Fraunhofer IBP

Messe Nordbau 2024

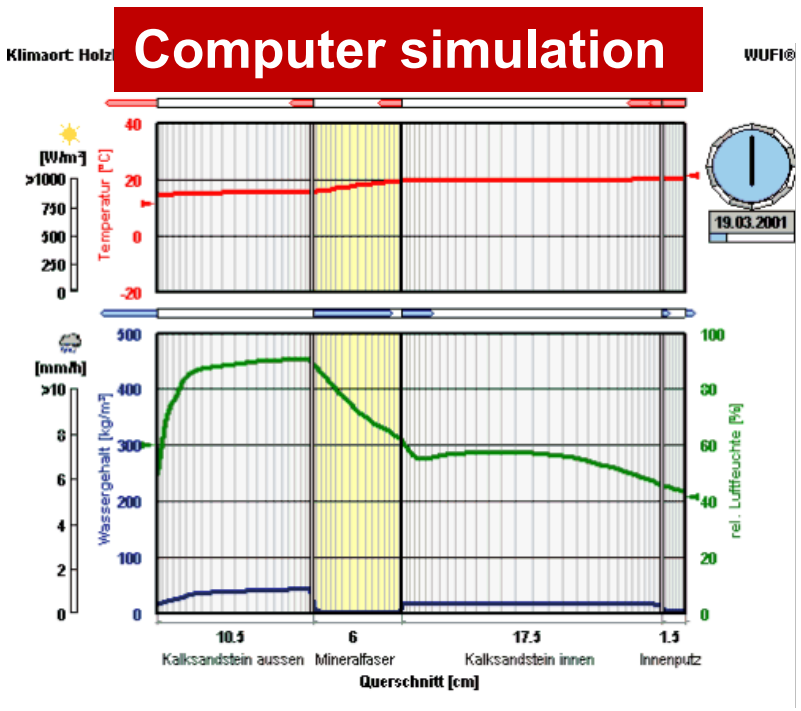
Sustainable moisture protection of timber structures and bio-based insulation materials

Introduction – Building Science Background at Fraunhofer IBP

Building research and innovation based on experimental and computational studies.

Investigating the integral building performance focusing on heat, air and moisture transfer in building materials, systems and components (hygrothermal performance) to ensure comfort, energy efficiency, durability and sustainability of constructions.

Bringing science to practice and learn from each other.



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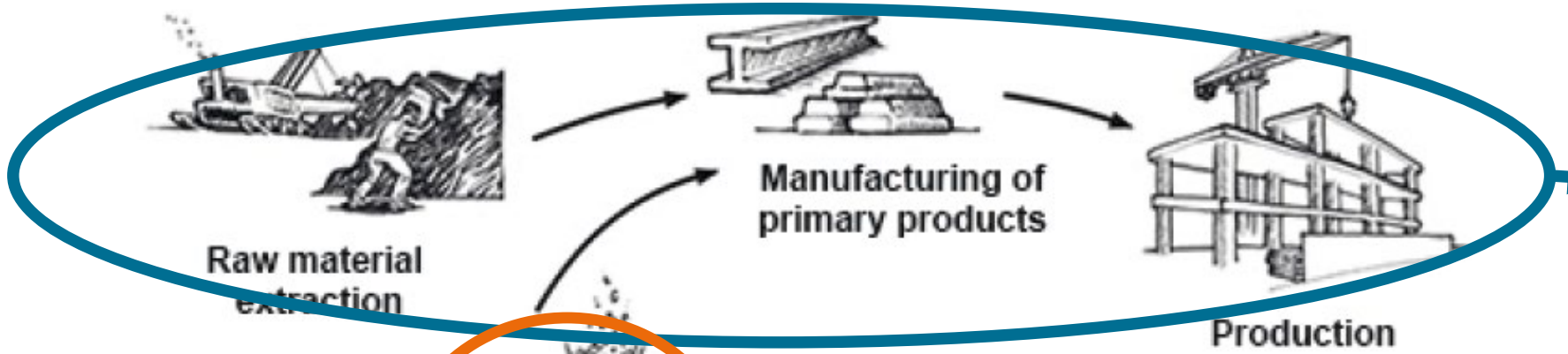
Introduction – Environmental impacts of buildings

Life cycle engineering is the basis for Sustainable Buildings



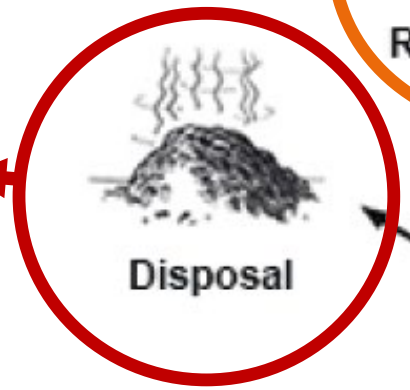
Embodied energy

Advantage bio-based materials & lightweight structures

Requires knowledge of all compounds

Good progress achieved (Net-zero energy)

Durability important



Urgent problem

Materials with fire retardants & and treated timber are often **toxic waste**

Best solution:

Bio-based materials without chemical additives

Moisture control by constructional methods

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Durability & hygienic aspects – Moisture and mold resistance

Bio-based building materials have 2 major weak points:
Fire (smolderding) resistance & **moisture susceptibility**

