TAMPERE UNIVERSITY OF TECHNOLOGY
Department of Civil Engineering

ANALYSIS METHOD TO DETERMINE SUFFICIENT VAPOUR RETARDER FOR WOOD FRAME WALLS

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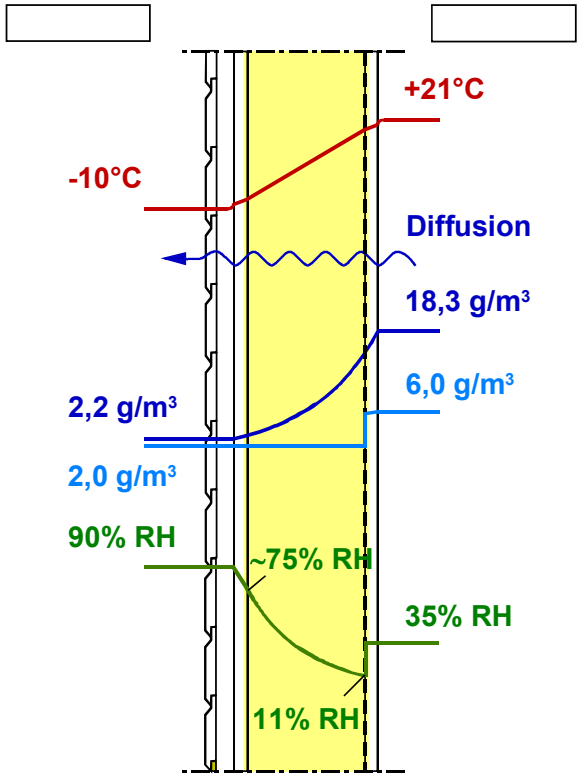
RESEARCHES OF WOOD FRAME EXTERNAL WALLS IN TUT 1994 - 2006

Objects of the researches:

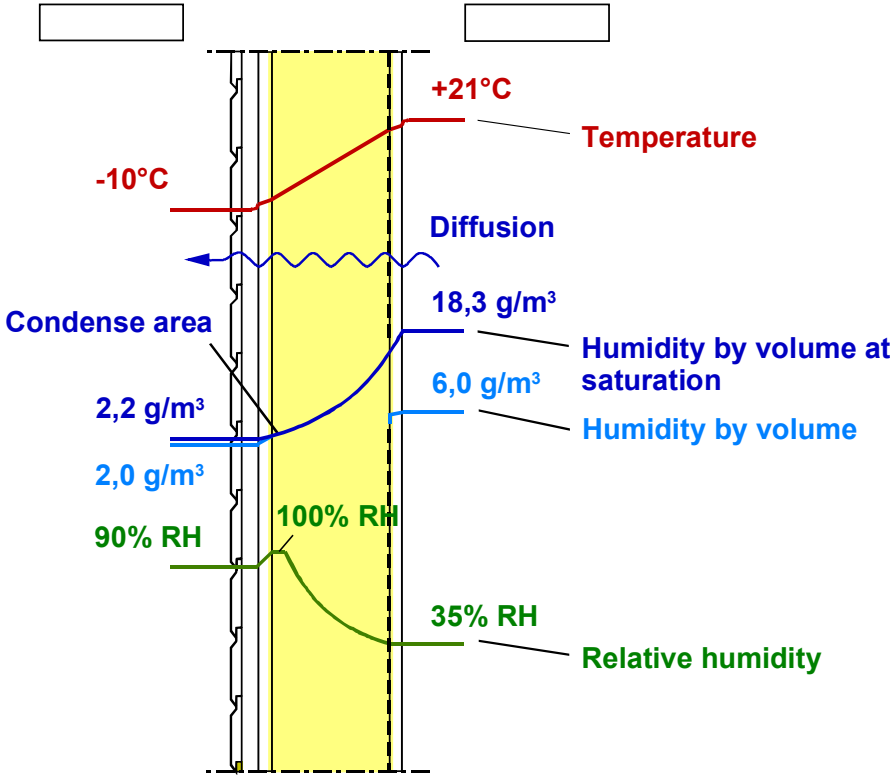
- To determine the performance criteria, limit values and boundary conditions for hygrothermal behavior of wood frame external walls in Finnish climatic conditions.
- To create new method and principles which can be used for determining sufficient water vapor resistance of vapor retarder in interior wall lining.
- To define the minimum values for the water vapor resistance ratio between the interior and exterior linings of different external walls.

