

How to ensure high performance in large well insulated roofs

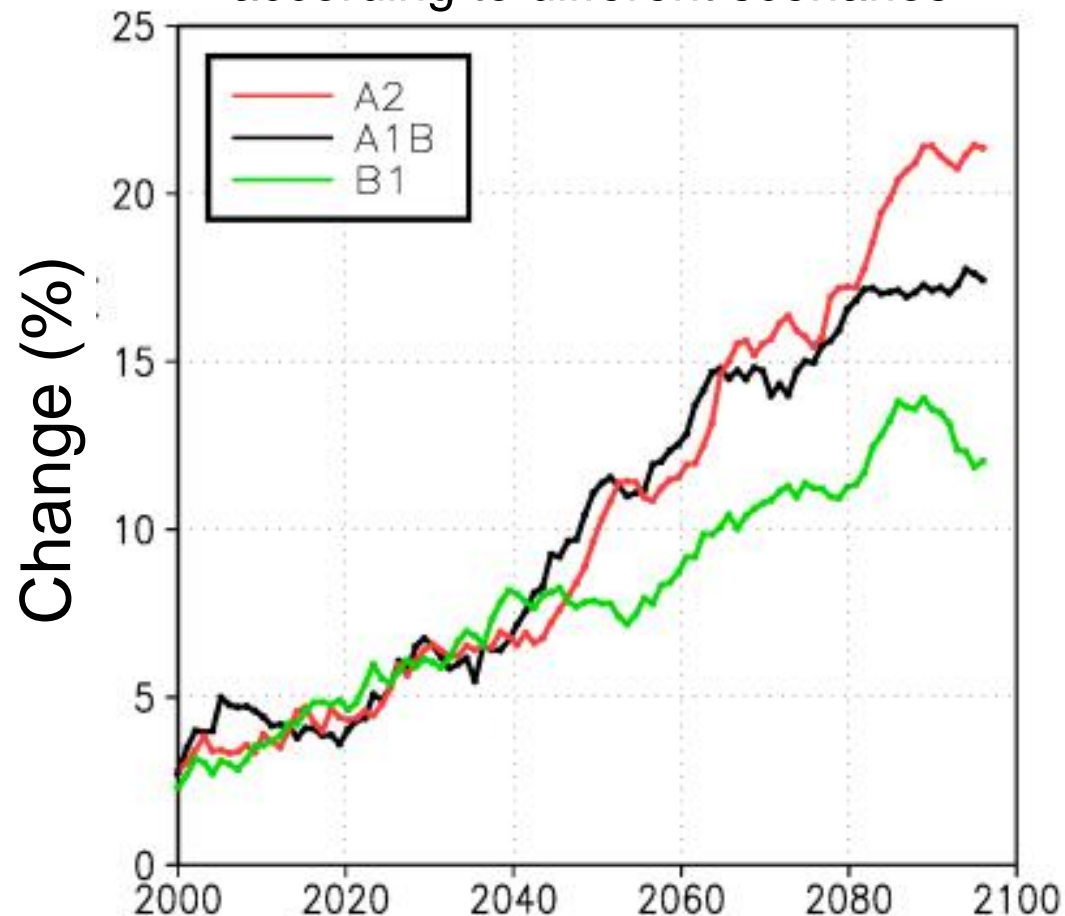
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Climate change

Yearly average rainfall in Finland according to different scenarios



- Possible long-term changes in climate in the North
 - Average temperature increases
 - Precipitation in winter increases
 - Cloudiness in winter increases
 - Snowfall decreases
- Consequences
 - Rain load on buildings increase
 - Conditions for mould growth increase
 - Possibility of rain leaks increase
- Hygrothermal quality requirements!
- **Climate change increases the moisture risk level in all buildings**

Amount of moisture

Reason for moisture	g/m ² h
Rain [■]	0,65 – 2,40
Diffusion	0,002
Air leakage	0,036 – 5,20
Built-in moisture	0 – 0,300
TOTAL	0,688 – 7,902

- Rain, with 1% of rain leaking in.

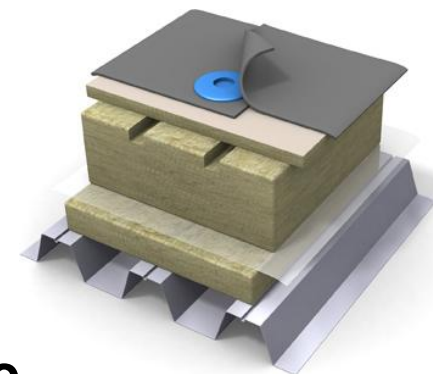
Normal and worst case gives big variation