Timber & aquaculture mat. seem to be more resistant

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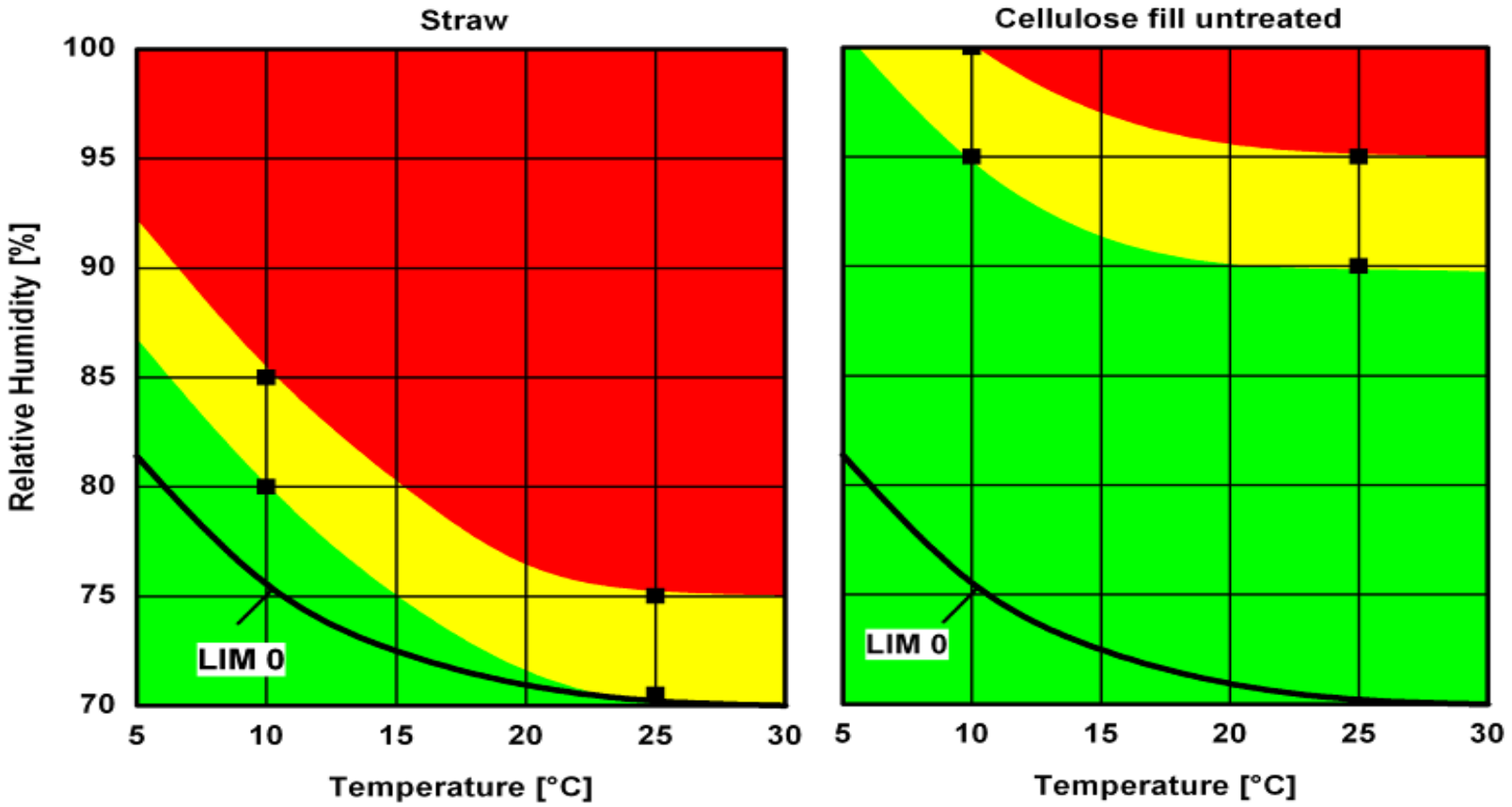
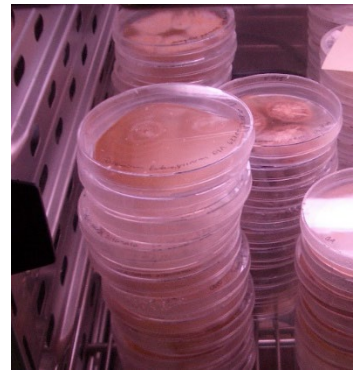
Health aspects – Mould sensitivity

Mould germination and growth as functions of humidity, temperature **and substrate**





The resistance of bio-based materials against mould growth depends on nutrient content and mould suppressant compounds

Limit curves dependent on the substrate (Lim 0 represents the growth on ideal nutrients). The traffic light colours indicate the growth risk for particular materials

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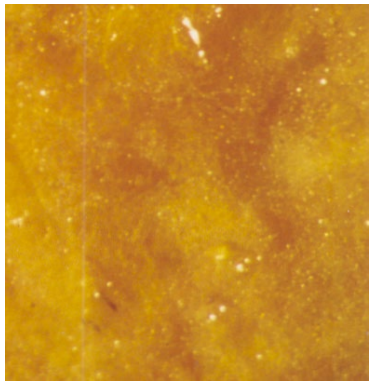
Hygrothermal loads

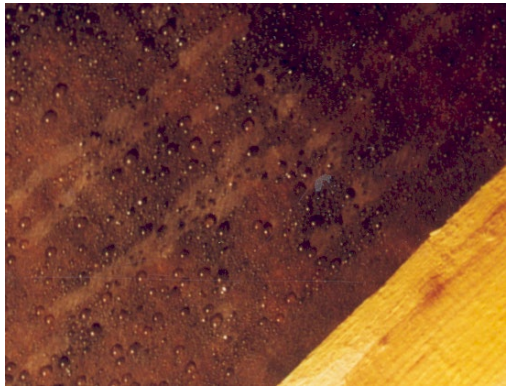
Relevant loads for timber constructions

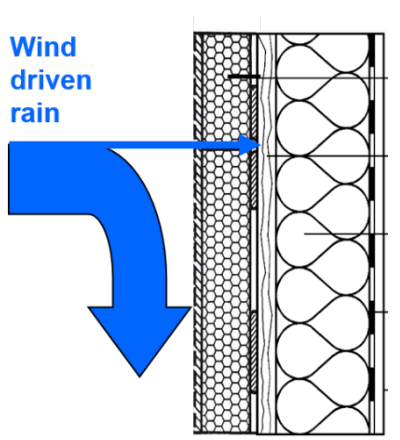
Ambient humidity (vapour pressure gradients)
- Vapour diffusion ↔
- Vapour convection ↔

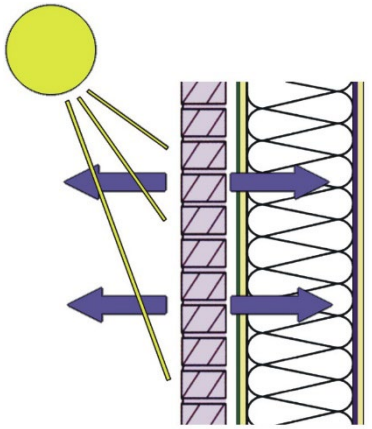
Exposure to bulk water (depends on location, orientation, height, roof overhang & neighbourhood)
- Surface water absorp. ± solar vapour drive
- Driving rain penetration

Initial moisture content (currently a hot topic in D)
- Manufacturing, storage & delivery conditions
- Construction site cond. & moisture in other mat.