MOISTURE PERFORMANCE OF WOOD FRAME WALLS FROM THE VIEWPOINT OF DIFFUSION

WALL WITH VAPOR BARRIER



WALL WITHOUT VAPOR BARRIER = MOISTURE-PERMEABLE WALL



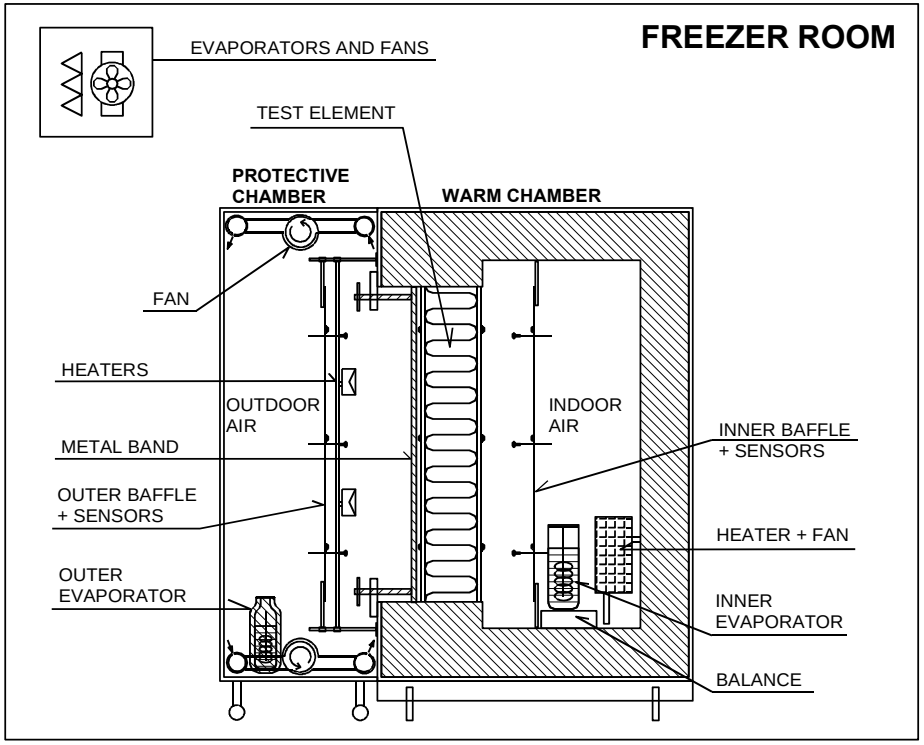
RESEARCH SCHEDULE

1.	Construction of the building physical research equipment	1994 – 1998
2.	Wall assembly tests in winter conditions (8 test walls)	1997 – 1998
3.	Field tests on wall assemblies of one-family house	1998 – 2000
4.	Wall assembly tests in autumn, winter and spring conditions (56 test walls), test series 2	2000 – 2004
5.	Testing of building physical properties of building materials (42 materials)	2000 – 2004
6.	Field tests related to functioning of ventilation gap of TUT test houses	2001 – 2003
7.	Field measurements on indoor air conditions in one-family and row houses (102 test houses)	2002 – 2004
8.	Benchmarking of HAM models and calculational modeling of wall assemblies	2001 – 2006

BUILDING PHYSICAL RESEARCH EQUIPMENT

Controllable quantities

- Temperature
- Relative humidity
- Pressure difference
- Heat radiation to exterior surface of test walls