Moisture in building structures

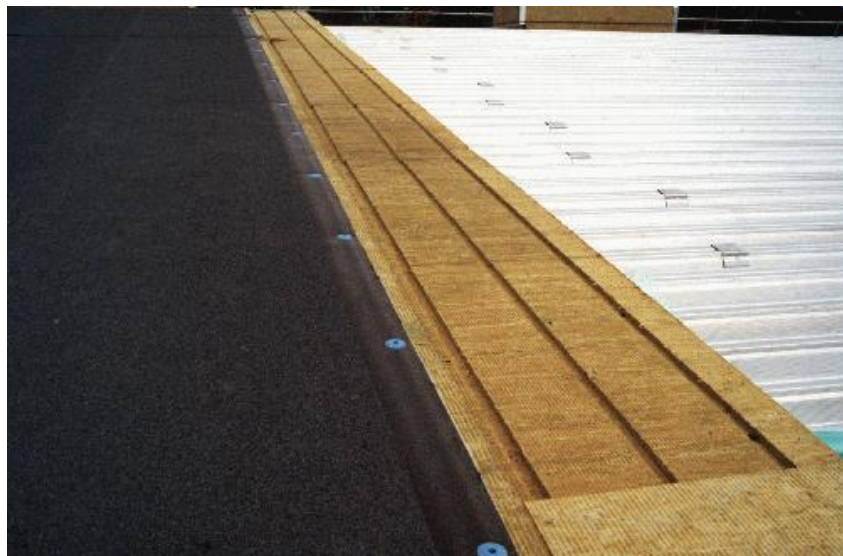
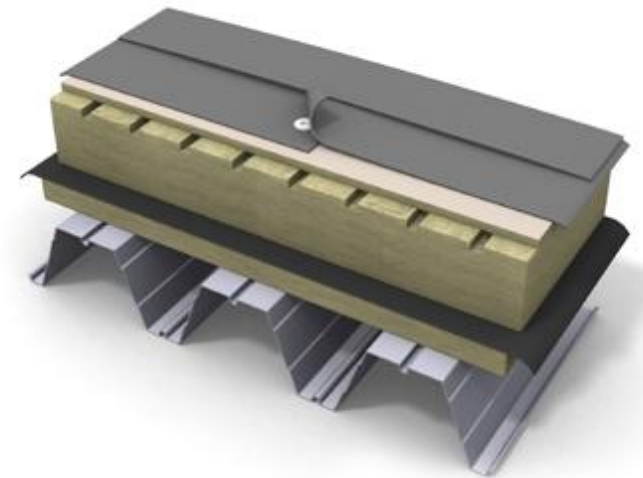
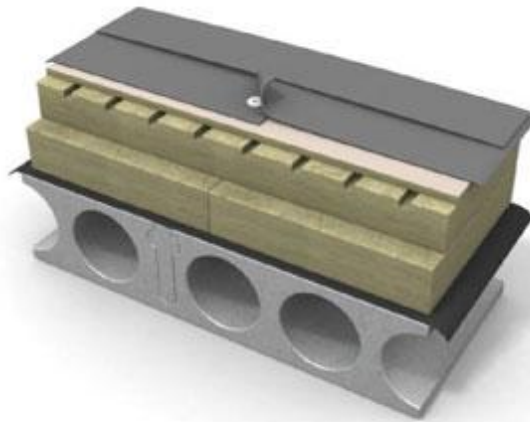
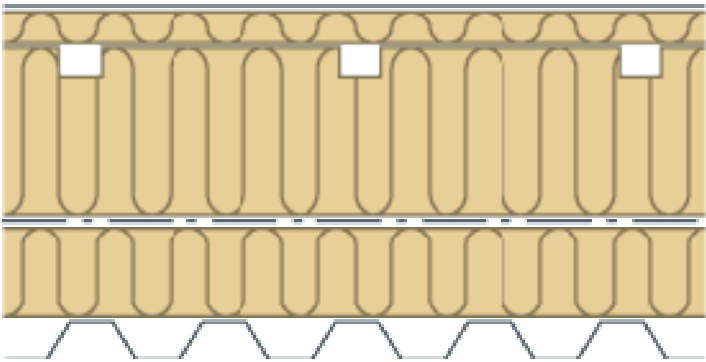
- Moisture damages are one of the main cause bad indoor air qualities and they affect the occupants´ health and comfort.
- Moisture is the main cause of deterioration of building materials and structures

Ventilated roof: Scope of application

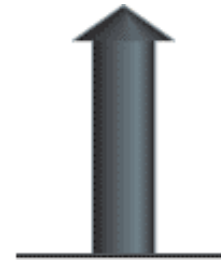
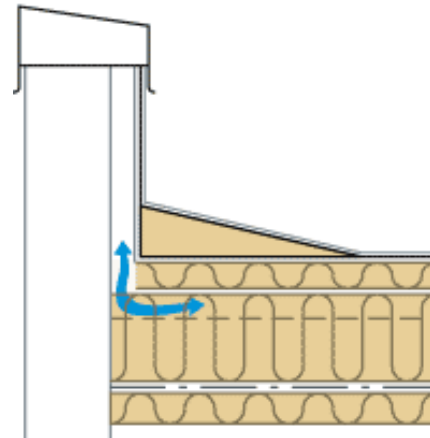
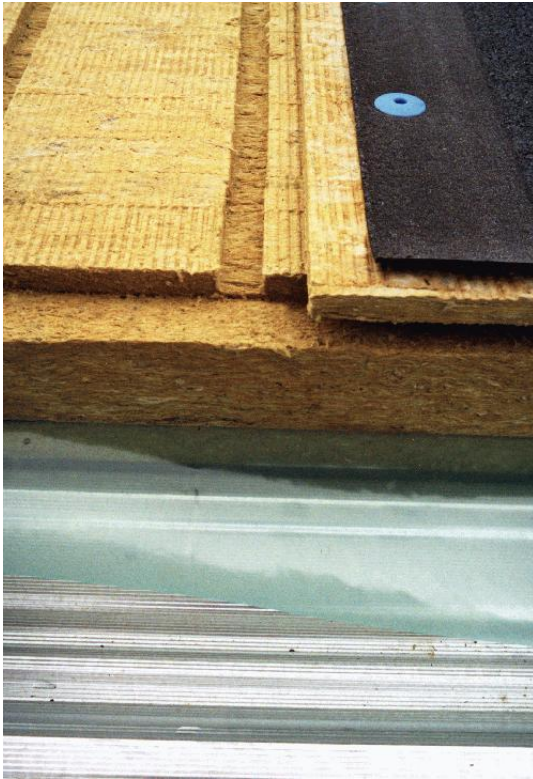
- “To ensure the drying of built-in moisture, and ensure a proper performance of the roof by minimizing the moisture risks during the life-circle of the roof”.
- No mechanical ventilation is needed
- Pre-requisitions for performance:
 - Design and construction made according to guidelines
 - Materials, construction methods and work supervision are carried out according to good workmanship.



Ventilated roof



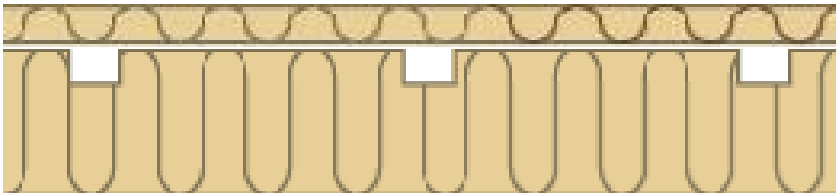
Openings



Performance of the grooves



- Micro climate around the building is the main driving force for the groove ventilation. Air speed 0,01 – 0,10 m/s.
- The air flow direction in the grooves is not constant but changes according to changes in the pressure field.



