Basic knowledge – Facades
Building physics

Contents

Plan for the future today
Energy-efficient construction

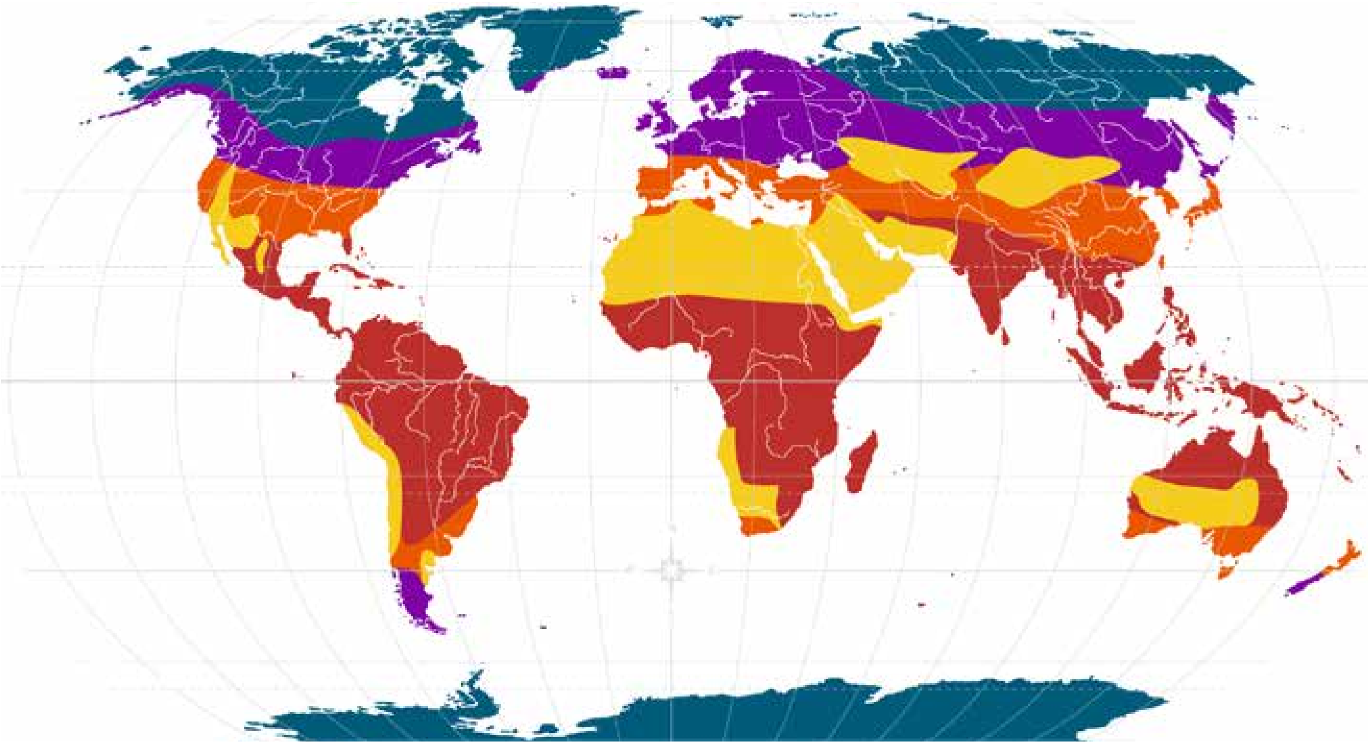
OK, so there may not be a magic formula that can make the greenhouse effect just disappear. But energy-efficient construction and renovation work can go a long way when it comes to preventing climate change.

As energy costs continue to soar, resources continue to deplete, and concerns about our planet continue to grow, energy efficiency is a topic right at the heart of discussions within the world of architecture – in relation to new builds and existing structures alike. And for good reason! After all, buildings that are planned out meticulously with everything implemented correctly in terms of building physics will allow for heating and air-conditioning costs to be reduced as well as helping to combat global warming, pollution, and CO_2 emissions.

The building physical requirements with respect to the energy efficiency of new and old buildings have increased enormously over the last few years. To be precise, new buildings in Germany nowadays only consume a third of the energy that was common 30 years ago. Yet, the total amount of energy consumed by German households has increased rather than decreased since 1990. This is also the case in other European countries. The main reasons for this are lifestyle changes, the growing demand for living space for each inhabitant, and the high number of poorly insulated old buildings.

Sto is pleased to present this brochure to provide you with information on ways to optimise energy efficiency in buildings in the long term. It covers the four main pillars of building physics: thermal protection, moisture protection, sound insulation, and fire protection. You will also find up-to-date information on the building physical properties of external wall insulation systems (EWIS) and handy hints on how to create a pleasant ambient interior climate and prevent the growth of mould.

It also comes with a table of the U-values for the most common wall structures and a glossary featuring all the key terms you need to know when talking about building physics.



With thermal insulation in cooler climate zones and measures to keep the heat out in warmer climes, insulation is needed all year round in every corner of the globe.

Insulating makes sense in all climate zones
Good building insulation is not just something that concerns providing protection against the cold. Looking at the issue of thermal protection worldwide and with respect to the individual climate zone, protecting buildings against the heat during the summer in the south or against the cold in the winter is of fundamental importance. Insulating makes sense in both cases.

Aiming for a pleasant ambient interior climate all year round
The thermal protection used must be able to react to a wide range of climatic conditions. The following measures are proposed in order to increase energy efficiency, lower energy costs, and benefit the' environment:

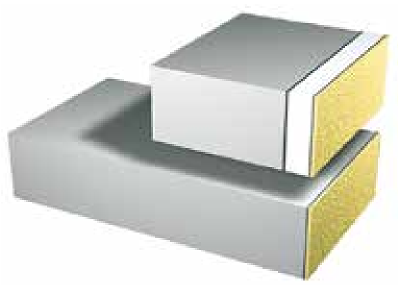
- Better thermal insulation – particularly in existing buildings
- Using renewable energy sources such as photovoltaics (in some cases even in the facade design)
- Using all the options available for improving energy efficiency (facing the building towards direct sun-light, fully insulated building enve-lope, modern heating system, air-conditioning system, windows and so on)
- Sustainable building (EPDs, seals of quality) – also with respect to the disposal of materials

The Sto Facade Planning Service can provide you with everything you need to plan an EWIS – U-value and moisture protection calculations, detailed plans, and so much more.

Insulating protects against the cold and heat

But which system is most efficient in which spot?

Do you opt for an external wall insulation system (EWIS) or a rainscreen cladding facade (RSC)? When it comes to choosing the right insulation system, both structural and climate requirements play a key role. EWIS are among the most effective and cost-efficient insulation systems around. They are weather-resistant, resistant, and are suitable for almost any load-bearing substrate. RSCs can be installed on uneven walls or soft render layers, such as in refurbishments, thanks to their separate sub-construction.
The numerous design possibilities using materials such as natural stone and ceramics mean that they are also often used on prestigious buildings.