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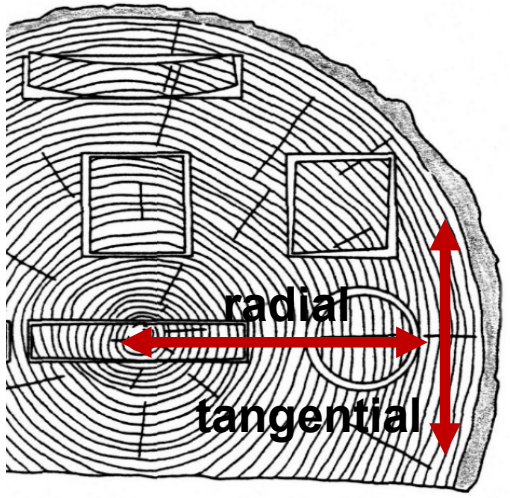
Timber protection principles

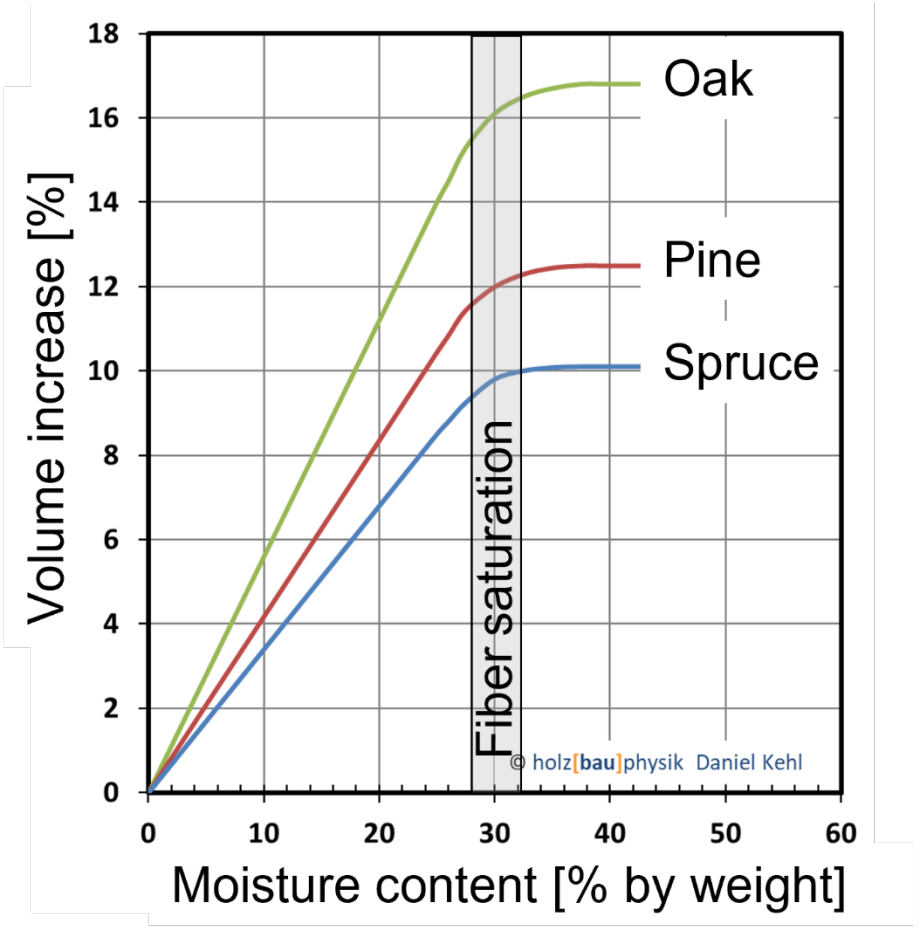
Moisture impact on mechanical properties

Timber protection

Stress and strain: swelling & shrinking



Ref.: Daniel Kehl



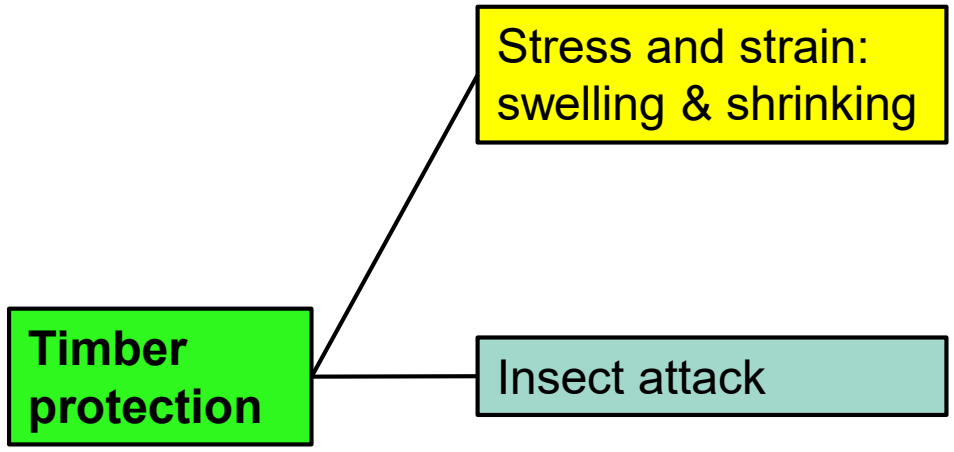
Typical swelling [%/% moisture]	tangential:	0.32	} 0.25
	radial:	0.16	
	axial:	0.01	

To prevent cracking or warping only timber with EMC ≤ 80 % RH (~ 15 m.-%) should be installed

Moisture limit for timber-based products: **18%**

Timber protection principles

Protection against insect attack



Ref.: Daniel Kehl

Insects can also live in dry wood (~ 15 m.-%)

The German approach to avoid insect attack:

