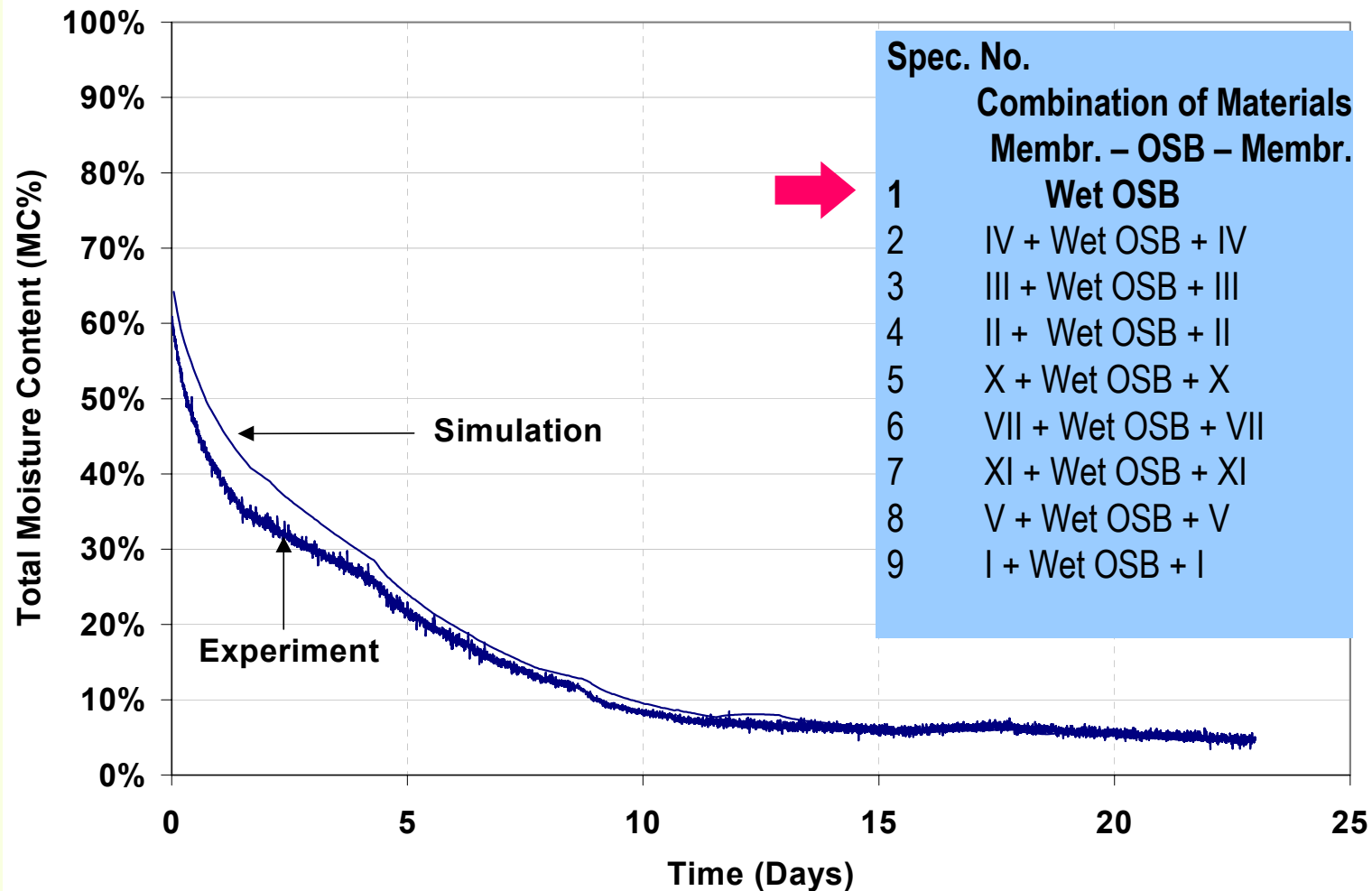
Initial & boundary Conditions



Mid-scale experimental results - Set #1



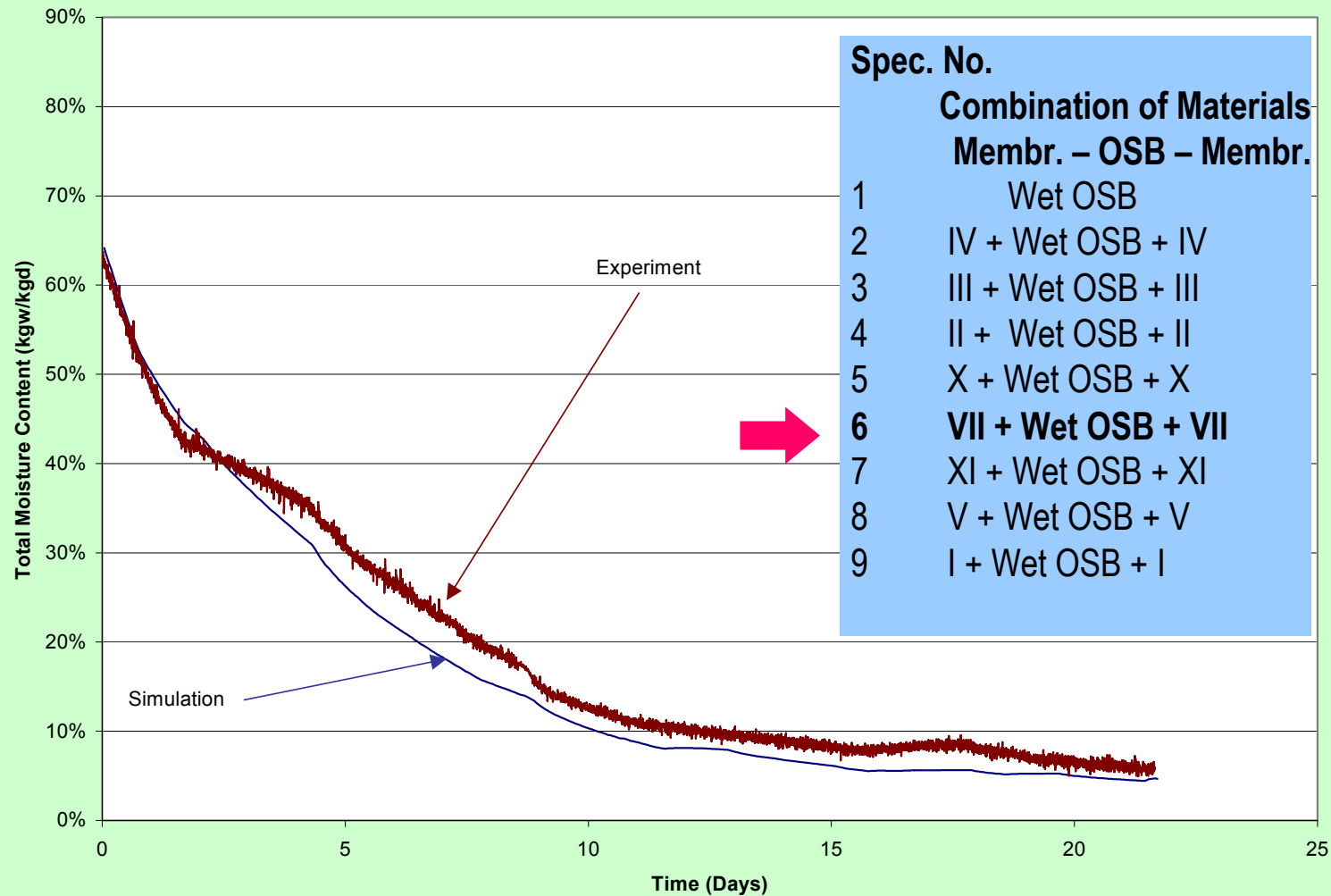
