9th Nordic Symposium
on Building Physics
Tampere
29 May – 2 June 2011

Forty years of building physics research – for what benefit?

Ingemar Samuelson

SP Technical Research Institute of Sweden

Building Physics, Lund University

40 years

- My experience of building damage
- Building physics research and quality assurance
- What we could have done better

Buildings then, now and in the future

Old buildings:

Simple design, a small number of materials

Easy to understand

“In the old days they could build a great house”

Not very good thermal comfort

Energy costs

But remember that all the bad old buildings have been torn down

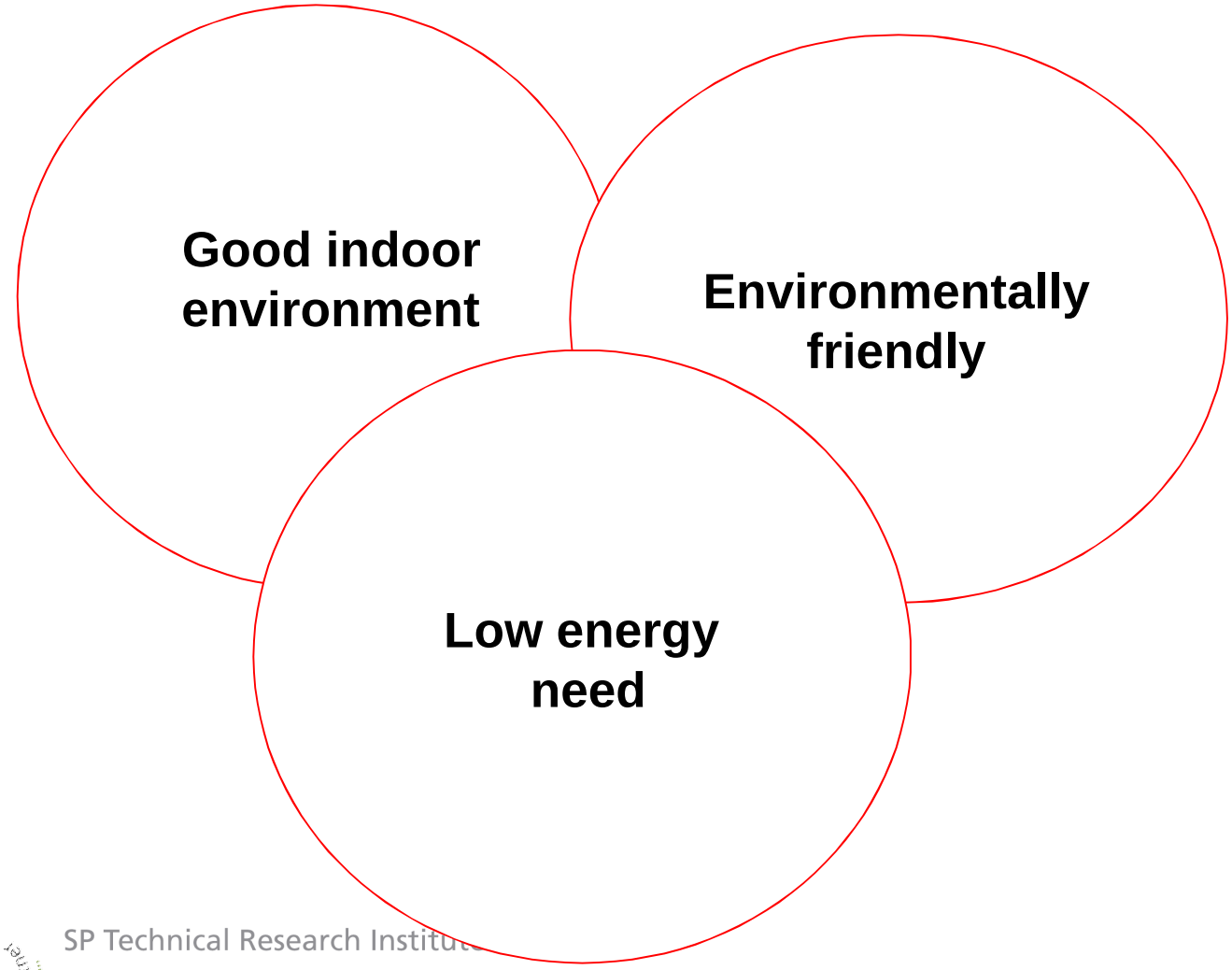
Buildings now and in the future

- Extreme design
- Focus on layout
- How about building physics?

Buildings now and in the future

- Complex structures
- Complex low energy systems
- Difficult to understand if you are not an engineer

There are many requirements to meet



A great number of low energy houses

- Low energy houses
- Zero energy buildings
- Passive houses
- Plus energy houses

The building of these houses seems to be OK in a small scale. But will it be OK when the consultants and the contractors start to build all houses as passive houses?

Environmentally friendly buildings

- No poisonous material
- Low energy need
- Low carbon dioxide production
- Locally produced

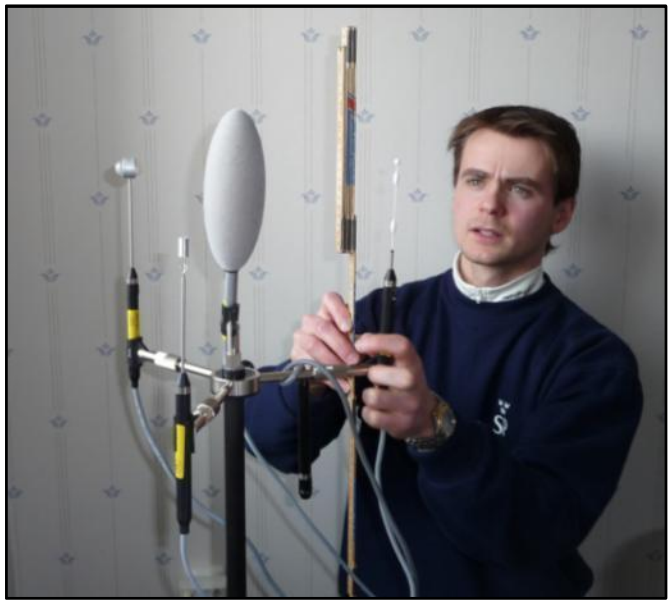
Replace hazardous materials with safer.
But make sure that the new material has as good a properties and does not lead to lower indoor air quality

The indoor environment

- Thermal comfort
- Indoor air quality
- Acoustics
- Lightning
- etc

There is no lack of knowledge. How to build and how to avoid damage.

And nevertheless, damage still occurs.



