

MOISTURE GUIDE

PAROC STONE WOOL



PAROC[®]

CONTENT:

1. Moisture

1.1. Moisture transport mechanisms.....	3
1.1.1. Bulk moisture and building moisture	3
1.1.2. Convection	3
1.1.3. Diffusion	6
1.1.4. Capillarity	6

2. Moisture and building envelope design

2.1. Foundation.....	7
2.2. Frost and floor insulation	9
2.3. External walls	11
2.4. Roof	14
2.5. Eaves and roof drainage systems	15
2.6. Design details (joints, flashings and other connections)	15
2.7. Air ventilation & Plumbing	16

3. Moisture risks

3.1. Corrosion	17
3.2. Mold	17
3.3. Loss of performance.....	18

4. Mold calculation for most typical constructionst

19

5. Moisture properties of Paroc stone wool

5.1. Moisture properties	23
5.2. Air and moisture control	25

6. Importance of Dry chain in building process.....

26

1. MOISTURE

We are surrounded with water. It covers 71% of the Earth's surface and is vital for all known forms of life. Water is present in the form of solid, liquid or gas.

The sun's heat recycles our planet's water as it evaporates into the atmosphere from the oceans, lakes, soil, people and vegetation. The term humidity generally refers to the amount of water vapor in the atmosphere. Humidity is most often used to describe how a person feels, often in conjunction with heat. If it is hot and humid, the air is usually uncomfortable.

The term moisture is used for all forms of water. Moisture is a measurable amount of water in air or another material.

1.1. MOISTURE TRANSPORT MECHANISMS

Building science is concerned with four different moisture transport mechanisms and their effects in buildings: transport of bulk moisture, humidity transported by air via convection, water vapor diffusion and capillary moisture movement. This means that moisture does not only enter a building in the form of liquid water or snow. The moisture movement can also be invisible and, thus, harder to control.

1.1.1 Bulk moisture and building moisture

"Visible" bulk moisture is the most frequent and widespread cause of building moisture problems. The primary sources of bulk moisture are external to the building and come from the climate (e.g. rain) and the earth (e.g. ground water). However, internal sources, such as plumbing leaks and wet cleaning processes, are also considered as bulk moisture.

Liquid water can enter the building via unexpected directions. Wind-driven rain or driving rain is rain to which the wind gives a horizontal velocity component. It is one of the most important moisture sources affecting building facades.

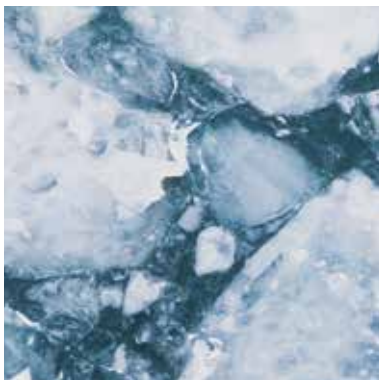
Building moisture is the excessive moisture subjected to building materials during their manufacturing process, storing or installation. This moisture aims to evaporate or dry during the construction process and building use. Building moisture is the amount of water that is removed from the structure before the structure is in moisture balance with its final environment. The moisture content of the building materials varies from 0 to 320 kg/m³.

1.1.2 Convection

"Invisible" moisture is more difficult to understand and avoid. In convection, moisture passes through warm air flow. This air flow can be either forced (air ventilation) or natural. The maximum amount of water which the air can contain depends on the air temperature. The amount of vapor in the air is described in two ways, either as vapor pressure (p , [Pa]) or as partial vapor density (v , [g/m³]).

Saturation density (v_k) or saturation pressure (p_k) tell us the maximum amount of vapor in the air at a specific warmth (either as density g/m³ or as pressure Pa). When the saturation pressure is exceeded, water vapor starts to condensate to liquid water if suitable condensation surfaces are available. These kinds of surfaces can be any solids.

The amount of water vapor in the air is usually less than that required to saturate the air. The relative humidity is the percentage of saturation humidity, generally calculated in relation to saturated vapor density.



Humidity is calculated as a percentage (%)

Relative humidity (RH) =

$$\frac{\text{Aktual vapour density pressure (v)}}{\text{Saturation vapour density pressure (v}_k\text{)}} \times 100\%$$

The most common unit for vapor density (v) is g/m³.

The relative humidity is a consistent measurement of the humidity only if combined with the corresponding temperature. For example, if the actual vapor density is 10 g/m³ at 20°C and the saturation vapor density at 20°C is 17.3 g/m³, then the relative humidity is 57,8%. Comfortable RH for indoor air is 40–60%.

Relative humidity =

$$\frac{10 \text{ g/m}^3}{17,3 \text{ g/m}^3} \times 100\% = 57,8\%$$

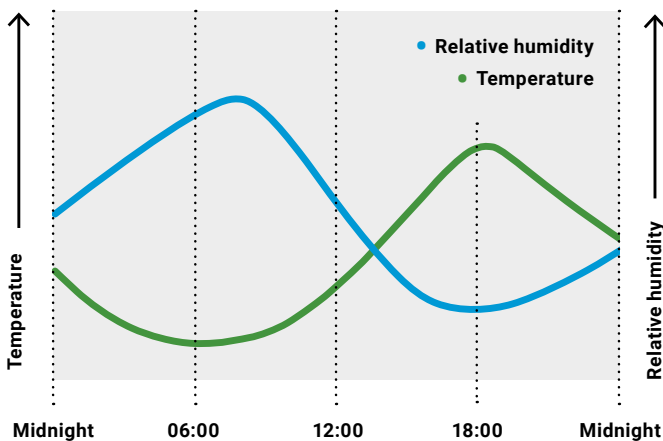
The term absolute humidity is easier to understand as it tells how much water there is in the volume of air (g/m³). For example, if we had 1 m³ of dry air in the vessel at a temperature of -10°C and add there 5 g of water, what would happen? From the table below, we can see that the saturation content of air at -10°C is 2.2 g – so part of the water (2.2 g) would vaporize to the air and the rest of the water (2.8 g) would freeze to the bottom of vessel. The absolute humidity value changes as air volume expands and contracts.

Common water vapor sources in buildings include diffusion due to vapor pressure difference, evaporation from people, wet surfaces and processes, generation from combustion, infiltration from outside and ventilation airflow. A reduced ventilation level inside the house increases the relative humidity. With proper ventilation, the vapor content will remain within feasible limits.

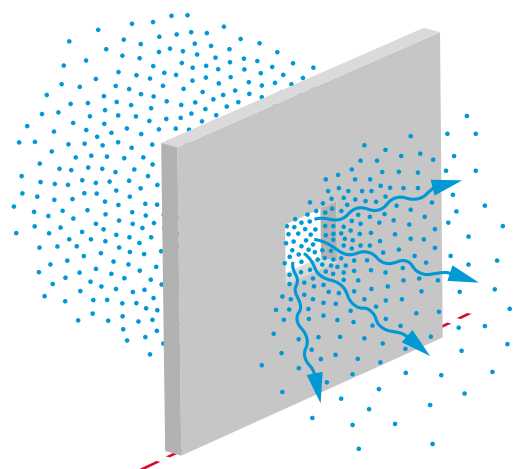
Water vapor is transported by warm air. The warmer the air, the bigger the amount of moisture is moving with it. When air finds a hole or crack from the envelope structure, warm indoor air leaks outwards through it due to temperature difference between outdoors and indoors. These small defects in the envelope might cause a big problem as one 10 mm-hole throughout the whole structure with 2 Pascal's air pressure difference across the structure can cause 1 liter of water transfer per month. It is good to note that this kind of moisture transportation requires that a hole or crack is going through the whole structure. A small hole in a vapor barrier behind an intact gypsum board will not cause any damage.

As the humid air travels through a building envelope, the moisture in it will condense on any tight surface whose temperature is below the dew point, i.e. when the saturation vapor pressure is reached.

The dew point is the temperature at which water vapor transforms into liquid water. This is a function of both temperature and the amount of moisture in the air. Water vapor will only condense onto another surface when that surface is cooler than the dew point temperature, or when the water vapor



The relative humidity of the air varies according to the temperature changes of the day.



Convection

Saturation vapor density v_k and Saturation vapor pressure p_k .

t °C	V_k g/m ³	P_k Pa	t °C	V_k g/m ³	P_k Pa	t °C	V_k g/m ³	P_k Pa
-20	0,87	102	-3	3,89	485	14	12,10	1602
-19	0,95	111	-2	4,19	524	15	12,86	1708
-18	1,04	122	-1	4,51	566	16	13,65	1820
-17	1,14	135	0	4,85	611	17	14,49	1939
-16	1,25	149	1	5,21	658	18	15,37	2064
-15	1,38	164	2	5,58	708	19	16,30	2197
-14	1,52	181	3	5,98	762	20	17,28	2337
-13	1,67	200	4	6,40	818	21	18,31	2484
-12	1,83	221	5	6,84	878	22	19,40	2640
-11	2,01	242	6	7,31	941	23	20,54	2805
-10	2,20	266	7	7,80	1008	24	21,74	2979
-9	2,40	292	8	8,32	1079	25	23,00	3162
-8	2,61	319	9	8,87	1154	26	24,32	3355
-7	2,84	348	10	9,45	1234	27	25,71	3559
-6	3,08	379	11	10,06	1318	28	27,17	3773
-5	3,33	412	12	10,71	1408	29	28,70	3999
-4	3,60	447	13	11,38	1502	30	30,31	4237

From the table it is easy to see, for example, how low the internal surface temperature of the window can drop before condensation happens in a room with a relative humidity of 50% and a temperature of +22°C? Vapor density in RH50% is $v_k = 0,5 \times 19,4 = 9,7 \text{ g/m}^3$. When looking at the saturation vapor density at a level of $9,7 \text{ g/m}^3$, we can see that the saturation temperature is around 10–11°C. That means that we have to keep all surfaces above 11°C to avoid condensation.

equilibrium in air has been exceeded. The dew point can be calculated using the following formula:

$$T_d = T - \frac{(100 - RH)}{5}$$

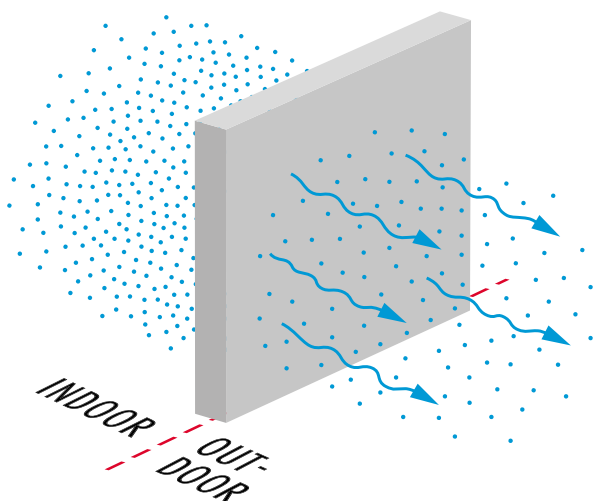
Calculation of dew point (T_d) based on temperature (T) and relative humidity (RH).