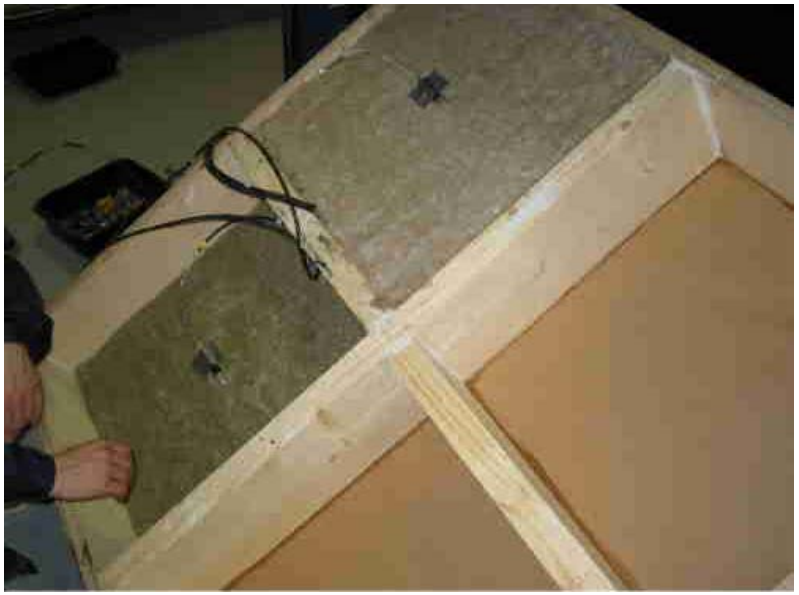


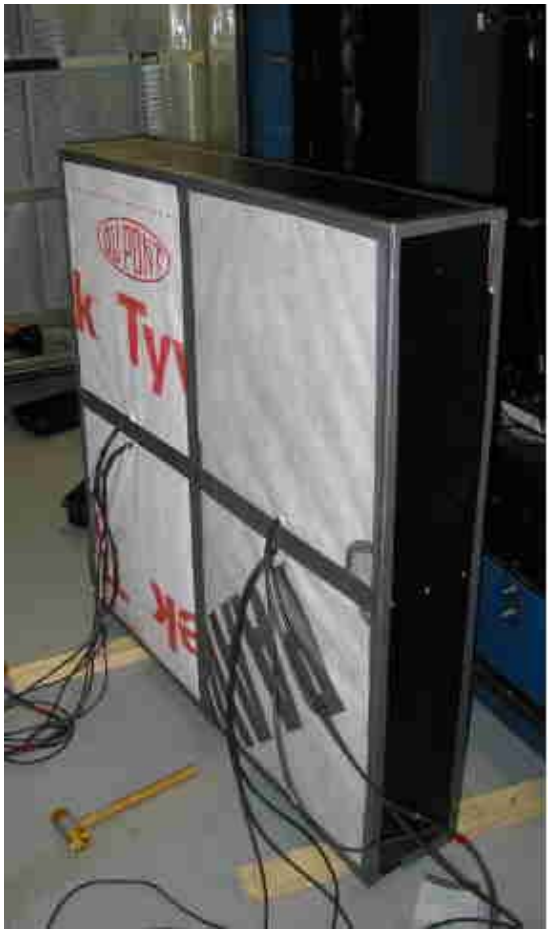
Test conditions

- Autumn, winter and spring conditions in Finland

TEST ELEMENTS FOR LABORATORY TESTS

- One test element consisted typically of 4 test walls.
- The test elements were installed and sealed so, that no air leakages occurred through the walls.





USED MATERIALS IN LABORATORY TESTS

Sheathings

- Gypsum board 9 mm
- Wood fiberboard 12 mm
- Wood fiberboard 25 mm
- Glass wool 25 mm
- Rock wool 30 mm
- Cellulose insulation board 25 mm
- Wood hardboard 4.8 mm
- Spruce plywood 12 mm
- Wind barrier membranes

Thermal insulations

- Glass wool
- Rock wool
- Cellulose insulation
- Flax insulation
- Sawdust + chipping