Indoor air quality

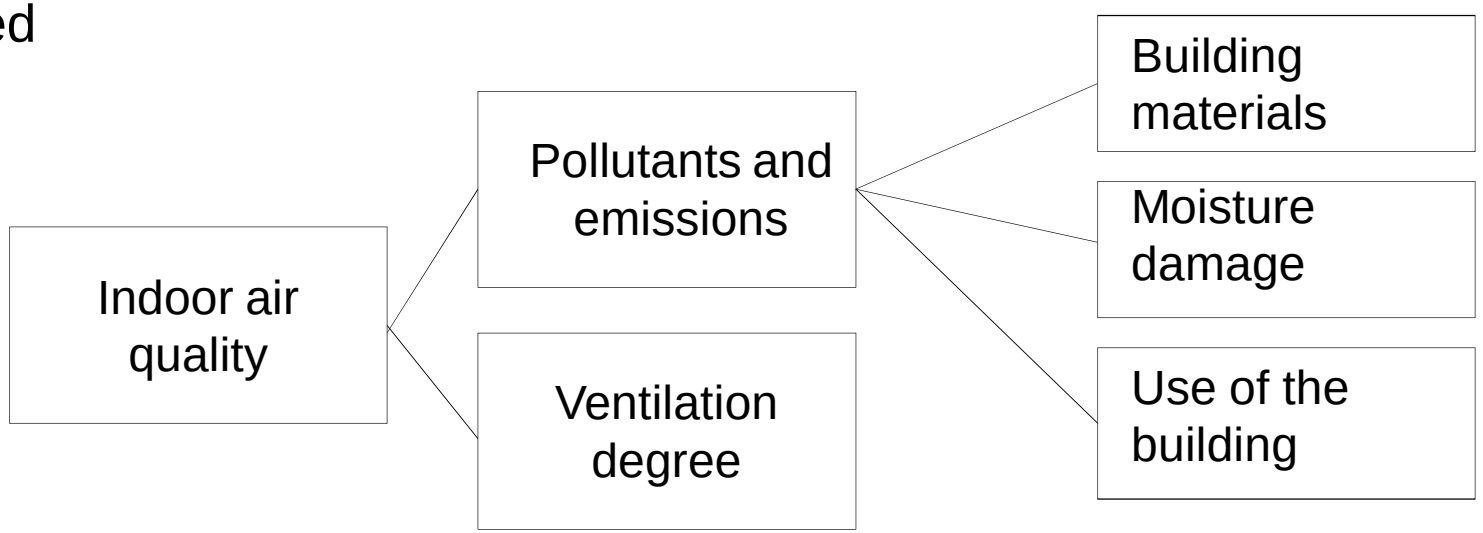
Emissions from building materials

Emissions from moisture damage

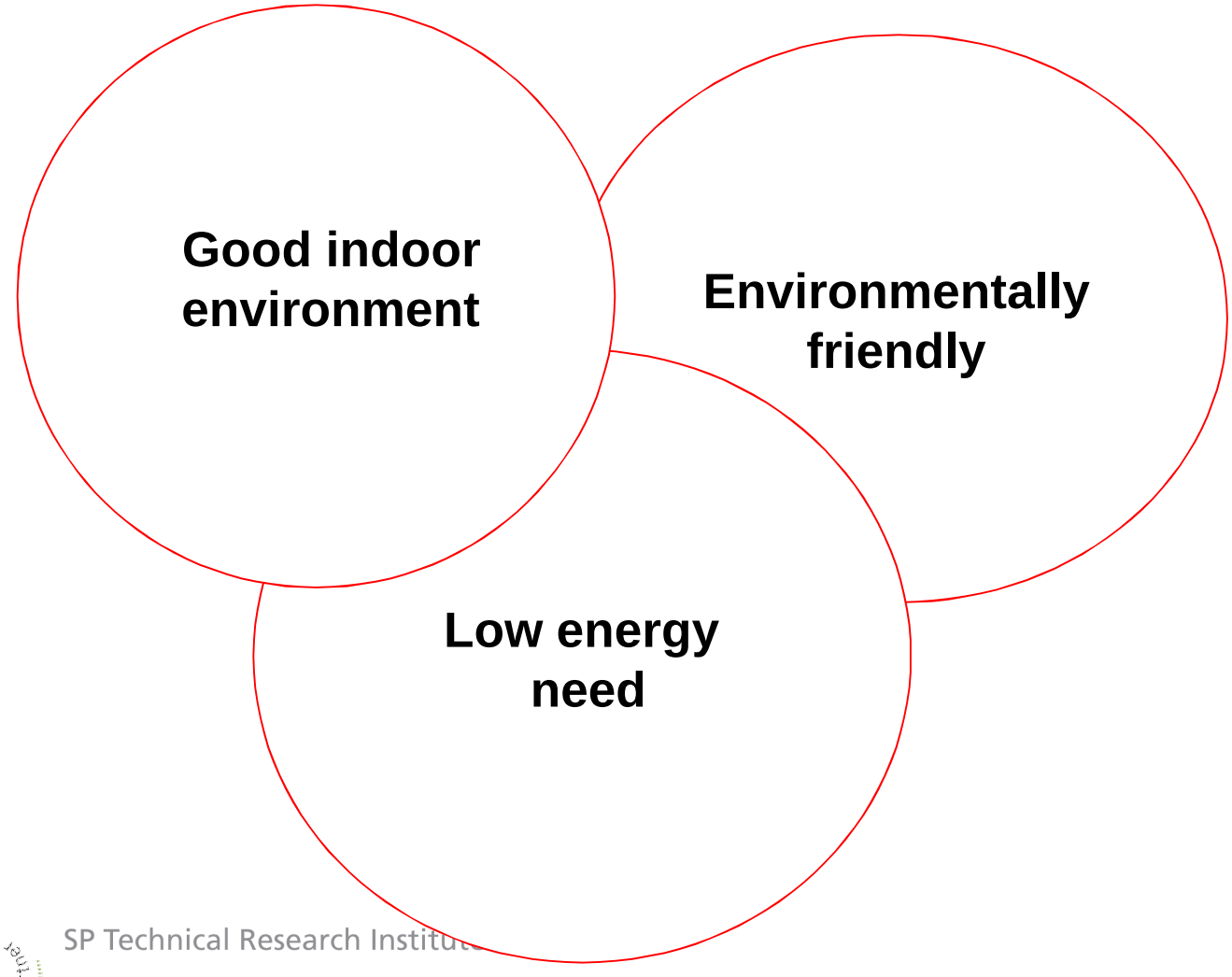
Emissions from the use of the building

- Keep the emissions low

The ventilation system makes sure that the indoor air quality is the desired



Good indoor environment has the highest priority



Good principles for moisture safety

Protect against rain
Heat insulation on the outside
Airtight
Negative pressure on inside
Vapor tightness if required
Protect materials and structure during construction
Allow construction moisture to dry out
Have additional security

Why does moisture damage occur?

There are many explanations:

Carry on as usual

Carelessness

Ignorance

<u>Difficulties for a moisture safe design</u>

- Energy-efficient designs
- Cost-effective structures
- Industrialized building
- New material
- Increased demands for good thermal comfort
- and more

What has been done to prevent moisture damage?

- Research in Building Physics
- Manuals and handbooks
- Education at all levels
- Building codes

National and international work

A lot of international research

- RILEM
- CIB

CIB W040 ”Heat and moisture transfer in buildings”

Working group with scientists from all over the world.

Started in the 1960s and has been going on with meetings every other year.

During the last decades: many conferences, seminars and other research exchange

CIB W040 1974

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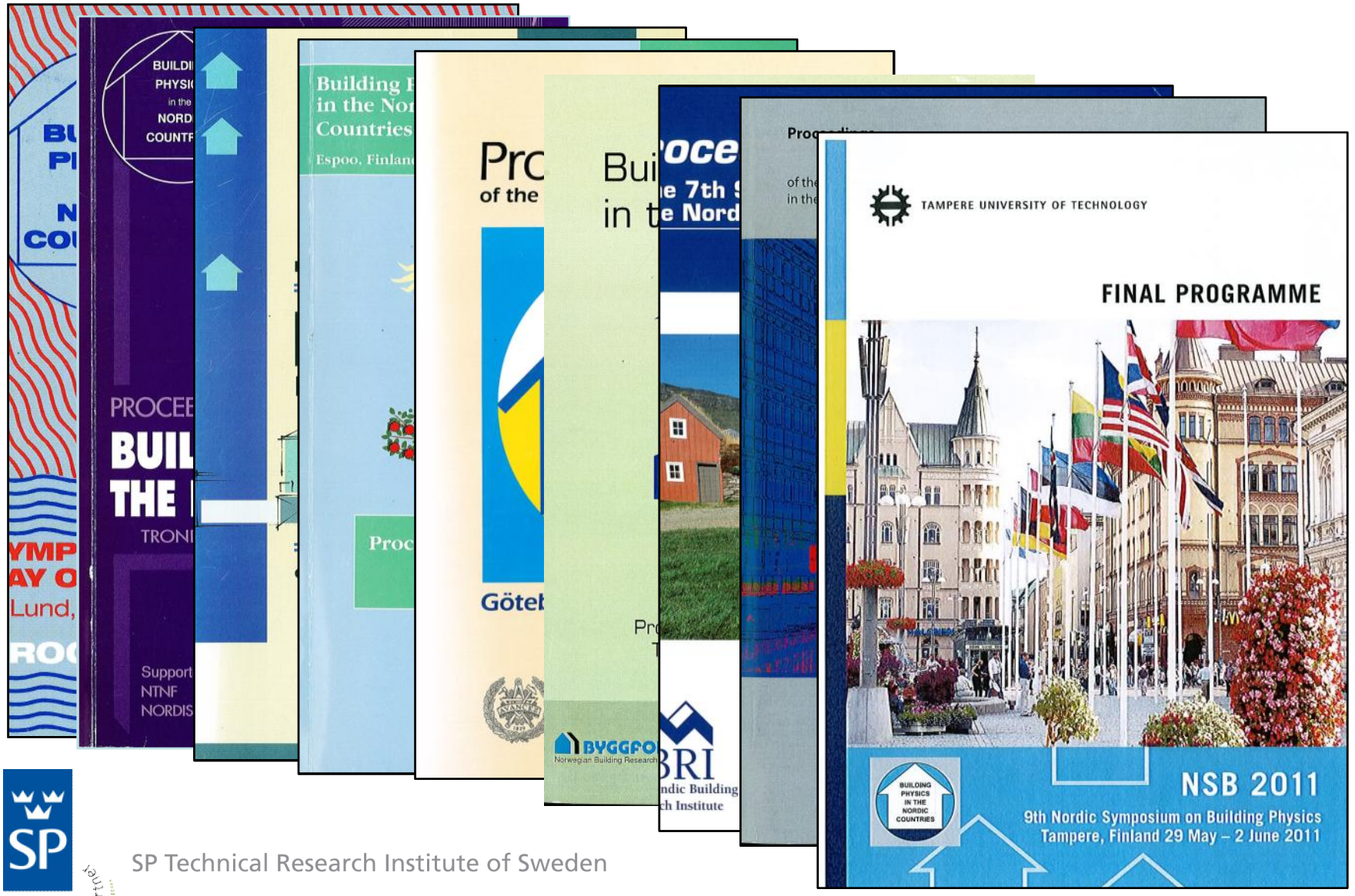
International work

Building Physics in the Nordic Countries

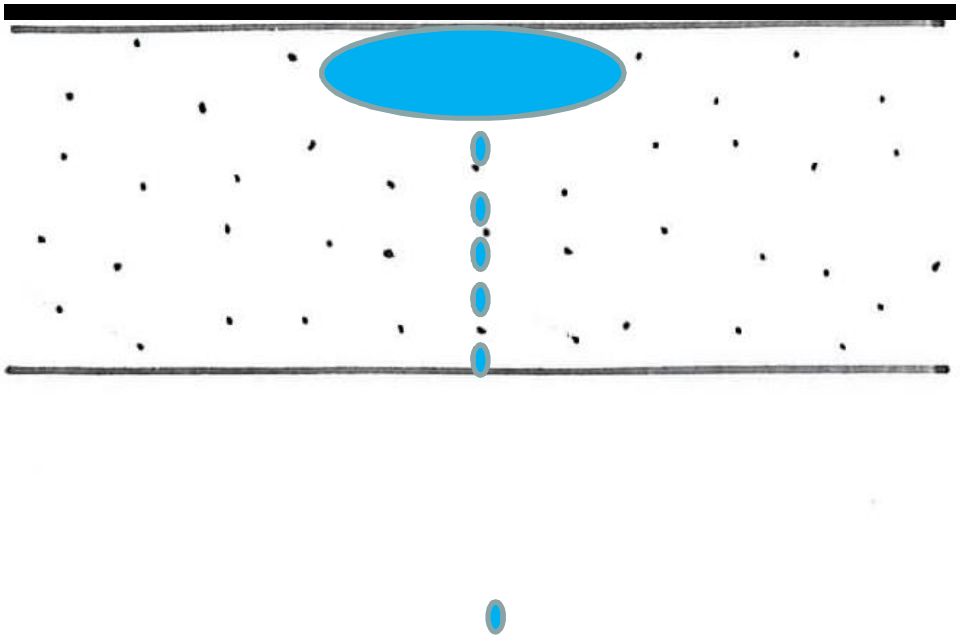


Healthy Buildings

National research and handbooks (Sweden)