Mid-scale experimental results - Set #1



OSB - alone

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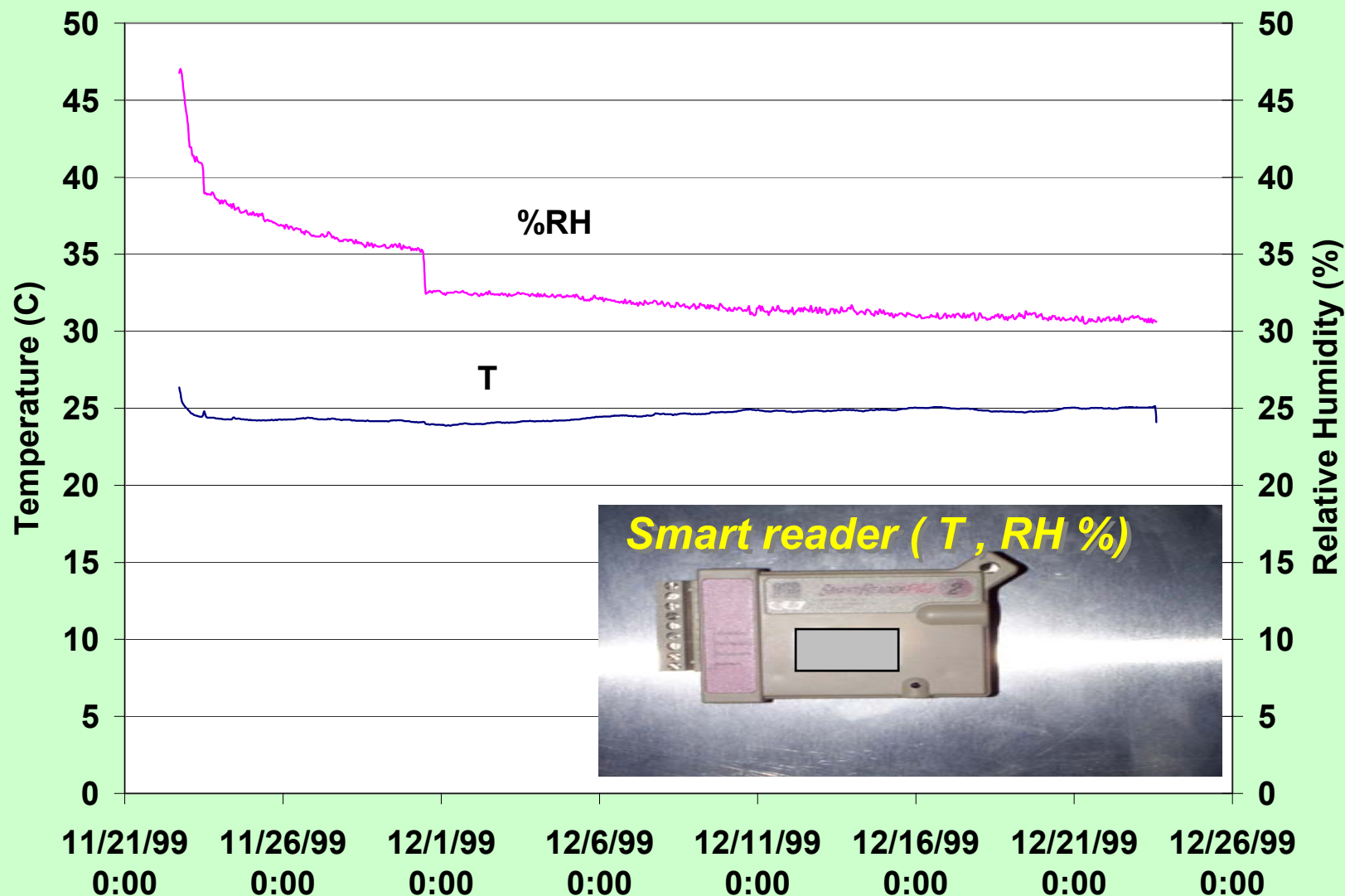
Mid-scale experimental results - Set #1