For example, if we have a dew point of 10°C, any surface in the room with a temperature of less than 10°C will have liquid water on it as a consequence of condensation. To prevent this, we can either raise the surface temperature or lower the relative humidity. The easiest method to control damage from water vapor and moisture is to reduce the amount of moisture generated.

1.1.3 Diffusion

Diffusion occurs due to differences in the vapor density/partial vapor pressure between two different spaces. At times of the year when heating is used, air is typically more humid on the inside. Due purely to differences in density/pressure, the humidity of indoor air tries to reach a balance with outdoor air, causing humidity to transfer as vapor from indoors through the building envelope to outdoors. In the absence of a vapor-tight barrier, the vapor density/partial water vapor pressures tend to get leveled via diffusion. However, if the water vapor diffusing through the structure meets a cold surface, it may get condensed. Diffusion occurs without any movement of the air itself. Vapor barriers are used on the interior (warm) side of the envelope to prevent the moisture intrusion to the structures.

All materials allow water vapor to pass through them to some degree. Condensation will not usually occur as long as two-thirds of the insulating value of the wall is located outside the vapor barrier.



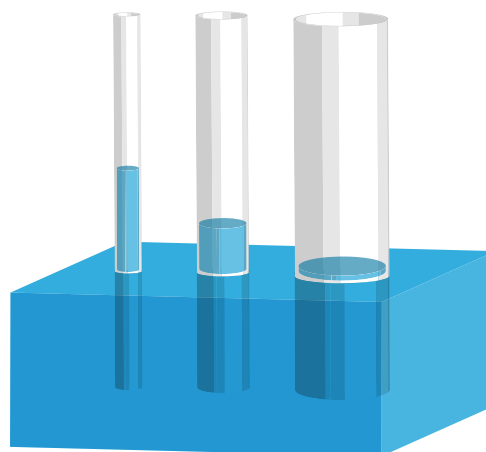
Diffusion

1.1.4 Capillarity

Capillarity is the ability of a liquid to flow in narrow spaces without the assistance of, and in opposition to, external forces like gravity. This phenomenon occurs, for example, in soil.

Similar to water moving upwards through a tube against the force of gravity, water moves upwards through soil pores, or the spaces between soil particles. The level of water rise depends on pore size.

Common areas where capillary rise is present are the footing into the foundation wall and capillary suction of water behind a siding. Capillarity can be controlled by sealing the pores or making the pores very large.



Capillarity

2. MOISTURE AND BUILDING ENVELOPE DESIGN

Moisture-originated health problems and damage to building can be very expensive. Liquid water is usually easy to detect but many water-related problems are less obvious and difficult to diagnose or see.

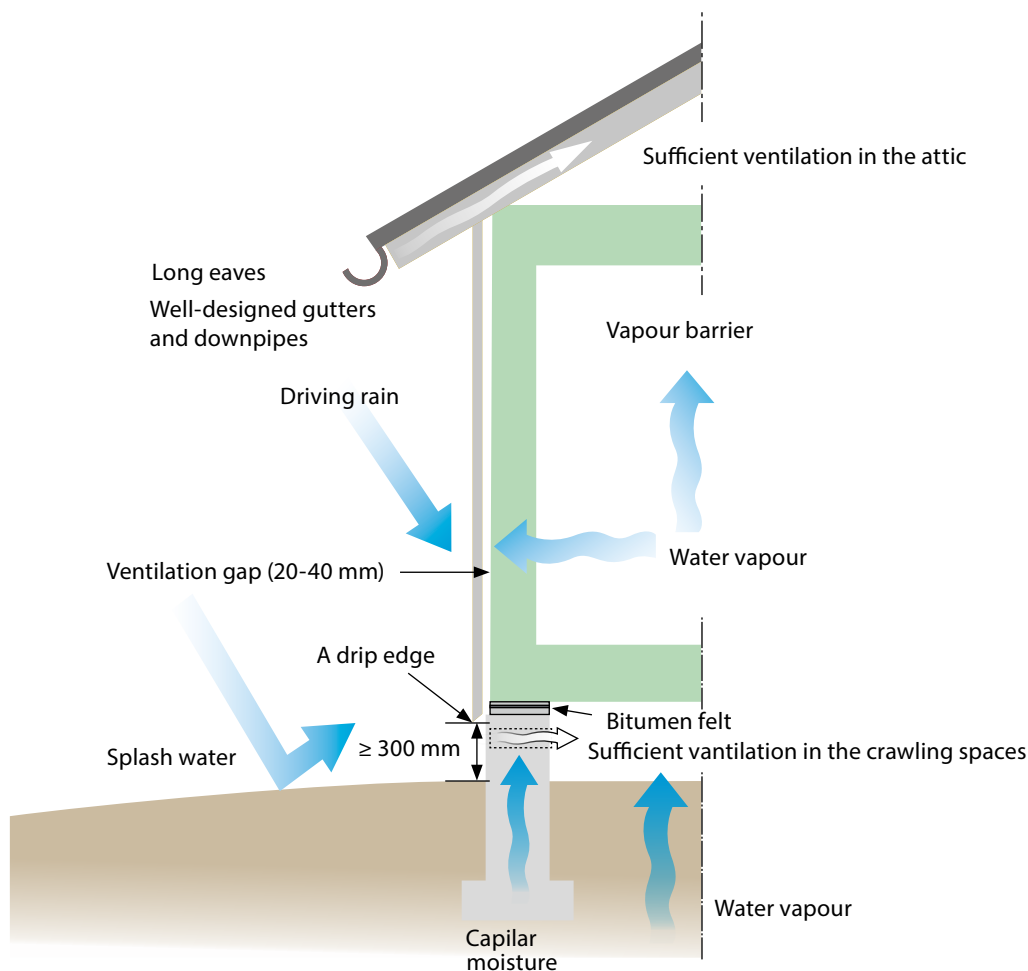
Moisture control is fundamental to the proper functioning of any building. A well-designed building envelope protects its occupants from adverse health effects and the building from physical or chemical damage. Good moisture control does not require that all the building materials are totally dry, rather that moisture-sensitive materials have to remain dry enough to avoid problems.

Most of the structural moisture problems in buildings are caused by ground moisture, rain or water used inside the building. Moisture control is an essential part of building design phase and, fortunately, the design rules are rather simple:

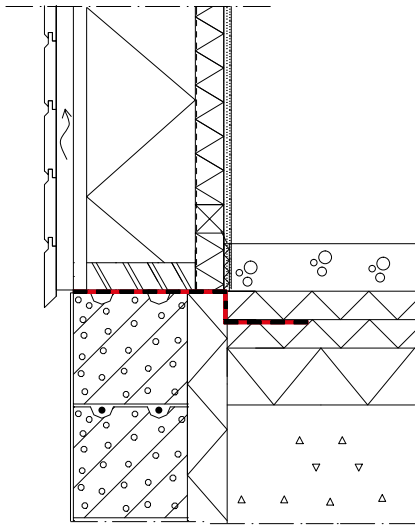
- **Make sure that moisture does not get inside the structures**
- **Make material choices to ensure that the moisture inside the structure is able to dry.**

2.1 FOUNDATION

Controlling moisture-driven capillary movement is one of the most important defenses against moisture and humidity from the ground. A good gravel-based building site makes ground moisture handling easier. Unfortunately, the best building sites are typically occupied and we have to utilize the ones remaining. If the soil is not suitable for building, it has to be changed.



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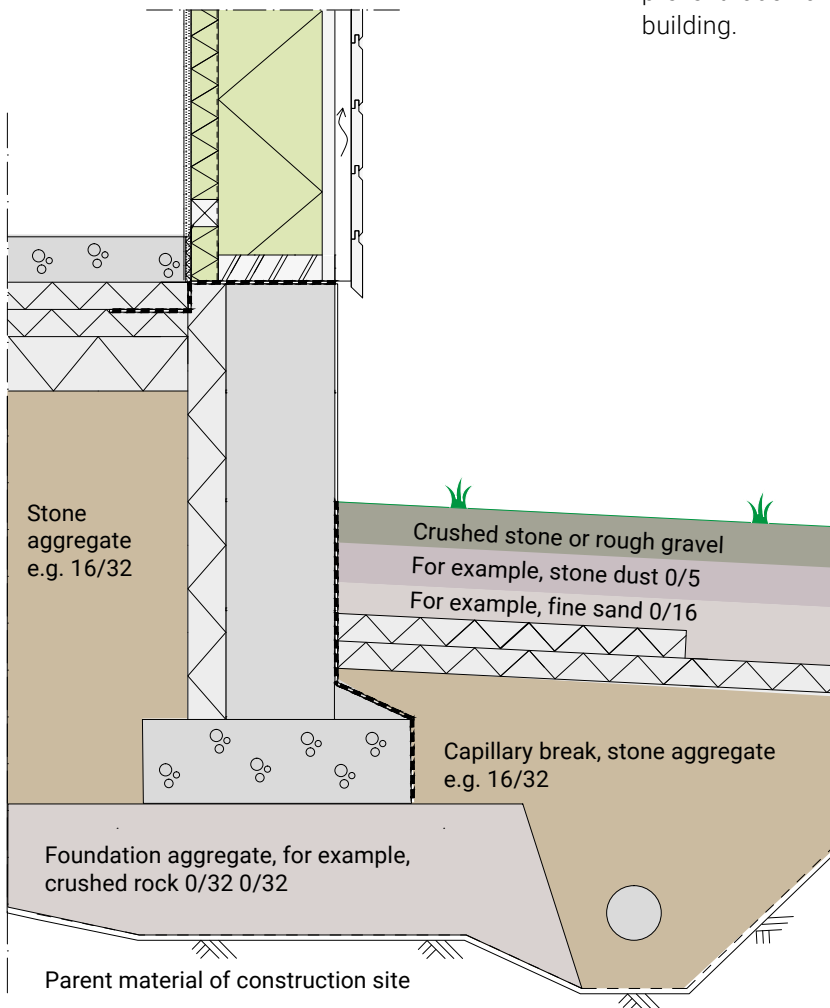
Capillary break

A capillary break can be created beneath the foundation slab and outside the foundation with a layer of suitable gravel (for example size 16/32). In the picture below, you can see an example of the different gravel and sand types used in foundations.

Perimeter drains are used around the outside of the foundation or basement footings to collect and transport subsurface water away from the building. If groundwater is likely to represent a major problem, the soil may not be ideal for a full basement foundation.

The adjacent picture below shows an example of a drainage system used for managing moisture in the ground. To direct rainwater away from the building, the recommended slope away from the building is 1:20 over a distance of 3 m (about 15 cm vertical difference over a distance of 3 m).

When the foundation is ready, it is important to add a capillary break between the concrete foundation and wall structure. This capillary break can be achieved by using suitable bitumen felt (welded or glued). The bitumen felt strip should be well fixed and wide enough so that it can be installed 150 mm under the floor slab. Bitumen felt makes the slab and foundation connection tight enough to prevent radon and other impurities from entering the building.