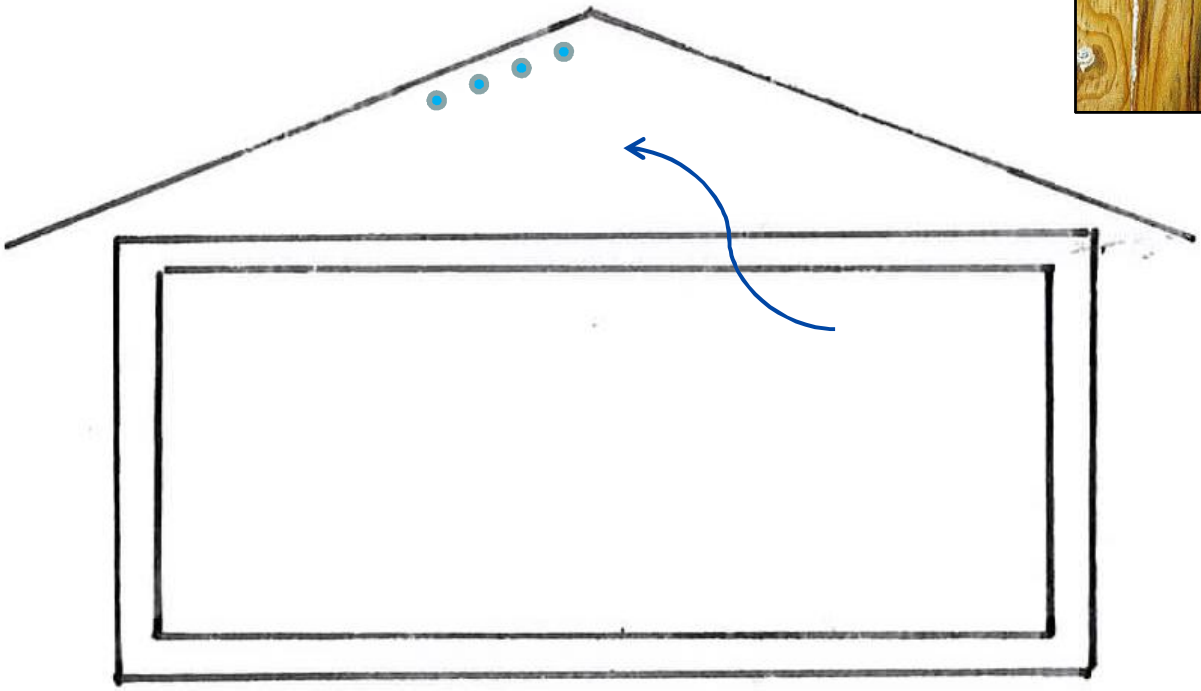
Moisture damage in Sweden 1960s

Leakage through roofs



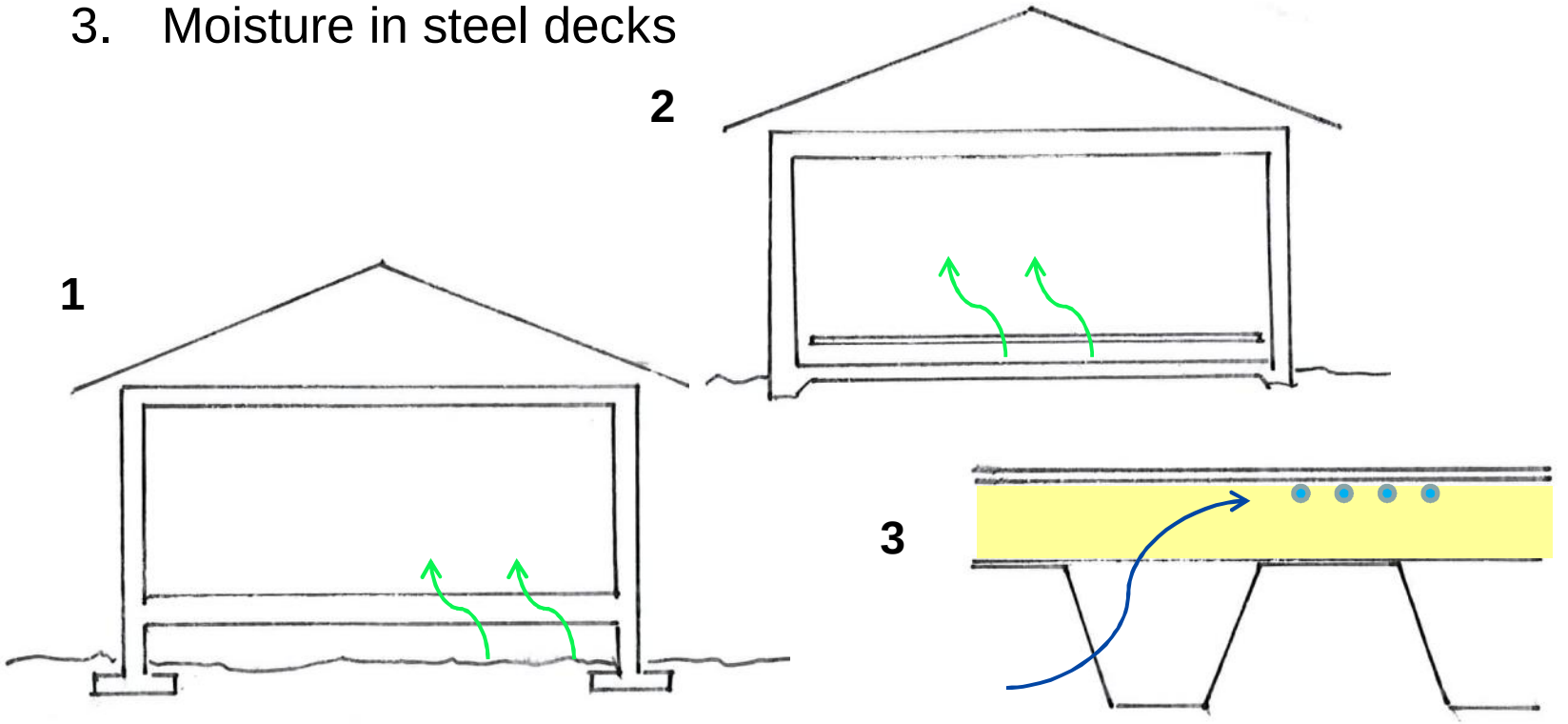
Moisture damage in Sweden 1970s

- Moisture damage in ventilated roofs



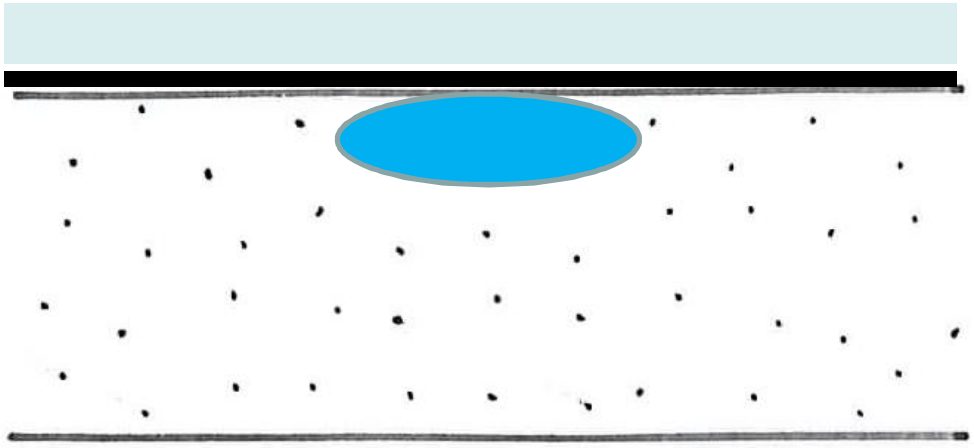
Moisture damage in Sweden 1970s

1. Unpleasant odour in houses with crawl space foundations
2. Unpleasant odour in houses with slab foundations
3. Moisture in steel decks



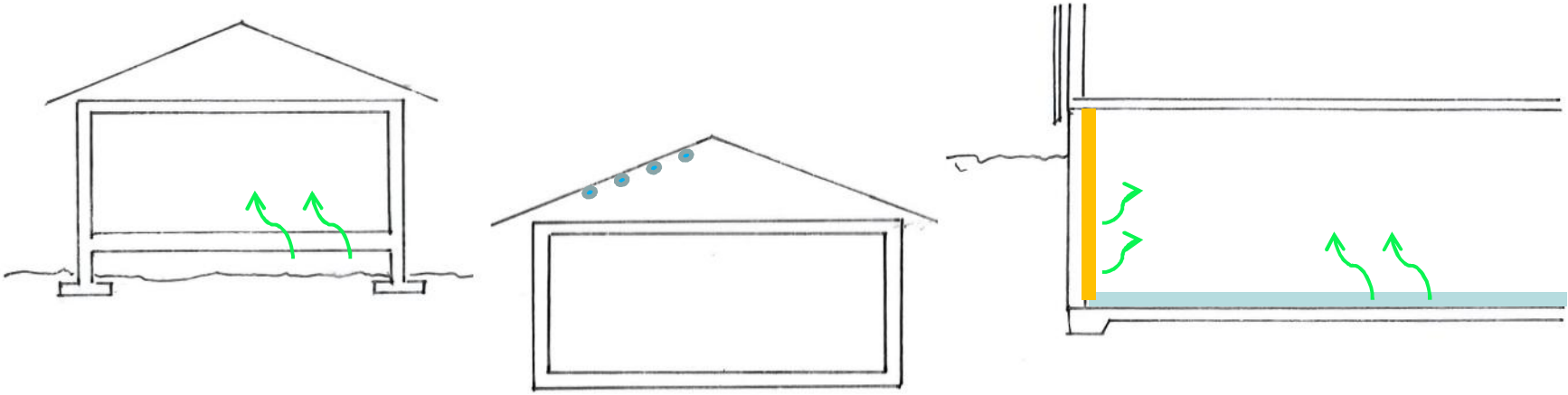
Moisture damage in Sweden 1970s

Leakage through sealing layers. Damage by ice.



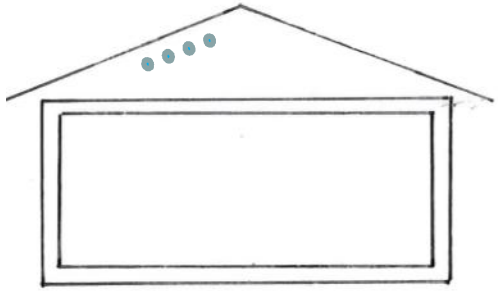
Moisture damage in Sweden 1980s

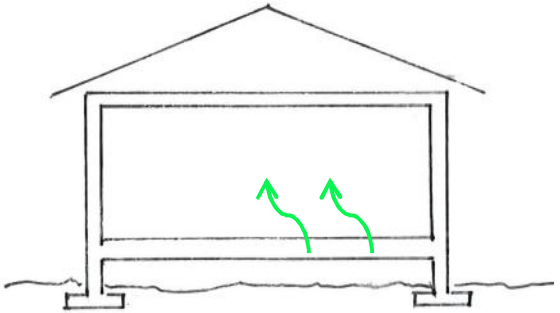
- Crawl space foundations
- Radon
- Smoothing compound
- Sick Building Syndrome
- Moisture damage in externally ventilated roof spaces
- Unpleasant odour in renovated basements



Moisture damage in Sweden 1990s

- Ventilated roof spaces
- Crawl space foundations

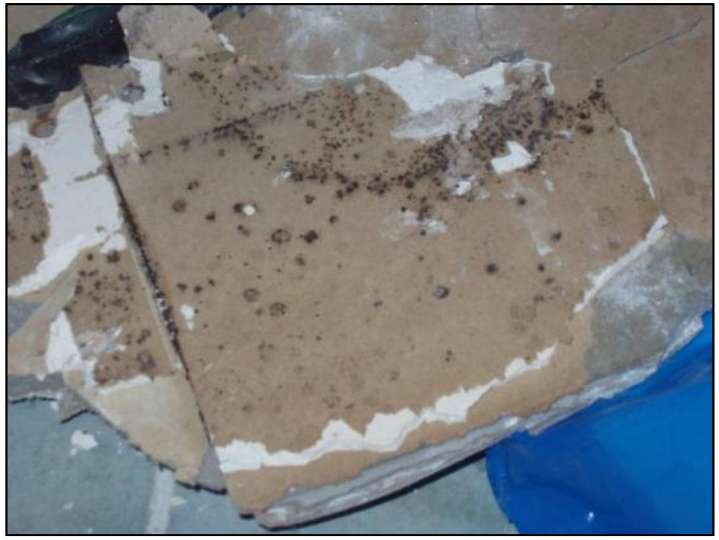




Moisture damage in Sweden 2000s

1. Ventilated roof spaces
2. Damage in wetrooms
3. External thermal insulation composite system walls (ETICS or EIFS-walls)

2



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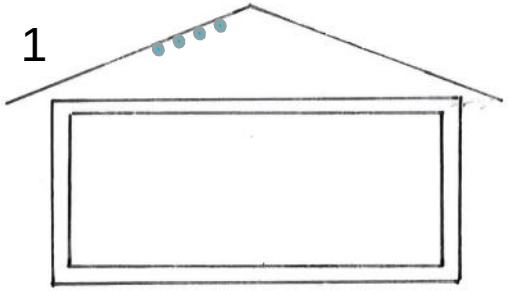

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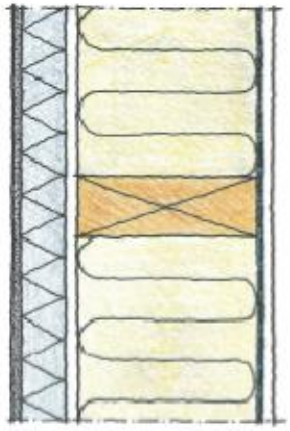