thickness

175 or 200 mm

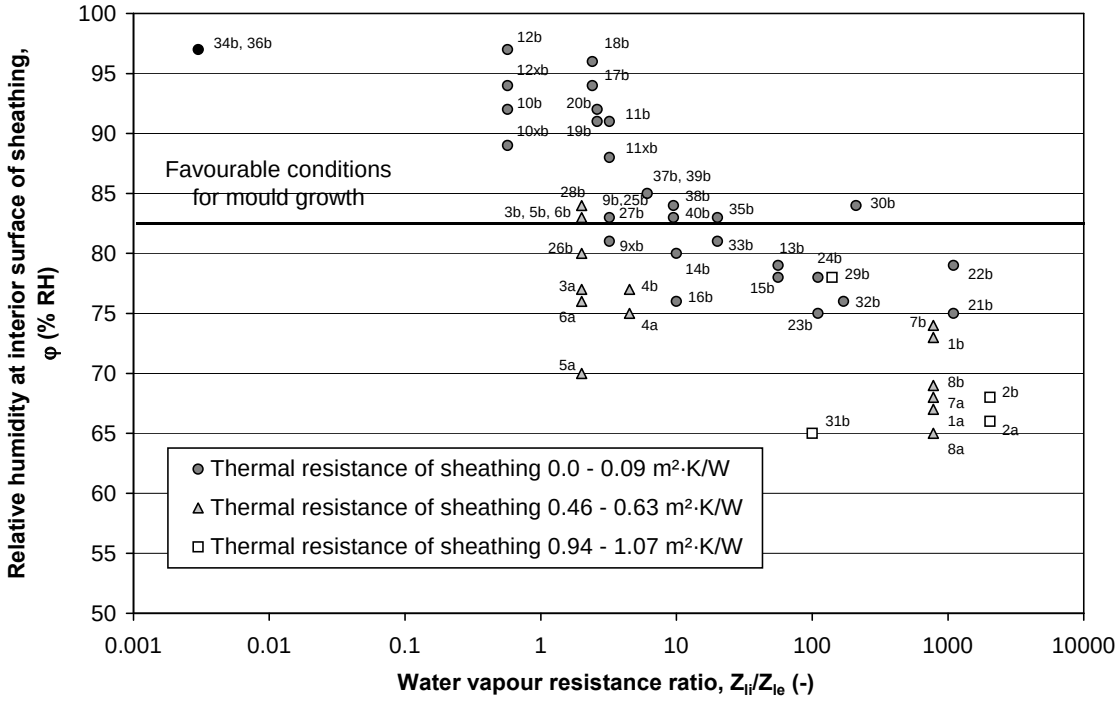
Air-/ vapor barriers

- Plastic foil
- Plastic coated papers
- Bitumen papers
- Air barrier papers

Interior board

- Gypsum board 13 mm

LABORATORY TEST RESULTS

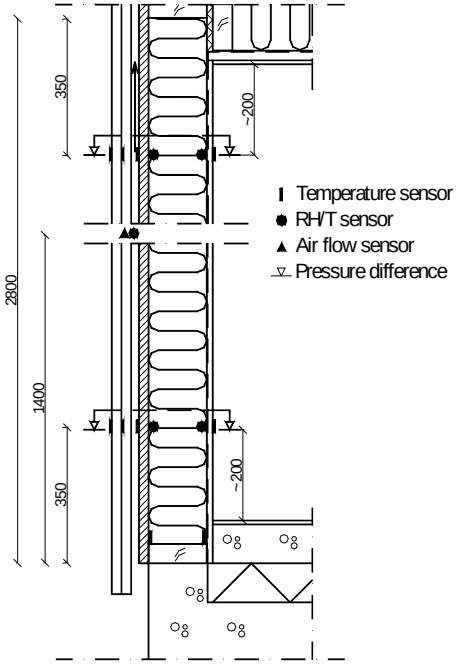


- Water vapor resistance ratio between interior and exterior wall linings affected remarkably to the moisture performance of walls.
- Some other factors were also important like thermal resistance and vapor resistance of sheathing.

MEASUREMENTS IN ONE-FAMILY HOUSE

Two wall assemblies

- Plastic vapor barrier + mineral wool
- Bitumen paper air barrier + cellulose insulation

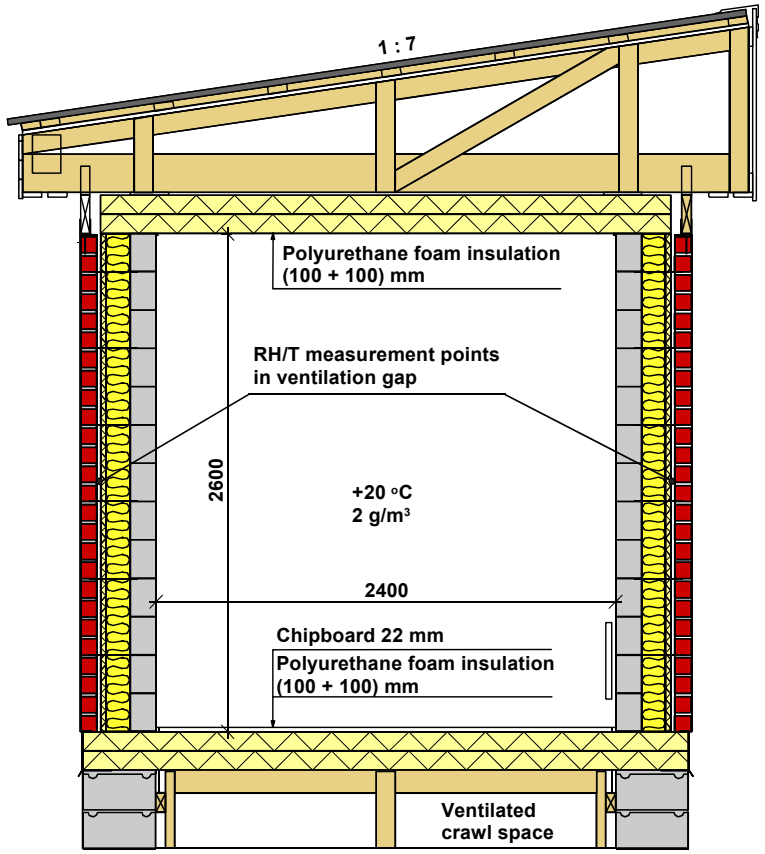


- RH values were higher at the interior surface of sheathing when bitumen paper was used as an air barrier.

MEASUREMENTS IN TEST HOUSES OF TUT

Monitoring of ventilation gap conditions in all cardinal directions

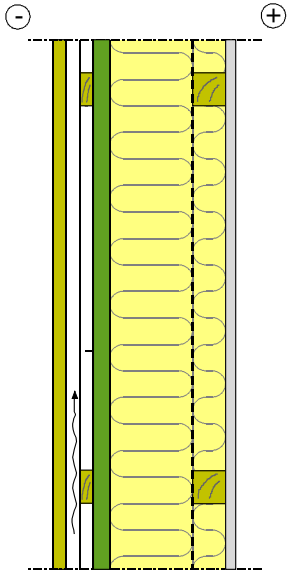
- Temperature
- Relative humidity
- Air velocity