Subsoil layers as part of moisture control



1	Foundation
2	Bitumen felt
3	Foundation waterproofing sheet
4	Ground surface
5	Frost insulation
6	Filling with gravel
7	Geo-textile
8	Sand/gravel
9	Perimeter drain
10	Rain water system
11	Plastic batten
12	Drainage inspection chamber

Underground drainage and rainwater drains

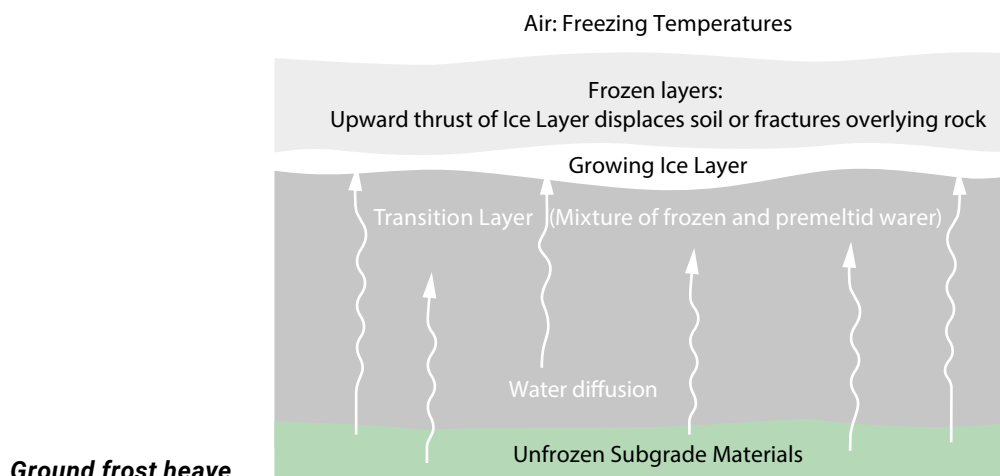
2.2 FROST AND FLOOR INSULATION

Frost heaving (or frost heave) is an upwards swelling of soil during freezing conditions, caused by an increasing presence of ice as it grows towards the surface, upwards from the depth in the soil where freezing temperatures have penetrated. Ice growth requires a water supply that delivers water to the freezing front via capillary and diffusion action in certain soils. If not controlled, frost heave can seriously damage buildings and other structures in cold climates.

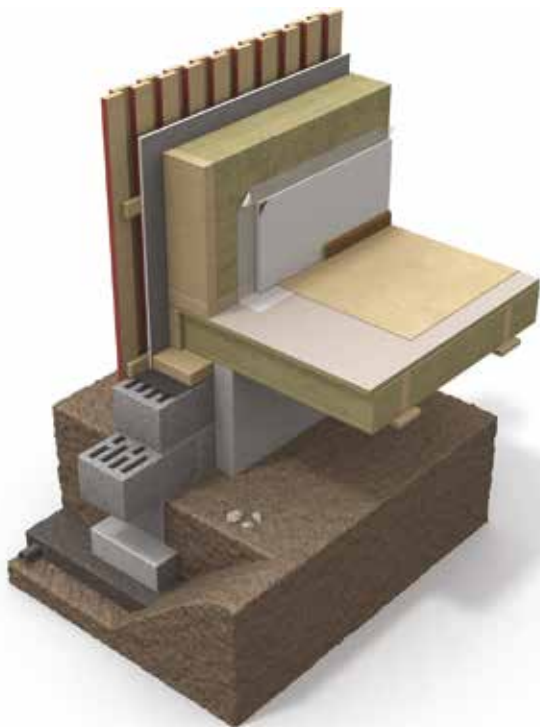
Underground capillary breaks from gravel or built draining systems help to keep water away from the vicinity of foundations but they will not

stop the upwards movement of water vapor via diffusion. Therefore, we have to prevent the ground from freezing by using frost insulation around the foundation. The required amount of frost insulation depends on building location, climate and building site.

The depth of frozen soil ranges from very shallow to in excess of 3 meters in northern areas. The colder the environment, the more insulation is needed. Frost insulation is installed on the external side of the foundation according to the foundation designer's instructions. Building corners should be insulated 40% better than other perimeter areas.



Ground frost heave



Ventilated floor

The foundation should also be insulated. Insulation can be installed on the outside, on the inside or into the middle of foundation.

The floor can be either ventilated or a ground slab cast on top of the ground insulation layer.

Ventilated floor:

In the case of a ventilated floor, it is important to ensure that rain water cannot get under the building and that there is sufficient natural ventilation in the crawling space. The crawling space has to be free from all organic material due to risk of mold related to very high humidity (ground moisture has RH 100%).

The ventilated floor is built in a similar fashion as an external wall. Due to the high humidity level beneath, the wind protection boards have to be well supported and resistant to moisture.

Ground slab:

The base floor of a building is typically built on top of the subsoil itself or on concrete slabs laid partly onto the foundation. The floor surface level should be at least 30 cm above the base floor.

Insulation can go above or below the slab, but how the occupants of the building use heating should be taken into account. If the building is to be in continuous use, install insulation under the concrete slab in order to utilize the thermal mass of the slab as a cover over the insulation.

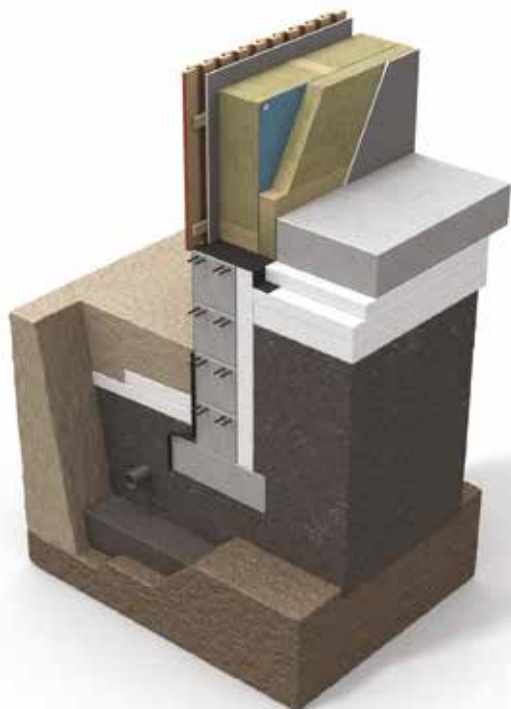
In base floors, moisture transport moves in either one or two directions; by diffusion or capillarity.

Moisture has to be removed from the structures after the concrete has been laid, either downwards, in which case the structure should not have a vapor-tight barrier, or upwards, in which case the floor should not have a moisture-tight coating before the concrete has dried.

At the building stage, the temperature of the subsoil under the base floor is normally between +6 and -16°C. At this stage, the structure dries easily from the direction of indoors outwards, if the insulation under the slab allows diffusion.

During building usage, the temperature of the subsoil is usually between +15 and 16°C. The less insulation there is in the base floor, the warmer the subsoil. When the temperature of subsoil rises, along with an increase in vapor density, the direction of diffusion in the structure can change and moisture can pass from the subsoil to indoor spaces. This often happens in the summer, when both indoor air and subsoil are warmer than during other seasons.

When planning to build the base floor on subsoil, it is important to ensure that the direction of vapor through diffusion is mainly from indoors outwards. A moisture-safe solution can be ensured through proper insulation of the base floor. The insulation



Ground slab

layer under concrete slabs should be thick enough to ensure that the temperature difference between the inner and outer surfaces of the insulation is at least 2 to 3°C. In addition, indoor temperatures should be kept at a level that allows the building to function as planned and moisture in structures does not exceed critical levels at any time of year.

There should be a sufficiently thick subsoil/gravel layer under the insulation to prevent capillary moisture from rising. The insulation should also help in this. The phenomenon of rising capillary moisture is independent of temperature.

There are also mechanical requirements on insulation installed under concrete slabs, so choice of insulation should not be made purely on the basis of moisture properties.

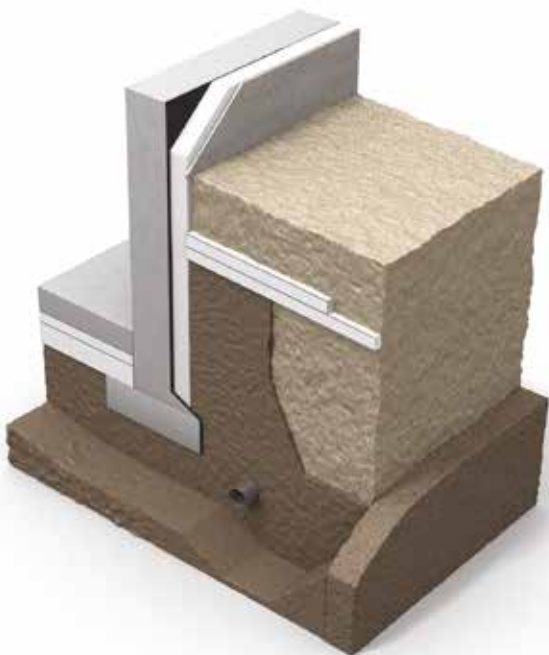
Basement walls:

The safest way to insulate a basement wall is to do it from the outside. Wall construction (concrete, blocks, etc.) has to be protected on the external side against moisture with a watertight bitumen layer or an equivalent solution. If the basement wall is constructed out of blocks, the surface has to be smoothed with rendering prior to waterproof membrane installation.

Thermal insulation is installed on the external side of the waterproof layer.

The internal surface of the basement wall has to be vapor permeable so that it allows structural humidity to dry inwards.

In this construction, it is important to ensure that moisture cannot enter behind the waterproof layer.



Basement walls

PAROC Stone wool in ground applications

Stone wool can be used in floors and foundations in heated buildings. When one side of the construction is heated and there is a temperature gradient across the insulation layer, PAROC stone wool works very well in the ground.

Porous stone wool allows casted concrete ground slabs to dry about 50% quicker than when using moisture-tight ground insulation under the slab. This is possible because moisture can dry in two directions; to indoors and outdoors (ground) via the insulation layer. If the insulation under the concrete slab is diffusion-tight, the only direction for moisture to dry is indoors. Fast drying concrete structures mean a faster building process and cost savings.

Insulation	Drying time of concrete to 85% RH	Drying time of concrete to 80% RH
Stone wool	100 vrk	130 vrk
EPS	226 vrk	443 vrk

Drying time of 80 mm-thick concrete on 200 mm-thick insulation and a 300 mm-thick gravel bed

[Moisture performance of stone wool insulation products, Tuomo Ojanen, VTT-R-04783-17, 2017]

As an open-cell material, stone wool can be used in underground solutions provided that one side of the insulation layer is constantly warmer than the other side. If there is no temperature gradient across the structure, the air inside the insulation will follow the relative humidity of the soil (100%) and, at temperatures below zero, freezing may occur. Therefore, stone wool is not suitable to be used as frost insulation. For frost insulation purposes, we recommend using extruded cellular plastics (XPS).