Moisture damage in Sweden 2010s

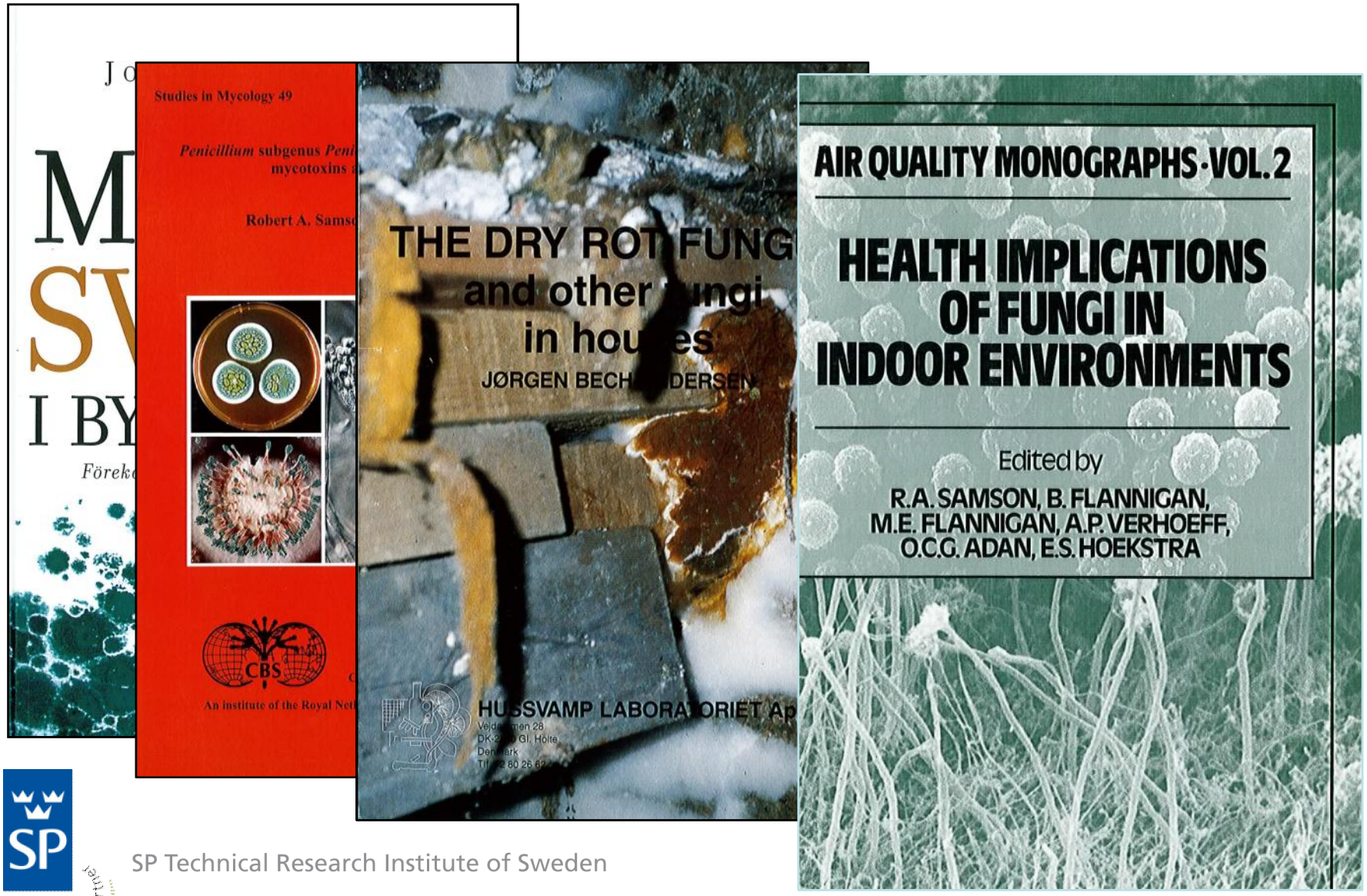
Damage in wetrooms

Moisture damage

- Collapse, exceptional but occurs
- Movements and cracks
- Miscoloring
- Bad health (?)
- Bad odour

Reports on building damage

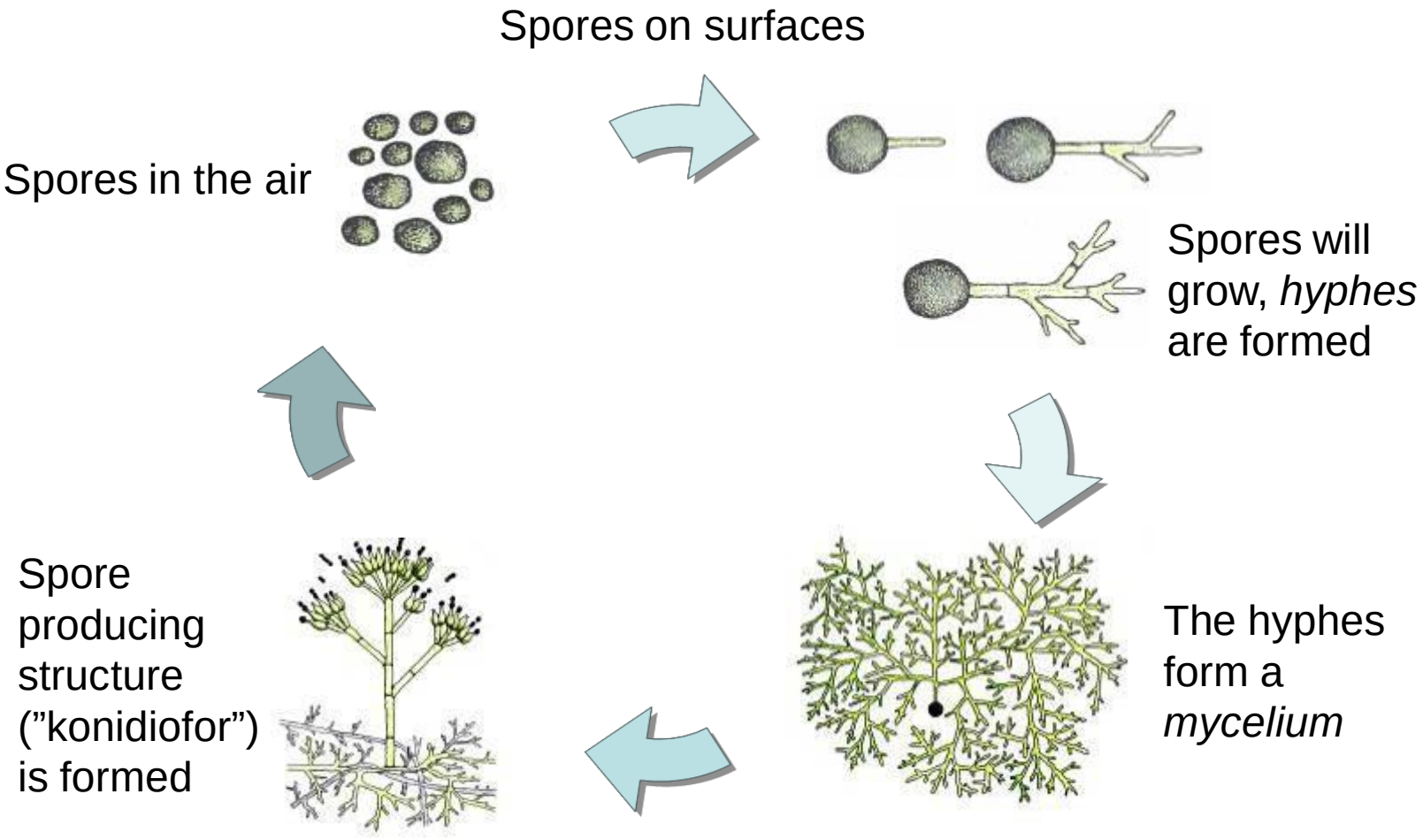
Information of mould



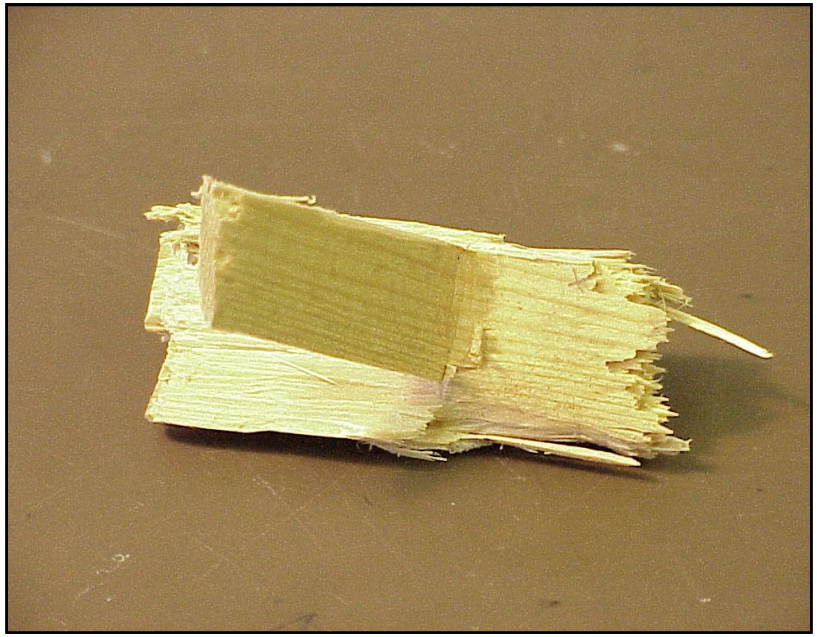
Mould and microorganisms

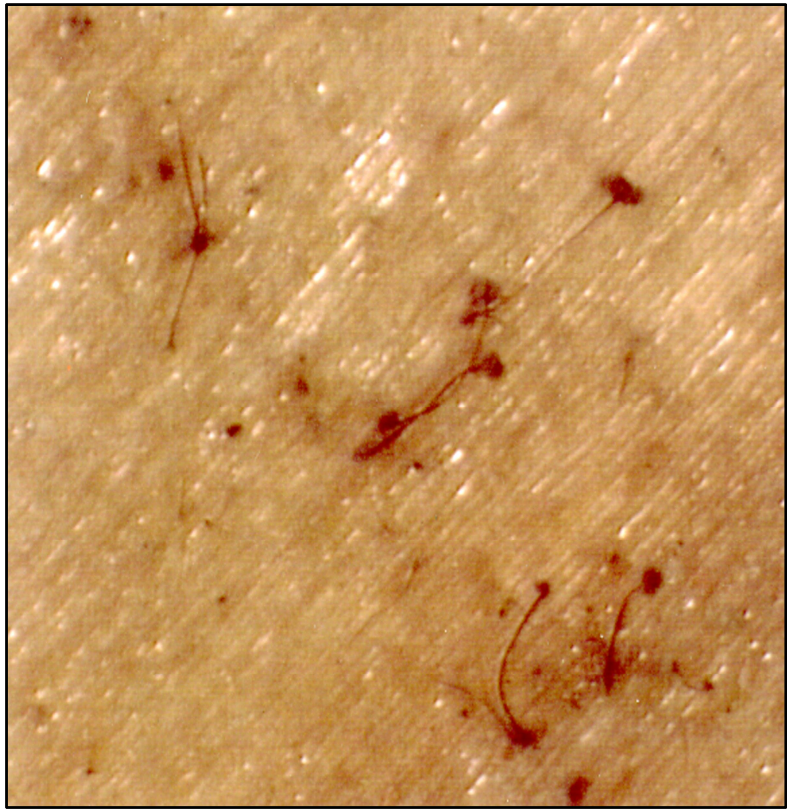
- Mould grows on most building materials. If the growth starts before the installation then the risk of damage is imminent, especially in well insulated structures.
- There is one problem. The growth is not always visible.
- So as long as the workers do not see any mould growth they do as they always do. This means that “a little water is no problem, it will dry out”.
- But this may mean that you build in a problem.

