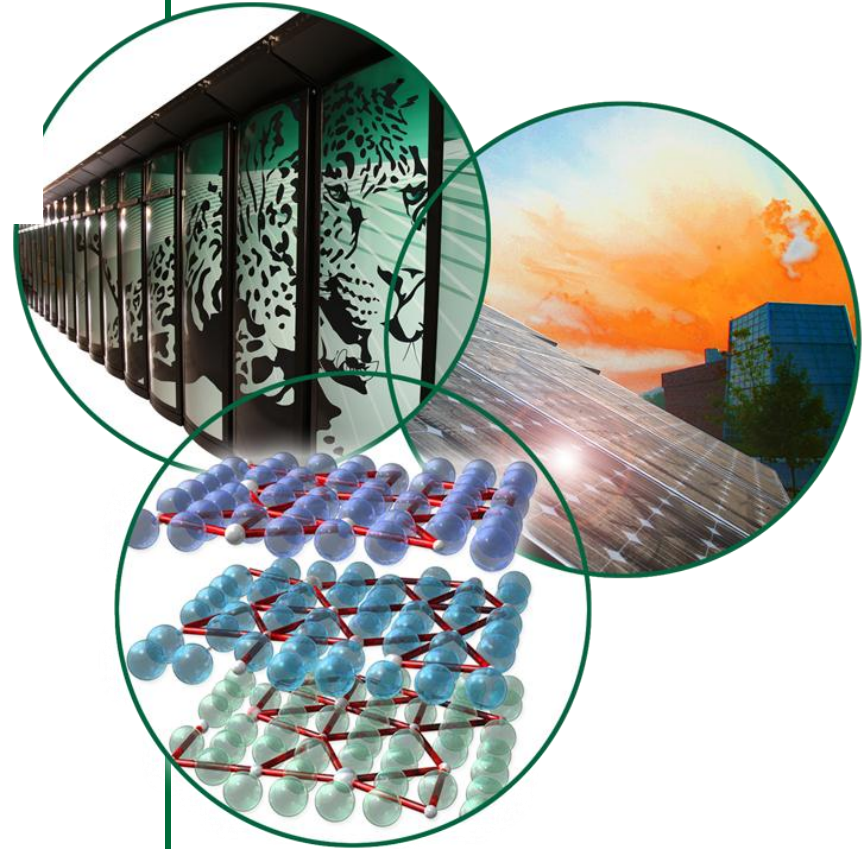


WUFI: Moisture Engineering in the 21st Century (and Beyond)

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Oak Ridge National Laboratory

15 September 2011



What is WUFI?



Presentation Summary

- **Are we concerned about moisture problems?**
- **What does moisture do to our buildings?**
- **How do we assess moisture issues today?**
- **Let's play with WUFI!**
- **Are there guidelines available today?**

Moisture Problems lead to Cities of Tarps



PAGE

A12

The Olympian

Business

EDITOR: FRIEDA BUSH (news@theolympian.com); 754-5403

WED

MARKETS IN BRIEF

10,727.19
80.61

DOW

3956.42
-23.87

NASDAQ

1,480.88
5.26

S&P 500

BUSINESS IN BRIEF

WALL STREET Paper, aluminum lead stocks higher

Old Economy stocks came out on top Tuesday as two stalwarts of traditional businesses — paper and aluminum — led the market higher, with a little help from an upbeat speech from Federal Reserve Chairman Alan

Weyerhaeuser makes offer in defective siding lawsuit

THE ASSOCIATED PRESS

FEDERAL WAY — The Weyerhaeuser Co. expects to pay as much as \$82 million to homeowners around the country to settle claims of defective exterior hardboard siding.

The settlement proposed Monday by the forest products giant is intended to resolve a class-action lawsuit filed in 1998 in Superior Court in San Francisco and similar litigation pending in Oregon, Iowa, South Carolina and Texas. The dismissal of a similar case in Washington state is on appeal.

“Weyerhaeuser is stepping up to the plate to solve problems with one of its prod-

ucts,” said Christopher I. Brain of Seattle, one of the principal lawyers representing homeowners.

Deterioration of the half-inch board, a tightly squeezed composite of wood chips, fiber, resin and wax, took many forms, including swelling, warping, splitting, rotting and even sprouting mushrooms, Brain said.

Weyerhaeuser is taking an \$82 million charge after taxes in the second quarter to cover claims by homeowners who installed the siding between Jan. 1, 1981, and Dec. 31, 1999, said Bob Dowdy, vice president and general counsel.

Dowdy would not say Weyerhaeuser was admitting

responsibility for the defective siding.

“What we’re saying here is that we would rather have a fair and independent process for people who have our siding to resort to than to continue to have a prolonged and expensive piece of litigation with an uncertain outcome for everyone involved,” he said.

Under a product liability settlement that was negotiated in 1996 involving Inner Seal pressed wood-flake siding, Louisiana-Pacific Corp. of Portland, Ore., had paid about \$470 million to settle claims as of early this year.

Georgia-Pacific, Jefferson Smurfit and Masonite also have settled class-action suits

over siding, while siding-related lawsuits are pending against Boise Cascade and Stimson Lumber.

Under the proposed Weyerhaeuser settlement, which is subject to review in the California court later this year, a court-appointed inspector would examine structures to assess claims for compensation.

Brain would not comment on the amount of the settlement or other terms but estimated the siding had been applied to hundreds of thousands of houses and other structures. He said “at least 500,000” people could receive payments over the nine-year term of the pro-

posed settlement.

About 2 billion square feet of the siding was produced at a Weyerhaeuser plant in Klamath Falls, Ore., over 35 years before the line was discontinued in 1996 — the year after the first claims were brought.

The siding carried a 30-year warranty, and company officials said there were warranty claims in about 2 percent of total square footage that was sold.

Most sales were to builders and contractors on the West Coast, but some also was distributed to consumers through retailers such as Eagle Hardware and Garden and Home Depot, Brain said.