2.3 EXTERNAL WALLS

Exterior cladding has a challenging task to keep out wind-driven rain or snow, which may push moisture into the structures from different directions. Therefore, it is essential that materials (all the details and connections in this "rain jacket"), are well designed and installed.

Ventilated facades

In a ventilated exterior wall, an air gap should be placed behind the façade cladding. The purpose of this gap is to remove moisture entering the building through façade cladding or via diffusion from the structure.

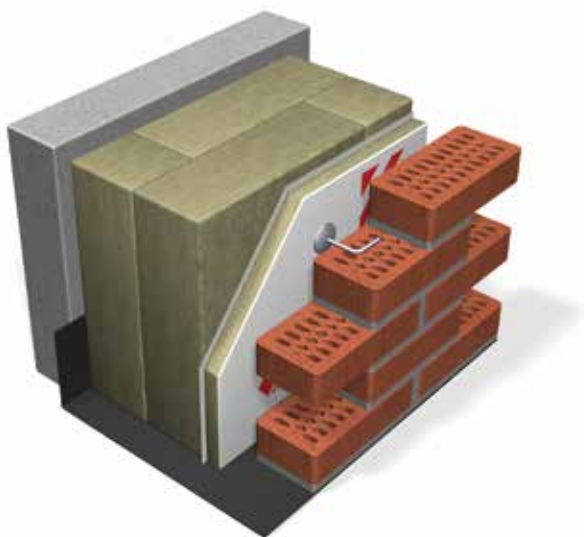
In the gap, the air circulation transfers the moist air up and releases it outdoors through the openings at the top part of the cladding.

As the cladding is not totally airtight and stone wool insulation is porous, the insulation needs to be protected from the wind. The wind protection layer has to be airtight but water vapor permeable to allow indoor moisture to pass through. A general rule of thumb is that the wind protection layer has to be five times more vapor permeable than the vapor-tight barrier (1:5). To allow drying, the outer wall structure must always be designed so that layers are consecutively more permeable, the further one moves from inner to outer layers of the structure.

Fire barriers installed into the ventilation gap should not block the ventilation nor collect moisture to the structure.

On the inside, the construction has to be air and water vapor-tight so that moist indoor air cannot cause the structures to get wet via diffusion. The vapor barrier prevents diffusion and prevents invisible moisture from entering the structure. It forms a tight inner layer throughout the whole building envelope. All the seams and construction connections need special attention.

Massive constructions do not need a continuous vapor barrier. In massive constructions, the most challenging areas are connections and joints, which require efficient tightness.



Ventilated facades

Concrete sandwich elements

Fresh concrete incorporates $\sim 150\text{kg/m}^3$ (100% RH) of moisture. Before concrete structures can be finished with surface coatings, the moisture content of the core structure has to decrease to a low enough level, typically to 80–85% RH corresponding to about 85–93 kg/m^3 moisture content. Too early coating with vapor tight layers may allow high humidity reactions, where emissions (VOCs) may adversely affect the indoor air quality.

Thermal insulation has a great effect on the drying time of the inner concrete layer. Porous insulation allows drying, both outwards and inwards.

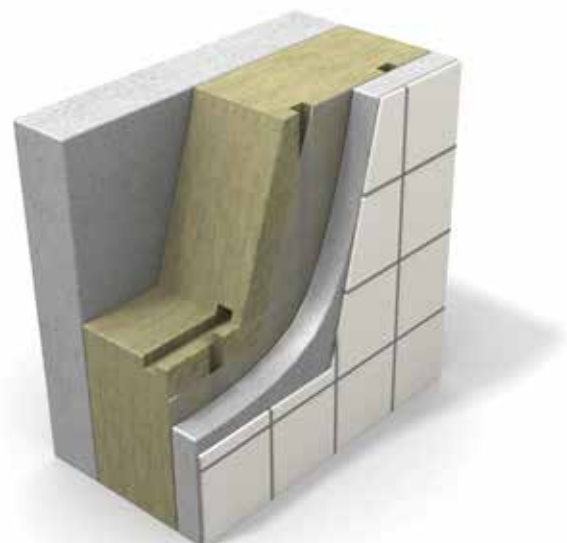
If the external surface of a concrete sandwich panel is vapor tight it is recommended to use grooved stone wool insulation to ensure fast drying of the structure.

In structures having boundaries with fresh concrete and thermal insulation, biological growth (mold) is not possible due to the pH-conditions created by the drying concrete. This is valid also for a rendered structure.

Rendered facades

The moisture performance of a rendered facade is based on the sufficient water resistance and vapor permeability of the rendering layer. When rendering and all connection details are done properly, the structure works well.

The drying mechanisms of rendered insulated walls are almost the same as those of the concrete sandwich element. The inner concrete core dries out significantly faster with stone wool than with more vapor-tight insulations.



Concrete sandwich elements

PAROC Stone wool in external wall applications

Stone wool is an ideal insulation material for use in different kinds of wall structures. Good-quality installation of stone wool, avoiding cracks and gaps, is easy.

Stone wool insulation is stable over long term: it maintains its dimensions in different climate conditions and temperatures. No changes are expected to the moisture performance of stone wool insulation throughout the lifetime of the building.

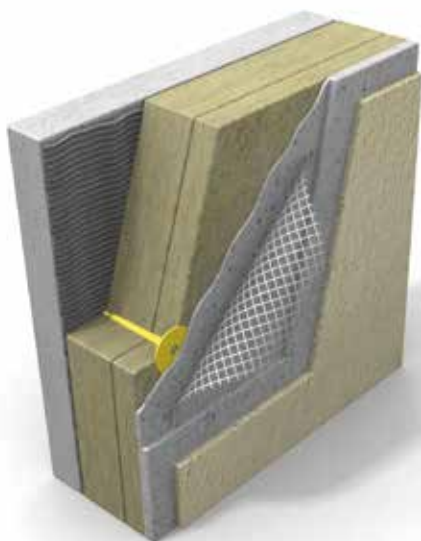
An open stone wool insulation structure allows

significantly faster drying of the inner concrete layer than thermal insulations with lower air/vapor permeability. According to VTT simulations, for stone wool the average 85% RH level for the inner concrete layer is reached in about 140 days while for materials with lower vapor permeability (EPS & PIR) the 85% RH level is attained in 460–470 days. For aluminum covered PIR insulation, it takes about 715 days to reach 85% RH.

* A big difference in drying times naturally means big savings in project times and costs.

Insulation	Outer wall structure	Drying time, 85 % RH	Dry coating of inner surface	Drying time, 80 % RH
Paroc stone wool , 220 mm	BSW	135 vrk	~4,8 kk	342 vrk
	Thin rendering	125 vrk		184 vrk
	Ventilated façade	178 vrk		336 vrk
EPS , 220 mm	BSW	474 vrk	~16kk	756 vrk
	Thin rendering	457 vrk		707 vrk
	Ventilated façade	514 vrk		808 vrk
PIR , 170 mm	BSW	458 vrk	~15,4 kk	621 vrk
	Thin rendering	440 vrk		701 vrk
	Ventilated façade	490 vrk		762 vrk
PIR (Aluminium surface), 170 mm	BSW	716 vrk	~23,8 kk	913 vrk
Phenolic foam 70 mm	BSW	402 vrk	~13,7 kk	493 vrk
	Thin rendering	392 vrk		486 vrk
	Ventilated façade	441 vrk		541 vrk

Drying time for an inner building envelope of 120mm-thick concrete with various insulation materials.



Rendered facades

During the wall insulation installation phase, it is possible that the insulation surface is exposed to wind-driven rain. According to VTT study and simulations*, moisture loads from driving rain to the exterior surface of the unprotected stone wool insulation do not cause moisture accumulation into the structures, even during a four-month unsheltered period. Insulation tends to dry out very fast when the rain stops.

However, driving rain may generate risks for the construction with an unprotected thermal insulation layer due to non-idealities in material layer boundaries. This risk is always present regardless of insulation material. Liquid water might get into the structure and cause the risk of wetting.

Porous and diffusion open stone wool insulation allows for effective drying of a wet construction. This adds some safety margin also for wind-driven rain where water can enter the structure via leaking connection details (e.g., around windows). Stone wool will not lock the moisture into the structure like vapor-tight insulation materials may do.

Due to the open fiber structure, moisture cannot condense on the inside of the stone wool insulation layer. As a consequence, if moist air enters the insulation layer via cracks and holes in the vapor barrier, condensation will occur on the first airtight layer on the external side of the wall structure, when its temperature is below the dew point.

Stone wool quickly reveals any leaks or damages in the structures or water pipes inside the structures as the insulation does not absorb moisture but let's water leak through the insulating layer to a place where it can be detected. As the fault can be detected straight away, it can also be repaired quickly. Rapid action prevents extensive structural damage and prevents mold formation.

The stone wool is hydrophobic, i.e. it repels moisture in liquid form. Neither does not absorb water from the surrounding air even in extremely high relative humidity (RH98%). Only dry insulation works as planned.

* [Source: Research reports VTT-R-04783-17 ja VTT-R-05677-17]

2.4 ROOF

Roofing prevents rainwater from accessing the structures. Well sloped roofs with long eaves typically give good protection from the rain. Most leaks on roofs happen around penetrations through the roof, such as plumbing vent exhaust fans or skylight. Flashings and sealant joints around these penetrations can fail and leak.

Moisture enters the roofing system and creates problems in three different ways:

1. During installation: rain and moist materials
2. Air leakage: indoor air humidity migrates from the building interior into the roofing system through the gaps in supporting structures or vapor barriers
3. Roofing material failure: break in the roofing material allows water to enter the roofing system from the exterior



Pitched roof

Pitched roofs

To ensure proper moisture removal in attic constructions, the ventilated space above the insulation layer must be high enough, at least 200 mm, when the roof pitch is <math><1:20</math>, and at least 100 mm in roofs steeper than that.

The exhaust air ventilators must be as high up as possible and the replacement air ventilators must be placed low. Natural ventilation in ventilation gap/space dries the structure due to the level difference and tendency of warm air to rise. Ventilation from the eaves can be ensured with a wind diverter and a ventilation gap above the wind diverter of at least 50 mm.

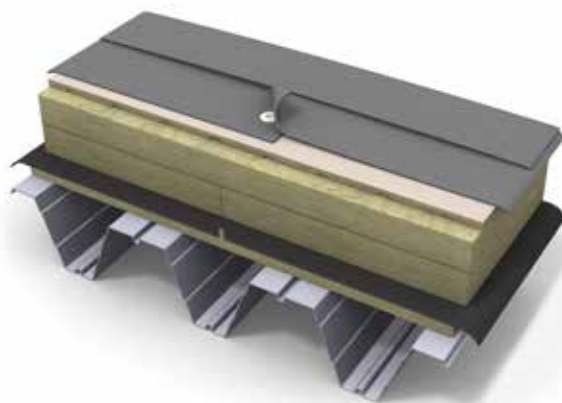
In the event of a discontinuous roofing material (e.g. roofing tiles) underlayment should be installed to protect the structures from moisture penetrating the seams of the roof. The underlayment should be sealed around roof penetrations.