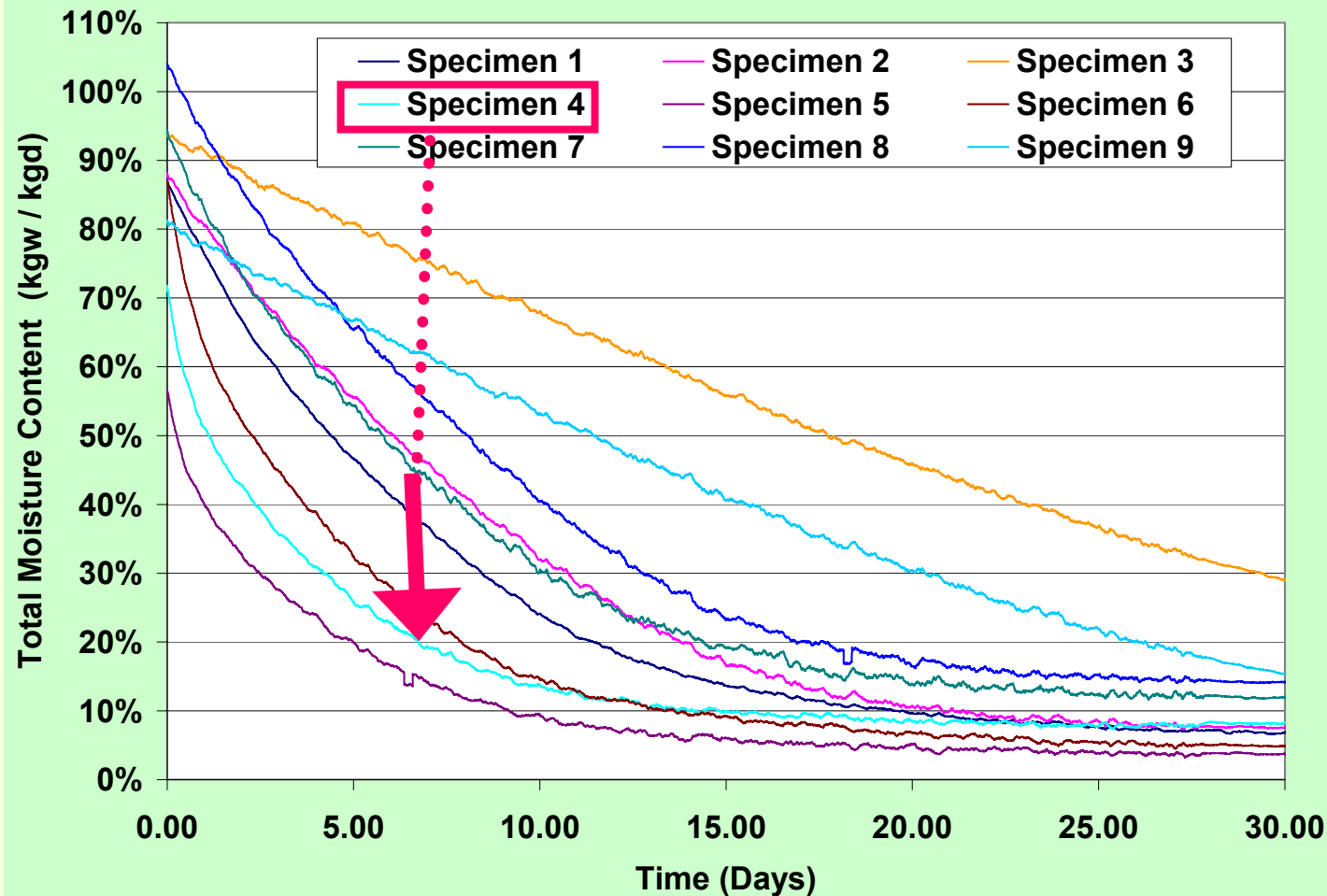
OSB - VII

NRC · CNRC

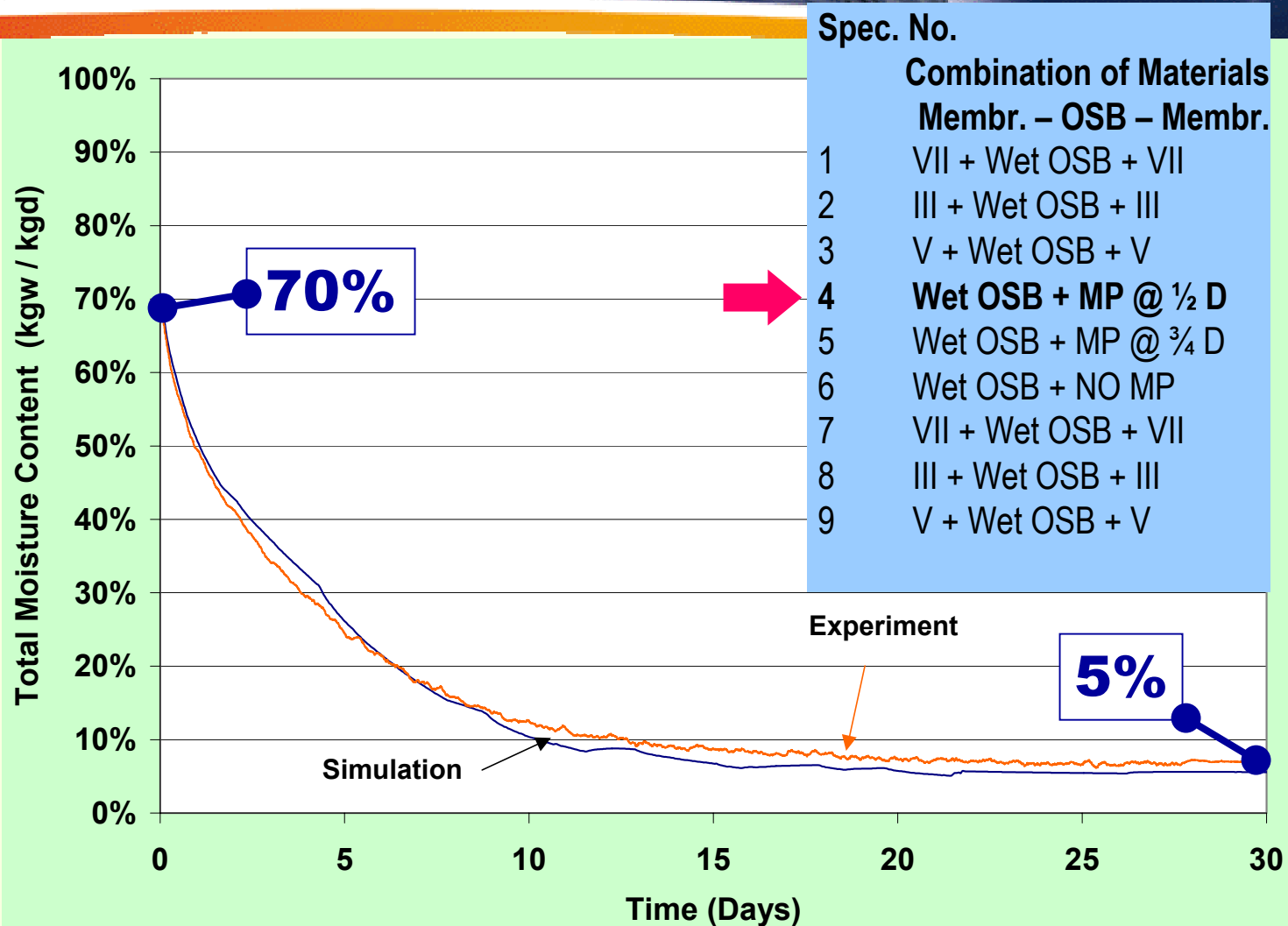
Mid-scale experiments- Initial and Boundary Conditions



Mid-scale experimental results- Specimen 4



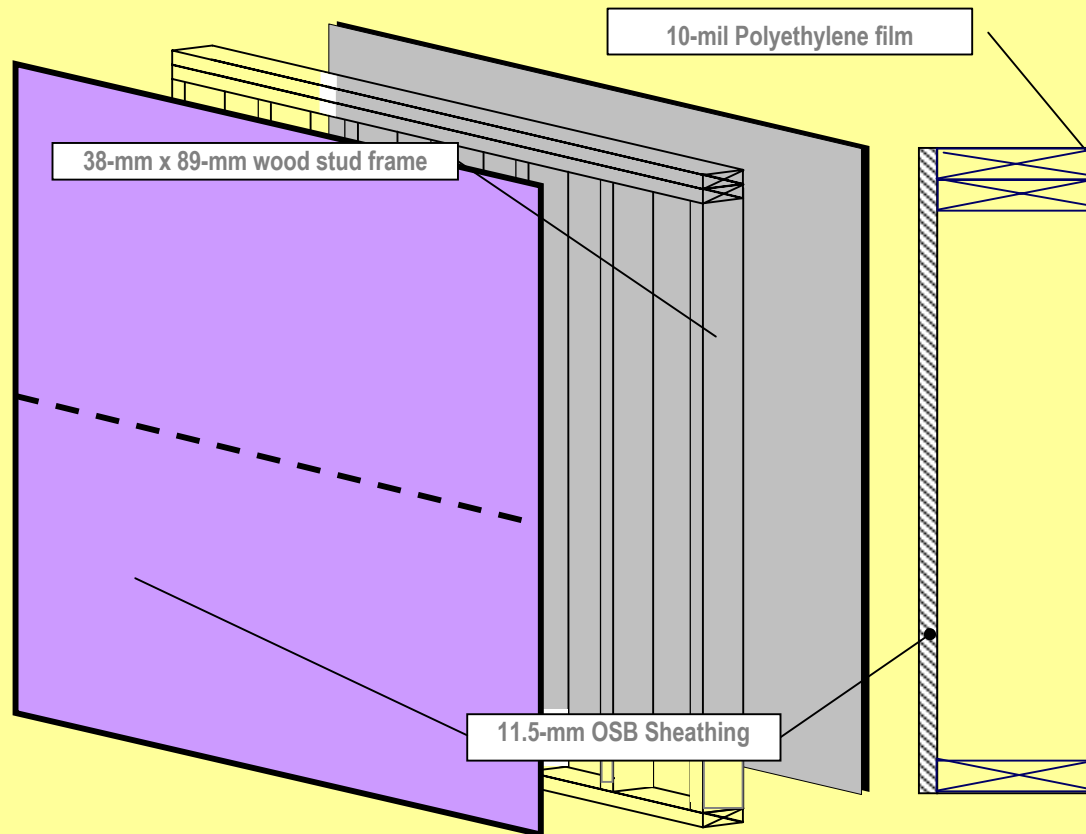
Mid-scale experiments- Comparative results - Specimen 4