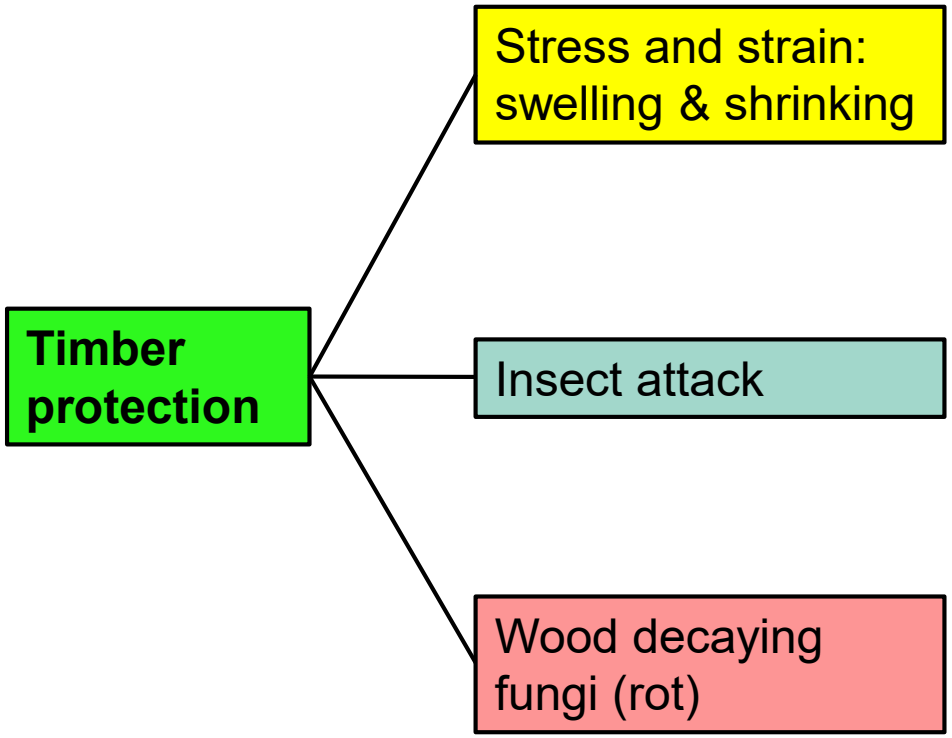
- Dry timber at > 55 °C (kills larvae)
- Prevent access for insects into envelope assemblies – avoid ventilated cavities **in direct contact with structural elements**
- Protect structural parts by water-proof but vapour permeable membranes

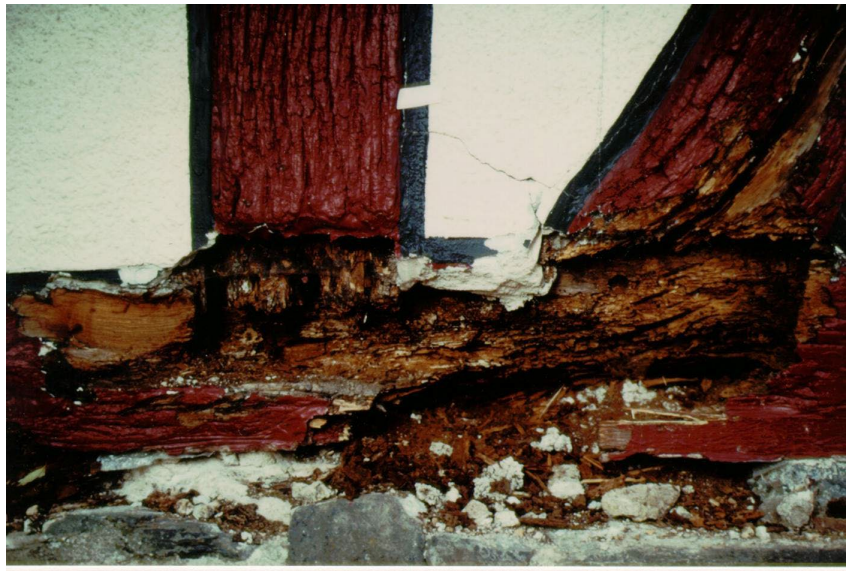
The occurrence of wood attacking insects depends on climate and wood species

German guidance on insect prevention may not be transferable to other climate zones

Timber protection principles

Protection against wood decay





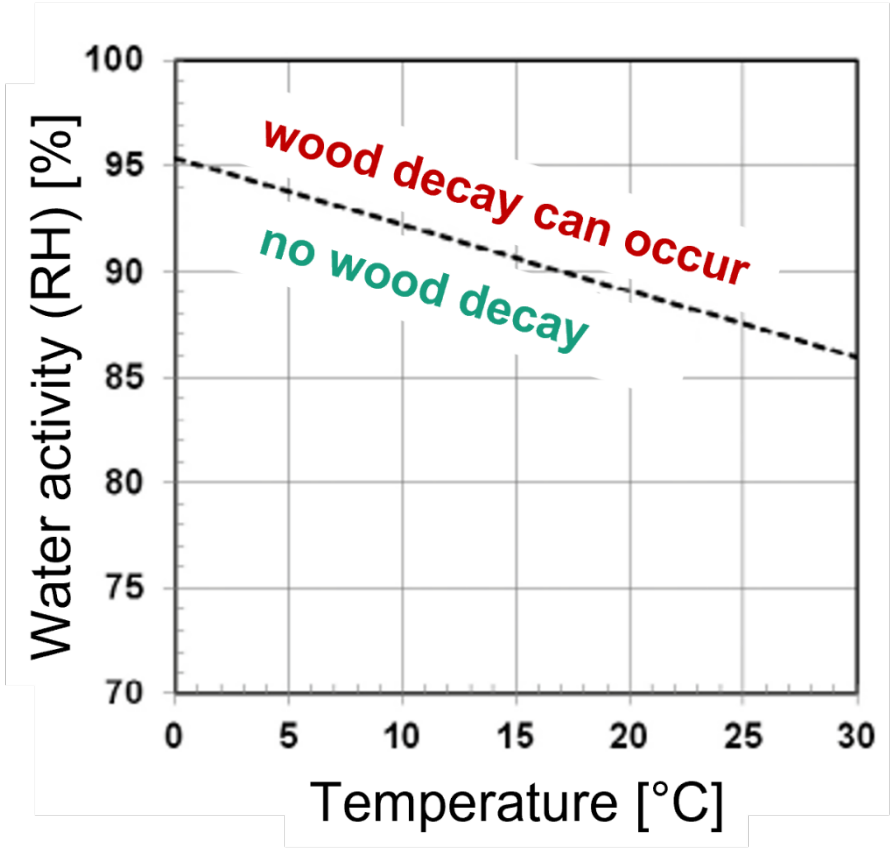
Rotting timber structure caused by driving rain