DOE's Concern

- **Are energy and ventilation standards to blame?**
 - **Until moisture issues resolved, advancements in energy efficiency and indoor air quality standards will be difficult**
 - **Occupant health continues to be a concern**

Importance of Moisture Research



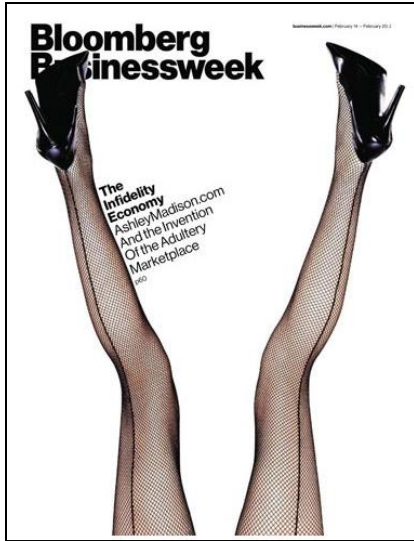
“Clearly conceived redundancy against water penetration...”



“Must follow ASHRAE Standard 160...”

“Hygrothermal behavior of all critical enclosure components must be demonstrated...”

Importance of Moisture Research



- Bloomberg Businessweek: “The Repair Bills Arrive from the Housing Boom” (14 Feb 2011)
 - “...Pulte Group, the largest U.S. homebuilder, recorded a one-time expense of \$272.2 million in the third quarter, or 25 percent of its revenue for the period, to increase reserves to cover losses when homeowners demand repairs to houses built in the past 10 years...”
 - “...At Pulte, most of the claims in the third quarter were related to water intrusion...”
- Dr. Carl-Eric Hagentoft, Report to IEA Annex 55 on Reliability of Energy Efficient Building Retrofitting – Probability Assessment of Performance & Cost
 - “We have an estimate that many attics (in Sweden) are damaged (due to moisture), around 60-80% basically due to high degree of thermal insulation on the attic floor.”



IEA Energy Conservation in
Buildings & Community Systems

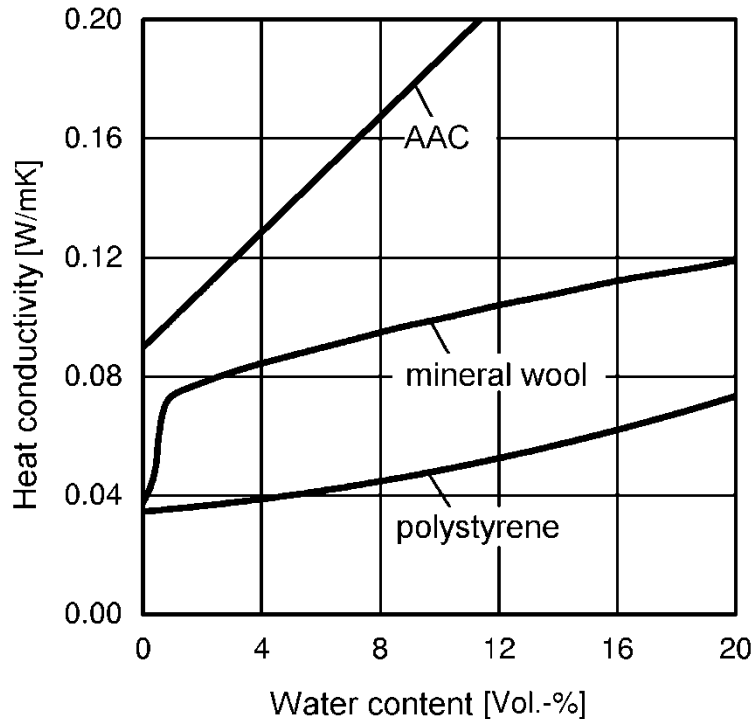
Moisture and Buildings

- **Moisture involved in almost all building envelope performance problems**
 - **Energy inefficiency**
 - **Mold (IAQ)**
 - **Corrosion**
 - **Wood rot**
 - **Termites**
 - **Staining**