Full-scale experiments - Preconditioning

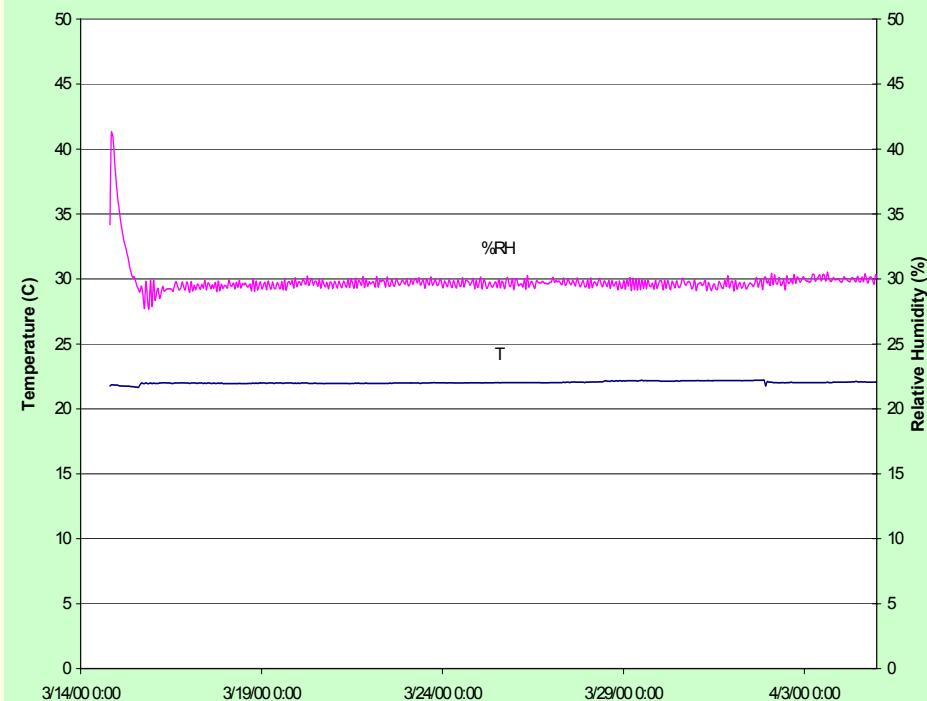


Full-scale wall configuration

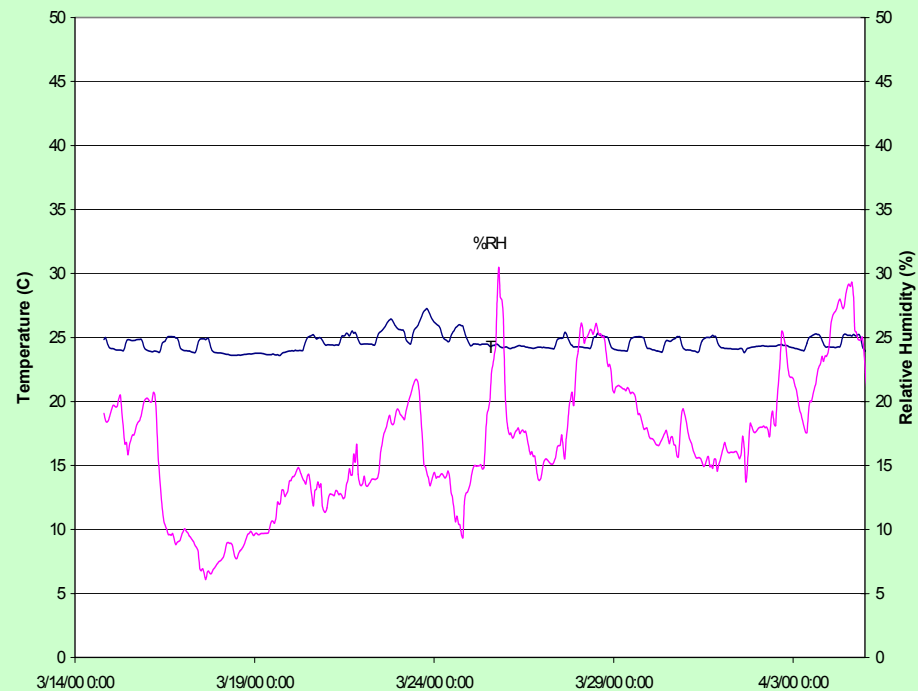


Initial & boundary Conditions

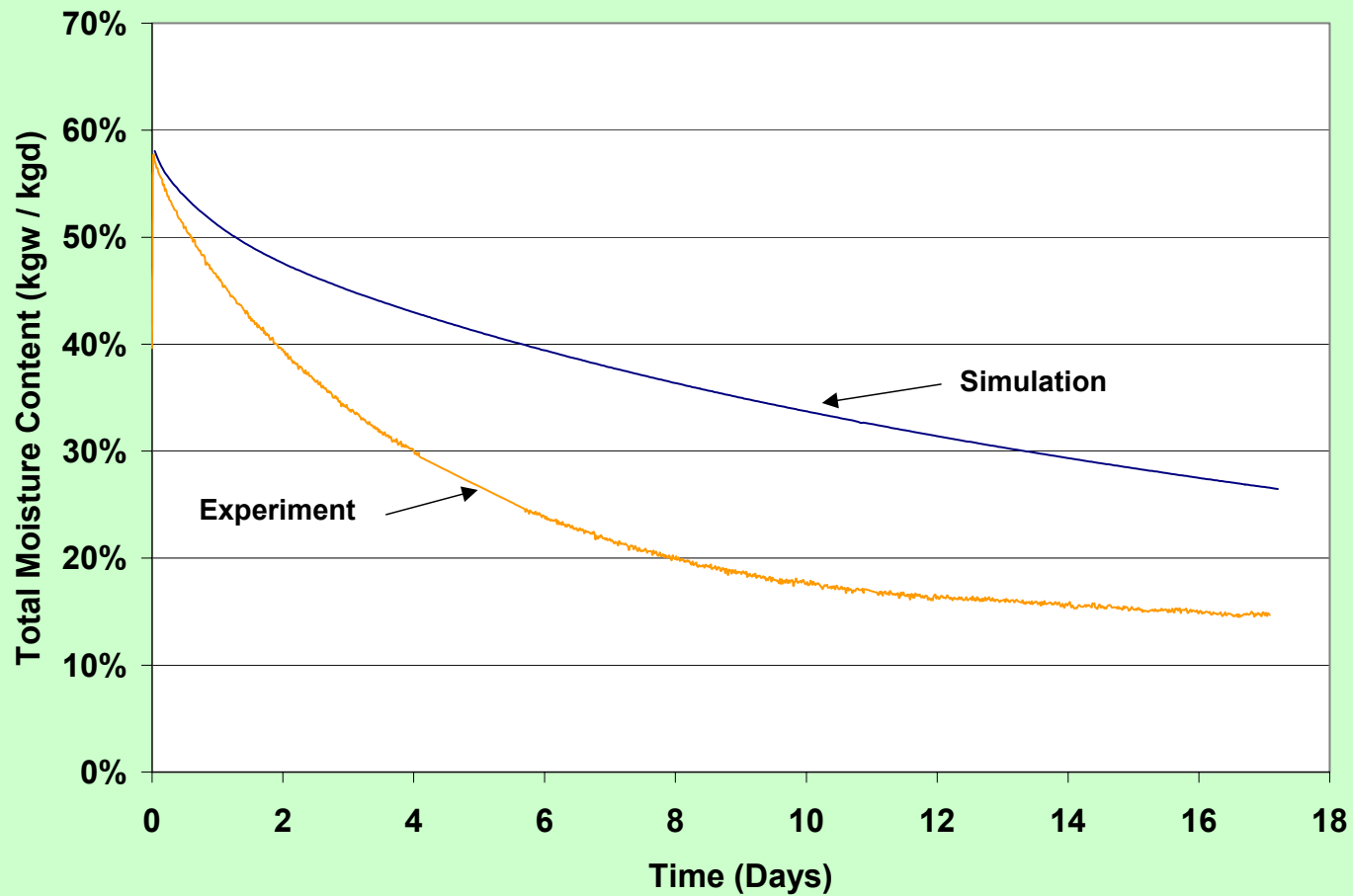
Conditions in the Mezzanine (Full Scale)