A facade with an EWIS needs much thinner walls than a monolithic wall structure to provide the same level of insulation.

How the insulation systems work and what sets them apart
EWIS are installed directly on the external wall. The regulated structure consists of a fixing system, an insulant, a reinforced base coat, and a finish (finishing render, resin brick slip, rigid cladding). RSCs are largely disconnected from the load-bearing wall via the sub-construction. The ventilation layer between the insulation layer and exterior envelope reduces overheating in summer and helps to dissipate humidity in the case of substrates with critical building physical properties.

Resistance to driving rain means...

that window sills need to be selected carefully to ensure that they can effectively absorb changes in length caused by thermal conditions. This stops gaps from forming at the joints and thereby keeps water out of the EWIS. With this in mind, window sills should be welded all the way round, watertight, and fitted with expansion strips at the sides.

The light reflectance value...

is important when choosing the colour for the facade. As a measure for the reflectance of a colour shade, it indicates how far away its brightness is from black (minimum reflection = value 0) or white (maximum reflection = value 100). Colours with values lower than 20 have long been frowned upon because they absorb too much light (= heat), which can lead to thermal stress on the system build-up. Sto has developed its X-black Technology with heat-reflective properties to allow for finishing render and colour coatings to be applied to EWIS and RSC systems in colours with a light reflectance value of less than 20.

The advantages of effective facade insulation extend well beyond savings on your heating costs...

1) **Save energy**
Insulation is a solid investment in the face of energy costs that are constantly rising.

2) **Protect the environment**
Energy consumption is harmful to the environment. Insulating reduces pollutant emissions related to heating.

3) **Generate added value**
Insulating protects the building substance. The value of old and new buildings increases or is retained for longer, boosting their rental value.

4) **Improve the quality of the living environment**
Insulating creates a comfortable, balanced indoor climate: in colder regions thanks to higher wall surface temperatures (without draughts) and in warmer regions thanks to pleasant coolness in the living space.

5) **Combat the occurrence of mould**
Insulating increases the interior wall surface temperature and thereby prevents the formation of condensation, damp wall-paper, and the development of mould.

6) **Eliminate thermal bridges**
With good insulation, critical details such as radiator alcoves, lintels, concrete ring beams, ceiling junctions, and external corners no longer form weak points.

7) **Improve heat storage**
Insulating makes optimum use of the heat storage potential of the masonry.

8) **Guarantee weatherproofing**
Insulating provides optimum "breathable" weatherproofing: seamless and resistant to driving rain, whilst also being permeable to water vapour.

9) **Improve sound insulation**
Special EWIS structures and RSC systems can improve the sound-proofing properties of external walls.

10) **Reduce thermal stresses and crack formation**
Changes in the length of building elements due to thermal stress are significantly reduced. The risk of cracks forming as a result of the temperature, e.g. in heterogeneous blockwork, is no longer a problem.

11) **Optimise crack refurbishment**
Even old buildings full of cracks can be renovated using systems provided by Sto.

12) **Design attractive facades**
Various insulation systems can provide old and new buildings with an attractive and seamless facade design.

13) **Gain living space**
EWIS allows the external wall thickness to be reduced to the structural minimum.

14) **Incorporate experience and safety**
Recommended by specialists, chosen by the trade: Sto EWIS have proven their worth across more than 400 million square metres.

**Did you know:
efficiency and aesthetic appeal go hand in hand**

Many people believe that facade insulation and aesthetic appeal are mutually exclusive and you will often find builders and architects grappling with this dilemma when considering the energy footprint. But it is simply not true! Thanks to the wide range of surfaces available now, including glass, natural stone, ceramics, and various render textures, there are no restrictions when it comes to designing insulated facades.

Stolit Effect render with Sto-Glass Pearls

The detailed technical specifications and information on the products contained in the Technical Data Sheets and approvals must be observed.

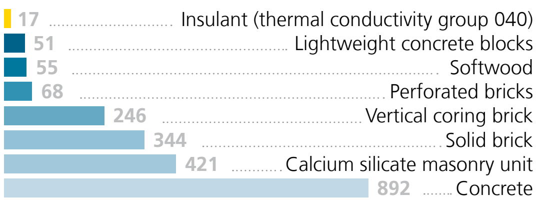
The weather may be beyond our control

But our indoor climate is not

Walls, ceilings, roofs, floors, windows, and doors... Buildings and rooms where people spend long periods of time must be protected just as much against heat loss as they are against the excessive supply of heat. Buildings and building elements should therefore be constructed in such a way that they optimise thermal protection in summer as well as in winter. In order to make a healthy and comfortable living environment, insulation is required that provides effective protection both against climatic conditions (such as humidity and front) as well as against damage.

Insulating reduces energy consumption dramatically
Around 80 % of the energy that a private household consumes is for heating. Domestic hot water, lighting, and electrical appliances only account for 20 %. Most heat is lost through the walls and the roof. Yet this loss can be reduced dramatically with facade insulation. Another "outlet" are the windows: 13 % of heating energy is lost as a result of ventilation, 20 % due to transmission, i.e. by the exchange of heat when the windows are closed.

Layer thickness of different building materials with the same insulation effect (in cm)

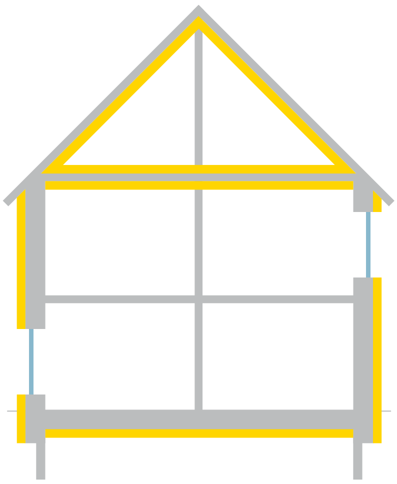


20 cm of insulant will provide more effective insulation than 9 m of concrete.
It's not actually the thickness of a building material that determines its level of thermal protection – it's the thermal conductivity that matters.

Effective measures for thermal protection

The umbrella term thermal protection includes all measures that reduce the transfer of heat between interiors and the outside air or between rooms with different temperatures.

- Insulating the entire building envelope



- Insulating against unheated rooms (for example cellars)
- Avoiding thermal bridges
- Ventilating and heating correctly
- For new buildings: aligning the building (taking factors such as solar radiation and wind load into account)

Physical definitions of thermal protection

Thermal transmittance (U-value) and insulant thickness

Currently applicable across Europe, the U-value or thermal transmittance (measured in W/m^2K) indicates in watts the extent of the heat flow that passes through a surface of 1 m^2 at a temperature difference of 1 kelvin (1 °Celsius).

What is thermal conductivity?

The better a building material is at conducting heat, the more adept the heat is at escaping to the exterior. Thermal conductivity λ ("lambda") indicates in watts (W) the extent of the heat flow that is transferred through a building element that is 1 metre (m) thick at a temperature difference of 1 kelvin (K). It is measured in W/mK. When building a low energy house, for example, an insulant with a thermal conductivity rating of just 0.035 W/mK should be used with insulation thicknesses of more than 16 cm.