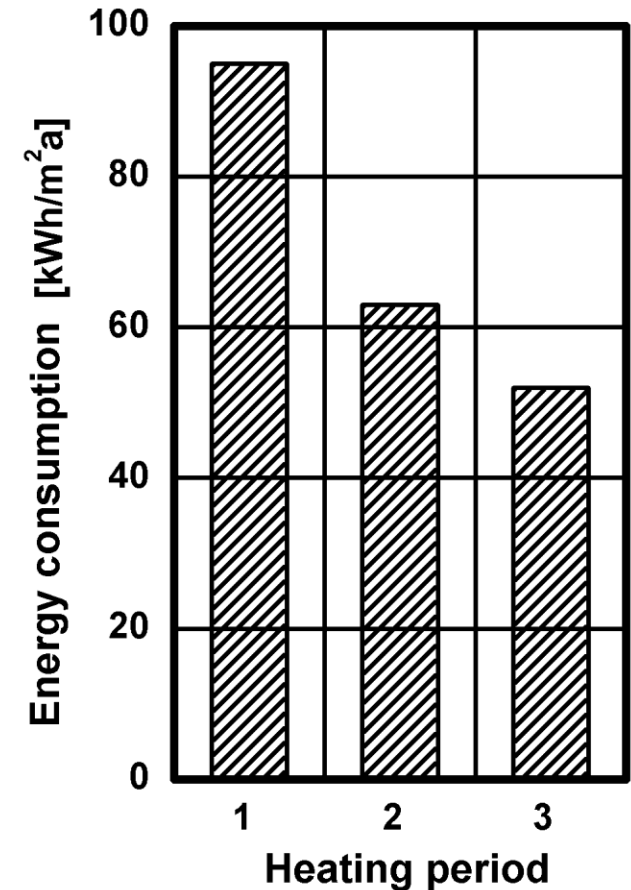
Moisture Effects

Increase of heat transmission

- Influence on thermal conductivity
- Latent heat effects



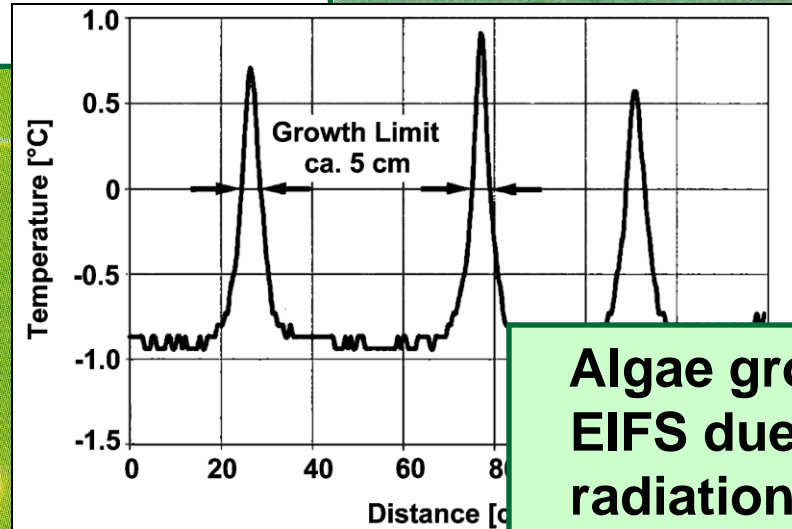
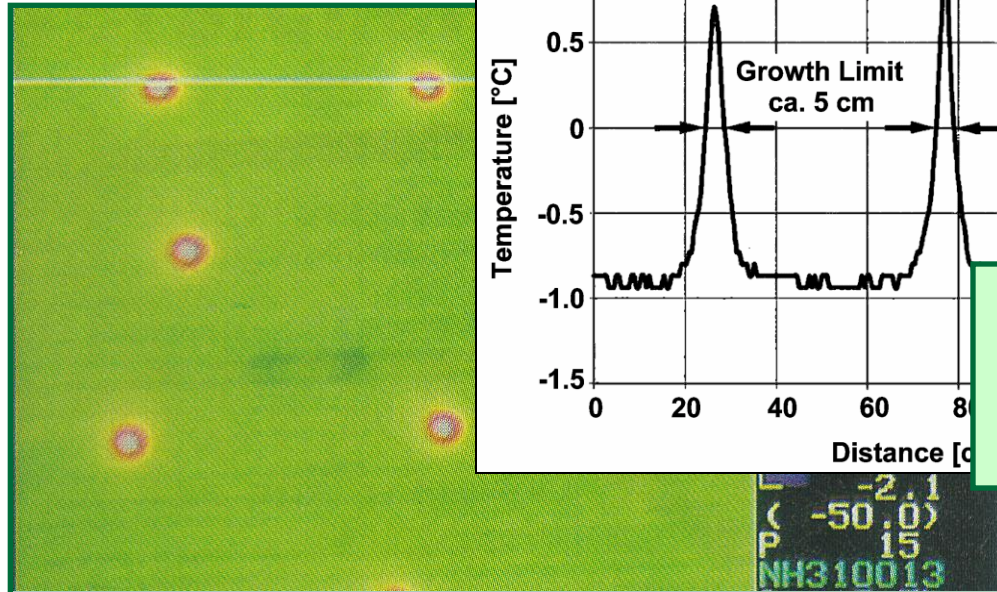
Energy-efficient AAC-house



Moisture Effects

Optical degradation

- Soiling, staining
- Microbial growth



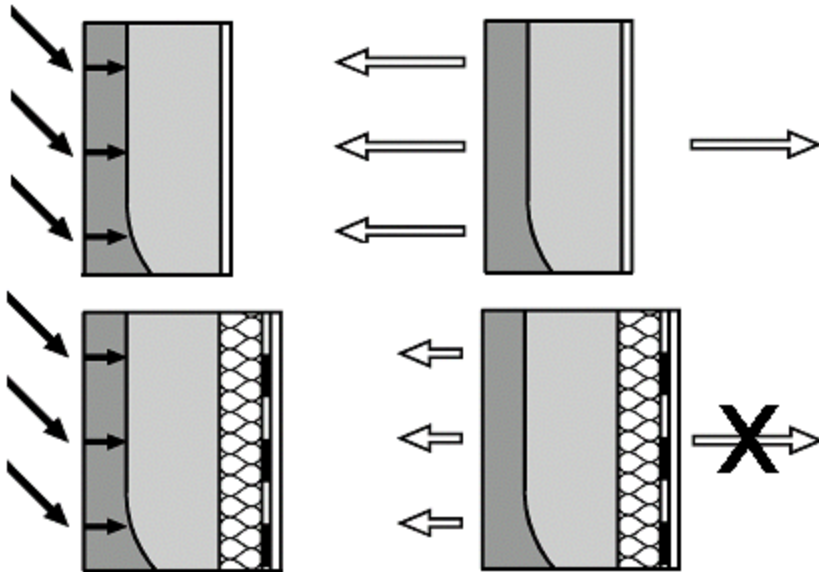
Algae growth on stucco of EIFS due to night time sky radiation (overcooling)