FACTORS AFFECTING THE ACCEPTABILITY OF MOISTURE PERFORMANCE OF EXTERNAL WALLS

1. The performance criteria and limit values

2. Outdoor air conditions



3. Indoor air conditions

4. The wall assembly solution and used materials

Construction-time moisture

CALCULATIONAL MODELING

The performance criteria selected for calculational modeling

- Moisture condensation within the wall assembly
- Mould growth within the wall assembly

Two performance criteria →
Two moisture reference years (MRY)

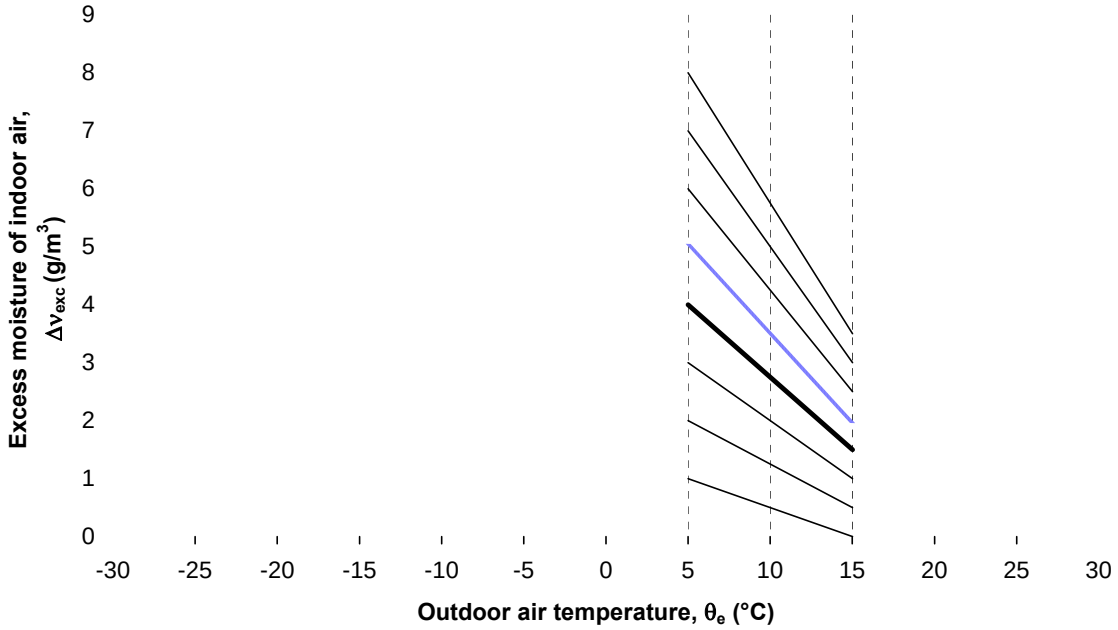
Outdoor air conditions

- 30 years measuring data from four Finnish localities (Vantaa, Lahti, Jyväskylä ja Sodankylä).

Indoor air conditions

- Design values of indoor air excess moisture based on measuring data of 102 one-family and row houses.

EXCESS MOISTURE OF INDOOR AIR



Severe conditions = living space < 30 m^2/ occupant and/or extra humidification

- Results are based on measurements in 102 one-family and row houses.
- The biggest difference between these design values and values presented in EN ISO Standard 13788 is that in this case excess moisture increases also when temperature is over 15°C.