Definition: thermal resistance (R)

Thermal resistance R (measured in m^2K/W) is calculated from the layer thickness of the material (d), divided by the thermal conductivity λ:$R = d/\lambda$.

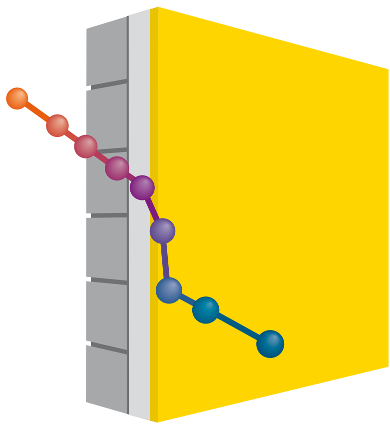
Definition: total thermal resistance (R_T)

Total thermal resistance R_T (measured in m^2K/W) is the total of the individual thermal resistances of the various layers and the heat transfer resistances for the interior and exterior.

Stopping the walls from sweating

Thermal protection against the cold and moisture in winter

Thermal protection in winter reduces heat loss and provides constructions with lasting protection against the weather-related effects of humidity. A minimum requirement with respect to thermal protection is therefore to prevent thermal bridges. When it is implemented correctly, thermal protection ensures that the surface temperature at the internal surfaces of building elements is high enough during the heating period. In turn, this prevents condensation from forming on the wall surfaces when the ambient interior climate is "normal".



From a building physical perspective, external insulation is almost always the right solution and has virtually no disadvantages. The cold is kept outside and the temperature of the masonry is close to that of the room.

Avoiding the build-up of heat with overlay

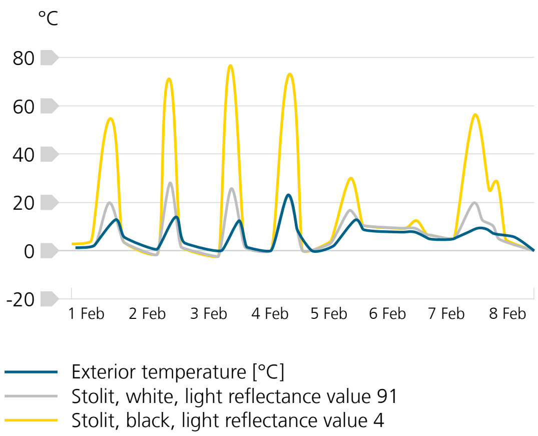
Thermal protection in summer keeps living spaces cool

The job of thermal protection in summer is to limit the extent to which rooms heat up as a result of solar radiation (which usually comes through the windows) as much as possible in order to ensure a comfortable ambient interior climate. The following is generally true: dark external walls heat up more than light building elements because they absorb more solar radiation. Since this can in turn lead to thermal stress on the system build-up, it is recommended that light-coloured facades are used in all spots where the sun can shine down brightly.

The colouring of a facade has a significant impact on its relative humidity and external surface temperature.
The darker a facade is, the higher the temperature of the external surface. The reflectance of a colour shade is indicated by the light reflectance value (refer to page 6 for more information on this).

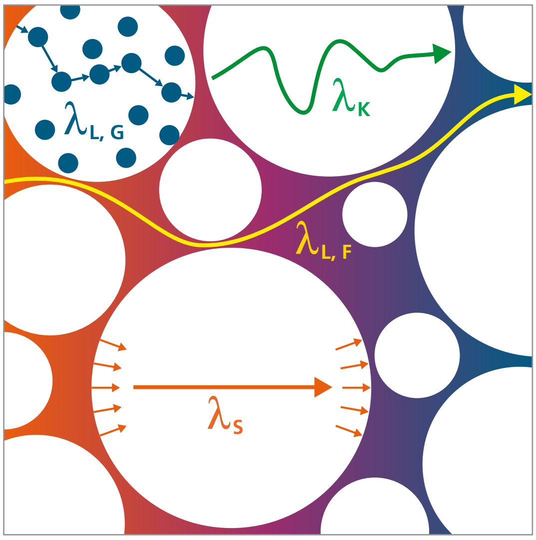
The benefit of the rainscreen cladding facade type is the fact that the heated air continuously rises through the ventilation space between the sub-construction and facade elements. This is a benefit that comes particularly into effect with dark facades.

Surface temperatures
Effect of colouring



Boasting effective energy efficiency, health, and ecological properties

Modern insulants tick all the boxes



Air molecules migrate through air pores measuring just a few µm to get from the warmer to the cooler side of the wall, where heat is transferred. Insulants with coated porous interior walls transfer less infrared radiation, allowing less heat to escape.

From an energy saving point of view, thermal insulation for buildings took on a whole new level of significance in the 90s. And the result was a huge leap in the development of insulants in terms of their energy efficiency, health, and ecological properties.

Criteria for selecting insulants

- **Thermal conductivity**
  Thermal conductivity plays a key role when selecting an insulant.

  Insulants are generally divided according to their origin (organic or mineral), their composition (name of the base materials), or the manufacturing technique (e.g. (foaming) that is applied. Here is a handy overview of the main types of insulant:

- **Mineral fibre insulants**
  Insulants made from minerals such as glass or stone wool are non-combustible.

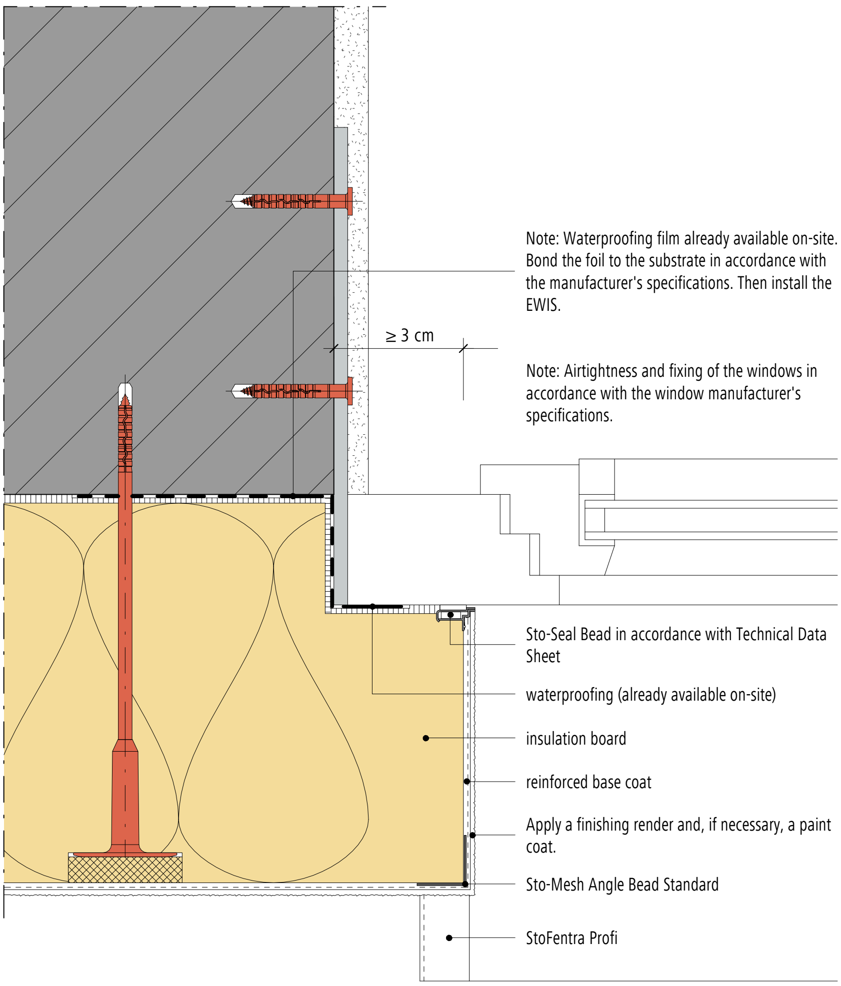
- **Cellular plastics**
  Man-made foam materials with a cell-like structure and low density have a low dead weight and low thermal conductivity, and are virtually free of internal stress.