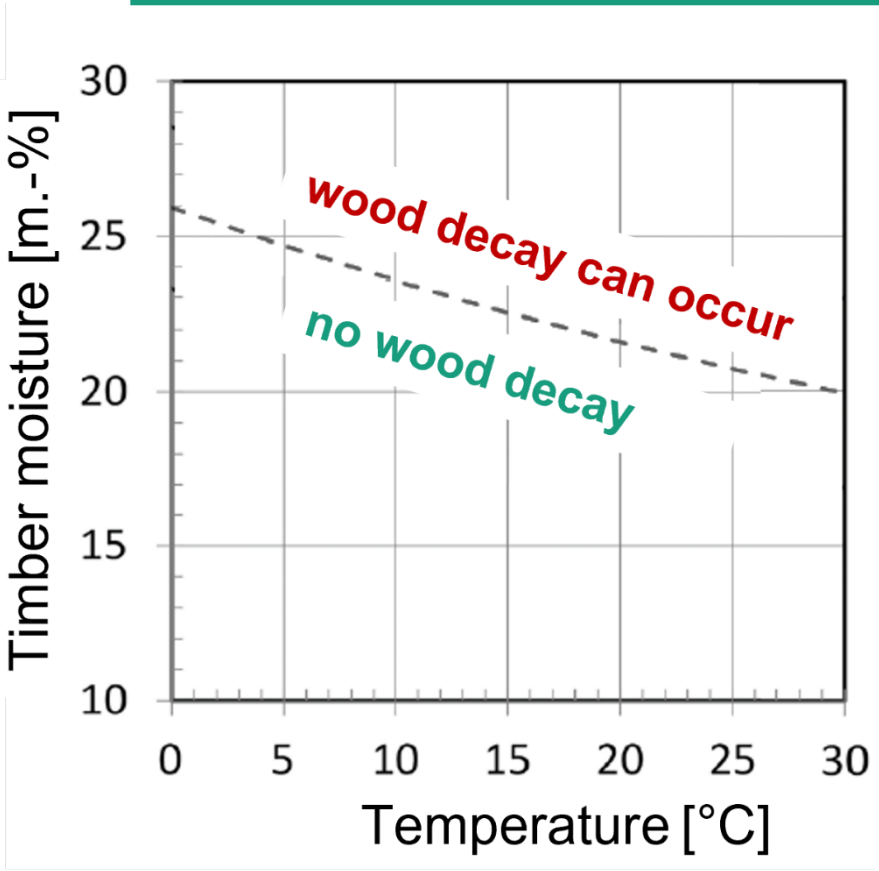
Rotting rafter caused by condensing outdoor humidity

Protection against wood decay

Moisture control based on WTA 6-8 guideline

Development of decay fungi depends on water activity (RH) **and** on temperature





Decay limit is on the safe side, more sophisticated models are currently being developed

Conversion to water content in soft wood by a typical average sorption isotherm

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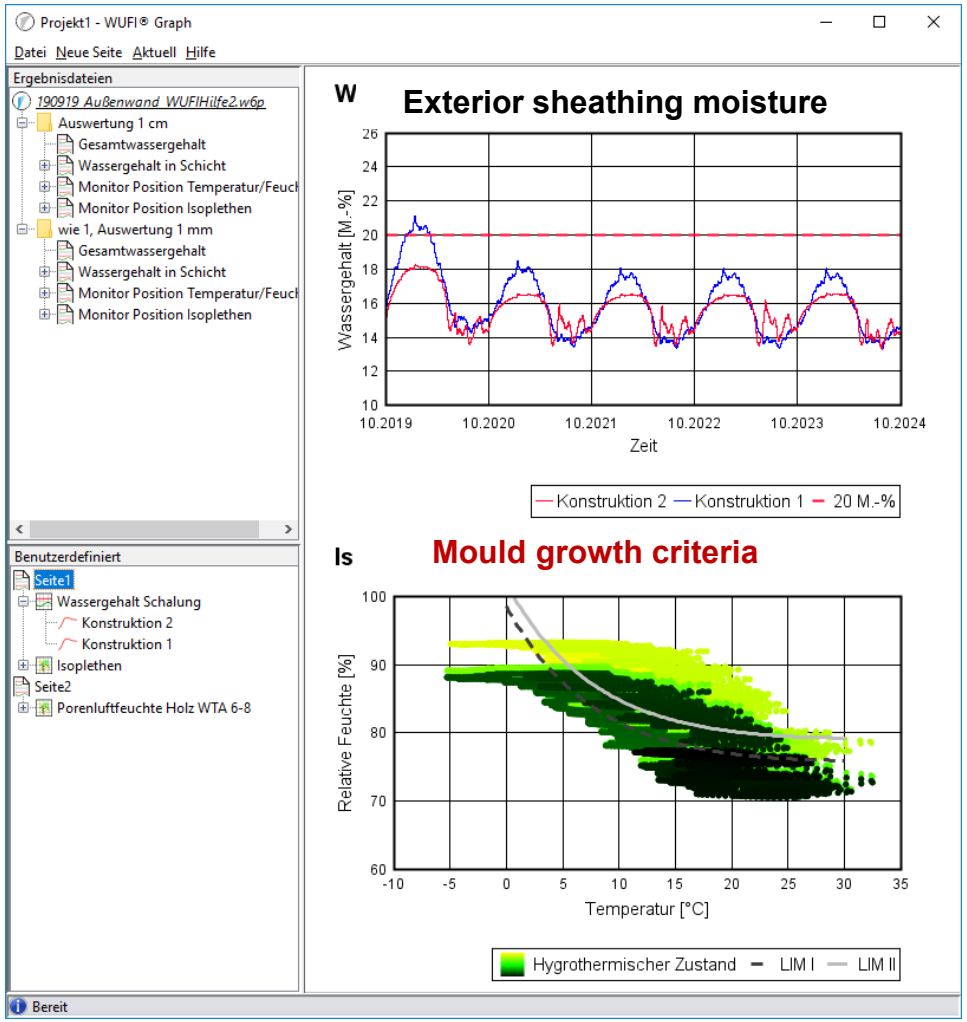
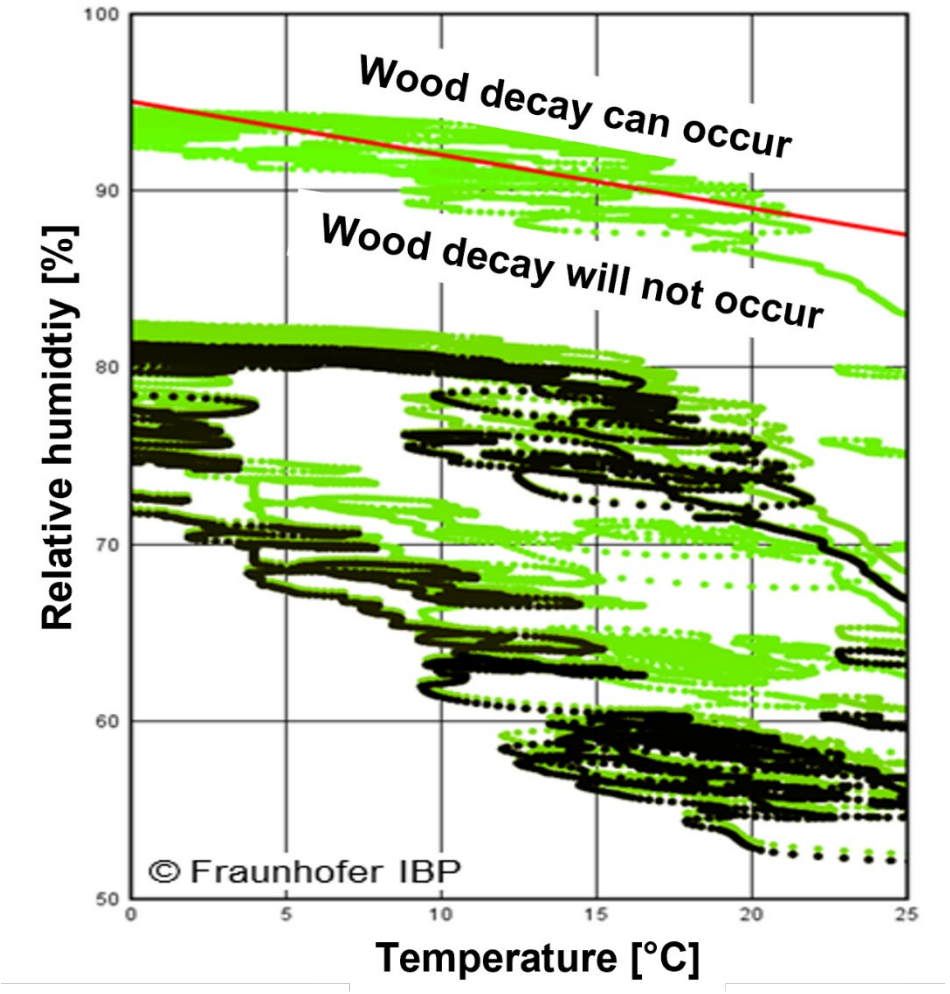
Protection against wood decay