Vapour barrier

Housing, offices and commercial buildings: Low indoor humidity in winter
< 50 %

Water vapour resistance 500-1000 m² s Pa/kg

Schools, sports halls, process industry: Medium indoor humidity in winter
> 50 %

Water vapour resistance 1000-2000 m² s Pa/kg

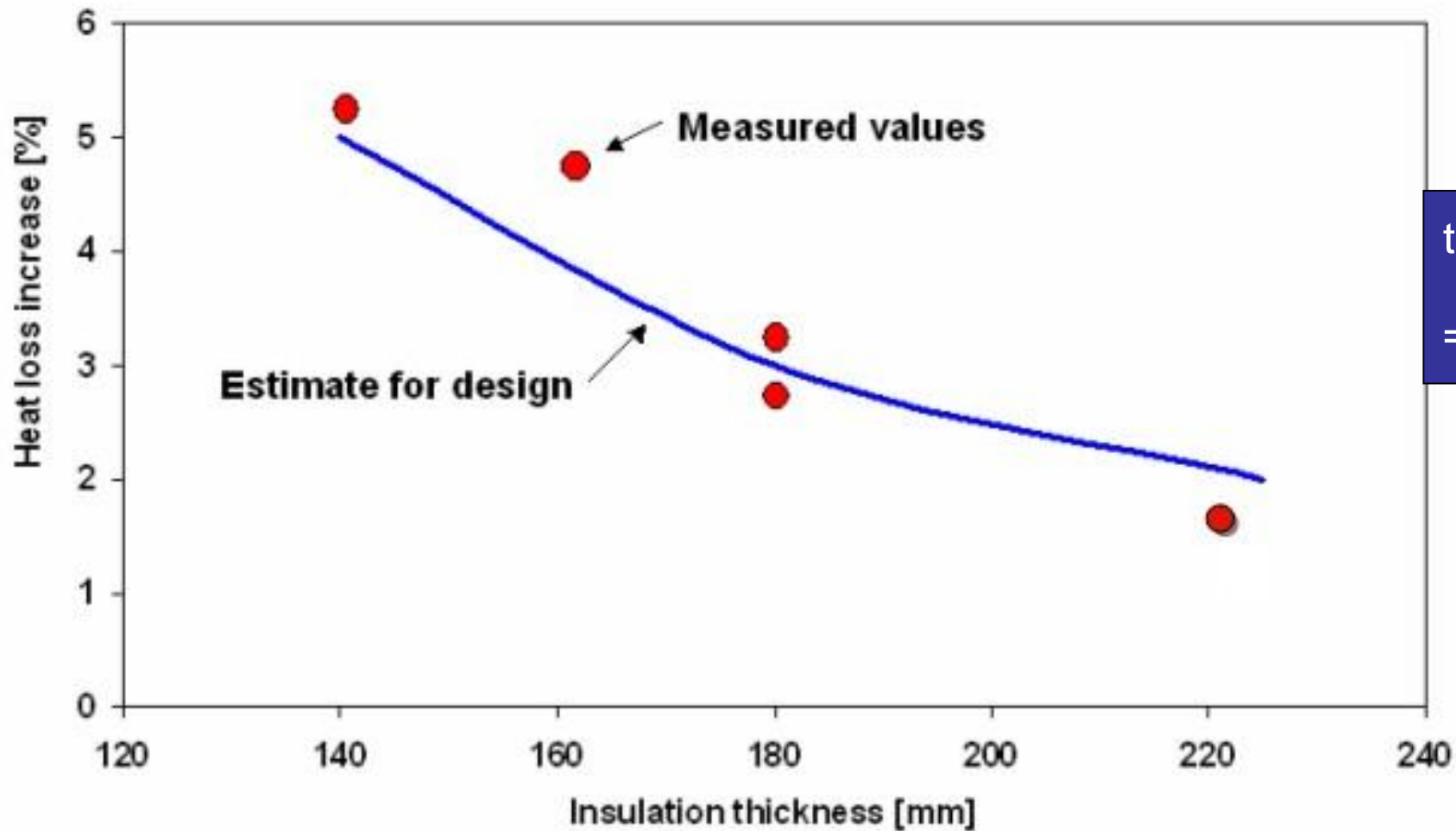
Swimming halls, pulp industry: Extreme conditions in winter especially
below roof > 80 %

Water vapour resistance 2000-10000 m² s Pa/kg

Vapour barrier can be , e.g., a bitumen membrane or rubberized bitumen membrane, or product with vapour resistance 500×10^9 m² s Pa/kg, minimum