SELECTION OF MOISTURE REFERENCE YEARS

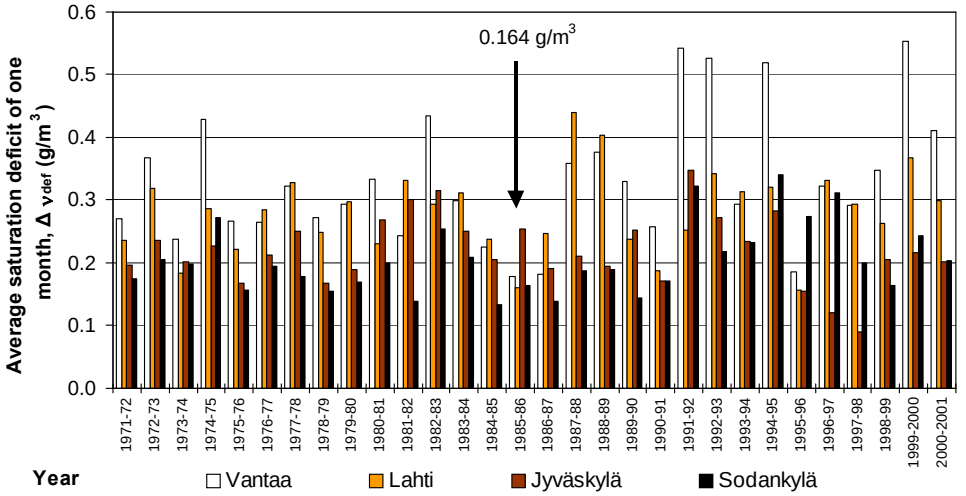
Moisture condensation

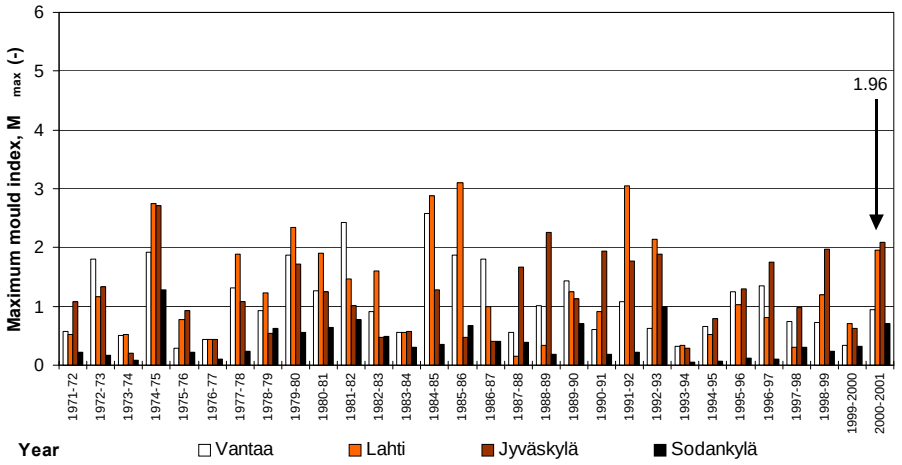
- Examination quantity: average moisture deficit of outdoor air in one month
- The most critical situation is in Northern Finland

Mould growth

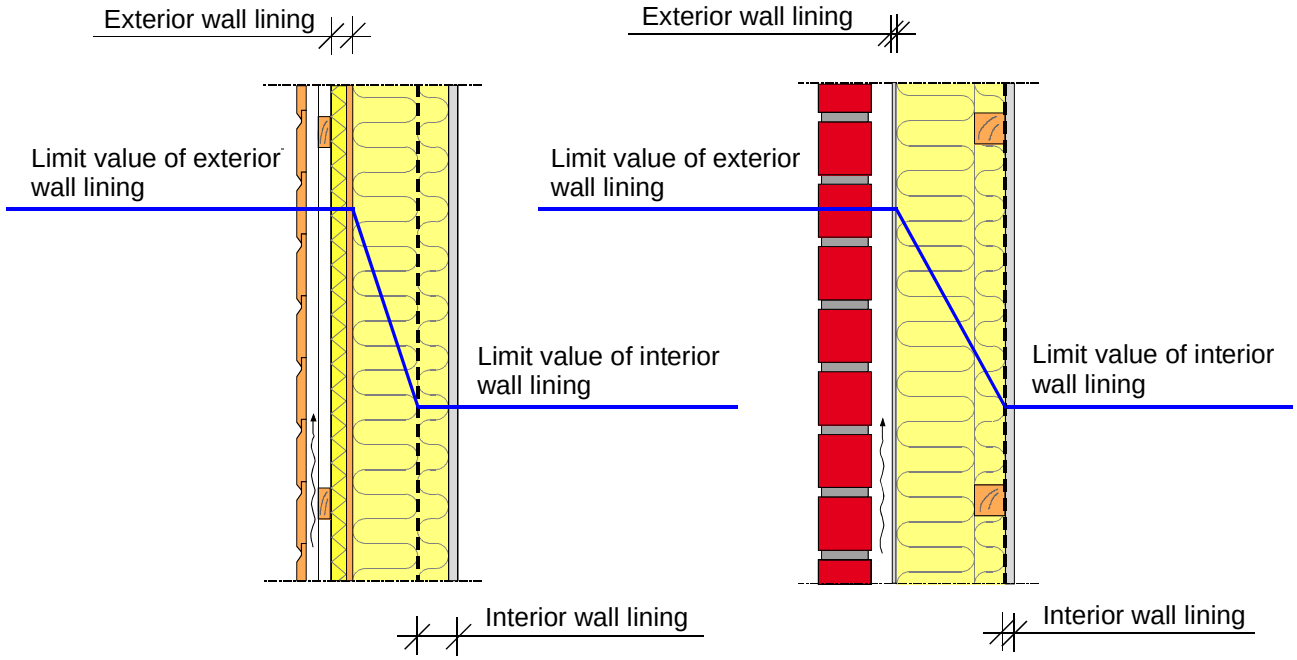
- Examination quantity: mould index (0-6)
- The most critical situation is in Southern Finland