- **Mineral foam insulants**
  These mineral insulants are made from lime and cement, and they are non-combustible. The diffusion-open insulation board has an excellent life cycle assessment.

- **Softwood fibre insulation boards**
  These are made of wood fibres as part of an industrial production process. Consisting of a natural, renewable resource, they have good sound-proofing properties and a high heat storage capacity owing to their high apparent density.

Sealing up the building envelope all over

Thermal bridges make transmission easier



Detail drawing of a window connection
Correct insulation reduces thermal bridges at critical points such as window reveals, frames, etc. and ensures that the heat does not escape outside.

Thermal bridges are points on or in building elements at which heat is dissipated from the interior to the exterior during heating periods. These areas tend to have a lower thermal resistance and therefore higher transmission heat losses. The causes of thermal bridges are wide-ranging: they can be related to the structure, geometry, or materials used.

Structural thermal bridges
...occur in constructions with varying thermal conductivity. Examples of this are reinforced concrete ceiling systems joined to external walls, concrete ring beams, radiator alcoves.

Geometric thermal bridges
...occur as a result of projections or corners in an otherwise homogeneous building element – if the internal surface (such as external corners on houses) is faced with a larger external surface through which heat is dissipated.

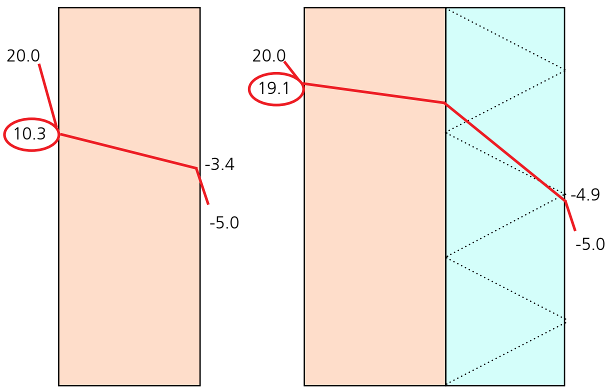
Material-related thermal bridges
...occur when different building materials are present in the cross section in the direction of the heat flow – for example in the case of recessed steel beams or lintels in brick slip walls.

Note: This detail is a general, non-binding planning suggestion, which depicts the execution only schematically.

Keeping things dry to combat condensation and mould

Thermal protection prevents condensation from forming

The enhanced thermal protection that we are used to today reduces the risk of condensation forming on the inside surfaces of external walls. Insulation offers the best protection against knock-on effects such as condensation and mould.



The temperatures on the inside surfaces of external walls are much lower in houses without insulation than they are in buildings with effective insulation. This means that the difference to the ambient room air temperature is much greater, which can lead to condensation forming on the wall surfaces. In the case of insulated wall structures, the surface temperature is much higher than the dew point.

The argument that "well-insulated walls cannot breathe and cause mould" is wrong!

Houses do not "breathe". After all, air never gets through the wall but through the window or ventilation instead – and with it up to approx. 98 % of the humidity. What is meant instead is the diffusion of vapour, i.e. the diffusion of the humidity through the exterior envelope. But this only adds up to a mere 2 %.

How condensation forms

Condensation occurs when water vapour (e.g. in damp air but also in porous materials) cools down to below a certain temperature – what is known as the dew point. Condensation typically occurs in:

- Thermal bridges in walls and ceilings
- Rooms in buildings that are not ventilated sufficiently
- Kitchens and bathrooms
- Poorly insulated external building elements and walls
- Surfaces of good conductors of heat such as metal, glass, natural stone, and tiles

Diffusion-open paints and renders repel water from outside whilst allowing water vapour from inside to escape.

Requirements
The formation of condensation is not a problem when some fundamental requirements are met:

- The water that accumulates inside the building element during the thawing period must be able to be released back into the surroundings during the humidification period.
- For roof and wall constructions, the amount of condensation for the surface area must not exceed 1.0 kg/m².
- If condensation occurs on contact surfaces with a capillary layer that cannot absorb water, the amount of condensation for the surface area must not exceed 0.5 kg/m².
- For timber an increase in the mass-related moisture content of more than 5 % and for engineered wood of more than 3 % is not permitted. Wood wool lightweight construction boards and multi-layer lightweight construction boards are exempt from this.

Product tip: rainscreen cladding facade

The StoVentec systems come in a variety of designs and offer maximum moisture protection.

The detailed technical specifications and information on the products contained in the Technical Data Sheets and approvals must be observed.

Putting an end to fires

Fire protection is an essential part of the planning phase

If there is a fire, the flames can escape from the building: they rip through the apertures above and can spread to the next storey. Fire protection measures for multi-storey buildings are therefore mandatory: in EPS insulation, a non-combustible strip of mineral wool prevents the flames from spreading across the entire facade.

Arranging fire strips
A fire strip consists of a non-combustible strip of mineral wool and must be at least 20 cm high. The distance between the lower edge of the fire strip and the lintel must be no more than 50 cm. In multi-storey buildings with > 10 to 30 cm of EPS insulation, the fire strip runs around the entire building horizontally on every other storey.