Roof ventilation and heat losses

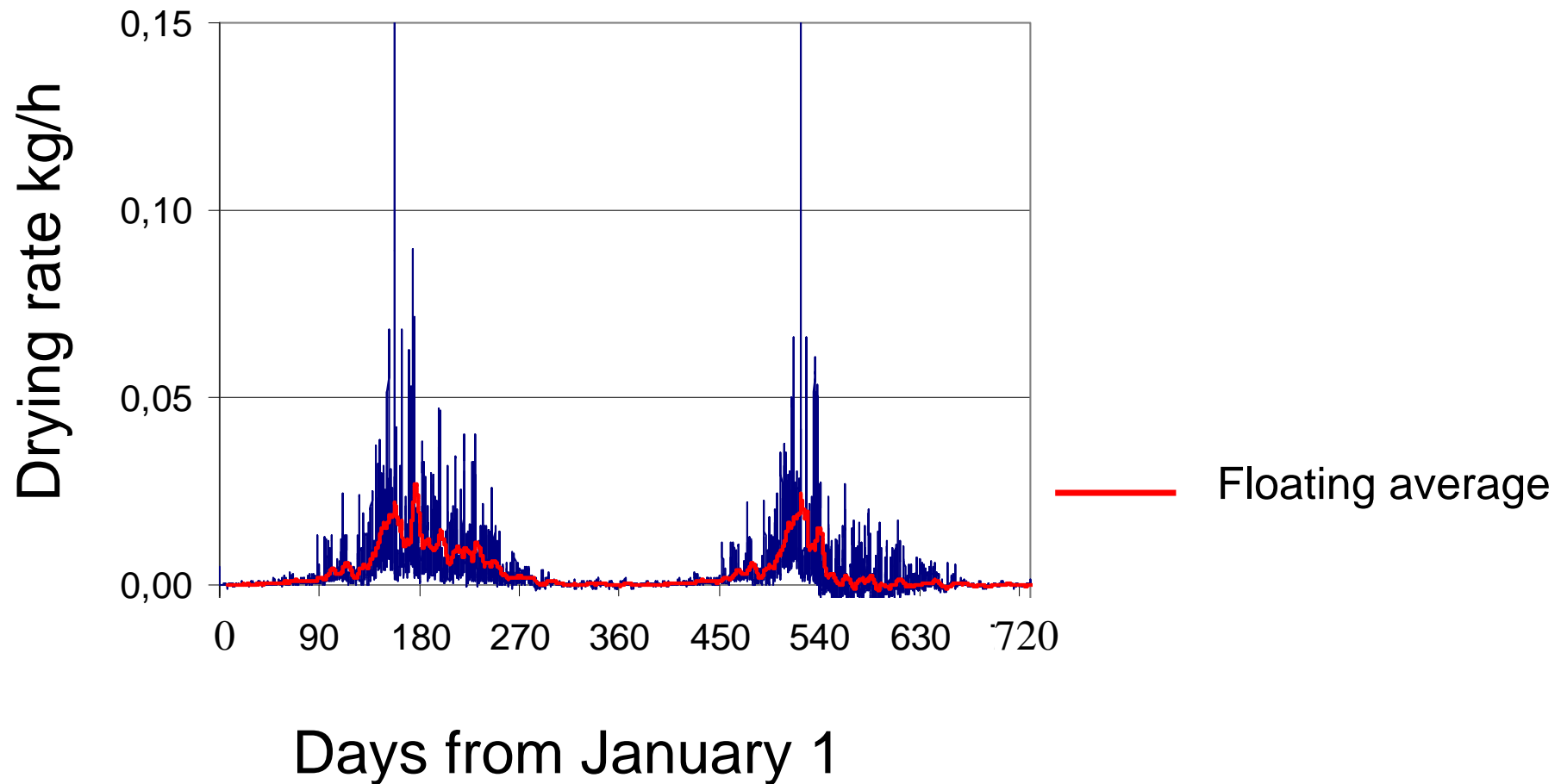
Effect of ventilation on heat loss



$t > 200 \text{ mm}: + 2\%$
 $= 0,001 \text{ W/m K}$

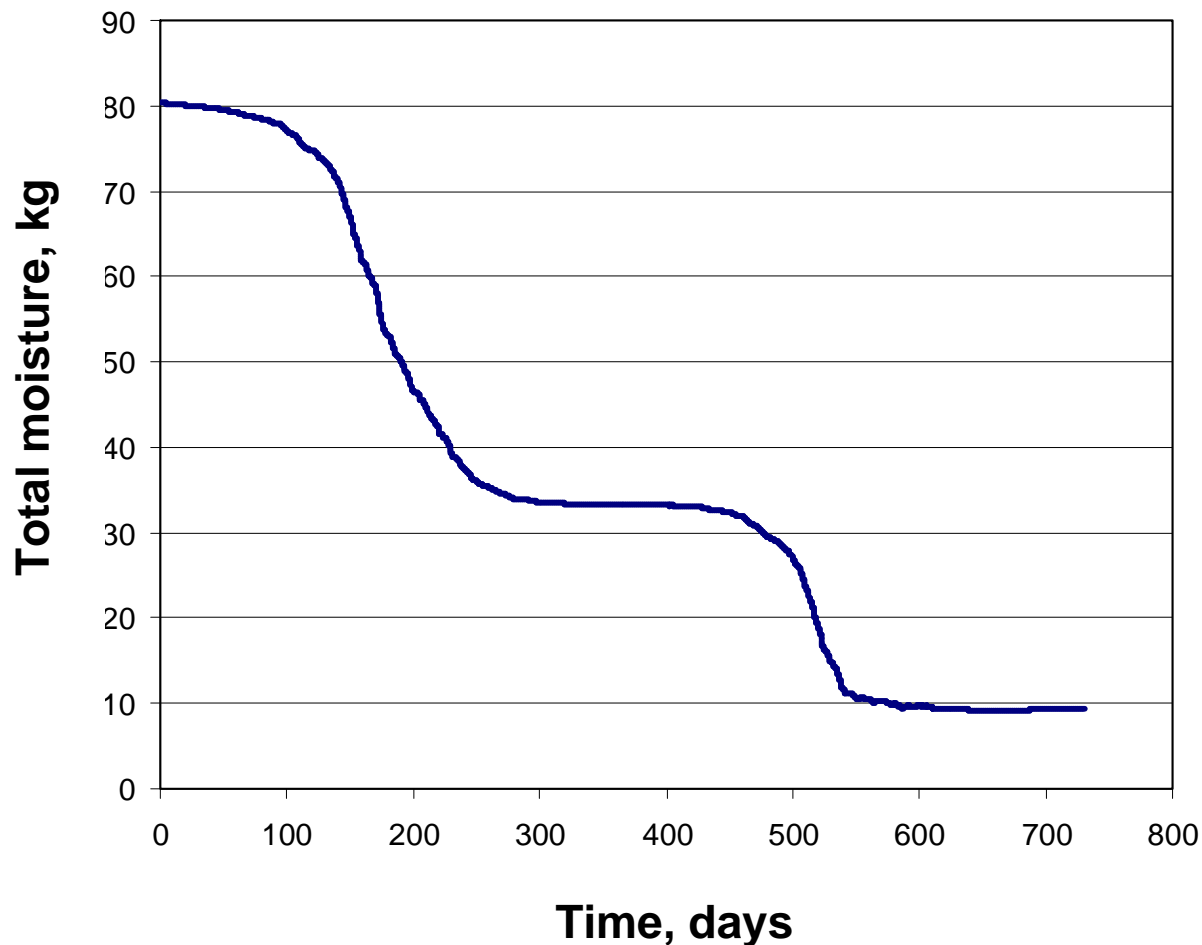
Drying potential, cold continental climate