Conditions in the Mezzanine (Full Scale)



Full-scale results - Set # 1



Starting point for the experiments



What is wrong?

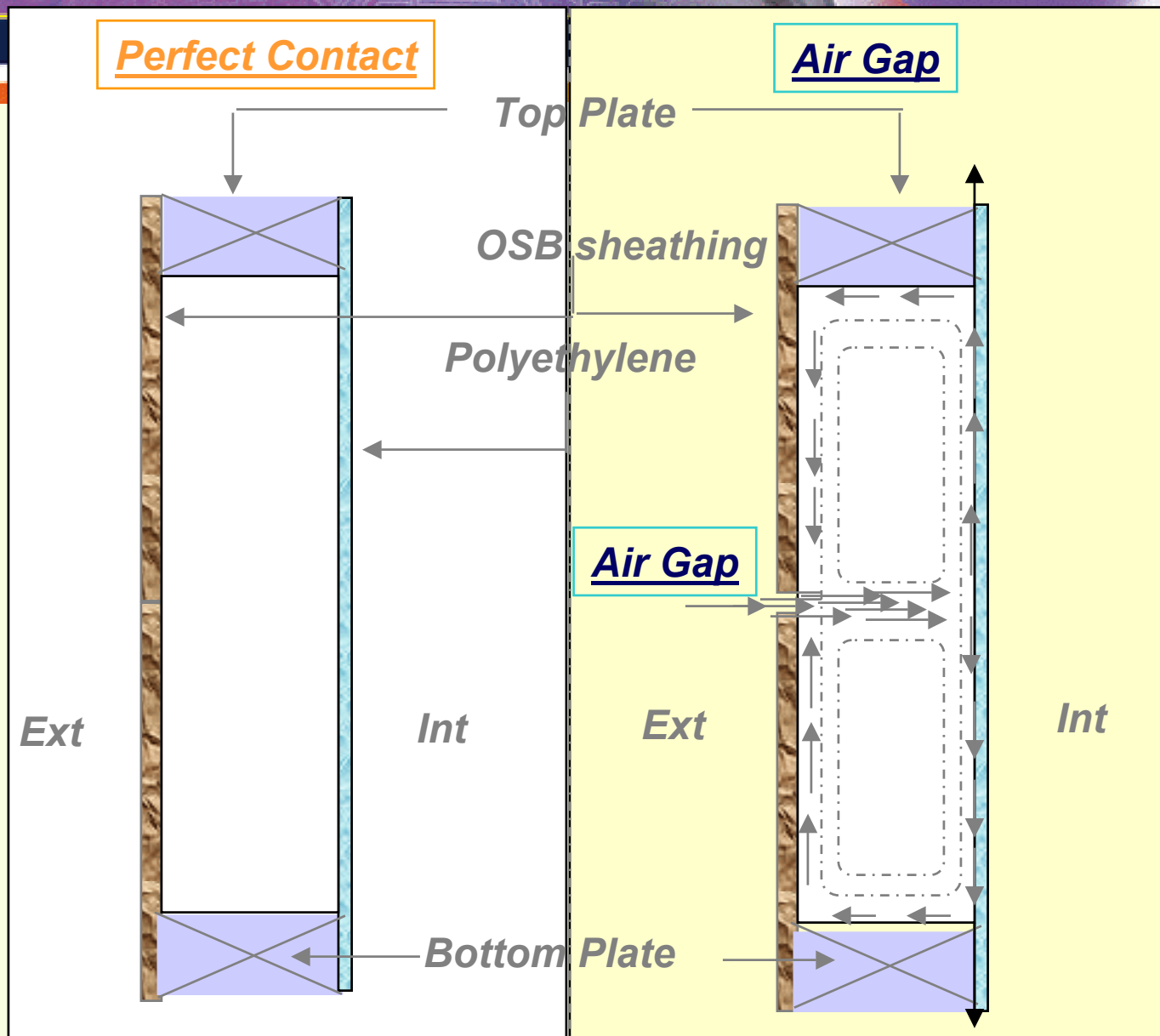
Experiment?

simulation?

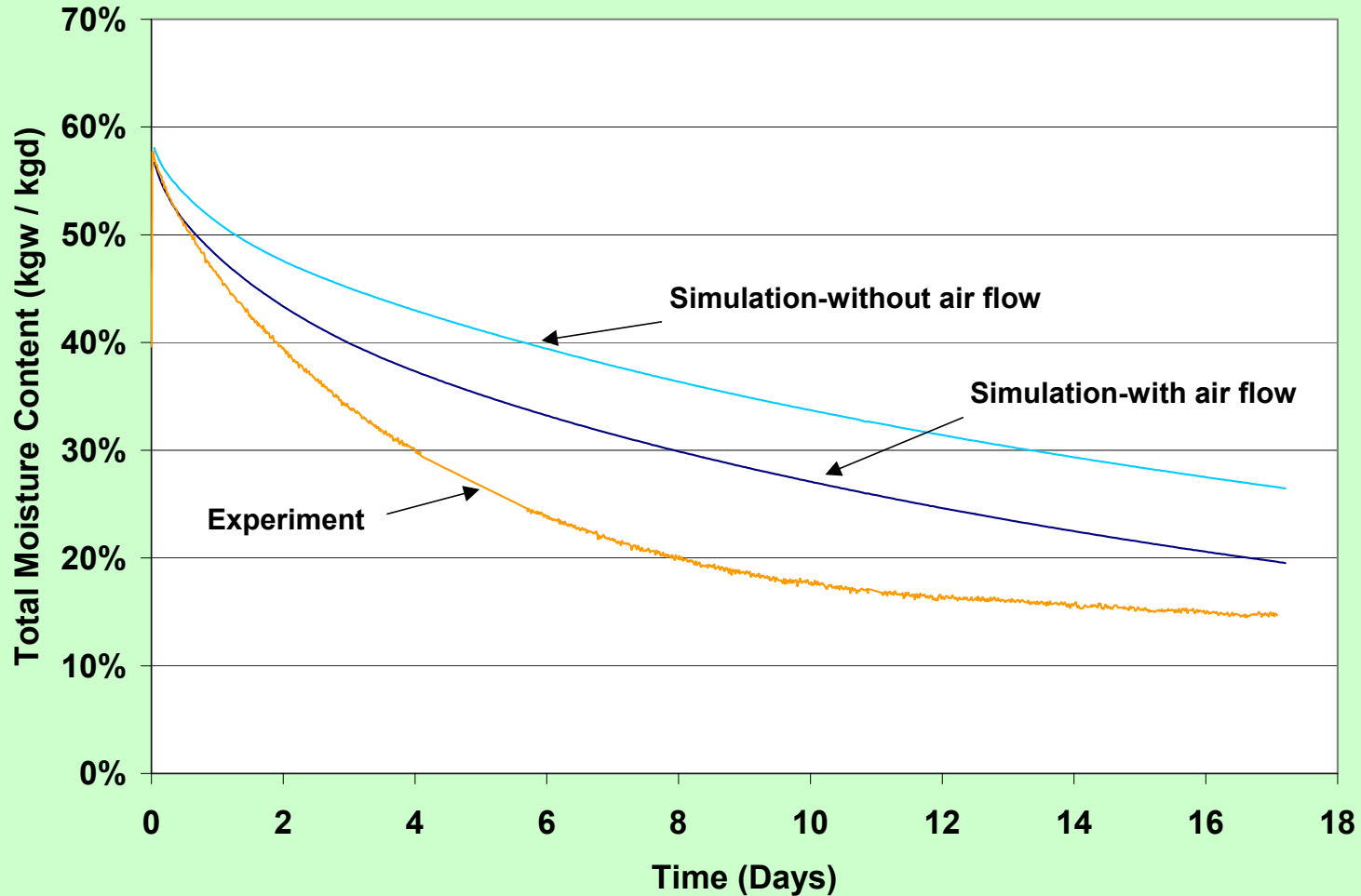
And.. ?