10 % level critical year was determined in both cases





PRINCIPLE TO SELECT LIMIT VALUES FOR INTERIOR AND EXTERIOR WALL LININGS

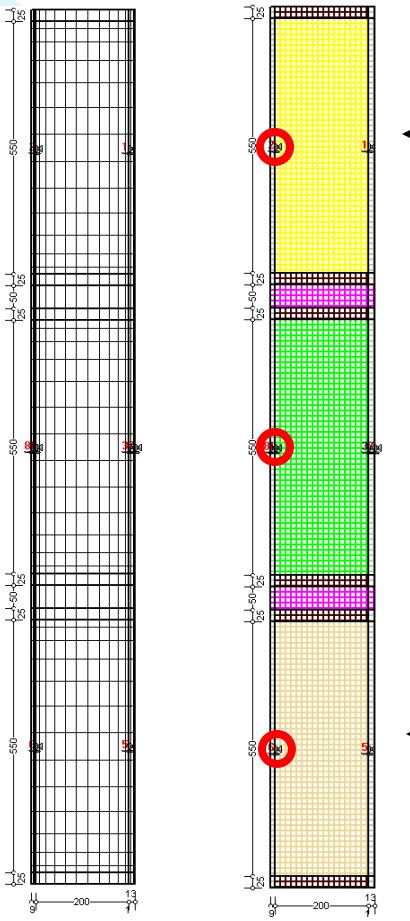


The temperature and moisture conditions for the exterior wall lining must not be more critical than with the most critical acceptable wall assembly (so-called reference wall) where said conditions are solely the result of outdoor air conditions.

- Maximum continuous condensation time 34 days (Sodankylä 1985-1986)
- Maximum mould index 1,96 (Lahti 2000-2001)

CALCULATIONAL MODELING OF WALLS (WUFI-2D –PROGRAM)

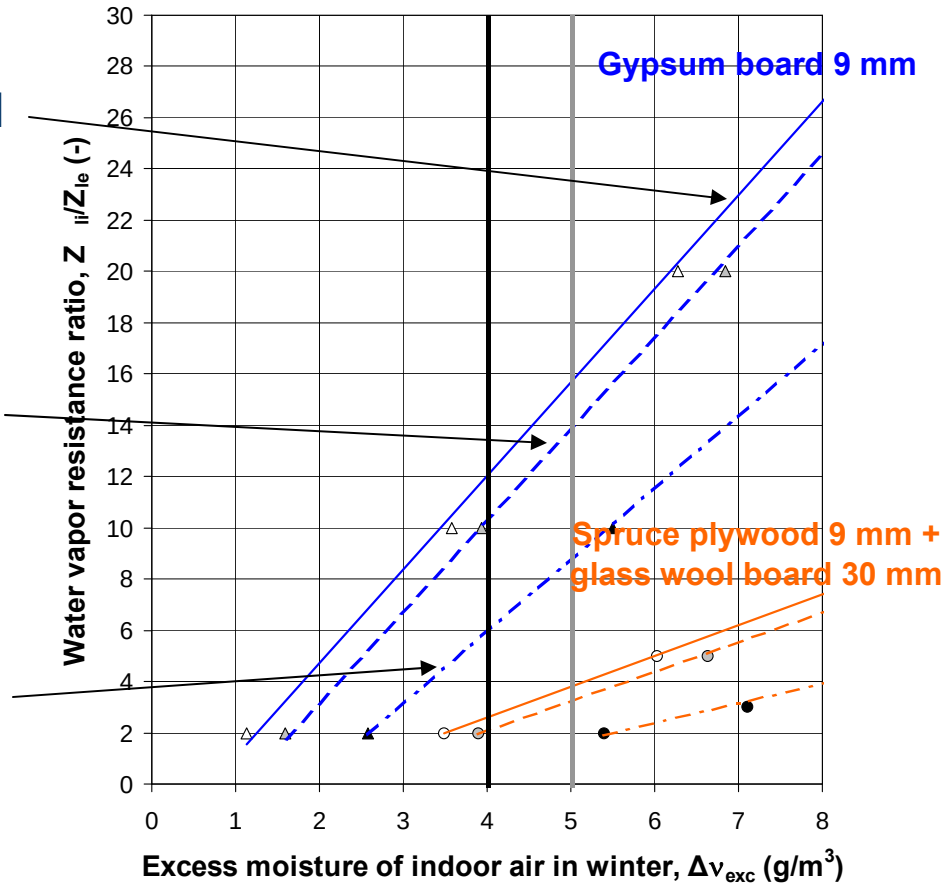
Example from mould growth analysis at the interior surface of sheathing