10 x 1 m² roof, ventilation 0,1 m³/m² h



Outcome in practise

Drying through ventilation



Example:

40 m² of wet roof due to rain during installation

Average moisture 10 % of weight corresponding to 2 kg/m²

Drying through ventilation, start January 1

Ventilation design step by step

Step 1

Identify type of use for the building

Step 2

Identify outdoor conditions

Step 3

Identify the roof ventilation conditions

Step 4

Identify roof type and required U-value

Choose of roof combination slabs, thicknesses of:

- Top layer
- Grooved layer
- Middle layer
- Bottom layer

Design step by step, continued

Step 5

Define moisture conditions and required ventilated rate

Step 6

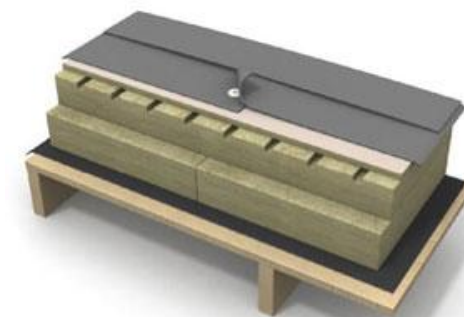
Define Ventilated area

Step 7

Define Dimensions for a ventilated area

Indoor air humidity in winter

Example of buildings	Indoor climate type, humidity in winter
Warehouse	Dry; < 30 %
Shopping centre	Low; < 40 %
Housing	Average; < 50 %
Office	Average; < 50 %
Process industry, sport halls	High; > 50 %
Swimming hall, pulp industry	Extreme; > 80%



Types of outdoor conditions

Climate type	Locations
Cold continental	Kiruna, Jyväskylä, Rovaniemi, Moscow
Mild continental	Kiev, Minsk, Warsaw, Riga
Cold maritime	Helsinki, St Petersburg, Stockholm, Tallinn
Mild maritime	Copenhagen, Gothenburg Oslo
Rainy maritime	Bergen

Total maximum moisture load

Calculated moisture load for dimensioning:

Climate	Total moisture load; kg/m ²	Average moisture load; g/m ² /h
Cold Continental	7,5	0,86
Mild Continental	6,5	0,74
Cold maritime	6,5	0,74
Mild maritime	5,7	0,65
Rainy maritime	8,2	0,94

Source: RESEARCH REPORT No VTT-R-03394-06

Roof ventilation conditions

Groove ventilation conditions	Open or low density area	Dense-developed area	Windscreen by topography or forest
Excellent	1 level roof, some obstructing structures	1 level roof, without obstructing structures	Forest high building, 1 level roof without obstr. struct.
Good	1 level roof with obstr. struct.	1 level roof, some obstr. struct.	1 level roof without obstr. struct.
Fair	Roof in 2 or more levels	1 level roof with obstr. struct.	1 level roof, some obstr struct.
Poor	Roof in >2 some obstr. struct.	Roof in > 2 levels	1 level roof with obstr. struct.

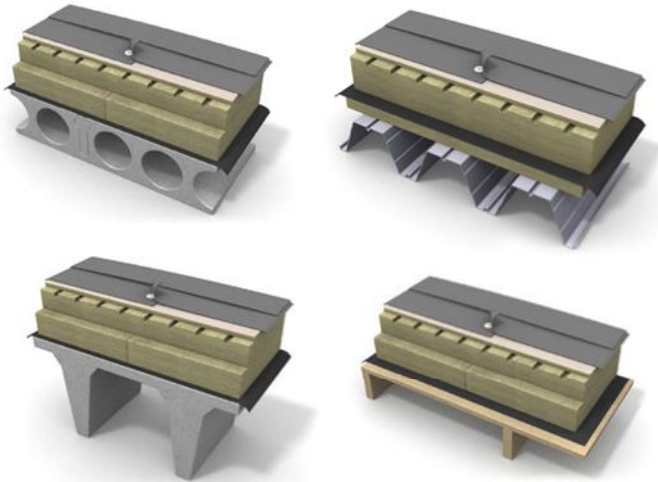
U-values and thicknesses

$R_{\text{membrane}} = 0.04 \text{ m}^2\text{K /W}$; $R_{\text{si}} + R_{\text{se}} = 0.14 \text{ m}^2\text{K /W}$

$\lambda_{\text{board}} = 0.039 \text{ W/m K}$; $\lambda_{\text{slab}} = 0.037 \text{ W/m K}$ with grooves

U-value	Total thickness	Bottom layer	Middle layer	Grooved layer	Top layer
0,10	360	60	140	140	20
0,11	330	50	120	140	20
0,12	300	60	120	100	20
0,13	280	60	100	100	20
0,14	260	60	80	100	20
0,15	240	60	80	80	20