Evaluation based on WTA 6-3 & WTA 6-8 guideline – Application example: timber wall construction



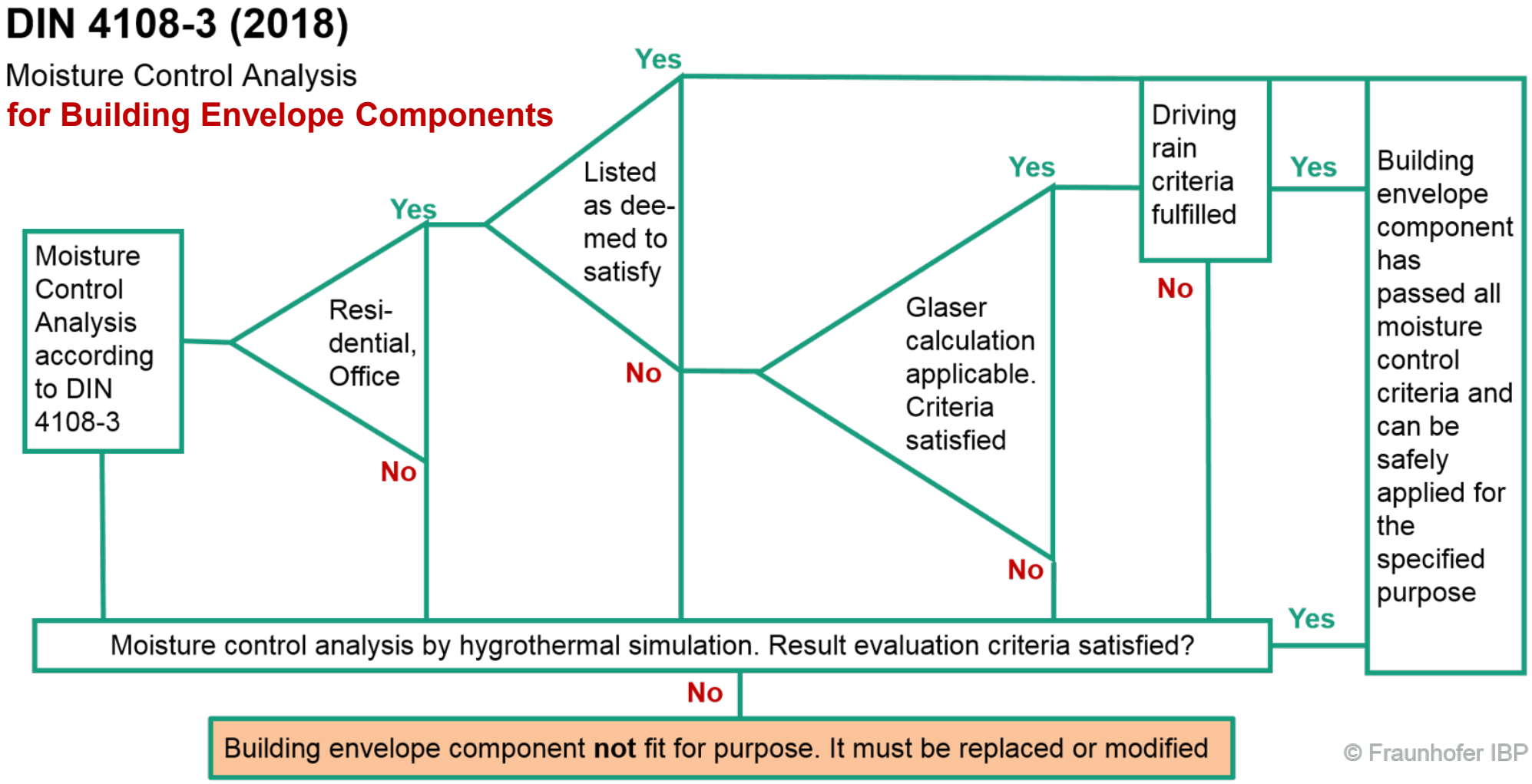
Wood decay criteria negative, i.e. no risk