When indoor air is warm and humid, and the air on the exterior side of the insulated structure is colder and drier, there will be a vapor pressure difference between the interior and exterior side of the structure. Driven by diffusion emanating from the vapor pressure difference, water vapor will attempt to flow through the material layers from the inside to outside.

Continuity and air-tightness of the vapor barrier from the wall systems to the roof is essential for a satisfactory moisture performance of the structure. To avoid moisture damage, seal all joints, conduits and connections.

Low sloped roofs

Flat roofs are roofs with a slope of between 1:10 and 1:80. Roofs with a pitch of less than 1:80 cannot be recommended due to risk of poor moisture handling possibilities.



Low sloped roof

The low sloped roof structure is a complete system. It typically consists of a supporting structure, a vapor barrier, insulation, waterproofing and effective ventilation. The supporting structure is usually double T slab, trapezoidal steel sheet, reinforced concrete slab or hollow core slab.

Effective roof insulation has three or four insulation layers. The lowest insulation layer forms a flat platform for the vapor barrier. The vapor barrier prevents moist air from leaking into the upper insulation layers. Due to the continuous stone wool platform, the vapor barrier remains intact even during small structural movements.

All penetrations must be tightened to the vapor barrier and waterproofing layer.

PAROC Stone wool in roof applications

Due to schedule and budget constraints, it is seldom possible to carry out the building process during only sunny and dry weather conditions. There may be rain or snow, which increases the moisture level in all the exposed structures. Therefore, it is essential to install only one area at a time, protect it against possible rain showers and ensure that any moisture can dry freely.

The ventilated insulation system PAROC Air dries out the building moisture from the roof structure very quickly through grooves in the insulation layer. The air temperature in grooves is generally 5°C warmer than the outside air temperature so it is able to carry moisture out from the structure via ventilation hoods.

It is good to note that a ventilated solution is only suitable for heated buildings. For cold storages and freezers we recommend using a non-ventilated solution.

The diffusion resistance factor (μ) for stone wool is 1. This means that water vapor moves in the stone wool insulation layer similar to pure air. Effective natural ventilation will carry evaporated moisture

out from the structures via ventilated spaces or ventilation grooves. A porous insulation does therefore not constitute a barrier to drying even for the deeper structural layers.

2.5 EAVES AND ROOF DRAINAGE SYSTEMS

The roof slope and eaves overhang determine how efficiently rain is deflected away from the enclosure. Good protection against rain can be achieved with adequately long eaves and enough roof slope.

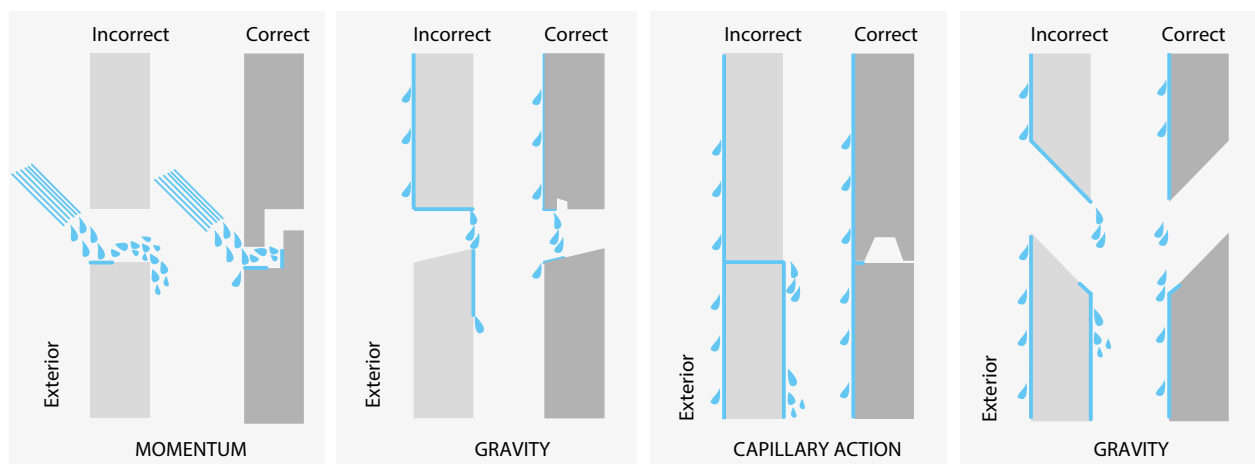
All water that enters the roof should be led away from the roof by sufficient sloping. The water flow should be controlled all the way from the roof through the drainage channels directly into the rainwater streams to avoid splashing on the facade. The selection of a right roof drain system depends on the type of roof, roof pitch, average rain volume, rate of drainage, etc.

2.6 DESIGN DETAILS (JOINTS, FLASHINGS AND OTHER CONNECTIONS)

Joints in cladding are inevitable and are a necessary aspect of rain screening. In some cases, joints are sealed with caulking. When detailing the joint width and geometry, the modulus of elasticity of the caulking material must be taken into consideration to accommodate movement from expansion and contraction of the joint. For open joints, it is critical to analyze the various moisture penetration mechanisms at play, and devise joints that satisfy the aesthetic style of cladding while providing acceptable performance.

The design of joints between panels, sheets or board stock used for cladding in rain screen wall assemblies is an important aspect. While the drainage cavity may have the capacity to convey water penetration away to the exterior, the material forming the cladding may become very wet, compromising

Design details



its appearance and durability. In climate zones with freezing rain events, ice formation may induce stress, resulting in deformation of the cladding.

Flashings are needed to manage rainwater on surfaces because most buildings have transitions between materials, assemblies, and components that represent either discontinuities and/or changes of the geometry in the water-resistive barrier and drainage space.

2.7 AIR VENTILATION & PLUMBING

Air ventilation

Air ventilation is necessary in buildings to maintain air quality and remove moisture.

Extra water vapor in indoor air caused by showering or cooking can be removed by dehumidification or effective air ventilation. For example, a shower room should be dry shortly after use. If not, the air ventilation is not effective enough and the risk of mold increases.

In the winter, when the air ventilation system brings fresh air into the building (-10°C / RH95%), the air is first warmed up to +20°C, implying that its relative humidity drops down from 95% to 12%. Too low a relative humidity indoors causes health effects similar to those generated by mold; eye irritation, dry skin, nasal stuffiness, throat irritation, etc. A very low relative humidity is not beneficial for the construction either; dry indoor air tends to pull out all the moisture from wooden surface materials causing shrinkage and cracking of the surfaces.

Air ventilation also has a significant effect on the air pressure difference between outdoors and indoors. Higher air pressure indoors (over pressure) pushes hot and humid indoor air into the wall and roof constructions. Lower air pressure indoors (low pressure) pulls in air from outdoors through the building envelope via porous building materials, cracks and gaps. This leaking air is never pure.

Natural ventilation works effectively only in colder climate conditions as its performance depends on temperature difference across the building envelope as well as wind conditions outdoors. A balanced ventilation system is designed to keep indoor conditions at the best possible level. The needed air pressure and indoor air conditions can be achieved only with an airtight building envelope.

A balanced ventilation system needs a constant supply of energy. Unfortunately, energy efficiency as well as cost saving targets may encourage the property owner to switch the air ventilation and warming off for the time the building is not occupied (e.g. weekends and holidays). This creates a big moisture risk as the indoor air temperature drops and moisture from the air starts to condensate on the

surfaces. Alternatively, the direction of diffusion from the ground can change.

Plumbing

Water is also brought into the building intentionally via water pipes. Leakage in plumbing is the most common cause of water damage, potentially causing unnoticed problems within the building structures, in particular if the pipes are hidden inside the structures.

Leaks in plumbing are always accidental but they can be taken into account in the building design phase by locating plumbing lines and components so that they are easy to inspect and repair. Many leaks are caused by freezing: it is important to make sure that pipes are properly insulated. Insulation is also essential to prevent moisture condensation on the surface of a cold water pipe.

PAROC Stone wool in HVAC applications

Without insulation, cold water pipes and ventilation channels might “sweat”. This means that moisture from the warm air condenses on the colder pipe or duct surface, the temperature of which is below the dew point. When water condenses, it can cause damage to the HVAC system (corrosion) or drip onto building structures, causing secondary moisture problems.

Secondary condensation effects can be mitigated with proper insulation. Thermal insulation with an airtight surface prevents secondary moisture risk by creating a barrier layer outside the insulation with temperature above the dew point. All the joints should be sealed so that moisture cannot penetrate through the insulation layer.



PAROC Stone wool in HVAC applications

3. MOISTURE RISKS

3.1 CORROSION

Any insulation material that is in contact with metal may contribute both passively and actively towards corrosion if there is a presence of water or moisture.

Insulation material may actively contribute to the progress of corrosion by increasing water's electrolytic capacity via release of water-soluble ions or via significantly altering its hydrogen potential (pH). In Paroc stone wool, the amount of water-soluble ions is very low, and the chemical balance does not promote corrosion.

Certain other types of insulation material may contain substances that directly contribute to events that cause corrosion, such as fire retardant salts. Paroc stone wool is non-combustible and contains no such materials.

Insulation material can passively contribute to corrosion if it binds water against the exterior of the metal.

3.2 MOLD

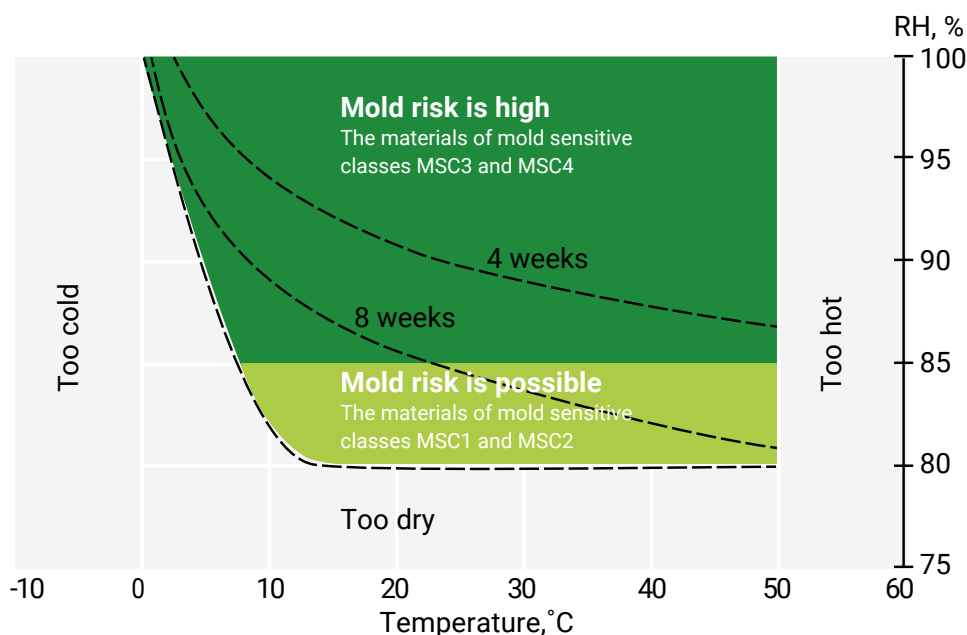
Mold is everywhere – in the air and on many surfaces in nature. Molds and fungi have been on the Earth for hundreds of millions of years and are a crucial part of the global ecosystem. Despite the coexistence and coevolution with humans, biological growth in buildings may cause health issues in modern society. As the mold spores are tiny and lightweight they can enter homes through many different ways

like open doorways, windows, vents, and heating and air conditioning systems. However, issues only arise if the extent of mold growth in a residence is exceptionally large and if the mold species dwelling in the structures causes symptoms in the human occupants.