Step 4



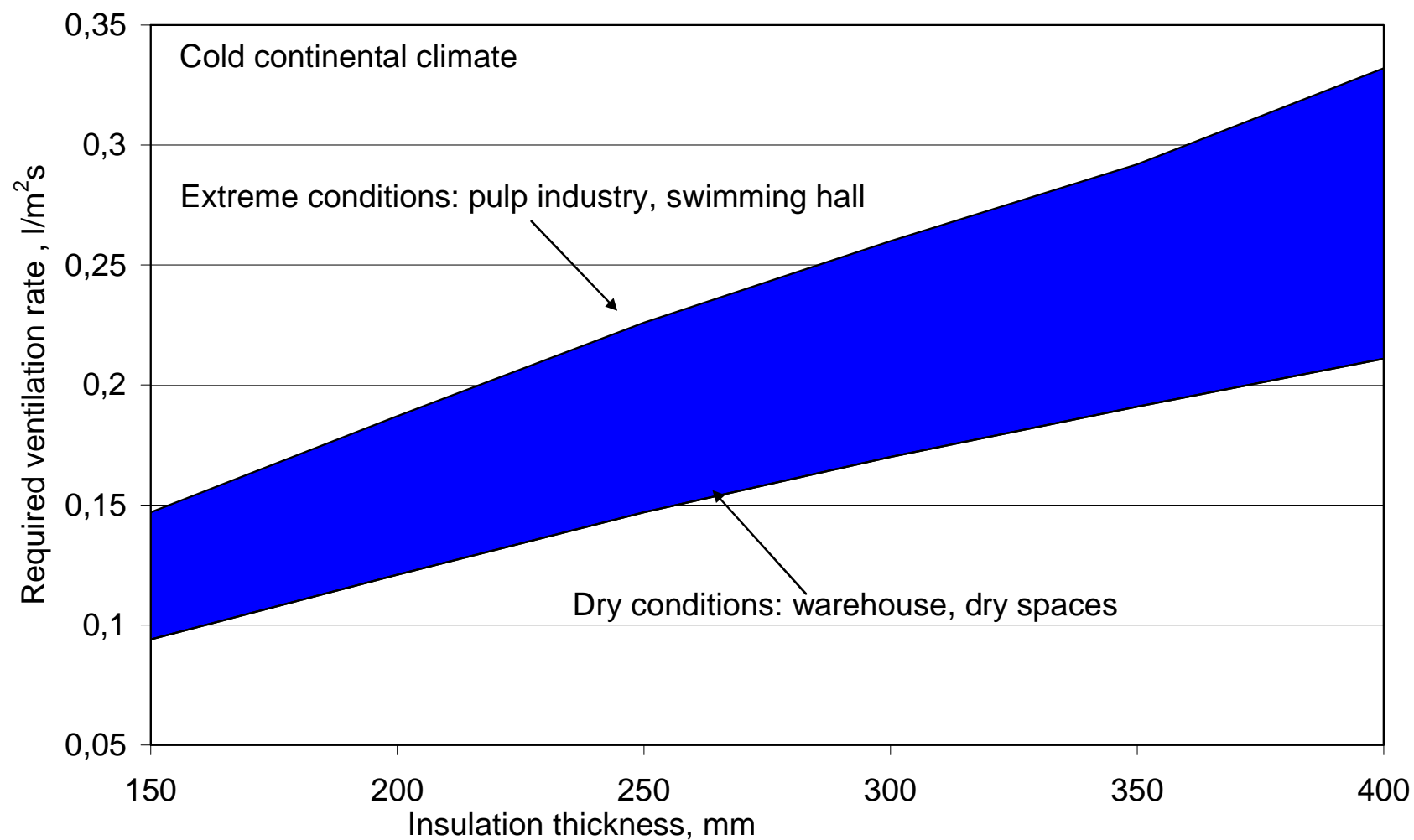
Build up of the roof

Recommended thicknesses of insulation layers from bottom to top

Alternative 1	Vapour/air barrier	Bottom layer	Middle layer	Grooved layer	Top layer	Roofing
	Bitumen membrane	30 -160 mm	30 - 160 mm	100 -160 mm	20 - 30 mm	According to design
Alternative 2	Bottom layer	Vapour/Air barrier	Middle layer	Grooved	Top layer	Roofing
	20 - 50 mm	Bitumen membrane	30-160 mm	100 -160 mm	20 - 30 mm	According to design

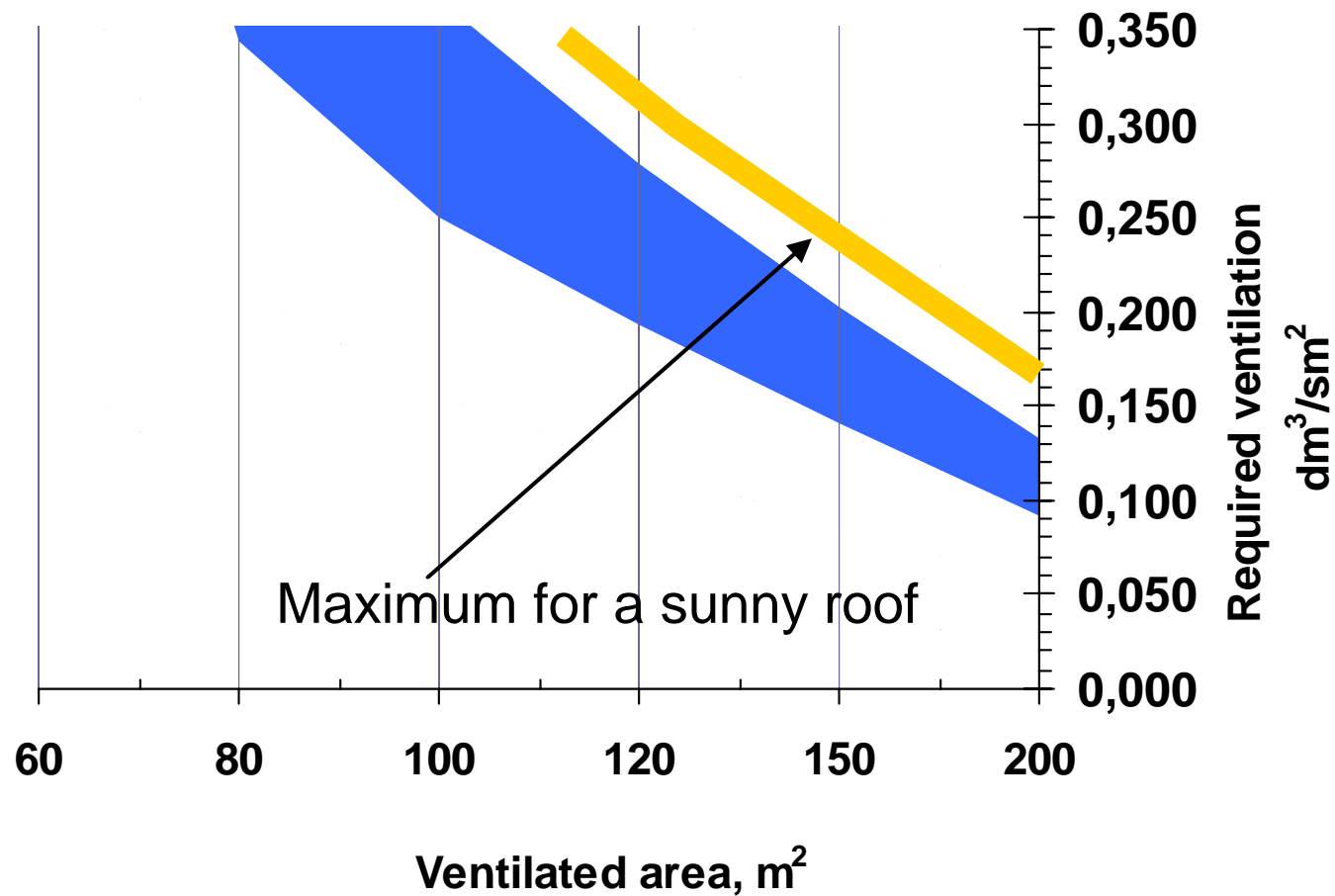
Define moisture and required ventilation rate