The life cycle of mould



Mould is not always visible



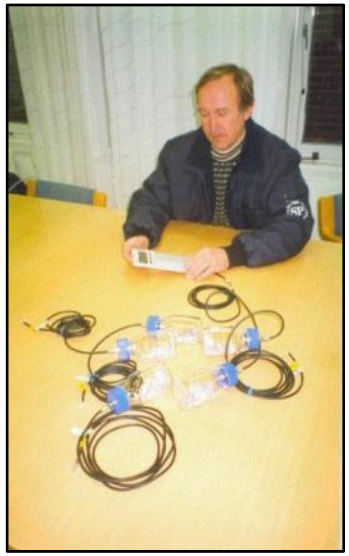


Mould is not always visible

0	There is no growth on the surface
1	Small, or widely spread growth
2	Weak, dispersed, sparsely growth
3	Patchy heavy growth
4	The entire surface with heavy growth
5	The entire surface is more or less covered by heavy growth

Investigation - damage

- The investigation must be conducted in a systematic way
- Measurements of temperature and relative humidity tells about the conditions of damage and what caused damage
- Analysis of mold and chemical emissions can be a complement.



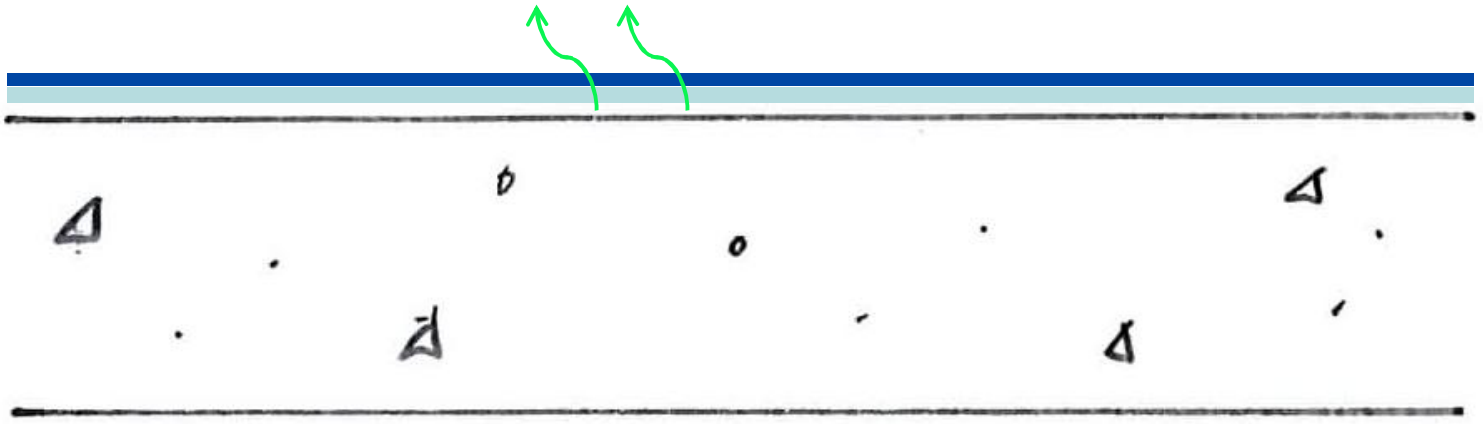
Investigation?

Examples of damage with focus on moisture

- Smoothing compound
- Unpleasant odour from mould growth
- SBS
- Moisture damage in wet rooms
- Damage in buildings with extreme indoor climate
- External thermal insulation composite system walls (ETICS)

Smoothing compound

- 1978 – 1983
- Almost all buildings during this time were built with this compound
- In too thick layer or on damp concrete, it could be damage
- Very expensive clean up of large housing estates in Sweden

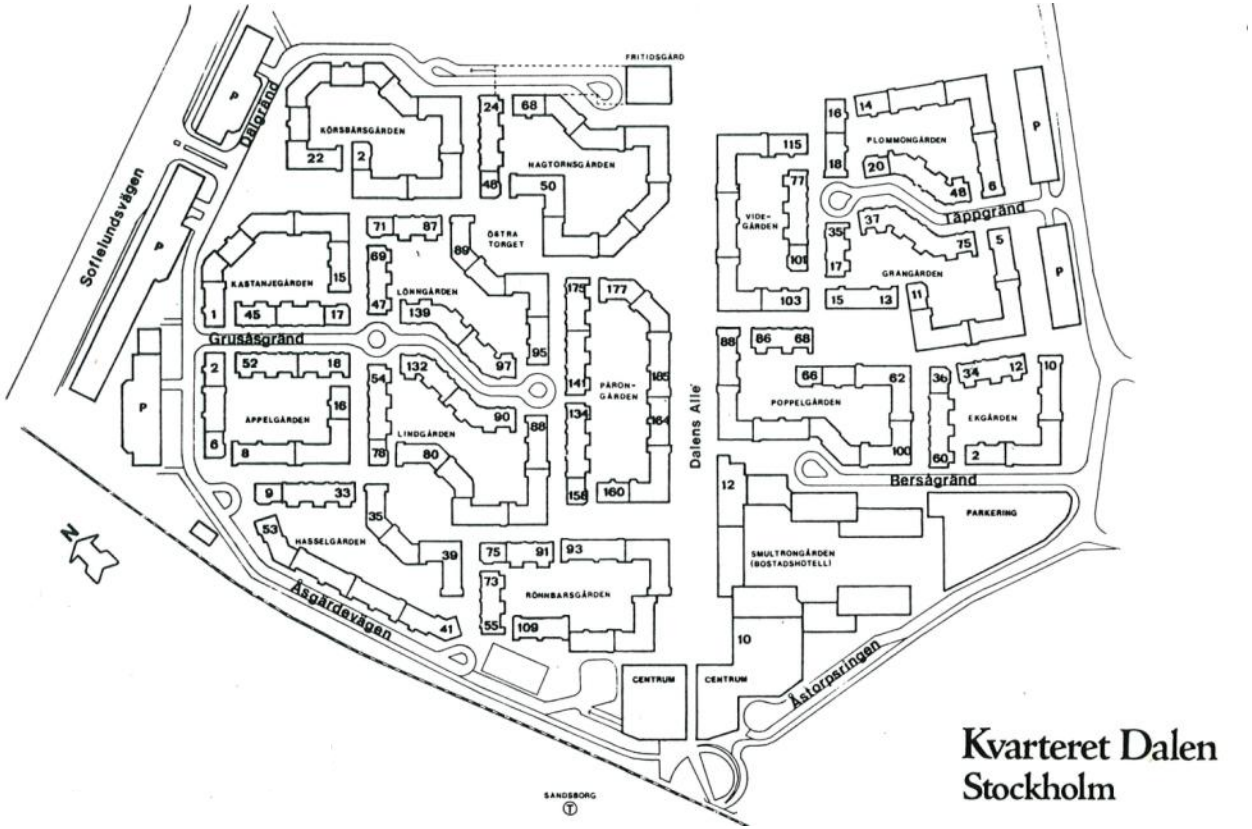


Why did this happen?

- Lack of knowledge
- The smothing compound worked well in thin layers on dry material
- The limitations of the material was not clarified when it was introduced

Sick Building Syndrome

- Large housing estates in Sweden in the 1980s
- Many office buildings
- Many schools



Kvarteret Dalen
Stockholm

Why did it happen

- In some cases the problems were explained by moisture damage or bad indoor quality
- But not always. Sometimes these problems had other explanations

Good principles for moisture safety

Protect against rain
Heat insulation on the outside
Airtight
Negative pressure on inside
Vapor tightness if required
Protect materials and structure during construction
Allow construction moisture to dry out

Have additional security

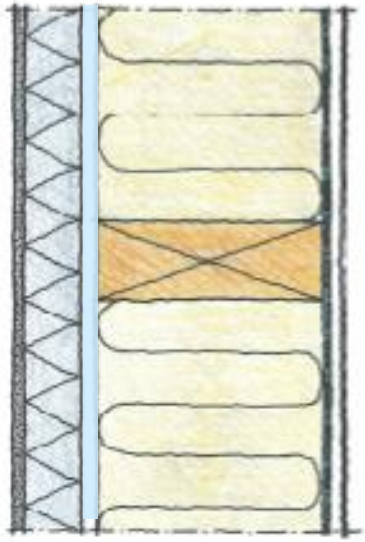
”Additional security” what is that?

If moisture for some reason (which we can not always predict) will enter the structure should this not lead to serious damage. To reduce this risk, there are systems for drainage and ventilation.

Here are two examples of designs with no "extra security"