Moisture Effects

Damage caused by elevated water content

- Freezing

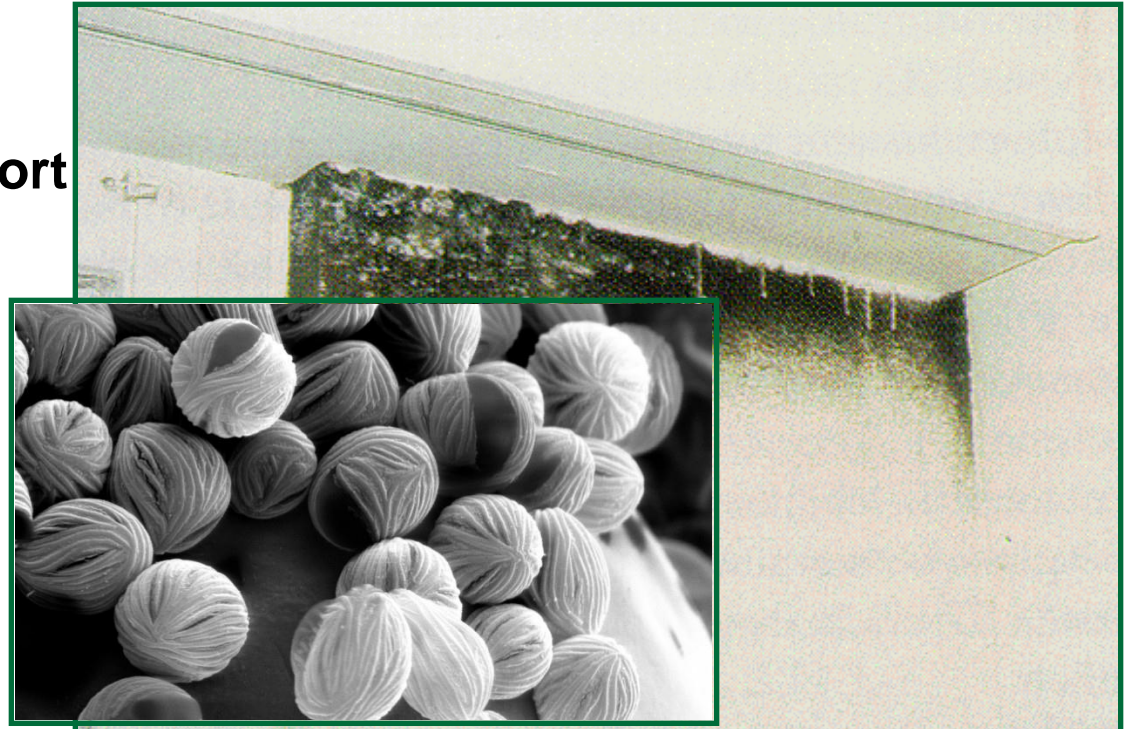
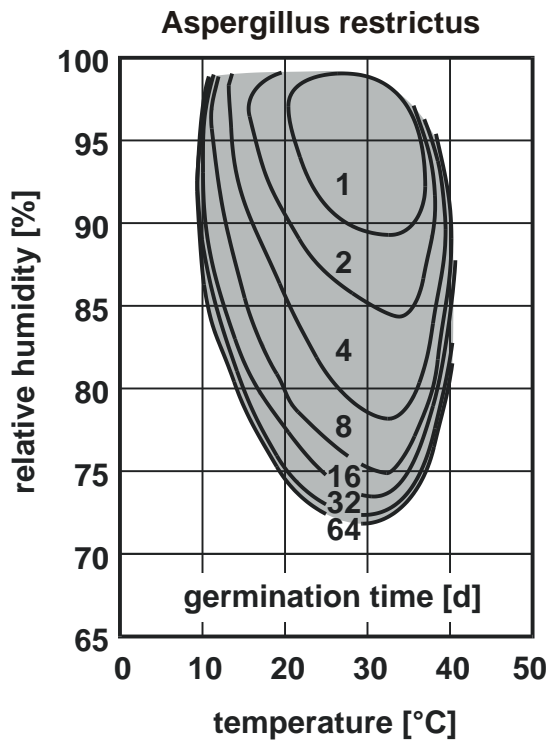
Frost damage at stucco facade after applying interior insulation



Moisture Effects

Health aspects

- Hygrothermal comfort
- Air quality



Mold growth caused by elevated surface humidity

Modern Simulation Methods

Simulation of the real hygrothermal situation

- **Diurnal cycles (summer condensation, freeze-thaw)**
- **Seasonal cycles (interstitial condensation)**
- **Precipitation cycles (driving rain / solar radiation)**

Distinction of important influence factors (sensitivity analysis)

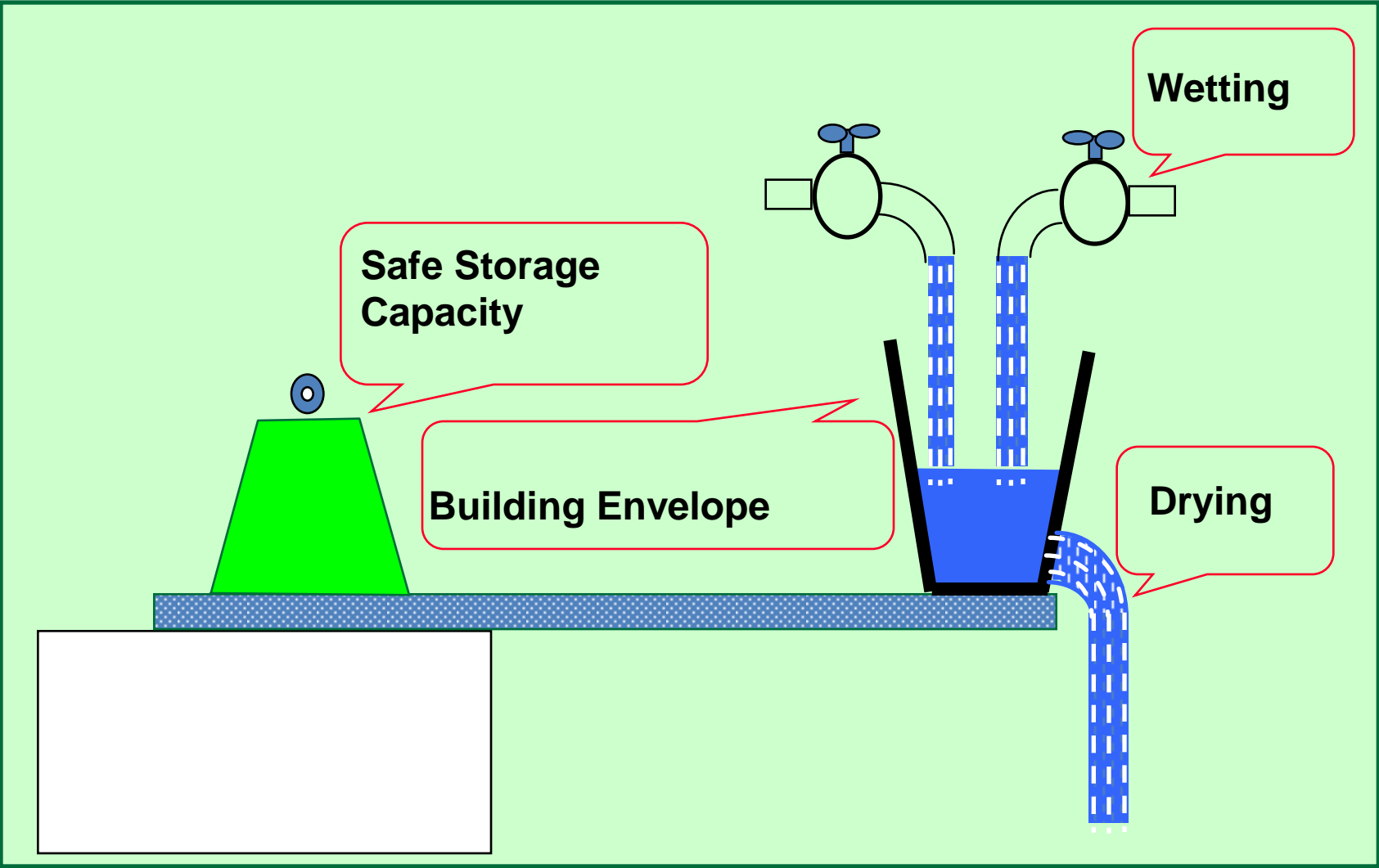
Extrapolation in time, transfer to different indoor / outdoor climate