Cold continental climate

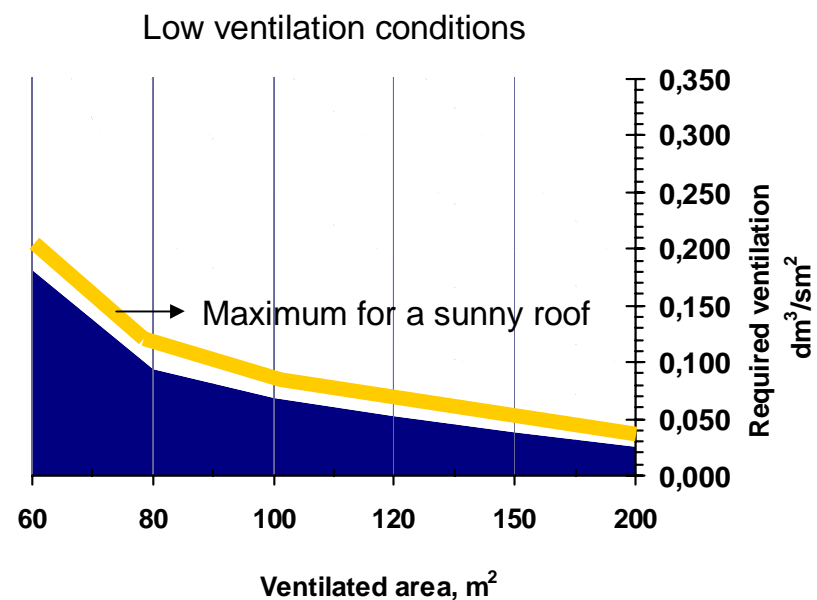
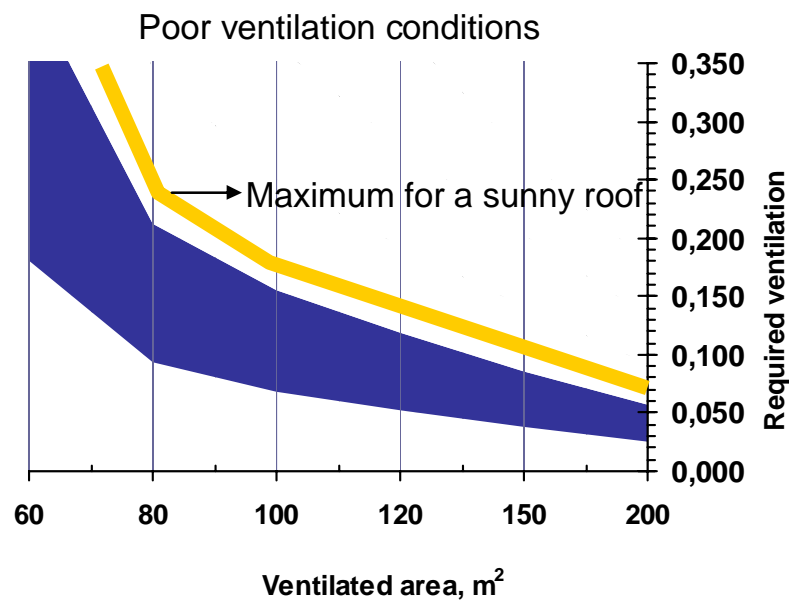
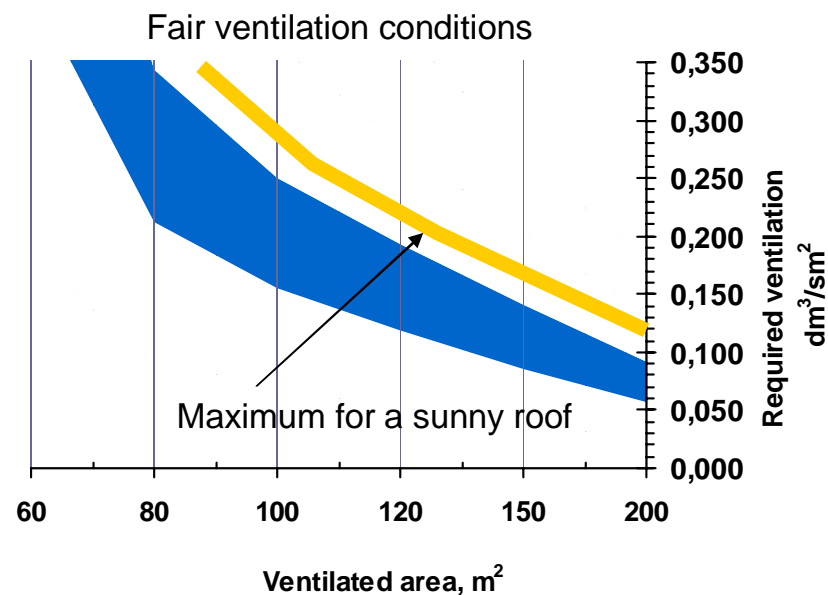
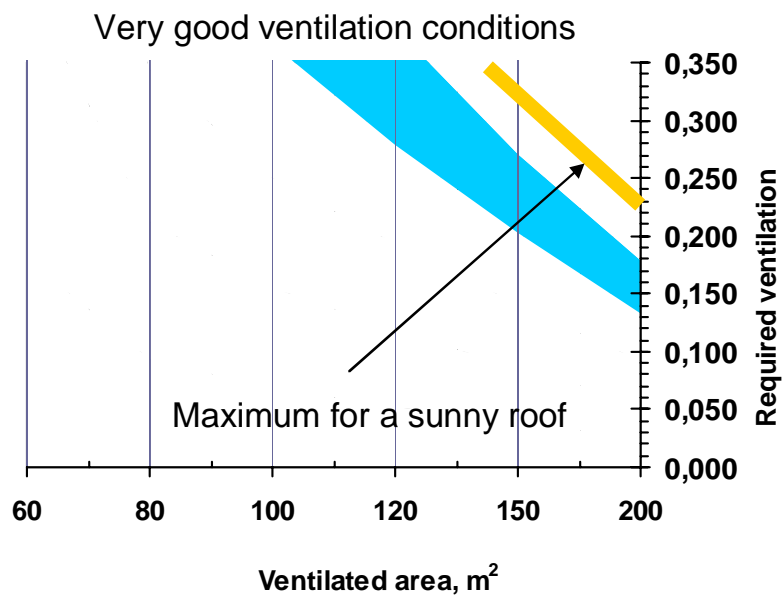