Mould growth criteria positive but risk is low



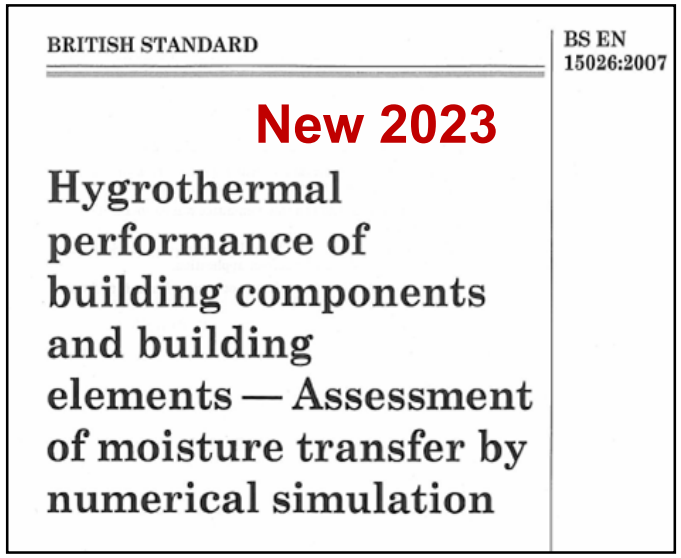
Protection against wood decay

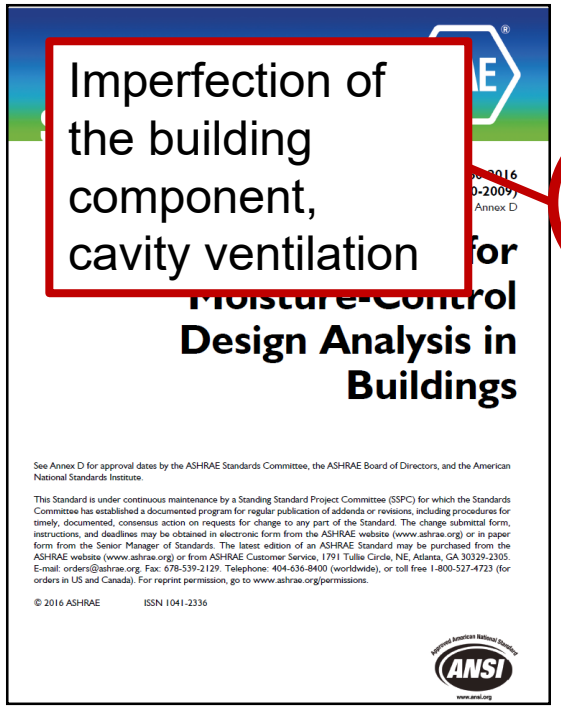
Moisture control design according to DIN 4108-3 “Protection of buildings against moisture…”