Product optimization and development

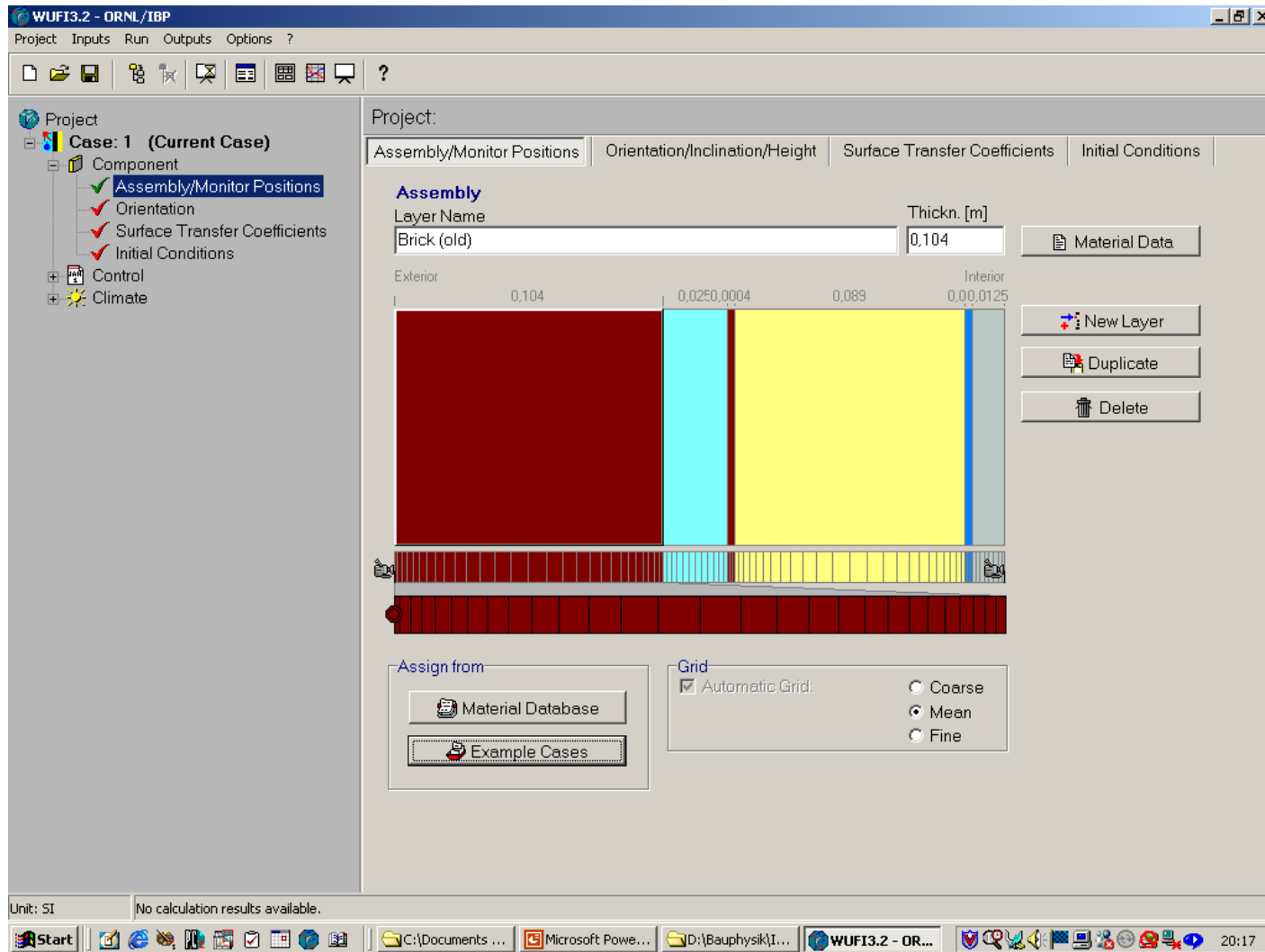
Fast and cost effective

Expertise required

Hygrothermal Balance



Definition of the Assembly in WUFI



Material Properties Selection

Material-/Layer Data

Layer/Material Name: Brick (old)

Material Data | Info-Text


Basic Values

Bulk density [kg/m ³]	1670.0
Porosity [m ³ /m ³]	0.196
Specific Heat Capacity, Dry [J/kgK]	840.0
Thermal Conductivity, Dry [W/mK]	0.4
Water vapour diffusion resistance factor [-]	16.0