The following structural fire safety measures with EPS insulation should be taken to protect against exposure to fires starting on the outside of a building:

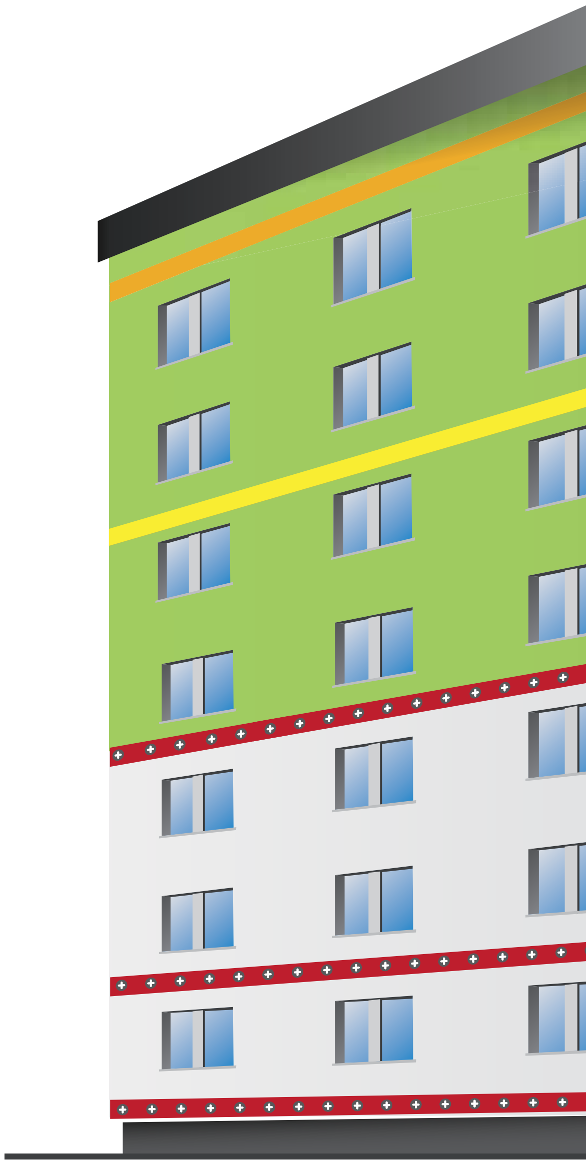
1) Fire strip: max. 0.9 m above the point of intersection with the ground or adjacent horizontal building parts in use
2) Fire strip: in the ceiling area of the first storey above
3) Fire strip: in the ceiling area of the third storey above; additional fire strips should be fitted no more than 1.0 m below adjacent combustible building products (such as roofs).

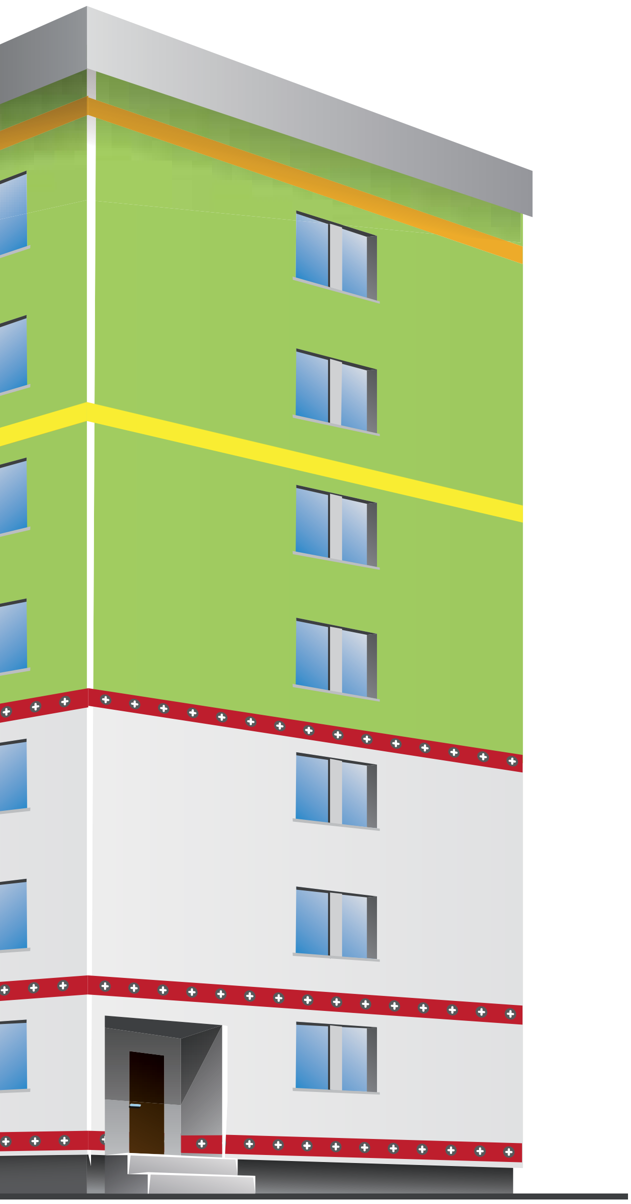
The advantage is that instead of placing individual strips above each window, you now just have to insert a single continuous band into the EPS insulation with limited combustibility. Incompatibilities with window blind and roller shutter boxes are a thing of the past!

In general, the following applies:

- In the case of doubling-up, a mineral wool strip used as a fire strip must be fully bonded to the masonry. The old insulation must be removed from this point.

- In multi-storey buildings, e.g. those with fully glazed staircases, window tapes, loggias, or offset openings, the fire strip runs around the opening.





Having a separate fire flashover strip above every facade opening has been the industry standard up until now. But the all-round fire strip alternative is equally in line with building regulations and it is actually easier to install.

Classification of reaction to fire in accordance with EN 13501-1

The classifications of reaction to fire stipulated in the European Technical Approvals (ETAs) describe the behaviour of a building product in the event of a fire. In addition to the main classification criteria for flammability, spread of flames, and release of heat that are used to define the building material class, classifications are also provided for the following phenomena which occur parallel to the fire: the production of smoke and flaming droplets or particles of building materials.

The classification of a facade insulation system is included in the corresponding European Technical Approval (ETA). Nevertheless, national regulations relating to fire protection must always be observed.

Building material classes in accordance with EN 13501-1

Building materials class	Time to flashover in room corner test
A1	No flashover; calorific potential ≤ 2 MJ/kg
A2	No flashover; calorific potential ≤ 2 MJ/kg
B	No flashover
C	10 – 20 mins
D	2 – 10 mins
E	0 – 2 mins
F	No performance determined

Classification of smoke production as additional criterion

Class	Maximum SMOGRA* in m^2/s^2	Maximum TSP ** in m^2
s1	30	50
s2	180	200
s3	Value exceeding maximum or untested	

* SMOGRA = **Smo**ke **G**rowth **Ra**te
** TSP = **T**otal **S**moke **P**roduction

Classification of production of burning droplets/ particles of building material as additional criterion

Class	Burning droplets	
	within 600 seconds: no	**within 600 seconds: yes longer than 10 seconds: no**
d0	✓	
d1		✓
d2	Value exceeding maximum, ignition of filter paper or untested	

Dealing with annoying noise

Good insulation can quieten things down

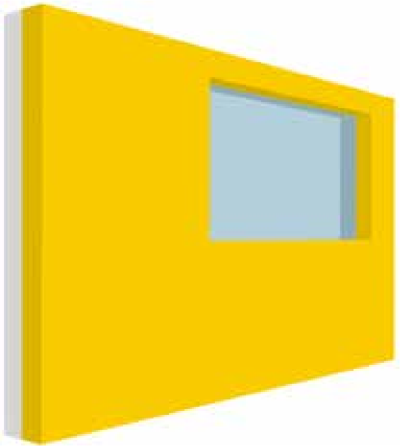
Noise can be harmful to our health, causing issues such as stress, hearing impairments, and cardiovascular problems. Keeping noise pollution as low as possible is therefore quite literally a healthy basic requirement. Since we have been able to measure the extent to which building materials and building elements conduct sound or insulate, it has also been possible to implement sound insulation measures. This involves measures that are just as economically viable as they are effective with respect to the relevant requirements.