?????

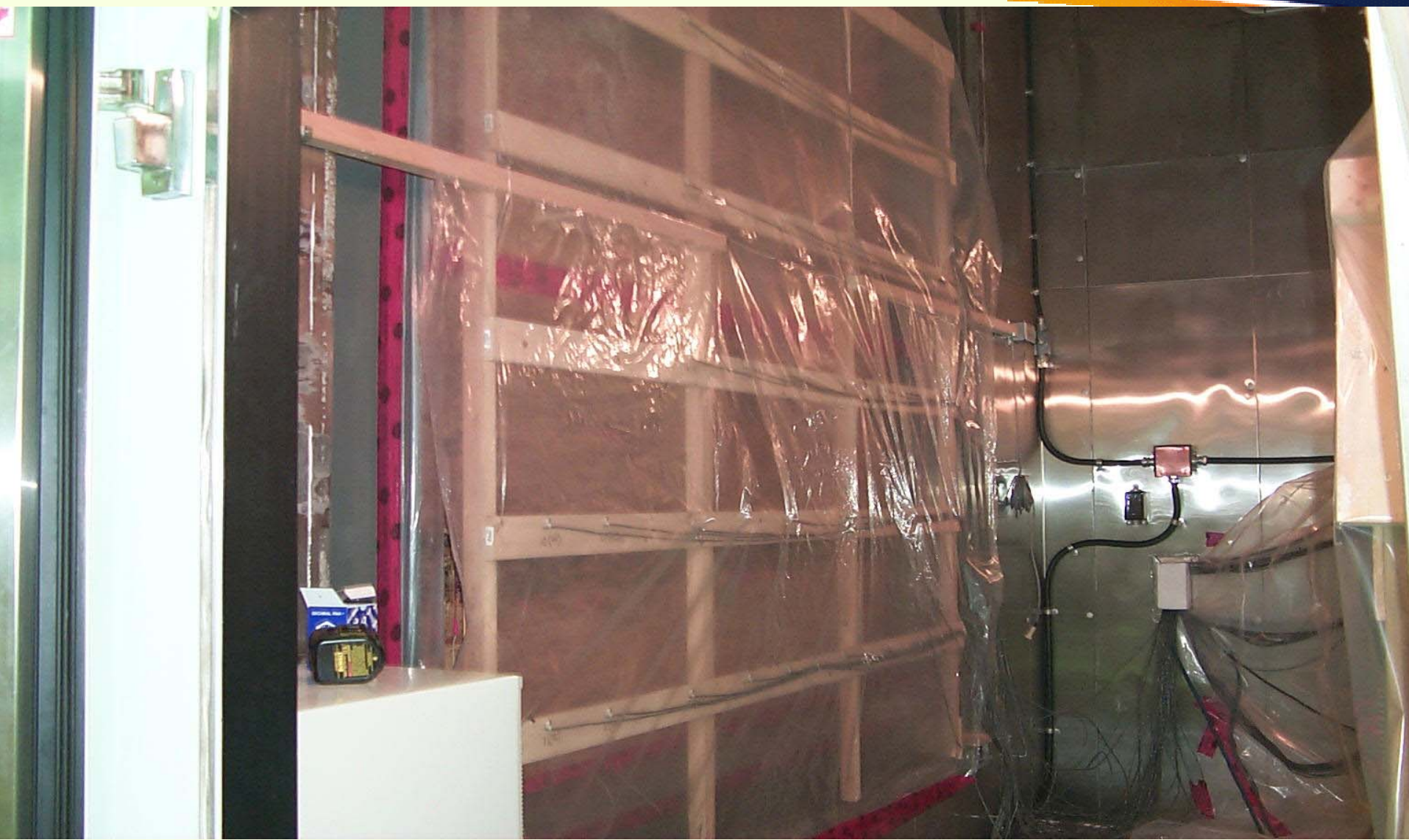
?