Optional Parameter

Moisture-rel. Thermal Conductivity Supplement [%/m]	8.0
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Typical Built-In Moisture [kg/m³]: 3.34

Color: 

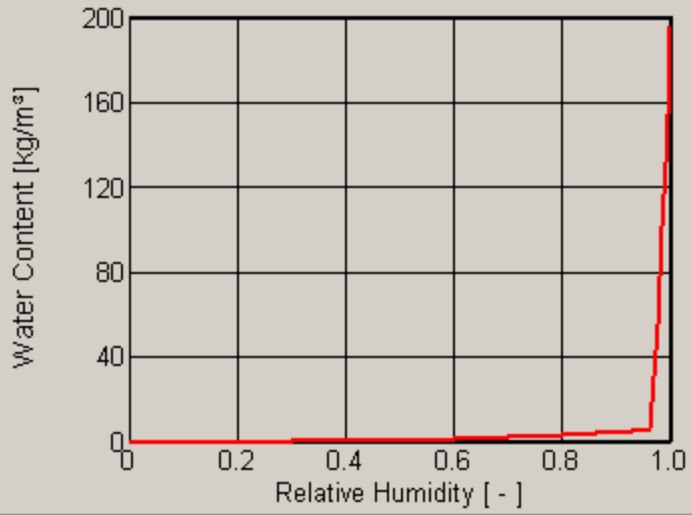
Layer Thicken. [m]: 0.104

Optional Data

Moisture Storage Function

- Liquid Transport Coefficient, Suction
- Liquid Transport Coefficient, Redistribution
- Thermal Conductivity, moisture-dependent
- Water vapour diffusion resistance factor, moisture-dependen

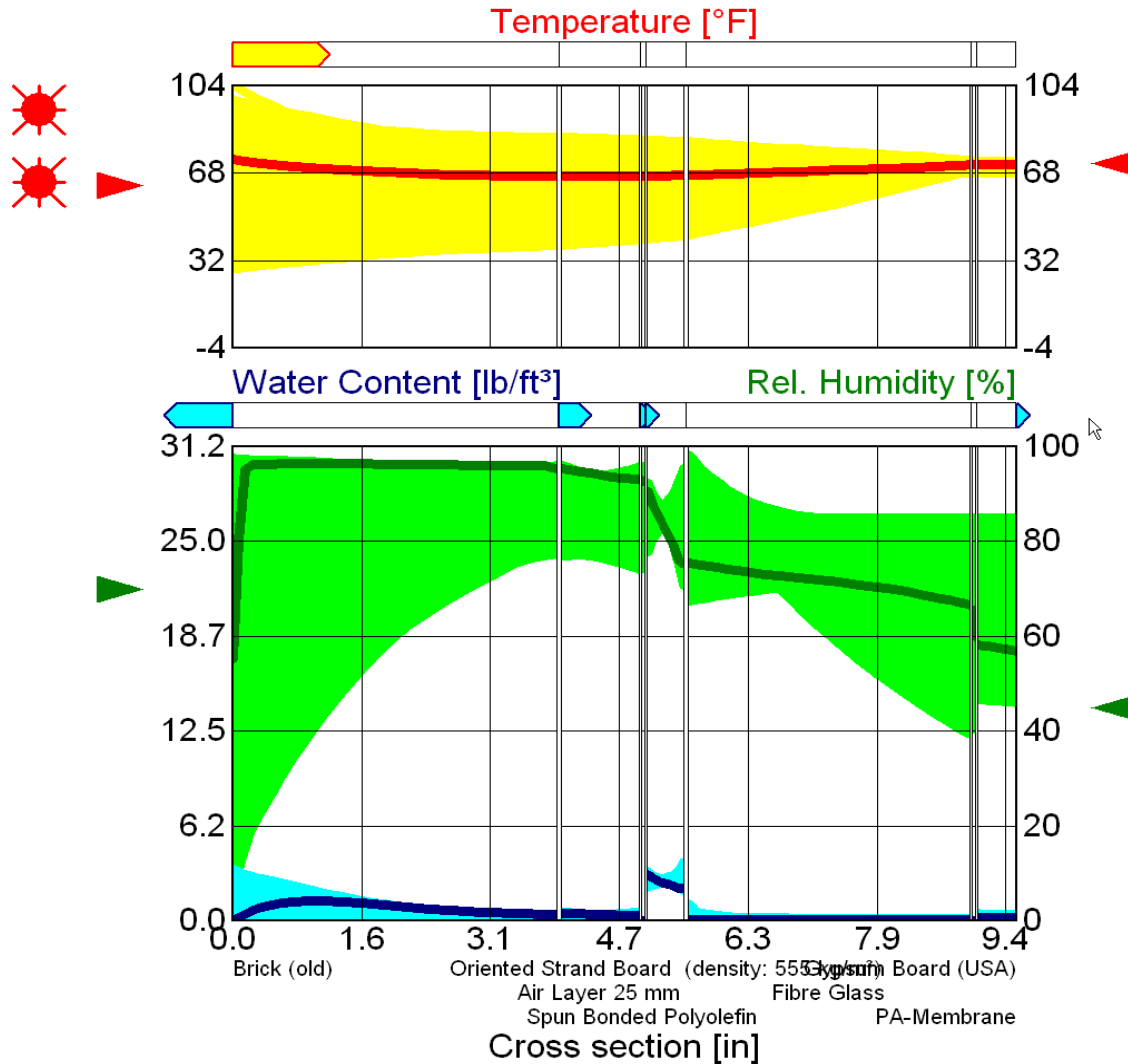
Graph | Table



Relative Humidity [-]	Water Content [kg/m ³]
0.0	0
0.2	0
0.4	0
0.6	0
0.8	0
0.9	0
0.95	0
0.98	0
0.99	40
1.0	200

OK Abort Help

Hygrothermal Models Outputs



WUFI® 3.3 Pro. ORNL
View Film...