Sound attenuation

The sound attenuation of a building element is calculated by carrying out comparative measurements on finished elements: a high sound attenuation means that the level of transmission is lower and that the element has good sound insulation properties. With respect to solid external walls, the mass per unit area is crucial: the heavier (concrete, calcium silicate masonry unit, solid brick) and thicker the wall is, the better (= higher) the sound attenuation that it achieves will be.

Protection from airborne sound and sound attenuation

Whether due to road or rail traffic or aviation noise – the demands placed on external building elements with respect to airborne sound insulation depend on the noise level and the type of project and room. A significant factor for airborne sound insulation is sound attenuation (R’w,R), measured in dB.



Sound insulation: wall with EWIS
(in this case: 20 cm polystyrene, elasticised + 14 kg/m² render) + window
35 dB window
55 dB wall (= 50 dB calcium silicate masonry unit incl. plaster + 5 dB EWIS)
Total with proportion of window surface area of 25 % = 40.9 dB

EWIS (in cavity wall structures) can affect sound attenuation in different ways due to their vibration characteristics. The same rule applies for both thermal protection and sound insulation – it's better to be safe than sorry and add too much in than too little.

Not all thermal insulation has a positive effect on the level of sound insulation: the frequency of the resonant vibration determines whether an EWIS has a positive or negative impact in terms of the perception of exterior noise.

The impact of the EWIS on the sound insulation of the wall depends on the type of system. Key factors are:

- Dynamic stiffness of the insulant
- Thickness of the insulation (insulant thickness)
- Type of fixing (bonding surface proportion/anchor)
- Weight of the render system (weight of the render layer)

The influence of windows on sound insulation

Window surfaces are the weak spots of the facade with respect to sound insulation. The sound insulation of the “wall and window” external building element is therefore primarily determined by the windows. If the demands placed on the airborne sound insulation for the external elements are high, sound insulating windows must be installed. We also recommend the use of rainscreen cladding facades (e.g. StoVentec, seamless RSCs). These can improve the rated sound attenuation (R`w) for the wall by between 8 and 10 dB.

The influence of windows on sound insulation

	Sound attenuation		
	Wall	Window	Total*
Calcium silicate masonry unit (1800 kg/m², 17.5 cm thick, incl. 15 mm plaster)	50 dB	35 dB	40.6 dB
Calcium silicate masonry unit improved by 5 dB through EWIS	55 dB	35 dB	40.9 dB
Calcium silicate masonry unit worsened by 5 dB through EWIS	45 dB	35 dB	39.9 dB

* With proportion of window surface area of 25 %

Feeling the pressure of the wind

Factors for calculating the wind load

Wind load is one of the climate-related factors that have an impact on constructions and building elements. It arises as a result of pressure distribution around a construction exposed to wind flow. Wind load values can vary widely depending on the size, shape, alignment, and location of a building. Wind load is also not the same at each part of the building: the highest wind loads usually act on the corners and edges of buildings.

Positive or negative wind load?
Each building can be divided into zones, which vary in size, shape, and dimensions. The wind load acting on a building consists of both (positive) pressure and (negative) suction forces, which in general act perpendicular to the surface – as what is known as distributed load.

The negative forces in particular (negative pressure) play an important role when it comes to the construction type: the slowing of the flow on the windward surfaces of a building causes positive pressure to occur. The airflow alternates at the edges of the roof and sides of a building and generates negative pressure (suction). As a result, negative pressure is also generated at the rear of the building due to subsequent swirls of air.

Recommended anchor fixing
In the event that a standard fixing technique is not sufficient, additional fixing measures (bonding and anchors) are called for. The position and number of anchors needed depend on the height of the building, its location, the type of insulation, and the wall material.

Anchor pattern for a board size of 0.5 m²

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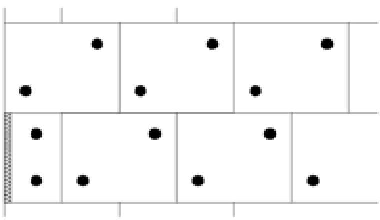

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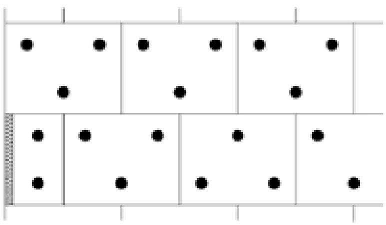

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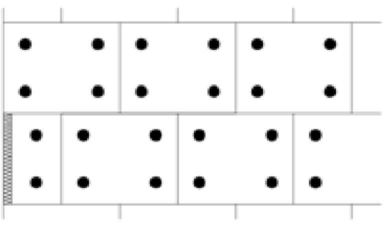

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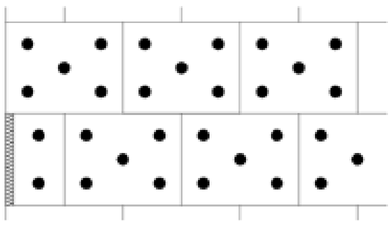


* Number of anchors per m²

Trusting people as the best measuring devices around

Insulation boosts comfort and general well-being

A wide range of factors influence our well-being in interiors: the temperature of the air and on the wall surfaces is just as important as humidity and air movement when it comes to creating a pleasant ambient interior climate. And at least as vital as the ambient room temperature is the temperature on the surfaces that enclose the room, for instance. If they differ, you will notice it immediately – on your skin.

Real and perceived temperature
When it comes to ambient room air temperature, the key factors are heating, cooling, and thermal insulation: 17 to 24 °C is regarded as comfortable. The difference between the temperature of the ambient room air and that of the surrounding surfaces should be no more than 3 °C.

At an ambient room air temperature of 20 °C, a normally dressed person has an average skin temperature of 33 °C. The temperature difference between the surface of the body (skin) and the environment means that the body is continuously losing heat. The temperature as it feels to us is not the same as the ambient room air temperature. Instead, it equates to the average of the ambient room air temperature and the wall surface temperature.