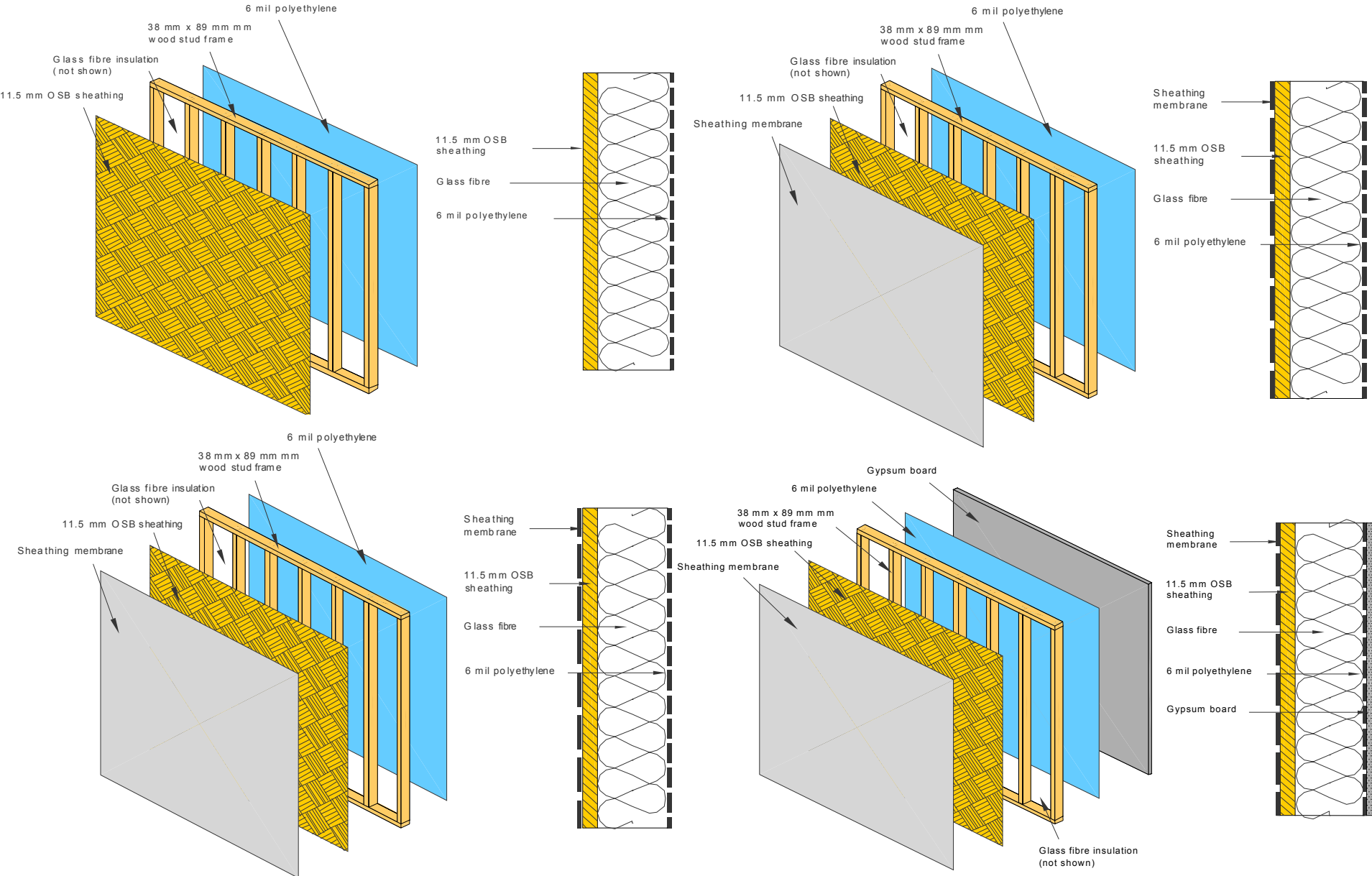
Full-scale results - Set # 1



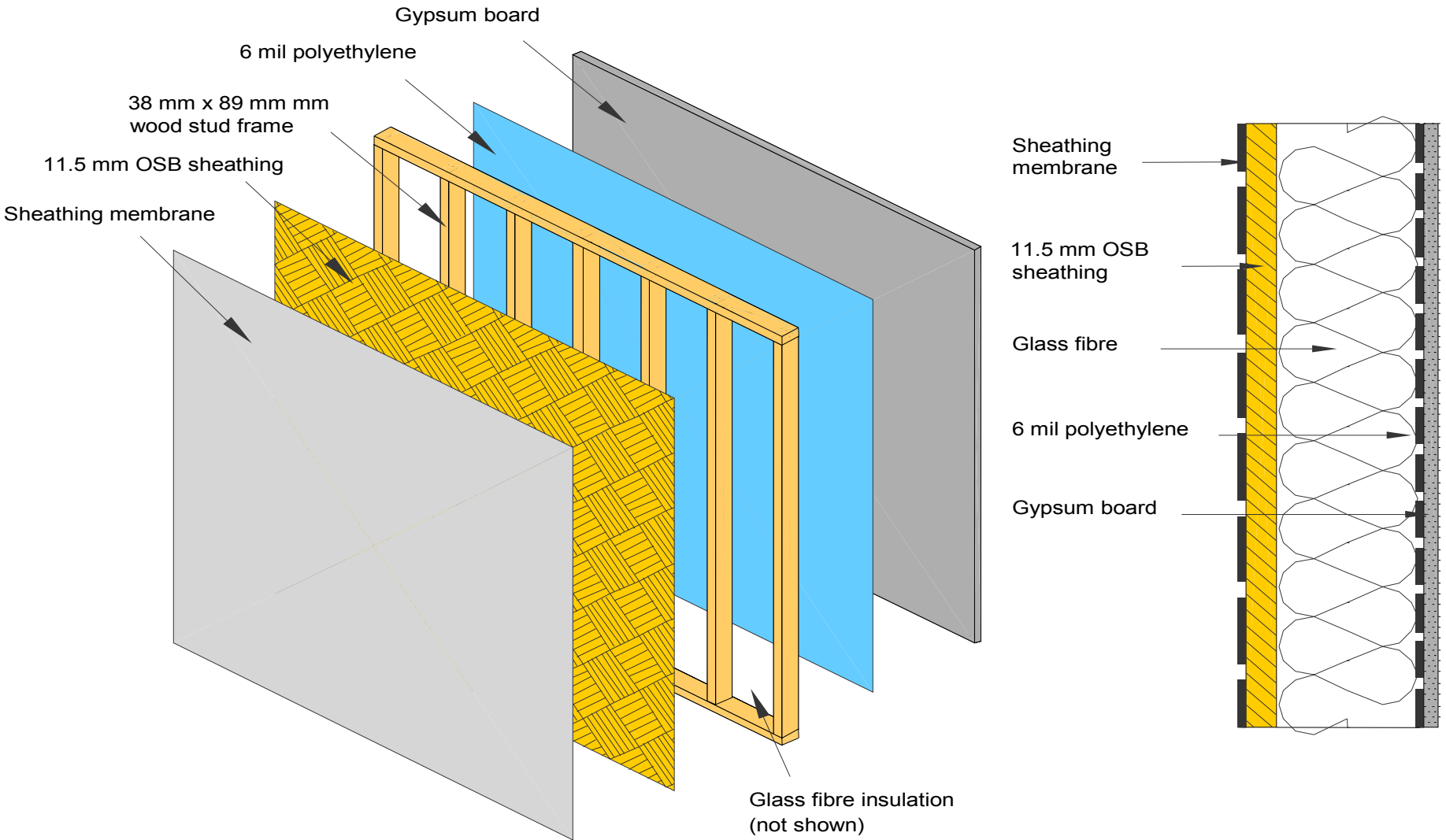




Full-scale experiments- Wall configuration



Full-scale experiments- Set # 4 wall configuration



Envelope Environmental Exposure Facility (EEEF)



***Wetting of
material or
assembly***



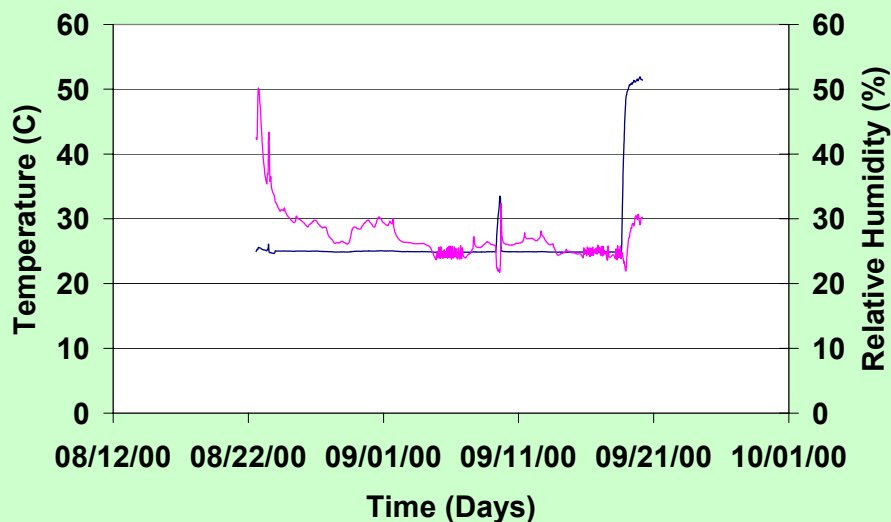
***measure rate of
weight loss
(drying) under
controlled
conditions***