Wet room wall behind tile

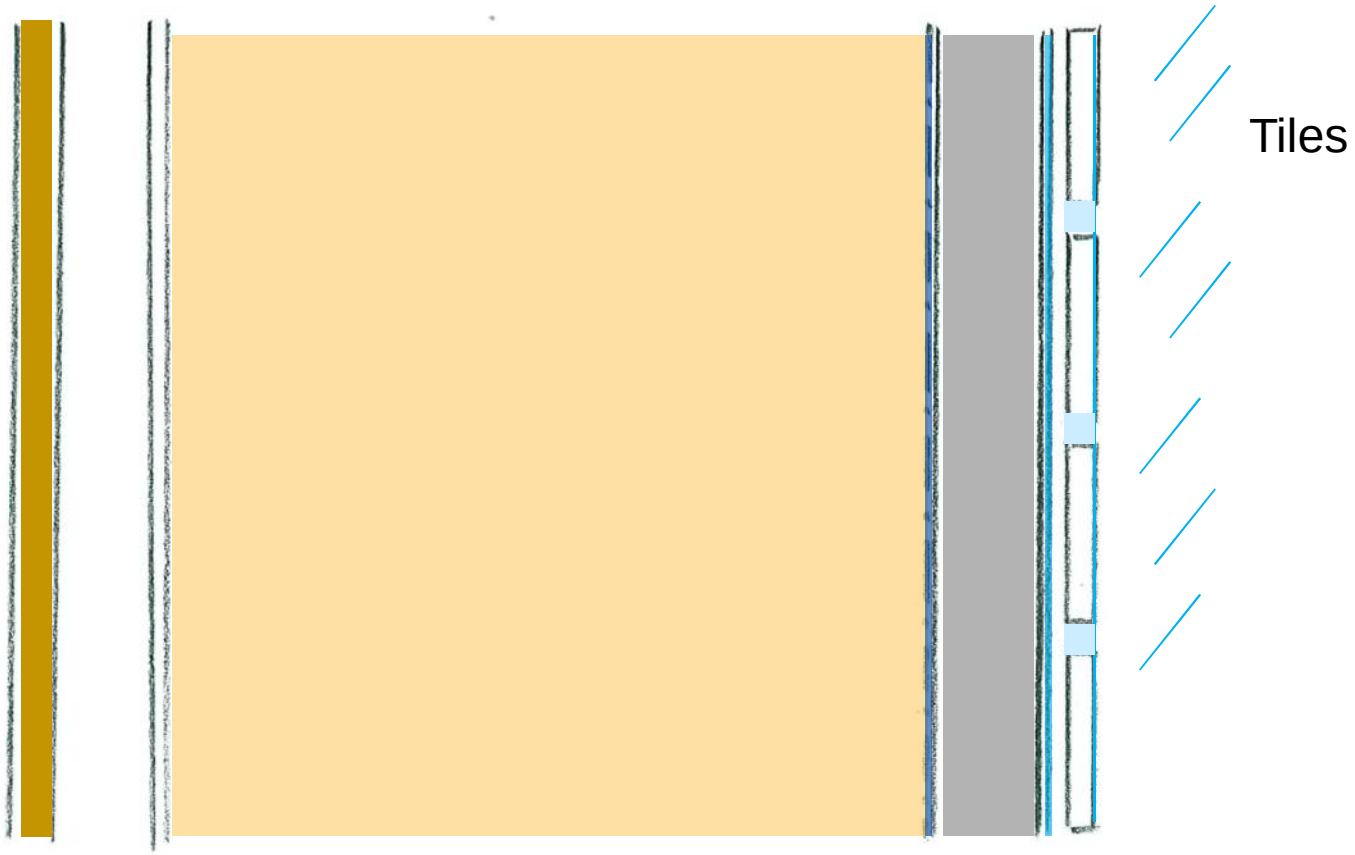
EIFS stud wall



Moisture damage in wet room walls with tiles

Structure

Gypsum board with
paper covering



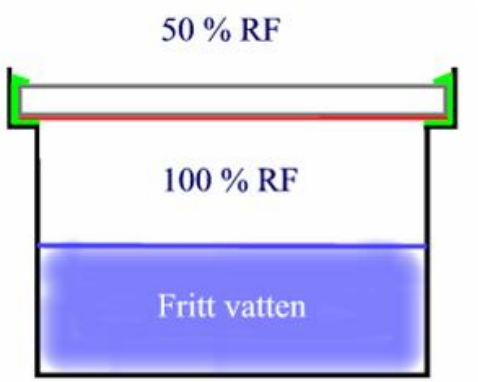
Tiles

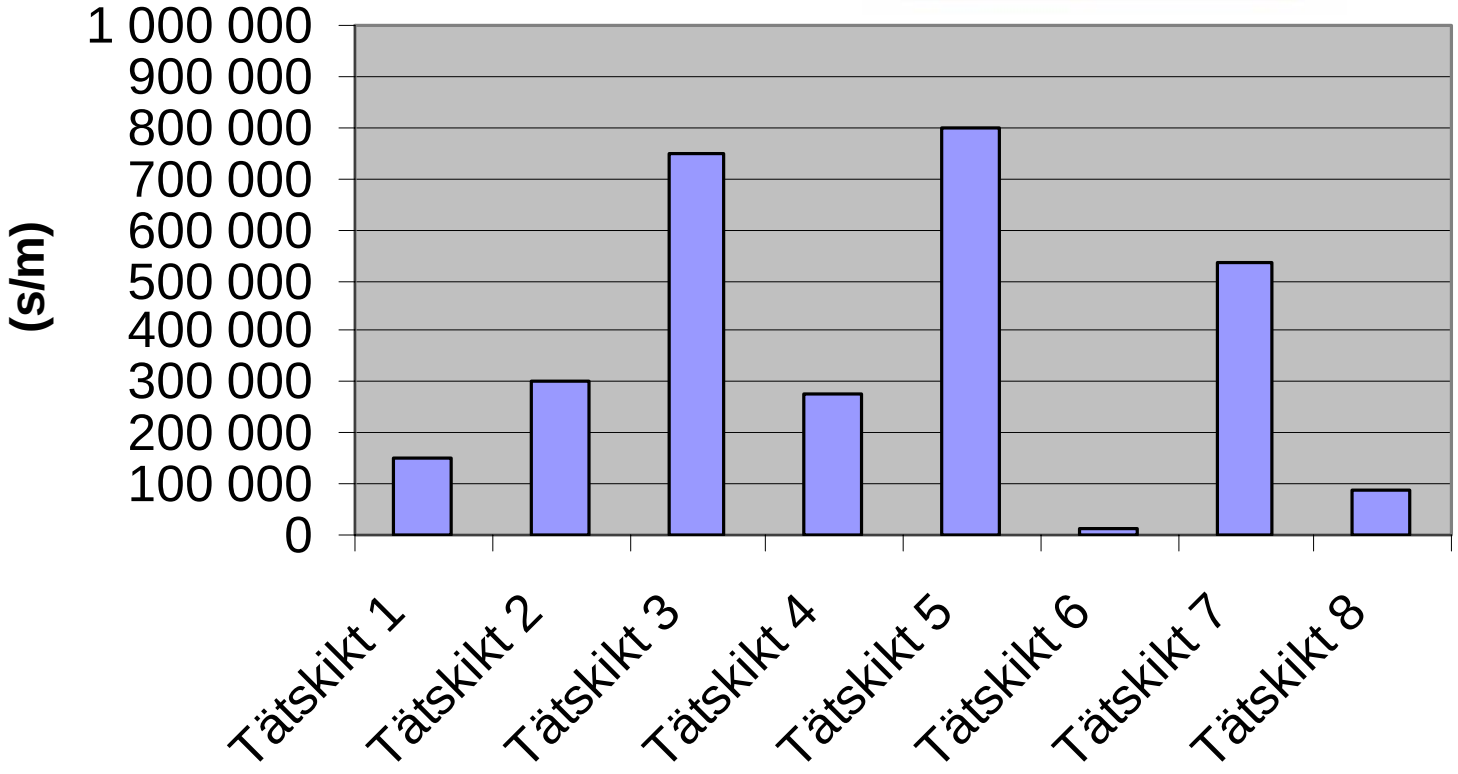
Plastic foil

Water proofing

Is it vapour proof?

Measured values



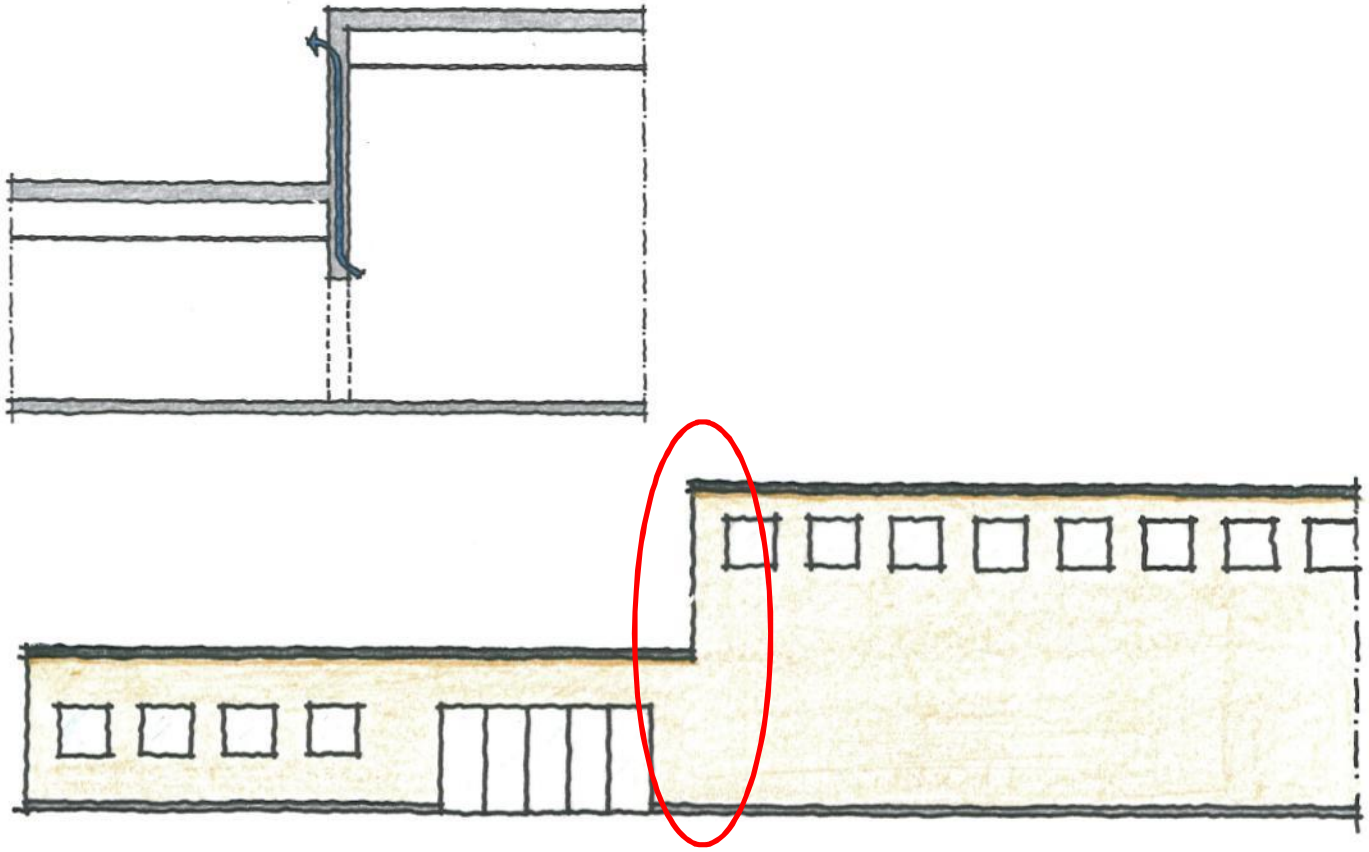


Why did it happen?

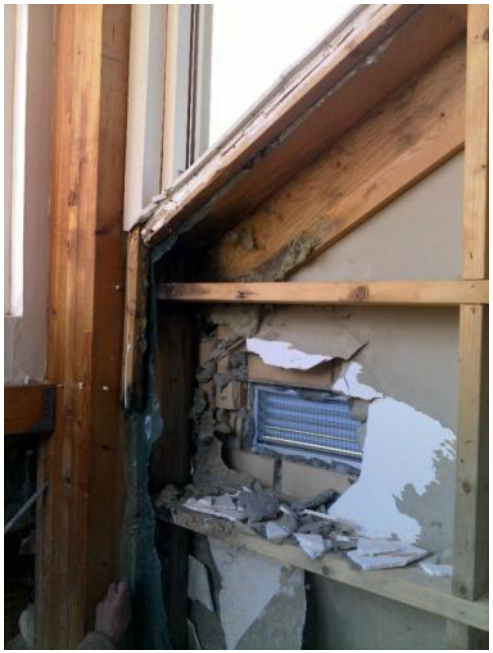
- The water proofing membrane was not intended for this wall construction
- It should be used as water proofing behind tiles on concrete or stone walls
- No one thought of a moisture safety design before applying the membrane on the wall

Never use a moisture sensitive material between vapour tight membranes.

Moisture damage in buildings with extreme indoor climate



Severe damages



Why did it happen?