Example:
Ambient room air temperature =
20 °C
Wall surface temperature = 18 °C
Perceived temperature
(20 + 18) : 2 = 19 °C

Air movement (convection)

The rise of warm (= light) air and the fall of cold (= heavy) air results in constant air movement in enclosed spaces (convection). We generally do not notice this when the speed is below 0.2 m/sec. However, if the difference between the surface temperature and the ambient room air temperature is greater than 3 °C, the air cools down so quickly that we do notice it and we feel a draught.

Wall structures

Wall structure	Thermal conductivity [W/mK]	Thermal transmittance		Wall surface temperature	
Concrete B 25	2.10	2.75	0.35	+9.3	+18.6
Vertical coring brick	0.58	1.36	0.31	+14.7	+18.8
Calcium silicate masonry unit	0.70	1.54	0.32	+14.0	+18.8
Perforated lightweight brick, apparent density 800 kg/m²	0.33	0.89	0.27	+16.5	+18.9

Wall structures without additional insulation, 30 cm (with 1.5 cm plaster on both sides)
Wall structures with 10 cm Sto EWIS (with 10 cm PS 15 SE on both sides)

The surface temperature rises as a result of having more effective thermal protection. The table illustrates the wall surface temperatures with and without insulation given an ambient room air temperature of +20 °C and an outdoor air temperature of -10 °C

The effects of relative air humidity
In living spaces with a temperature of 18 to 22 °C, relative air humidity of 40 to 60 % is normal. If it differs from this, we feel that our well-being is being affected or even disturbed.

Excessively dry air
(relative air humidity < 40 %)
- Causes the mucous membranes to dry out
- Promotes the formation of dust and its dispersion in the ambient room air

Excessively humid air
(relative air humidity > 60 %)
- Makes breathing difficult
- Affects perspiration (sweating)
- Promotes soiling and the growth of mould
- Increases the risk of water vapour condensation on walls
- Promotes the spread of germs

Growth of mould and counter-measures
The microclimate indoors and outdoors are hardly ever the same. Especially during cold times of the year, temperature differences of over 30 °C can occur. The external walls play a key role in this respect as they form a boundary between both zones. If the wrong construction type is used or the living space is not used as intended, problems are bound to occur.

Key causes of the growth of mould
- Inadequate thermal insulation
- Incorrect heating or ventilation

Appropriate countermeasures
- Ensure sufficient thermal values for external surfaces (external walls, windows, ceilings)
- Avoid thermal bridges
- Use insulated glass windows
- Heat rooms that have cooled down in good time prior to using them
- Ensure sufficient ventilation
- Do not place any large furniture on external walls

Product tip: the Sto interior silicate range

With the Sto interior silicate range, mould and mildew have no chance. Sto's natural interior products* create the perfect conditions to guarantee a healthy indoor climate and reliable protection against mould and mildew.

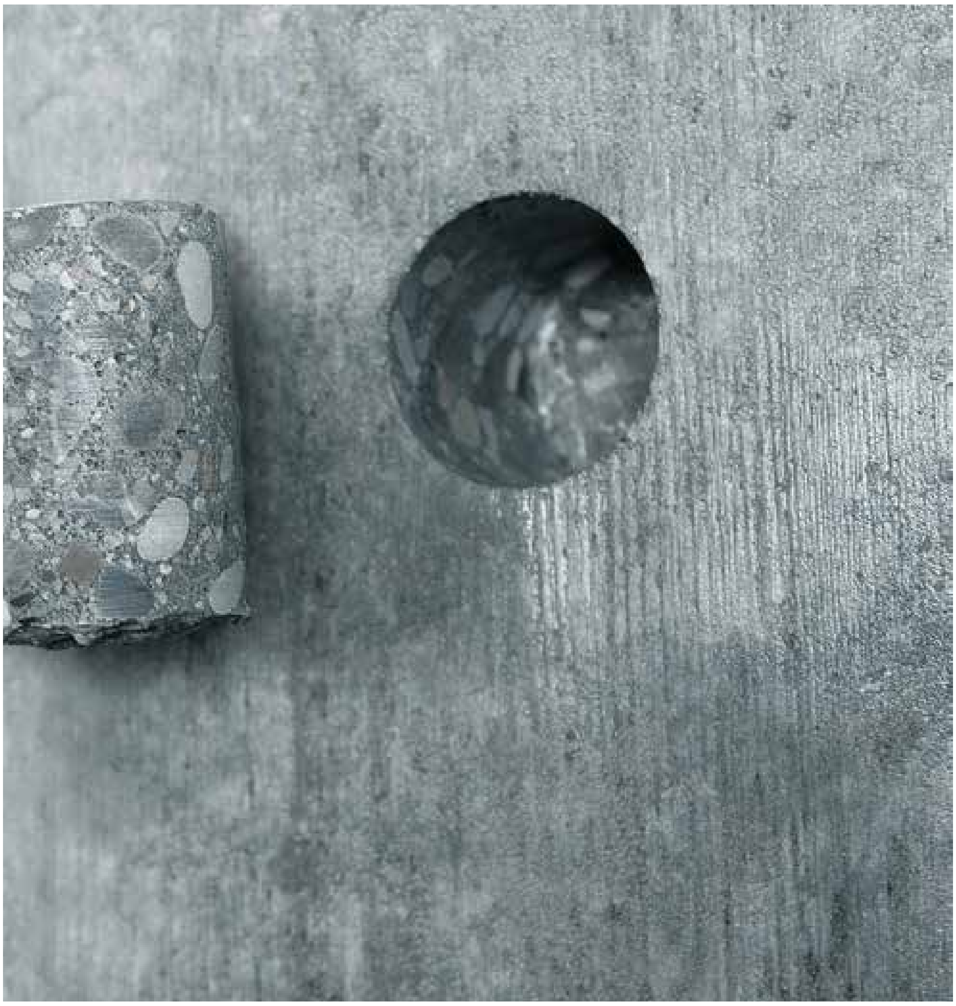
* In-depth look at our interior product overview

Working from the starting point
Mineral and organic substrates

Every coating and every external wall insulation system is installed on a pre-existing substrate. As well as the load-bearing capacity of this substrate, the materiality is also significant. After all, in order to avoid damage and cracks, e.g. due to temperature fluctuations, the following basic rule applies: the substrate must be stronger than the layer on top. Otherwise, damage is almost bound to occur. That is why it is also important that the system components in a facade insulation system are precisely matched.

The substrates are basically divided into 2 types:

- Organic substrates: they are flexible and cannot therefore be coated with mineral and rigid materials.
- Mineral substrates: they are relatively rigid and can therefore be covered with both mineral and organic materials.



Concrete is a mineral substrate. That means it can be covered with both rigid, mineral and flexible, organic materials.

Material	Substrate type
Concrete	Mineral
Lime paint/lime render	Mineral
Lime/cement render	Mineral
Calcium silicate masonry unit	Mineral
Cellular concrete	Mineral
Sandstone	Mineral
Emulsion/silicone resin	Organic
Silicate paint/render	Mineral

Getting a huge impact from a minor difference

Binding agents for facade paints and renders

The binding agent joins minute firm ingredients together in the facade coatings and is crucial in terms of the key properties. The type and amount of binding agent determine whether a facade paint is particularly weather-resistant or whether a render is particularly diffusion-open, for instance. The clever use of functional filler materials, pigments, co-binding agents, and additives reinforce these confirmed basic properties boasted by the binding agent and can even lead to new ones in some cases. This is what we call iQ – INTELLIGENT TECHNOLOGY.