The software interface displays a film player for simulation results. It features a circular icon with a sun, a clock, and a film strip. Below the icon, a date box shows "10 May 2004". A progress bar indicates the simulation progress from 0% to 100%. The interface includes control buttons for Start, Play, Stop, and Options, as well as a speed slider ranging from Slow to Fast. At the bottom, there are Help and Close buttons.

New ASHRAE Standard Passed

ASHRAE 160 Standard: *Criteria for Moisture Control Design Analysis in Buildings*



ANSI / ASHRAE Standard 160-2009 Flow-chart

Performance criteria to prevent mould growth

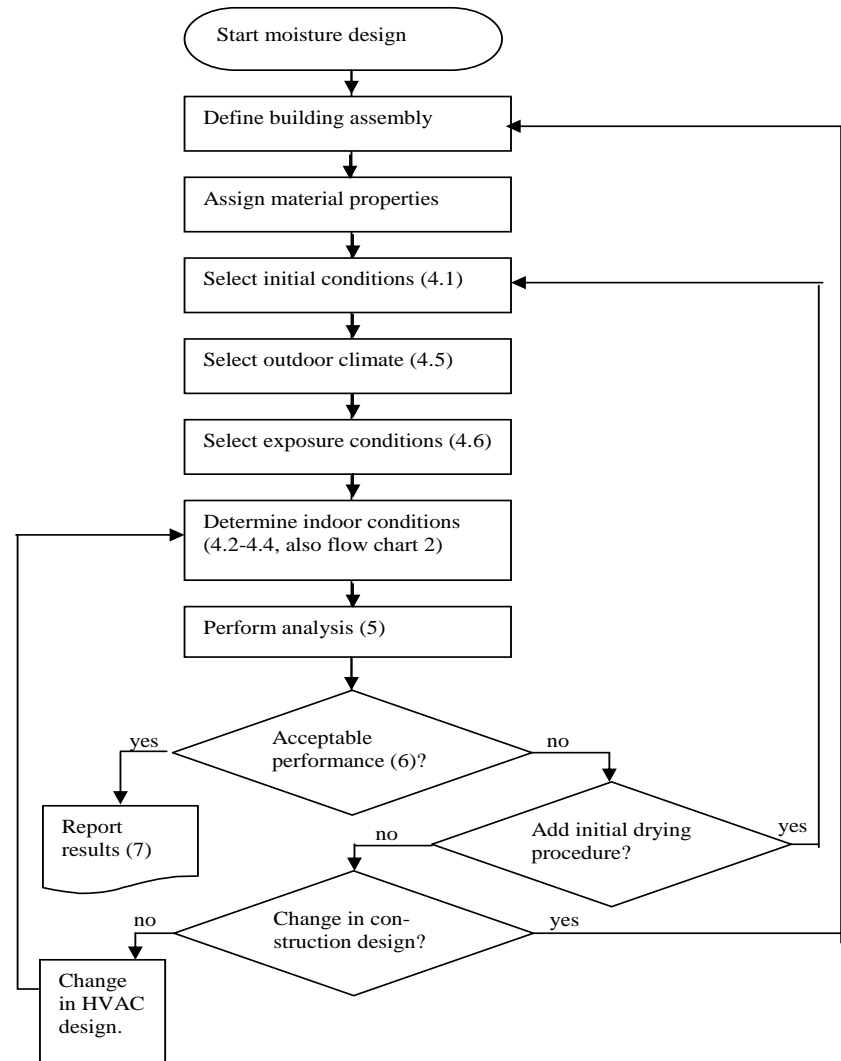
Surface humidity:

φ_s (30 d run. av.) < 80% RH

φ_s (7 d run. av.) < 98% RH

φ_s (24 h run. av.) < 100% RH

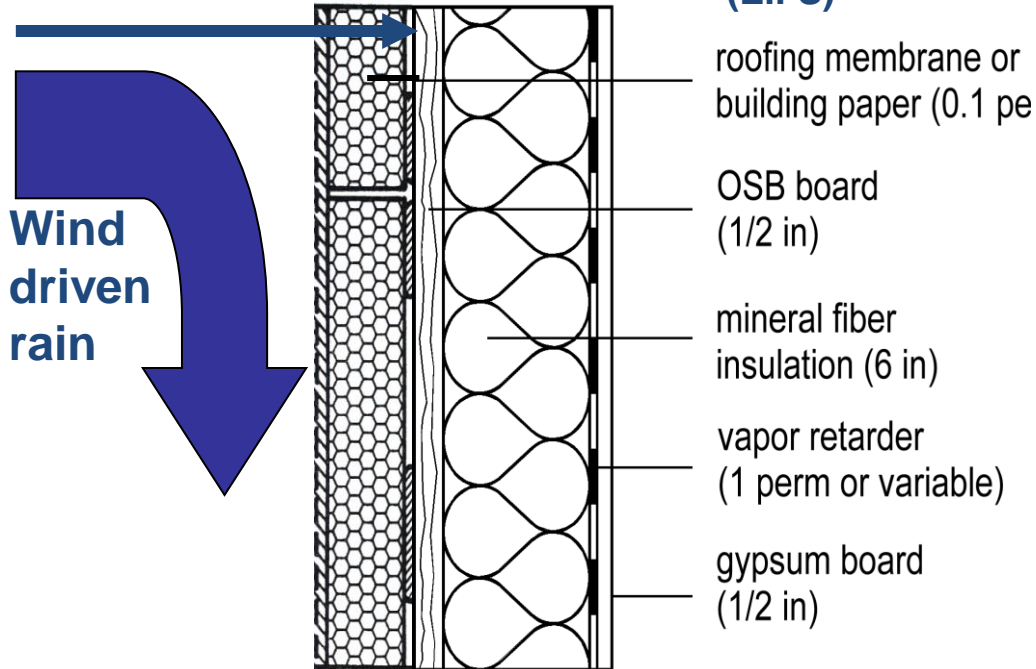
and $5\text{ }^{\circ}\text{C} \leq \theta_s \leq 40\text{ }^{\circ}\text{C}$