Mold grows where warmth, nutrition and moisture are present. Mold starts to grow when relative humidity is high (\geq RH80 - 85 %), temperature is above 10°C and there is enough organic material for them to eat. Mold growth also needs time. Short moisture exposure is not dangerous.

In buildings, the most favorable conditions for mold growth are on paper and wood products but molds can also grow in dust, paints, wallpaper, insulation, drywall, carpet, fabric and upholstery. The best way to prevent mold growth is to keep constructions dry, surfaces clean and the indoor air humidity level low enough.

One well-known model (H. Viitanen /VTT) to estimate the probability or risk of mold growth is presented below. It shows the time it takes to develop mold growth on wood in various temperatures and relative humidity. The same model can be used for other building materials by scaling coefficients for equations. Different construction materials have been divided into different classes based on their sensitivity to mold growth, according to the table on the next page.



The Finnish Mold Index Model (VTT)

Source: TTY/VTT (Viitanen 2001)

Sensitivity class	MSC	Description
Very sensitive	1	Untreated wood, which contains high amount of nutrients
Sensitive	2	Planed timber, materials and films with paper coating, wood-based boards
Medium resistant	3	Mineral wool , cement or plastic-based materials
Resistant	4	Glass and metal, products containing mold-preventive additives

Favorable relative humidity and temperature conditions for mould growth in different mould sensitivity classes.

Exposure to damp and moldy environments may cause a variety of health effects, or none at all. For sensitive people, molds can cause nasal stuffiness, throat irritation, coughing or wheezing, eye irritation, or, in some cases, skin irritation. For people with allergies, the symptoms might be more severe.

Stone wool is an inorganic material. 96–98% of its weight is of volcanic stone. The remaining 2–4% is organic binder. Paroc stone wool products have been tested in an external laboratory* and found resistant towards mold growth. The test was conducted at 95–100% relative humidity and 22°C temperature for 28 days with the most typical mold species found in buildings

* SP Sweden, test report ETI PXX07404 / 17.2.2011

3.3 LOSS OF PERFORMANCE

Dimensional stability

Dimensional stability is important for the insulated structure to function properly over time. Requirements are set either on dimensional stability at a constant temperature or stability under temperature and humidity cycle. If the thermal insulation shrinks or swells due to the influence of surrounding conditions, cold bridges and tensions are formed in the structures, which might contribute to the moisture behavior of the structures.

Dimensional changes in materials can be caused for example by their thermal expansion coefficients. This is the rate at which materials shrink or expand

when they are cooled down or heated. Practically all materials have an expansion coefficient that is dependent on the chemical composition of the material. Dimensional changes may also originate from thermal expansion of foaming agents or other gases embedded in the insulation material or moisture uptake (swelling).

Stone wool is an inorganic material and it keeps its shape and dimensions in all conditions.

Mechanical stability

When insulation is used as a structural component of construction, such as low-slope roofs or sandwich panels, more properties need to be declared, such as compressive, tensile or shear strength. Products with an extensive list of declared properties may be more sensitive to environmental effects, e.g., UV radiation, chemical exposure and moisture.

Naturally stable stone raw material ensures the very good moisture durability of stone wool product properties. Due to low organic content, minor changes are possible if the products are heavily exposed during the transportation, storage and/or installation.

The stone wool is in practice totally dry when it comes from the factory. In normal conditions (relative humidity in air between 30 and 80%), the moisture content in stone wool is ca. 0.3 kg/m³. The water absorption properties of the structural wool are excellent and can be easily verified by pouring a small amount of normal tap water onto the wool. If the water droplet keeps its spherical form on the wool surface, the liquid water repellence is guaranteed.

Irrespective of the selection of insulation material, the insulation products must be protected at the building site. For Paroc stone wool, any water exposure – such as rain water – is normally confined to a thin surface layer (1–6 mm) of the wool. This layer can be totally wet but it will not affect the strength properties of the whole construction.

Our recommendations are therefore:

1. Check that the stone wool is dry and that the water absorption properties are adequate.
2. Protect the stone wool from heavy rain and water both during storage and installation.
3. If the wool surface is totally wet (1–6 mm) the product should be allowed to dry or changed before closing the construction.

4. MOLD CALCULATION FOR MOST TYPICAL CONSTRUCTIONS

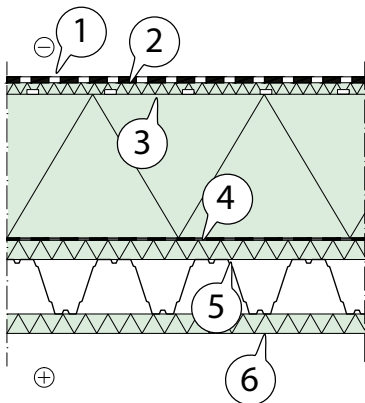
The real moisture performance insulating material is demonstrated when it is part of a construction. Therefore, it is essential to assess insulation products in their application conditions to verify that the building physics of the whole structure is functioning as planned.

According to external studies, calculations and simulations carried out for 13 different well-

insulated structures, no moisture or mold risks were detected in any parts of the structure.

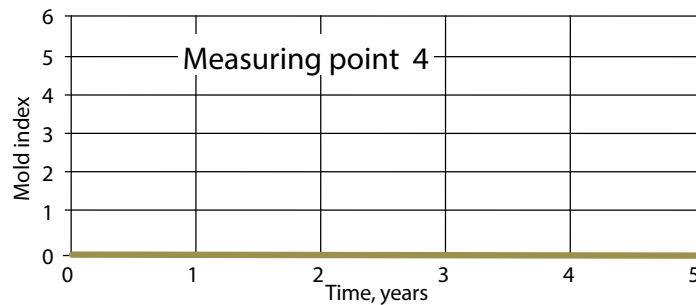
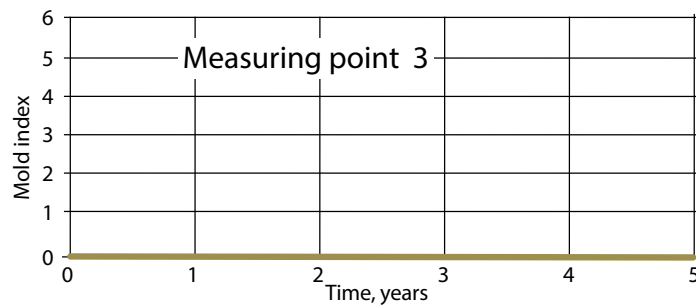
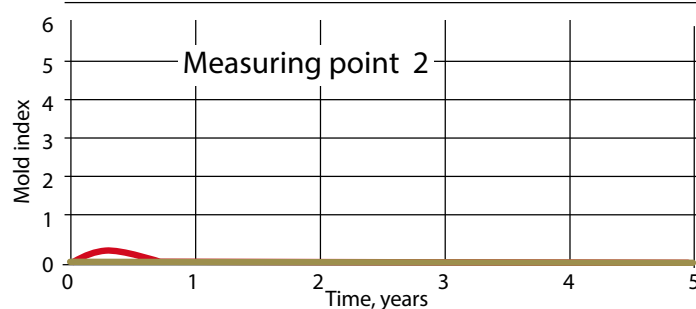
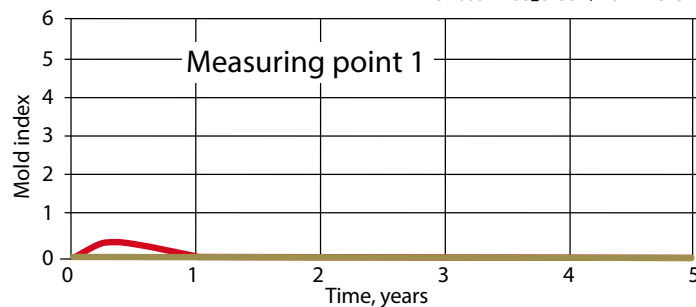
Paroc stone wool insulated structures were studied in assumed 2030 climate conditions, setting the relative humidity parameter to RH80% and RH 95% by using the Mold Index model developed by VTT (Viitanen 2001).

Example:

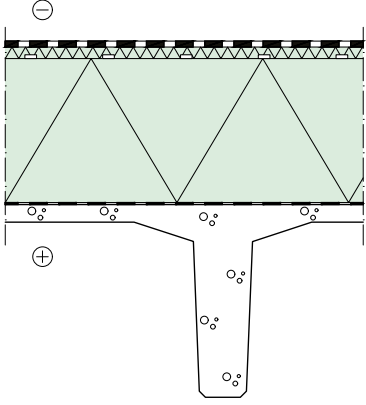
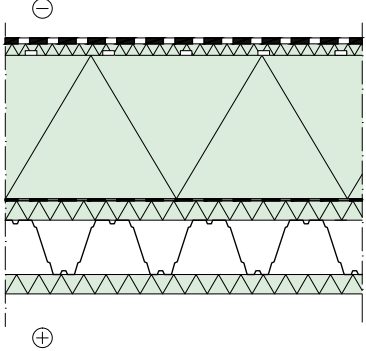
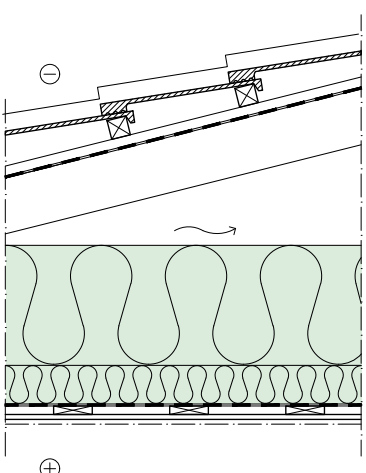


- RH 80%
- RH 95%
- Vantaa 2007
RH 80%

*Sweco RA08_61351 / 16.12.2015



Here are some examples from studied constructions:

ROOFS		
	<ol style="list-style-type: none"> 1. roofing membrane 2. PAROC ROB 100grl 30 mm 3. PAROC ROL 30 370 mm 4. vapor barrier, bitumen 5. load bearing structure 	<p>Roof construction with Paroc stone wool insulation is a technically functional construction for moisture control.</p> <p style="text-align: center;">No mold risk detected !</p> <p><i>Moisture management at the construction phase is important for all low-slope roof solutions regardless of the insulation material used.</i></p>
	<ol style="list-style-type: none"> 1. roofing membrane 2. PAROC ROB 100grl 30 mm 3. PAROC ROL 30 370 mm 4. vapor barrier, bitumen 5. PAROC ROS 50 6. load bearing structure, trapezoidal steel sheet 7. PAROC FPS 17 for fire protection – if needed 	<p>Roof construction with Paroc stone wool insulation is a technically functional construction for moisture control.</p> <p>In calculation, the vapor permeability of steel sheet was not taken into account and it was assumed that indoor air can flow freely through the seams. Therefore, this calculation is also valid for perforated steel sheets.</p> <p style="text-align: center;">No mold risk detected !</p>
	<ol style="list-style-type: none"> 1. roofing 2. underlay 3. wooden roof trusses 4. ventilated attic 5. PAROC BLT 6 310 mm 6. PAROC eXtra 100 mm 7. wooden frame from the truss 8. vapor barrier 9. wooden joists 10. Gypsum board 11. surface 	<p>Roof construction with Paroc stone wool insulation is a technically functional construction for moisture control.</p> <p style="text-align: center;">Ventilation of the attic has to be sufficient.</p> <p style="text-align: center;">No mold risk detected !</p>

EXTERNAL WALLS

	<ol style="list-style-type: none"> 1. thin rendering 2. PAROC Linio 80 220 mm 1. concrete 150 mm 2. surface 	<p>ETICS is a widely used external wall structure. The moisture performance of this structure is based on the sufficient waterproofness and water vapor permeability of the thin rendering layer.</p> <p>When the surface layer is intact the structure is working well.</p> <p>No mold risk detected !</p> <p><i>The detail design as well as implementation of the design of the structure is important for all rendered façade solutions regardless of the insulation material used.</i></p>
	<ol style="list-style-type: none"> 1. surface 2. concrete 3. PAROC COS 5ggt 210 mm 4. concrete 5. surface 	<p>External wall construction with grooved Paroc stone wool insulation is a technically functional construction for moisture control.</p> <p>No mold risk detected !</p>
	<ol style="list-style-type: none"> 1. surface 2. brick façade 130 mm 3. ventilation gap 40 mm 4. PAROC Cortex pro 50 mm 5. PAROC eXtra 150 mm 6. concrete 150 mm 7. surface 	<p>External wall construction with Paroc wind protection and stone wool insulation is a technically functional construction for moisture control.</p> <p>No mold risk detected !</p>
	<ol style="list-style-type: none"> 1. façade cladding 2. Ventilation gap 22 mm 3. wind protection, gypsum board 9 mm 4. PAROC eXtra 175 mm / wooden studs 50*175 mm cc600 5. vapor barrier 6. PAROC eXtra 50 mm 7. Gypsum board 13 mm 8. surface 	<p>External wall construction with Paroc stone wool insulation is a technically functional construction for moisture control. The width of ventilation gap is suitable for both wooden and panel facades.</p> <p>No mold risk detected !</p>

The Finnish mold growth model used in this study is based on the original mold growth model for wood. The model can be used to evaluate the mold risk on a surface of different material samples or inside structures in changing temperature and relative humidity conditions. The mold risk is described with mold index M which is calculated from hourly

temperature and relative humidity values. Mold risk is graded from 0–6.

The differences in the mold growth sensitivity of building materials have been taken into account. Every mold sensitivity class and mold decline class has its own factors for calculating the mold index.

Finnish Mold Index –model (VTT/TTY), Mold index M describes the mold growth rate in material surface

Mold index M	Found mold growth	Notes
1	No growth	Clean surface
2	Growth seen by microscope	Growth is beginning in couple of places.
3	Clear growth seen by microscope	Mold growth is covering 10 % of area studied (microscope). The growth is many places in the area.
4	Growth seen by eyes. Rich growth seen by microscope	Growth is covering 10 % of area studied. (eyes) Growth is covering 50 % of area studied. (microscope)
5	Rich growth seen by eyes	Growth is covering 50 % of area studied. (eyes)
6	Very rich growth	Growth is covering 100 % of area studied, dense mold growth.

5. MOISTURE PROPERTIES OF PAROC STONE WOOL

5.1 MOISTURE PROPERTIES

Paroc stone wool insulation is one of the best performing insulation materials when it comes to overall moisture properties. Our confidence and statement is based on long experience as well as extensive experimental study and simulations done for various building insulation materials by an external independent laboratory.

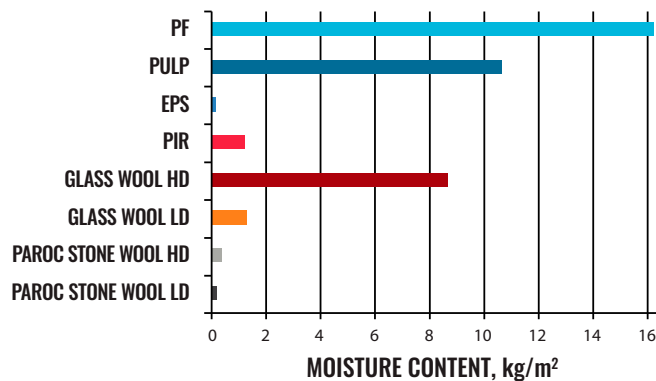
The comparative study* presented below included stone and glass wool, EPS, PIR, phenolic foam and cellulose insulations and measured the materials in terms

of hygroscopic properties, water absorption in partial immersion, water absorption by diffusion, capillary water absorption as well as specific properties related to thermal insulation capacity. Also the drying of wet test specimens was monitored. The measurements made under laboratory conditions correspond to the wetting and drying of materials in practical situations.

From the following diagrams, it is easy to see exceptional performance of Paroc stone wool in a moist environment. The tests were performed for both low and high density products (abbreviated SW, LD and SW, HD; respectively).

* VTT-S-05337-17 Moisture in Building insulations. Determination of effect of moisture to the technical properties of building insulations / 2.10.2017

Equilibrium moisture content of materials (EN ISO 12571)



This diagram presents the equilibrium moisture content of the various insulation materials at 98% relative humidity measured at 23°C.

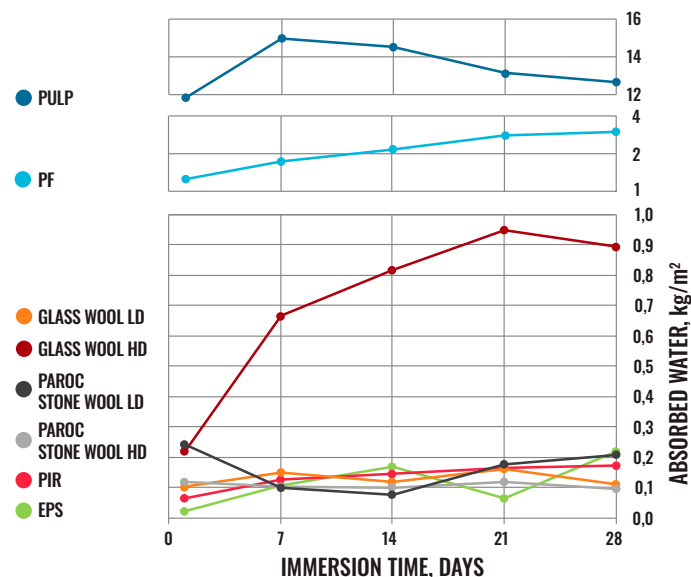
The measurement results correspond to conditions where the insulation materials are exposed to high air humidity, but are not in contact with liquid water.

This property is important to know, because it directly provides the quantity of water vapor that is retained by material.

Conclusion:

Paroc stone wool does not absorb moisture from the surrounding air. It stays dry even in very humid conditions.

Water absorption by partial immersion (EN 12087)



Water absorption in insulations with partial immersion corresponds to, for instance, conditions where an insulation package or insulation installed on a flat roof is exposed to rain

Conclusion:

When Paroc stone wool is immersed partially in water, the water penetrates only the open fiber structure with force as stone wool slabs tend to float. Water penetration happens only in that part of insulation which has been submerged under the surface.

When the insulation is lifted out of the water, the water runs out of the open fiber structure.

Regardless of the immersion time, whether one day or one week, the stone wool does not absorb water. The water absorption level of Paroc stone wool is very similar to plastic-based insulation materials (not excluding Phenolic foam).

Drying time of insulation after partial immersion test

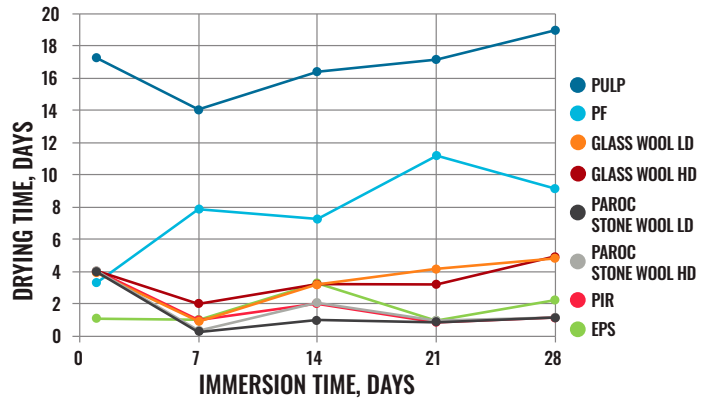
After completing the four-week immersion test, Paroc stone wool products dried in 1–2 days. The drying happened at normal room temperature +23°C and 50% relative humidity.

The thermal conductivity of stone wool was measured both before and after the partial immersion test. Insulation ability remained the same.

The dimensional stability of the stone wool slab was estimated by comparing percentage changes in test specimen length, width and thickness after the 28-day immersion test.

Conclusion:

Paroc stone wool dries very fast at normal room temperature. It maintains its thermal performance and dimensions after moisture exposure.

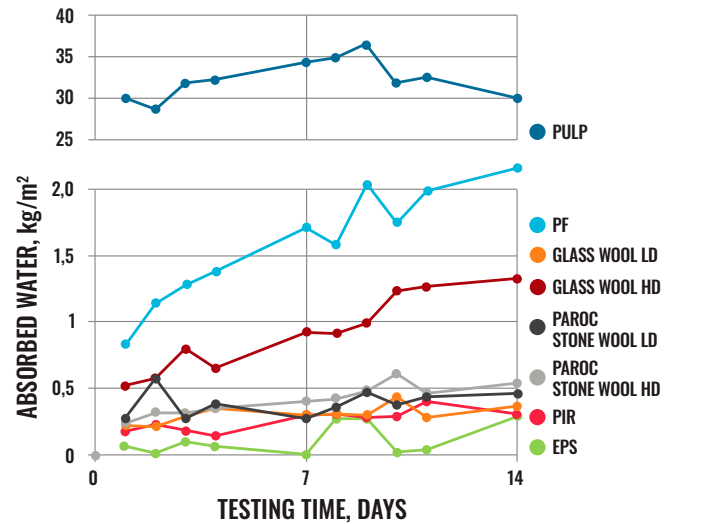


Capillary water absorption (EN 480-5)

The capillarity of insulation material was examined using a measurement method developed especially for measuring capillary water absorption, although the partial immersion method presented in the section above partly measures the corresponding properties.