No respect for the extreme moisture load

Poor collaboration between the construction and ventilation consultants

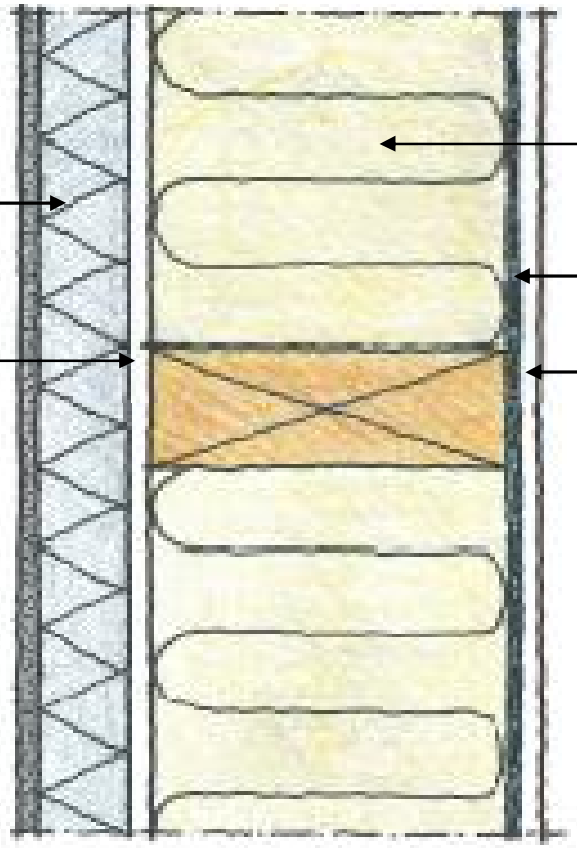
Building structures designed and erected as if it was a residential building

External thermal insulation composite system walls

Rendering

Rigid insulation

Gypsum board, plywood, chip board, mineral based board

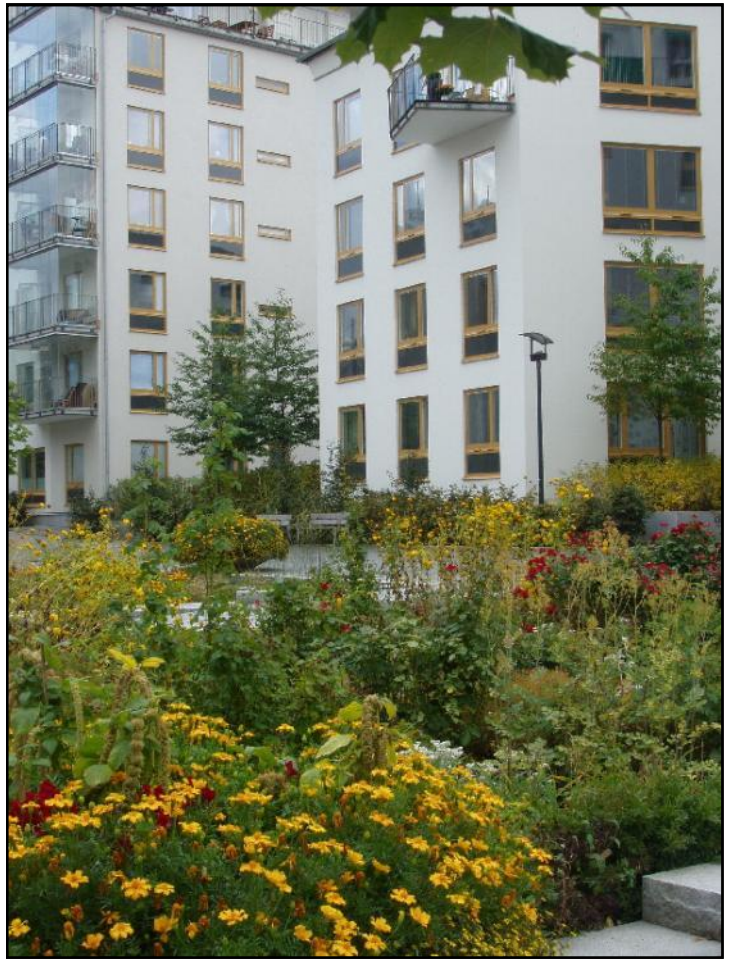


Mineral wool between wooden studs

Air and vapour barrier

Gypsum board

New buildings



New working places

Typical damage

Mould growth on the exterior gypsum board

Rot in a load-bearing beam after two years

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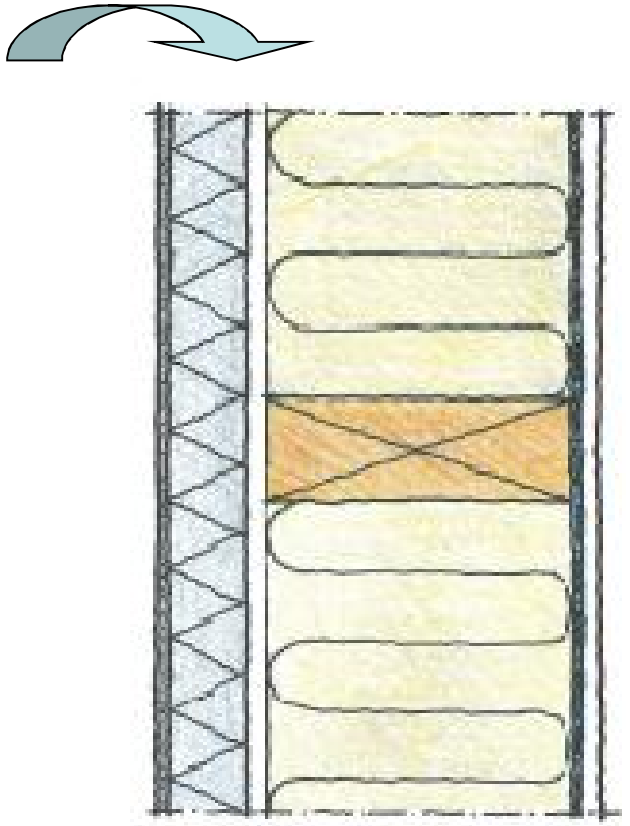
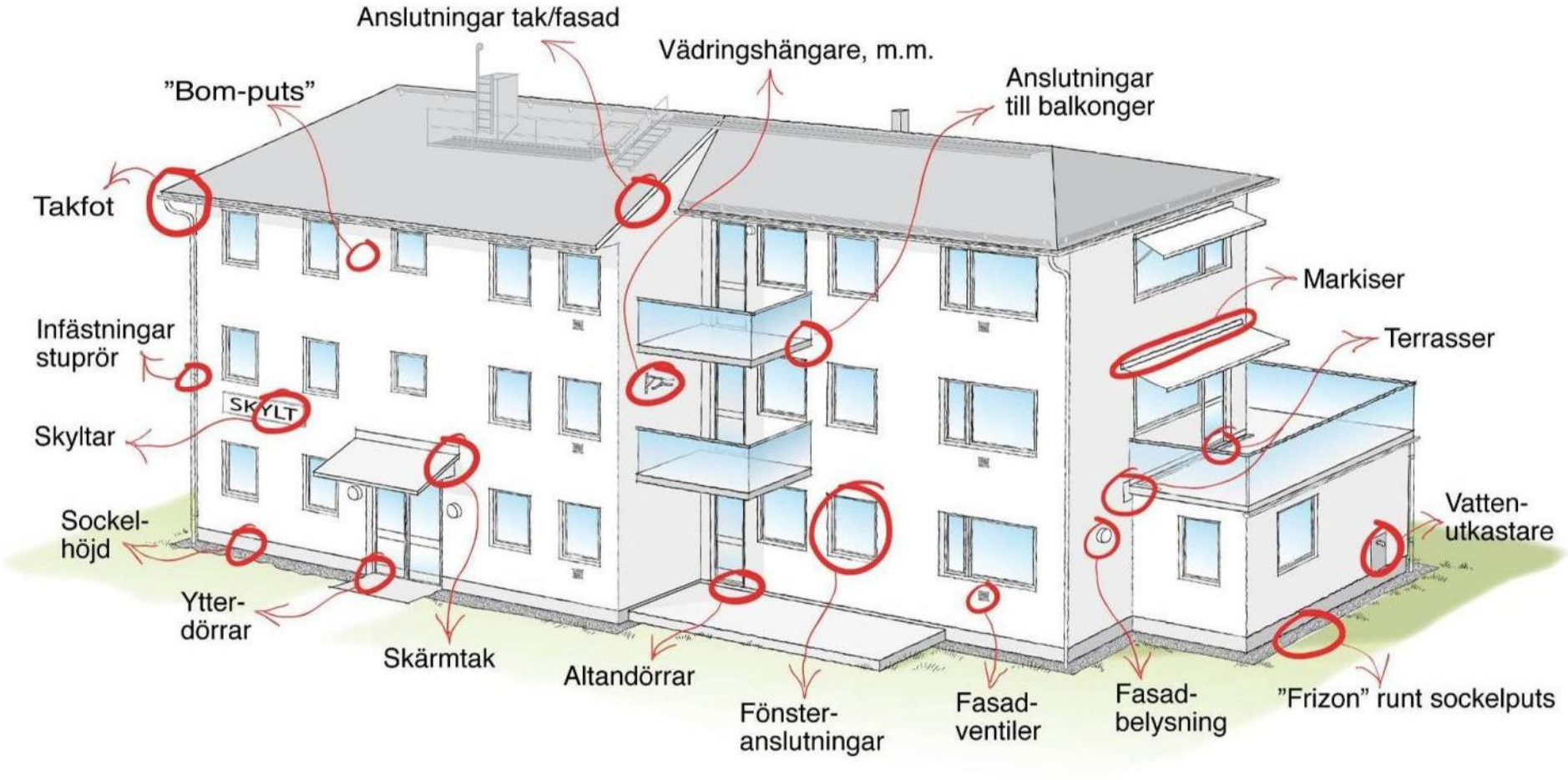
Inward leaking rainwater at details and connections

- Windows and doors
- Canopy
- Balcony
- Awning
- Antenna
- Exterior lamp



A lot of critical details in the facade

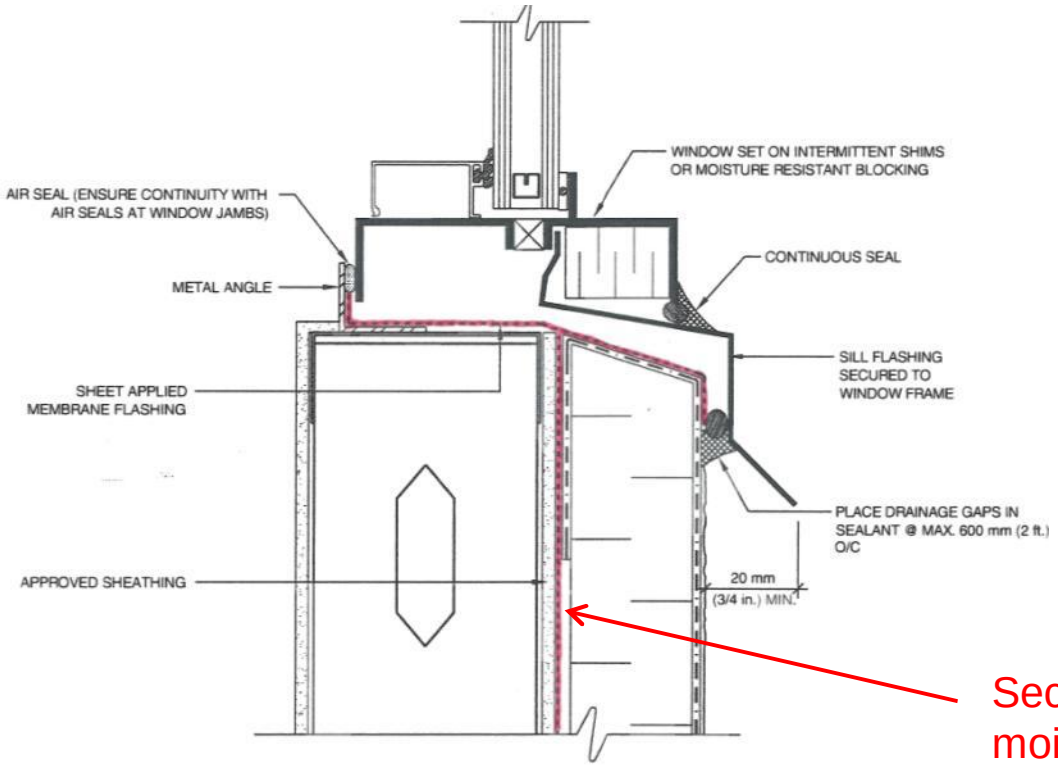


Why did it happen?