ANSI / ASHRAE Standard 160-2009

Safety feature: moisture tolerance – drying potential

1% rainwater penetration



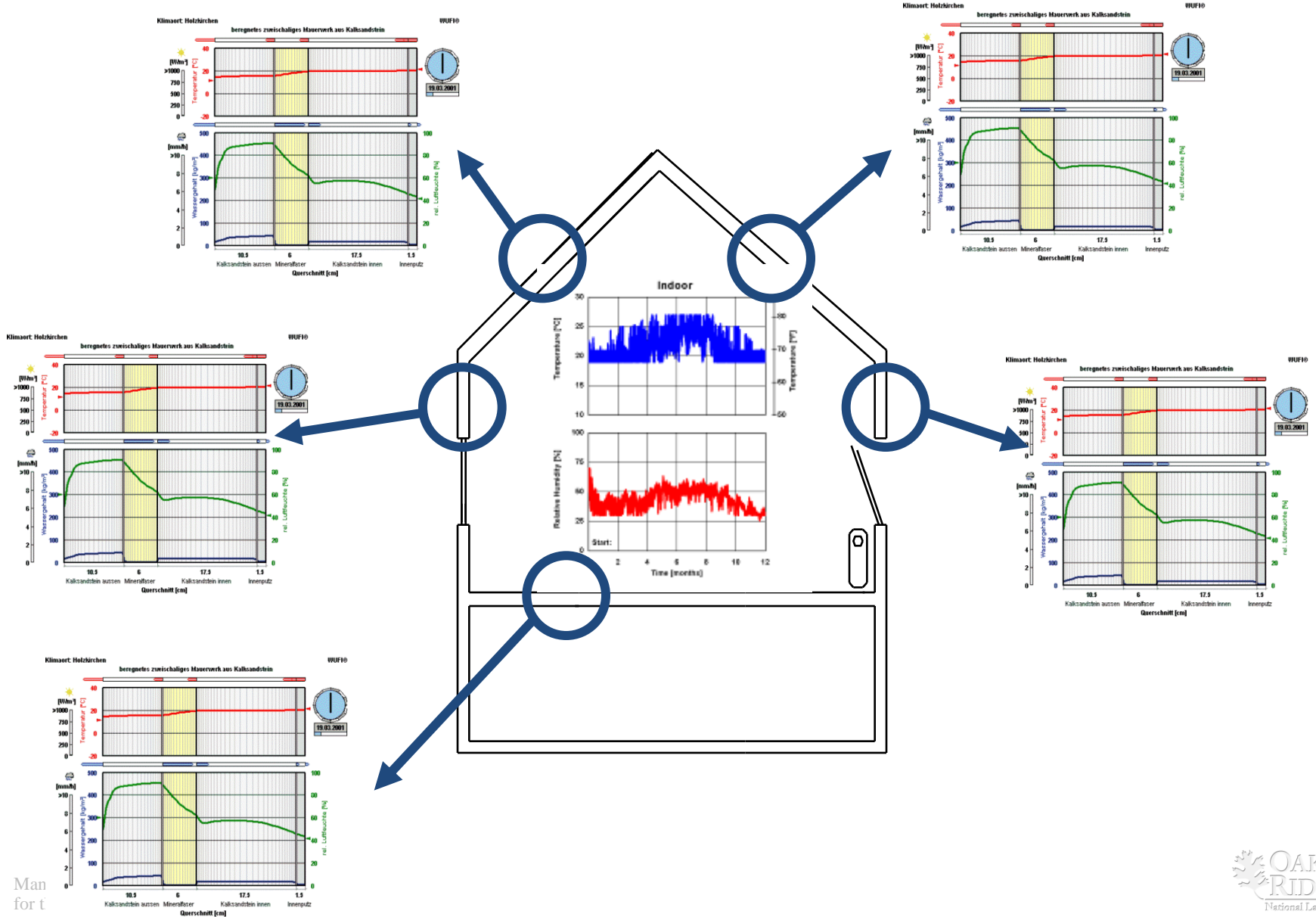
Rainwater penetration:

In the absence of specific full scale test methods and data for the considered exterior wall system.

the default value for water penetration through the exterior surface is 1% of the water reaching that exterior surface.

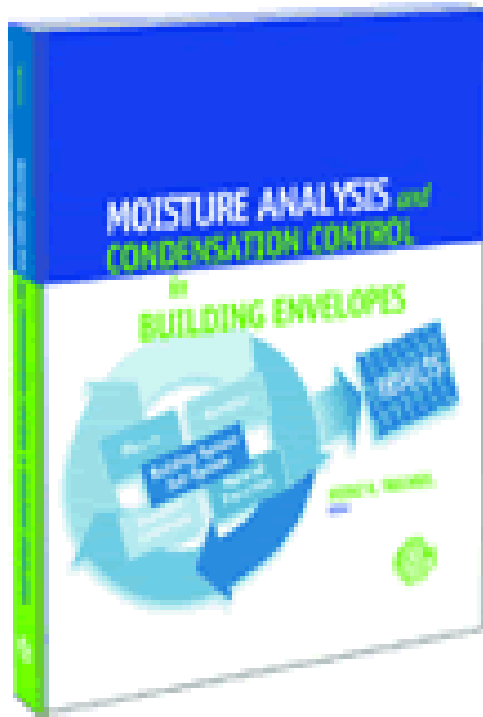
The deposit site for the water shall be the exterior surface of the WRB. If a WRB is not provided then the deposit site shall be described and a technical rationale shall be provided.

What's Next?



Great Reference!

ASTM MNL 40: Moisture Analysis and Condensation Control in Building Envelopes (2001)



Chapter 9: A Hygrothermal Design Tool for Architects and Engineers (WUFI ORNL/IBP)

*"To achieve results never before accomplished,
we must employ methods never before attempted."
- Sir Francis Bacon*

Questions?