Conclusion:

Based on the results, stone wool is one of the best insulation materials when used in applications where capillary water absorption may occur.



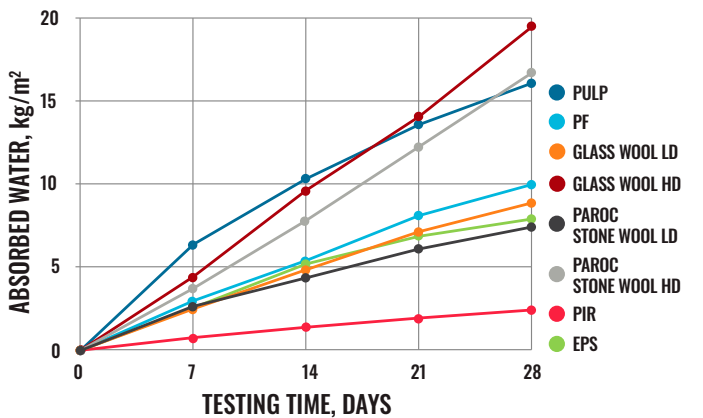
Water absorption by diffusion (EN 12088)

A test conducted in accordance with the standard EN 12088 simulates water vapor transfer into insulation materials caused by partial pressure differences by using a heated water basin maintaining a temperature difference of 50 °C across the test specimen.

The test sample was turned over at seven-day intervals.

Conclusion:

Paroc stone wool is a porous, diffusion open material so it allows water vapor transportation through it. The lighter the material, the faster the water vapor transmission.



The study shows that there are significant differences in the moisture absorption and drying ability of the various insulation materials. None of the materials studied will work on site without proper weather protection.

Paroc stone wool insulation is of great benefit in moisture removal during the construction period, increasing building safety and shortening construction times. In the event of damage, wet structures need extensive repair in order to prevent long-term effects, regardless of the insulation material.

5.2 AIR AND MOISTURE CONTROL

Modern building envelopes are rather complex. They require consideration for insulation continuity and air tightness early in the design process. Airtightness measurements together with a thermal imaging camera make sure that the structures are sufficiently tight already at the construction stage.

1. Simplify the building layout wherever possible.
2. Minimize the number of joints and connections.
3. Stop moisture penetration to the structures with a vapor barrier. Define the continuous line of the vapor barrier as early as possible. Protect the vapor barrier during construction. Decide and specify which materials will form the air/vapor barrier. Make the vapor barrier seams with a 100–200 mm overlap.
4. To achieve good overall air and moisture tightness in a building, seal and safeguard all joints, corners, walls adjoining ceilings and foundations, air barriers between window and door sills, penetrations for pipes, electrical installations, ducts and chimneys
5. Stop forced convection and wind-driven rain by using a wind barrier on the external side of the insulation.



Airtightness measurement detects the building leakage points even before the sealing of structures

6. IMPORTANCE OF A DRY CHAIN IN THE BUILDING PROCESS

The dry chain is a moisture management approach in the building process, which reduces the risk of moisture damage during the life cycle of a building. The operating model includes a risk list and a checklist showing ten key moisture risks. The management of these moisture risks avoids over 80% of the cost of tracking moisture damage.

RISK LIST BY KUIVAKETJU10:

1. **Moisture from outside can damage the foundations and floor structures**
2. **Rainwater can penetrate inside the external wall structure.**
3. **Rain water penetrates the roofing material and underlayment and leaks to the roof constructions.**
4. **Moisture passes from the leakage points of the air barrier layer to the external wall and roof structure, where it condenses into water.**
5. **Improperly dimensioned and adjusted ventilation does not remove excess moisture, but forces it into structures.**
6. **Water pipe breaks cause large water damage to the property.**
7. **In poorly executed wet rooms, moisture will damage the surrounding structures.**
8. **Coating of moist concrete structures causes damage in the coating material.**
9. **Wetting of materials and structures damages the building.**
10. **With poor maintenance, the building will ruin slowly but surely.**

This guide aims to answer most of the risk list points from the insulation material point of view. No one in the construction process can avoid moisture risks alone. The moisture management of a building process is team work that provides an uninterrupted moisture-safe chain between different functions.

The starting point for this chain is the goals and requirements set by the owner of the building for its design and implementation. The designer is responsible for the realization of the objectives with good moisture engineering design and gives the contractor instructions for the various stages of work. The contractor plans the steps of the construction process and instructs other contractors to work in accordance with the dry chain principles. Through the contracts, the main contractor arranges for the various building materials to be delivered to the site at the agreed time and in an agreed manner.

DESIGNER

Designs detailed moisture safe constructions.

Chooses the right materials based on their overall moisture performance in constructions.

OWNER

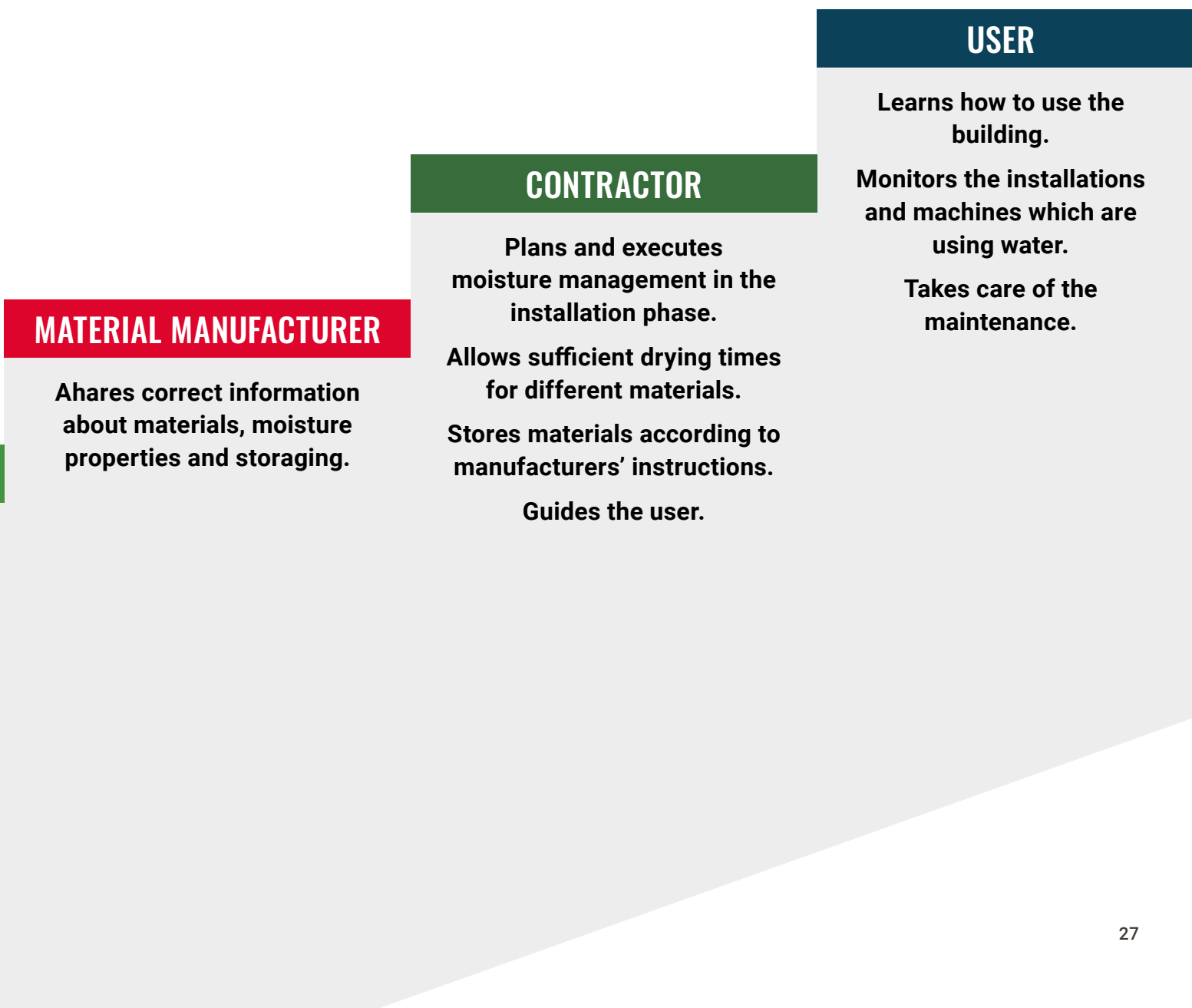
Sets targets, requirements and design instructions for a moisture-safe building.

Assures the quality with monitoring.

When ordering and delivering construction materials, it is good to follow the just-on-time principle to avoid external storage. Product packages for building materials are often inadequate for workplace conditions where variable weather and mechanical stresses can damage the packaging. It is therefore very important that building materials are lifted off the ground and protected from rain and snow with separate weather protection.

Some building materials, such as wood, always contain natural moisture, which dries fairly quickly. Some building materials are wet at the construction phase, they are wet (fresh concrete) or are

consciously installed wet (wet-sprayed cellulose). In most cases, such a short-term moisture load at the construction stage will not be a problem as the structures are designed to dry outwards. But if a wall or a whole building is closed on both sides with vapor-tight material, so that moisture stays in the structure for a long time, there may be a problem. Too tight a construction schedule is the worst enemy of the builder.



MATERIAL MANUFACTURER

Ahars correct information about materials, moisture properties and storaging.

CONTRACTOR

Plans and executes moisture management in the installation phase.

Allows sufficient drying times for different materials.

Stores materials according to manufacturers' instructions.

Guides the user.

USER

Learns how to use the building.

Monitors the installations and machines which are using water.

Takes care of the maintenance.



DURABLE

PAROC® stands for energy-efficient and fire safe insulation solutions of stone wool for new and renovated buildings, marine and offshore, acoustics and other industrial applications. Behind those products, there is an 80-year history of stone wool production knowhow backed with technical insulation expertise and innovation.



REUSABLE

Building Insulation offering covers a wide range of products and solutions for all traditional building insulation. The building insulation products are mainly used for the thermal, fire and sound insulation of exterior walls, roofs, floors and basements, intermediate floors and partitions. Sound absorbing ceilings and wall panels for interior acoustic control, as well as industrial noise control products, are available in the range.



**SOUND
REDUCING**

Technical Insulation offering includes thermal, fire and sound insulation in HVAC systems, industrial processes and pipework, industrial equipment as well as shipbuilding and offshore industry.



FIRE PROOF

For more information please visit www.paroc.ee



**MOISTURE
PROOF**



SAFE



**ENERGY
EFFICIENT**

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