- The structure was first used during 1980s
- The walls were carefully built with robust materials
- However, successively the structure changed, thick plaster (> 20 mm) was replaced by thin plaster (2-5 mm) and mineral wool was replaced by polystyrene. And the most important change was absence of careful workmanship
- Bad detailing allowed rainwater to enter the structure
- Moisture was trapped in a sensitive structure
- The damage that occurred was not visible unless the wall was opened

Two ways to solve the problem

- Prevent moisture to enter the structure by better detailing
- Allow moisture to dry out



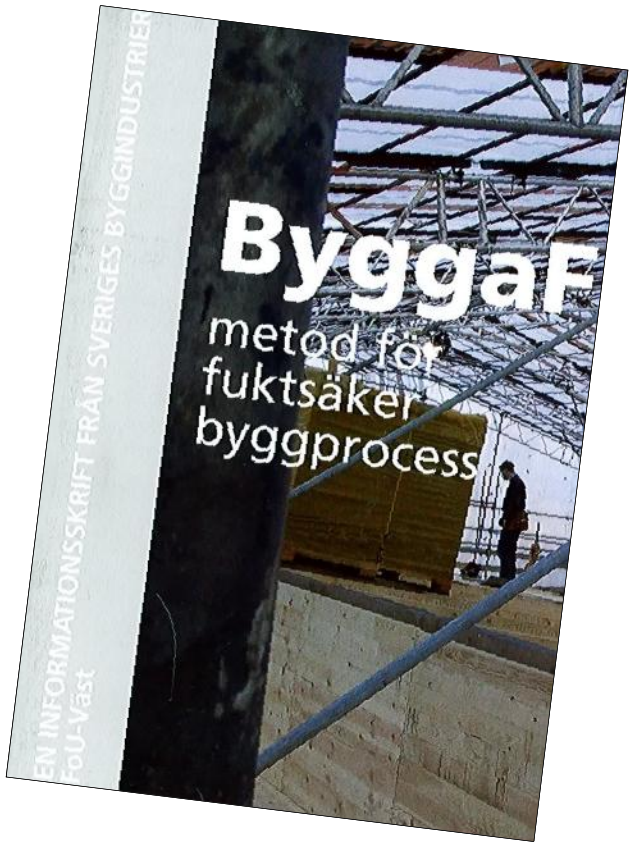
Second wrapping prevents moisture from reaching the sensitive parts of the structure

What do we learn from this?

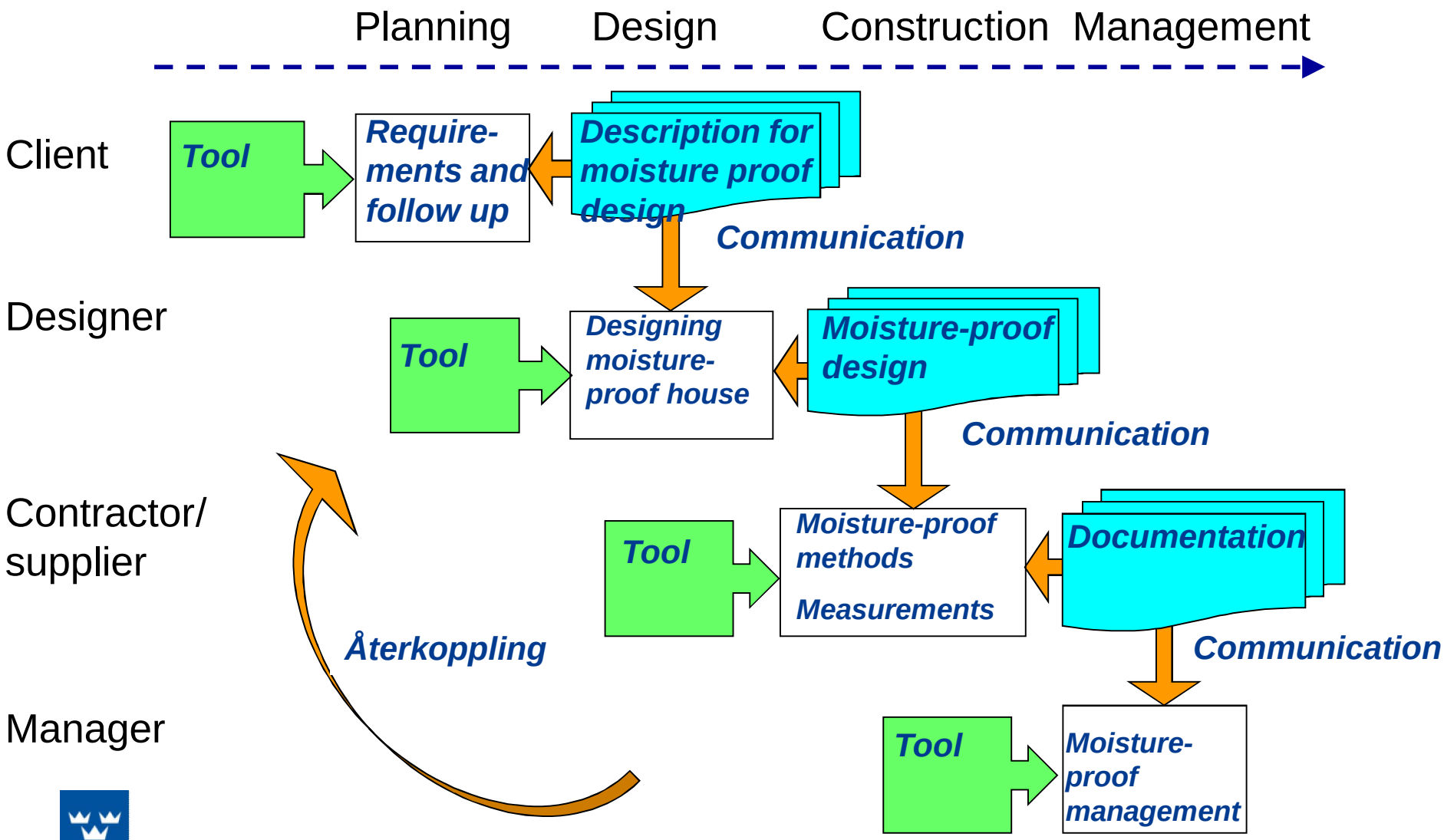
- Do not use vapour tight material that can trap moisture in sensitive materials

Quality management

- ByggaF is a system for moisture protection in the construction process. From planting requirements of clients through the design and construction process to maintenance and use.



ByggaF


Planning
Design
Construction
Management
Client
Designer
Contractor/
supplier
Manager
Tool
Require-
ments and
follow up
Description for
moisture proof
design
Communication
Tool
Designing
moisture-
proof house
Moisture-proof
design
Communication
Tool
Moisture-proof
methods
Measurements
Documentation
Communication
Återkoppling
Tool
Moisture-
proof
management

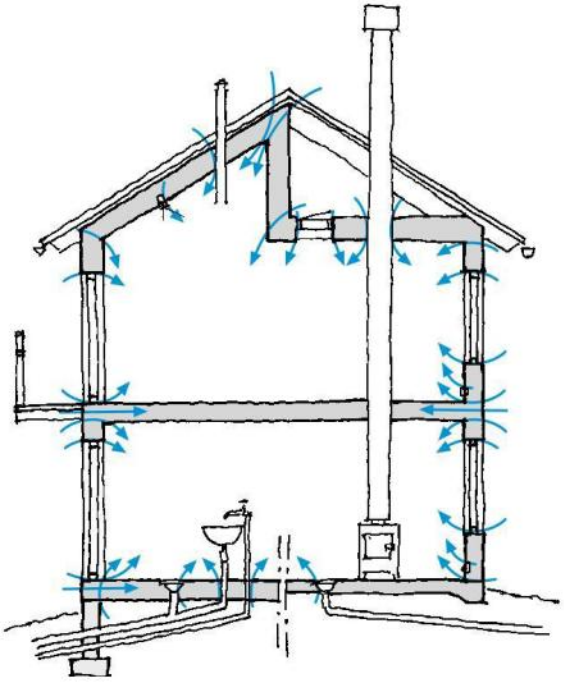
Similar systems for air tightness and energy saving

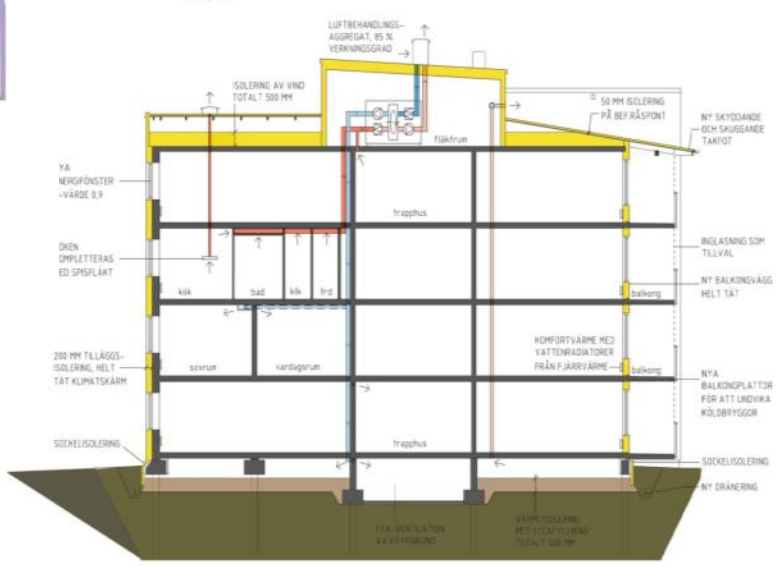
LUFTTÄTT

ByggaL

Program-skede	Byggherrens rutin och checklistor för det egna arbetet och kravformulering	Ambitionsnivå Inventering Kravformulering
Projekterings-skede	Projektörens rutin och checklistor Byggherrens checklista för uppföljning	Utbildning Checklista för projektering Kritiska arbetsmoment
Produktions-skede	Entreprenörens rutin och checklista för produktion av lufttät byggnad Byggherrens checklista för uppföljning	Utbildning Kontrollplan Tidig läcksökning Täthetsprovning

Överlämning och erfarenhetsåterföring





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Who needs building physics?

It seems as if the number of damage cases is increasing.

The more research the more damage.

Do we have the right focus?

Is the research in wrong areas, or is the focus too little on getting information out to the industry

Who needs building physics?

- The industry takes the help of experts when something has gone wrong.
- It would be much better to be involved in the problems from the beginning

We must bring the knowledge to practic use

- The research must continue but be sure to also bring the results to practical use. People in the building sector needs to know not only what to do but also why
- Handbooks, pamphlets and other literature for self-study is good but not enough
- More education is needed on all levels
- Information must be spread and understood
- Certified systems for building components must be more often used when the structures get more and more advanced

So

- Do your research in Building Physics
- Spread the knowledge
- And make sure that the results will be used

Think of this

- Some buildings are landmarks because of their architectural qualities
- But when will we se buildings that are landmarks because of their building physics qualities?

- I do not think that this will ever happen. It is considered obvious that buildings are sound, energy efficient and without moisture damage.
- This is what we must face. We must do our best and hopefully we will get credit for this even if it is considered obvious.