Define ventilated area

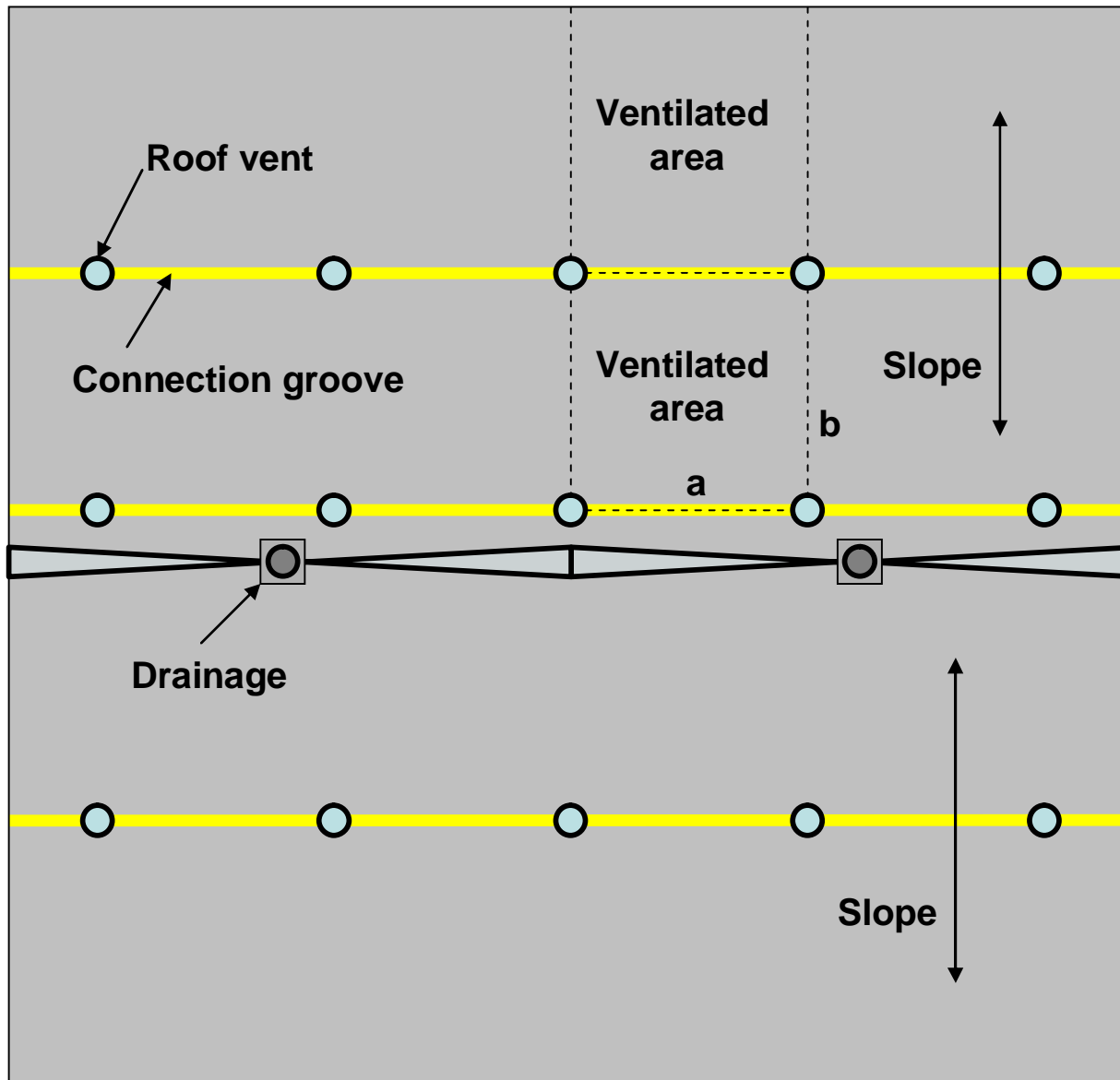
Good ventilation conditions



Other Ventilation conditions



Define ventilated area



Ventilated area = a x b;

a = distance between hoods

b = distance between connecting grooves

Suggested length of ventilated area

Indoor climate type	Roof characteristics	Open area No solar, m	Open area Solar, m	Shady area No solar, m	Shady area Solar, m
Dry, Ware house	1 level Large roof	20	20	20	20
Average humidity Offices, schools	Moderate area several levels	15 - 20	20	10 - 15	15 - 20
Extreme humidity Swim hall	Large roof, High building	< 10	10 - 15	< 10	10 - 15



Conclusions/Suggestions

- Moisture can be calculated
- Air leakage is the main problem
- Average ventilation guarantee drying
- Design based on required air flow rate
- Maximum length is set depending on available wind conditions



Thank You!