Moisture Control Design

International std. on hygrothermal simulation **What is new ?**

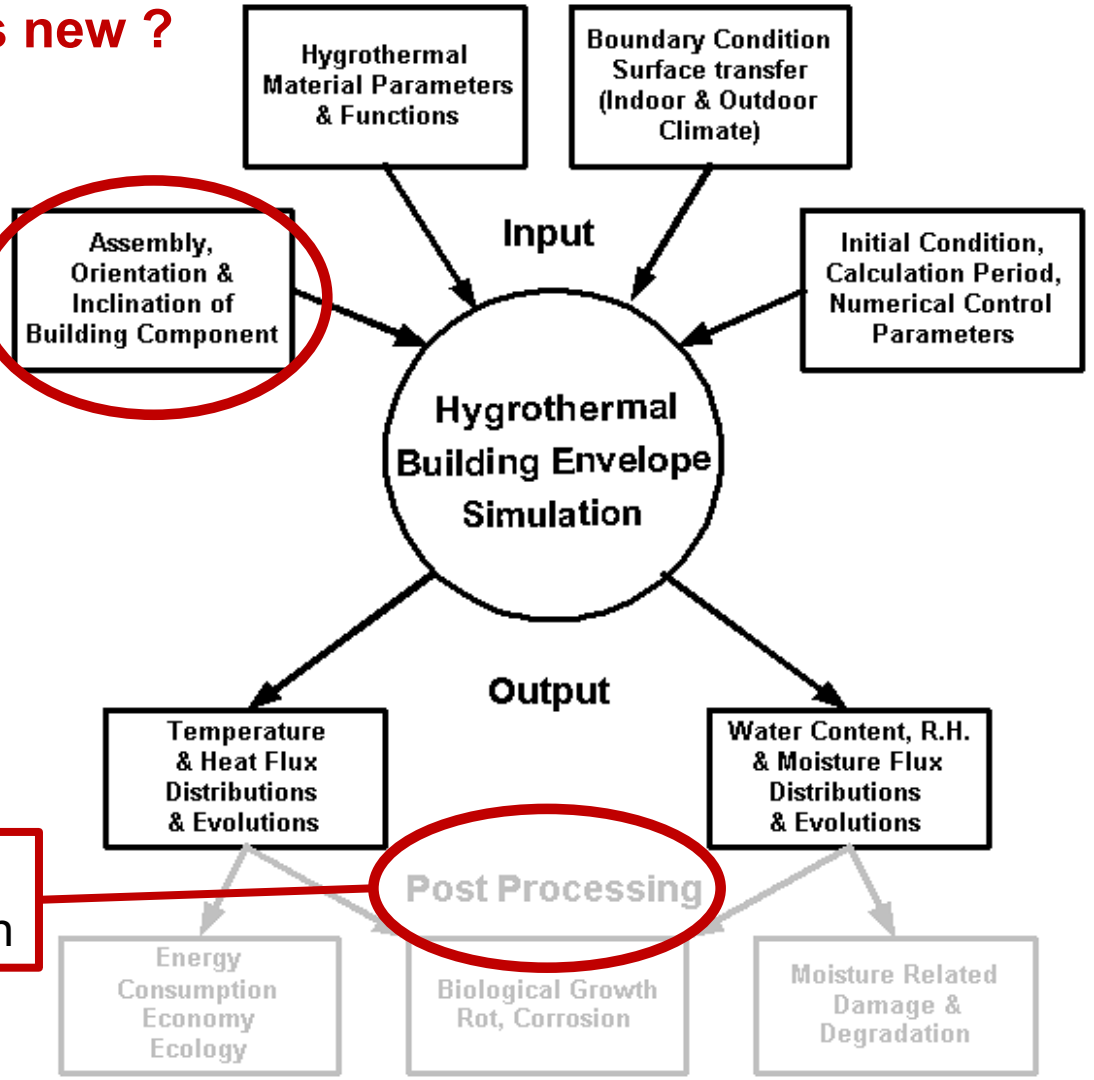




Imperfection of the building component, cavity ventilation

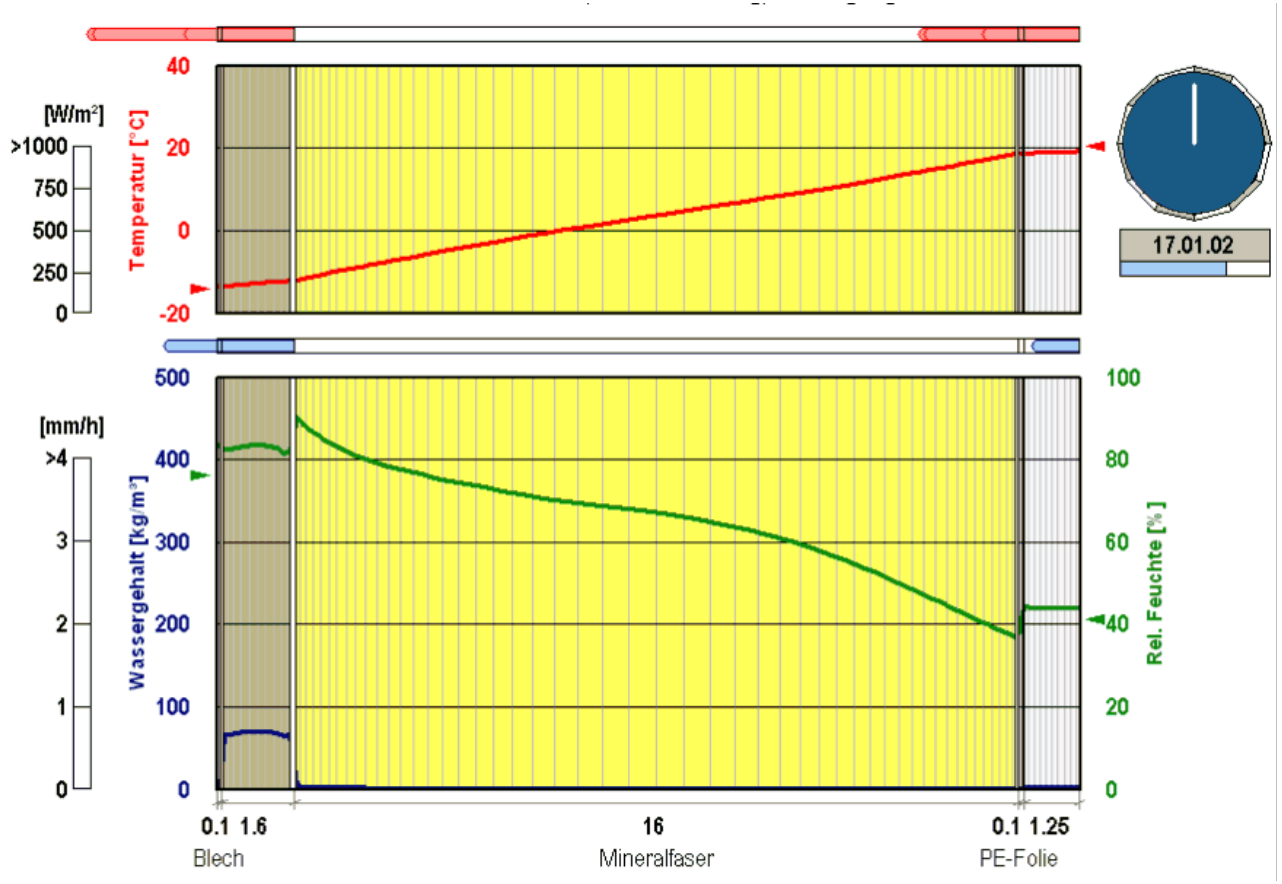
Hygrothermal analysis based on validated simulation models ref. to EN 15026 or Australian DA07 (≈ ASHRAE Std 160)

Models for mold growth, wood decay and corrosion

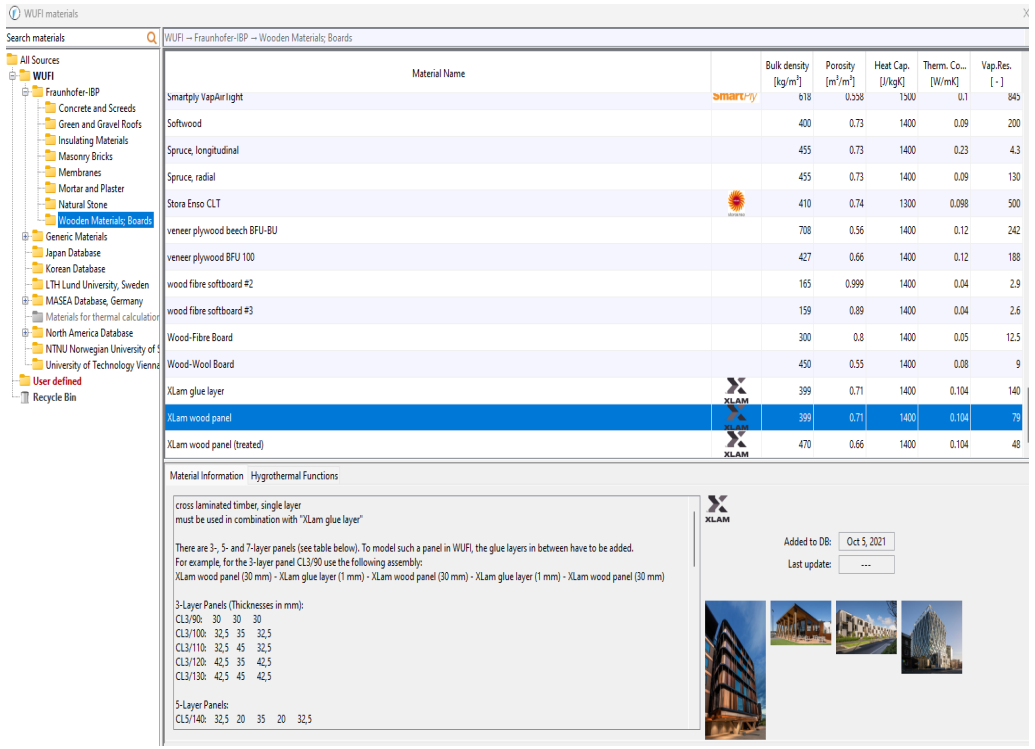


Moisture Control Design

Design using hygrothermal simulation



WUFI material database



WUFI V 7.0 will include European, American and Oceanian material data.

Summary timber preservation through constructional measures

To avoid the use of chemical treatment the following conditions must be met:

- Only dry timber should be installed (absolute max. 18 mc by weight)
- The moisture content of structural elements must not exceed the specified limits
- Insect access must be prevented – no ventilated cavities in contact with structural elements
- Good detailing of the design is paramount to prevent bulk water entry!

Moisture control design to ensure sufficiently dry conditions under all circumstances:

- The German list of DTS constructions may not be applicable to other climates
- Steady-state dew point (Glaser) calculations are not applicable to bio-based materials
- Hygrothermal simulation including the impact of imperfections ensure moisture tolerance

Stop the rot and the mold and avoid chemical timber treatment where possible!

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Thank you!