***Comparison to model
predictions***

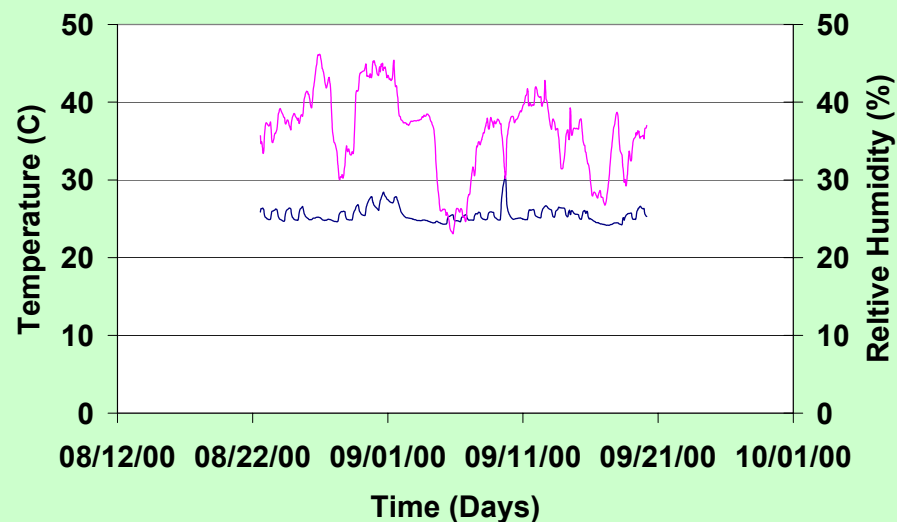
Full-scale experiments – Boundary conditions

Conditions in the EEEF (Test 4)



Outside

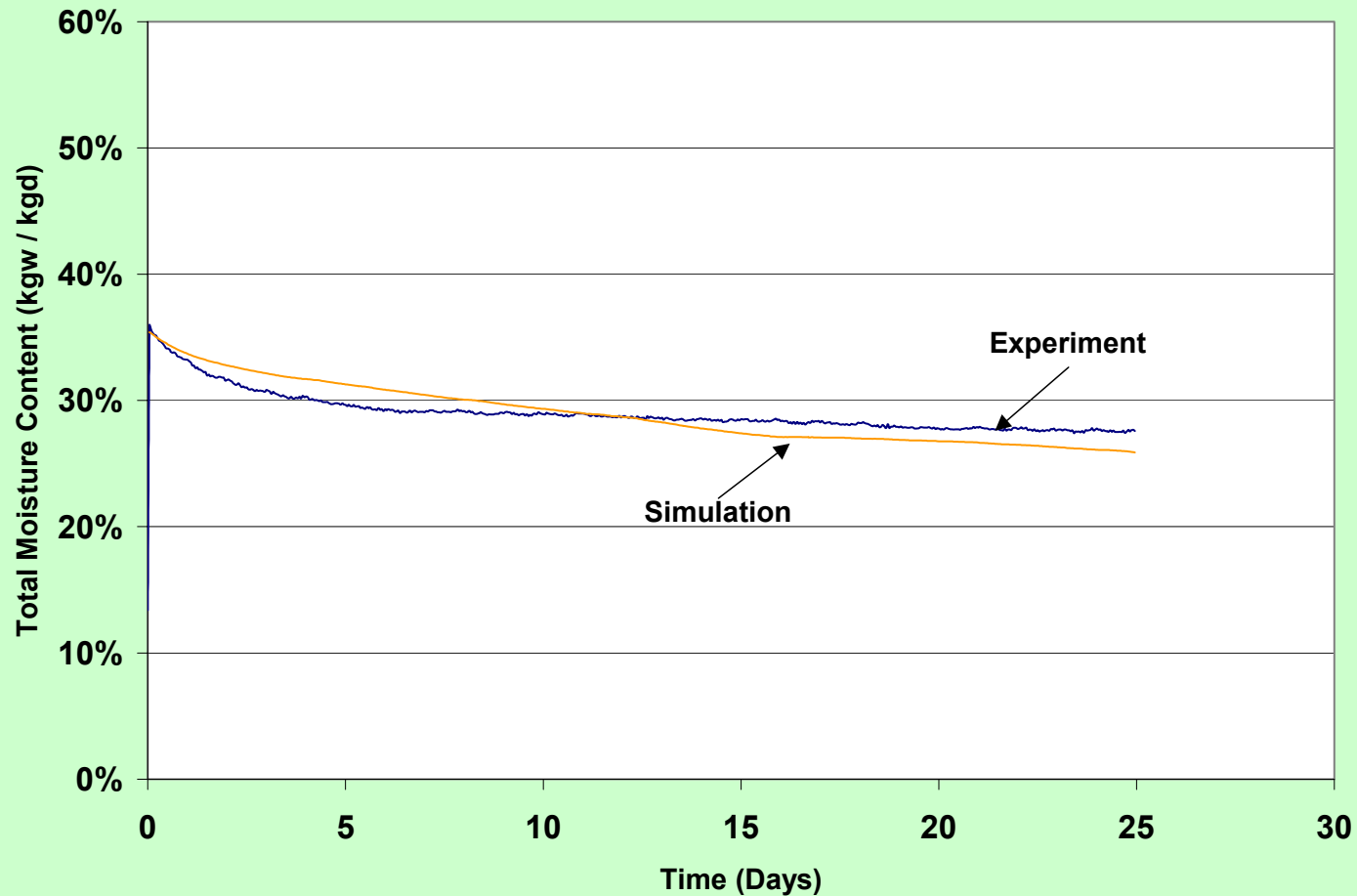
Conditions in the Mezzanine (Test 4)



Inside

Full-Scale Set # 4

Full-scale experiments- Comparative results – Set # 4





Summary

- **The result obtained by a simulation depends on the level of accuracy and details provided by the 4 ingredients of the model**
 - Moisture transport
 - Material properties
 - Boundary conditions
 - Numerical methods
- **All material properties used in simulation were characterized in the IRC lab.**



Summary

- Overall agreement between the experimental and simulated drying curves is good in terms of drying times as well as the shape of the drying curves derived from these experiments
- **hyglIRC** can adequately duplicate and help predict hygrothermal behaviour of wall components
- Benchmarking further enhances confidence when using **hyglIRC** to undertake broader parametric studies

Acknowledgements

- **MEWS consortium partners**

(<http://irc.nrc-cnrc.gc.ca/bes/mews/index.html>)

- **Canada Mortgage and Housing Corporation**
 - **Canadian Fiberboard Manufacturers Association**
 - **Canadian Plastics Industry Association**
 - **Canadian Wood Council**
 - **Dupont**
 - **EIMA (External Insulation Manufacturers Association)**
 - **Forintek Canada Corporation**
 - **Fortifiber Corporation**
 - **Louisiana-Pacific Corporation**
 - **Marriott International**
 - **Masonry Canada**
- **Raymond Demers, Nicholas Kourglicof, Tim O'connor, Don Onysko, Denis Richard, Nady Said and Mike Swinton**