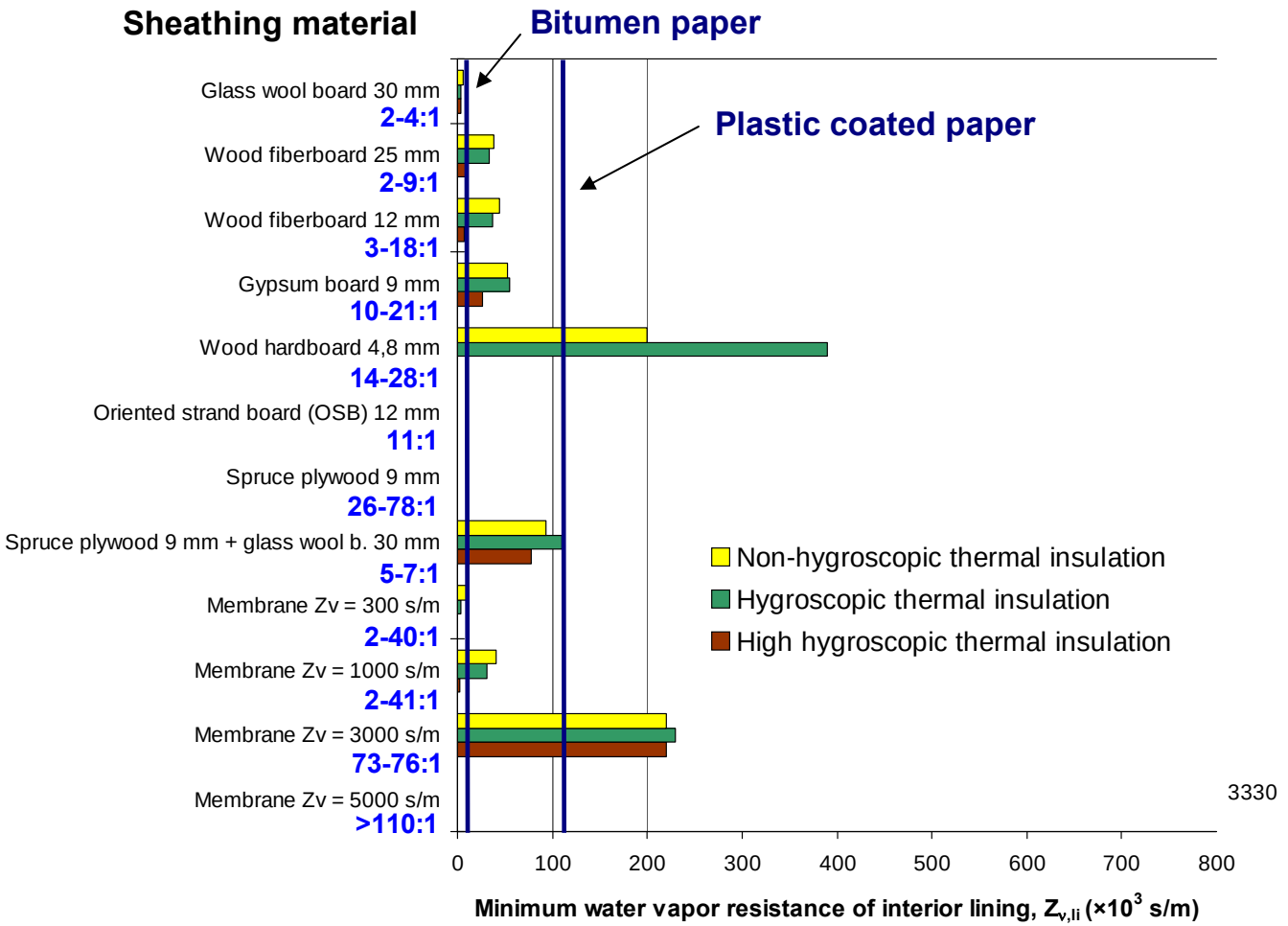
Glass wool

Cellulose insulation

Sawdust + chipping



MINIMUM WATER VAPOUR RESISTANCE VALUES OF INTERIOR LINING WITH DIFFERENT WALLS (Excess moisture of indoor air in winter 5 g/m³)



CONCLUSIONS OF THE RESEARCH RESULTS OF WOOD FRAME EXTERNAL WALL ASSEMBLIES

- Using a plastic vapor barrier behind the interior board is safe in all typical indoor and outdoor air conditions of the Finnish climate.
- A wall assembly may be implemented also without a plastic vapor barrier if the water vapor resistance of interior wall lining is sufficient.
- The present guideline of the Finnish Building Code of water vapor resistance ratio 5:1 is not sufficient in most cases.
- Recommendable water vapor resistance ratio is typically between 5:1 – 80:1, and with sheathings highly permeable to water vapor between 5:1 – 40:1.
- The water vapor resistances of the paper-based air barrier membranes are normally so low that they do not even meet the guideline of Finnish Building Code.
- The hygrothermal performance of external wall can be improved by using sheathing with high thermal resistance and low water vapor resistance.
- Hygroscopic thermal insulation retards the wetting of the wall in autumn but also its drying in spring.