- **Facade paints with Dryonic® Technology**
  Using the bionic principle behind head-stander beetles in a coating rich in binding agent allows for water management with regard to the formation of condensation and rain. This means that facades can dry off quickly, offering a natural form of protection against algae and fungal attack.
- **Facade paints and renders with Lotus-Effect® Technology**
  Silicone resin as a binding agent combined with a microstructured surface similar to the leaf of a lotus flower results in a drastically reduced surface with which dirt, algae, fungus, and so on can come into contact. Contamination can just run off in droplets when it rains.
- **Facade paints and renders with X-black® Technology**
  Teamed with near-infrared-reflective filler materials and pigments, these coatings reduce the maximum amount by which a facade surface can be heated up by sunlight. This even makes it possible to use dark, intense colour shades on insulated or heat-sensitive facade substrates.

Binding agents and their typical properties:

- **Silicone resin**
  Thanks to the silicone resin co-binding agent, the best properties of emulsion and silicate paints and renders are combined. Water is fully repelled from the exterior, with good permeability for water vapour ensuring that the substrate is dry. High resistance to weathering and effective protection for the facade are guaranteed in the long term.
- **Dispersions**
  For emulsion paints and renders, also known as organic paints and renders, the binding agent is a polymer dispersion primarily obtained from fossil fuels.
  Depending on the formulation and type used, emulsion-based renders and emulsion paints have an extremely wide range of properties, ranging from hard to soft and elastic, from impermeable to water to very diffusion-open, and from water-repellent to absorbent.
- **Silicates**
  Potassium silicate is a silicate binding agent that makes for a hard and transparent mineral binder. In its purest form, it is traditionally used in two-component pure silicate paints. These paints are very permeable to water vapour, but they do also absorb a lot of water. Their use must therefore be tailored specifically in line with the substrate, which must always be of the mineral variety. Traditionally, pure two-component silicate paints are used on plastered solid walls in interior and exterior spaces for the protection of historical buildings and monuments.
- **Mineral binding agents**
  Lime or cement or an optimum mixture of the two acts as the main binding agent for facade coatings. Mineral products boast impressive chemical hardening properties and they bind water, allowing for hard and rigid layers which can even have a considerable thickness. Non-combustibility and cost-effectiveness always go hand-in-hand.

Formulations with binding agents	Substrate	Water-repellent effect	Water vapour permeability	CO_2 permea-bility	Crack resistance	Pastel colour shades	Intense colour shades	Homogene-ous surface pattern	Self-cleaning effect
Lotus-Effect®	Organic Mineral	●● *)	●●	●●	●	●	●	●● *)	●● *)
Silicone resin	Organic Mineral	●●	●●	●●	●	●	●	●●	●●
Dispersion/organic	Organic Mineral	●●	●	○	●● *)	●● *)	●● *)	●●	●
Pure silicate	Mineral		●●	●●		●	○	○	●
Silicate with dispersion	Mineral	○	●●	●	○	●	○	●	○
mineral	Mineral	○	●●	●● *)	○	●		○	○

*) The most effective binding agent technology in this area

○ To a limited extent ● = To a good extent ●● = To an excellent extent

Building physical data

Thermal protection

Wall material [24 cm]	Design thermal conductivity λ*) [W/mK]	U-value [W/m²K] Without insulation **)	Design thermal conductivity λ*) [W/mK] – insulation	Thermal transmittance (U-value) [W/m²K] with insulation							
				6 cm	8 cm	10 cm	12 cm	14 cm	16 cm	18 cm	20 cm
Concrete 2400 kg/m³	2.10	3.00	45	0.59	0.47	0.39	0.33	0.29	0.26	0.23	0.21
			40	0.54	0.43	0.35	0.30	0.26	0.23	0.21	0.19
			35	0.48	0.38	0.31	0.26	0.23	0.20	0.18	0.16
			32	0.45	0.35	0.29	0.24	0.21	0.19	0.17	0.15
			22	0.33	0.25	0.20	0.17	0.15	0.13	0.12	0.11
Solid brick 1800 kg/m³	0.81	1.96	45	0.54	0.44	0.36	0.31	0.28	0.25	0.22	0.20
			40	0.50	0.40	0.33	0.28	0.25	0.22	0.20	0.18
			35	0.45	0.36	0.30	0.25	0.22	0.20	0.18	0.16
			32	0.42	0.33	0.27	0.23	0.20	0.18	0.16	0.15
			22	0.29	0.23	0.19	0.16	0.15	0.13	0.11	0.10
Vertical coring brick 1000 kg/m³	0.45	1.34	45	0.48	0.39	0.33	0.29	0.26	0.23	0.21	0.19
			40	0.44	0.36	0.31	0.27	0.23	0.21	0.19	0.17
			35	0.40	0.33	0.28	0.24	0.21	0.19	0.17	0.15
			32	0.38	0.31	0.26	0.22	0.19	0.17	0.16	0.14
			22	0.29	0.23	0.19	0.16	0.14	0.12	0.11	0.10
Calcium silicate masonry unit 1800 kg/m³	0.99	2.19	45	0.56	0.45	0.37	0.32	0.28	0.25	0.22	0.20
			40	0.51	0.41	0.34	0.29	0.25	0.22	0.20	0.18
			35	0.46	0.36	0.30	0.26	0.22	0.20	0.18	0.16
			32	0.43	0.34	0.28	0.24	0.21	0.18	0.16	0.15
			22	0.31	0.24	0.20	0.17	0.15	0.13	0.12	0.10
Calcium silicate masonry unit 1400 kg/m³	0.70	1.80	45	0.53	0.43	0.36	0.31	0.27	0.24	0.22	0.20
			40	0.48	0.39	0.33	0.28	0.25	0.22	0.20	0.18
			35	0.44	0.35	0.29	0.25	0.22	0.19	0.18	0.16
			32	0.41	0.33	0.27	0.23	0.20	0.18	0.16	0.15
			22	0.30	0.24	0.20	0.17	0.14	0.13	0.11	0.10
Lightweight concrete hollow block 1000 kg/m³	0.49	1.42	45	0.49	0.40	0.34	0.30	0.26	0.23	0.21	0.19
			40	0.45	0.37	0.31	0.27	0.24	0.21	0.19	0.18
			35	0.41	0.33	0.28	0.24	0.21	0.19	0.17	0.16
			32	0.39	0.31	0.26	0.22	0.20	0.18	0.16	0.14
			22	0.29	0.23	0.19	0.16	0.14	0.13	0.11	0.10
Lightweight concrete hollow block 600 kg/m³	0.32	1.04	45	0.43	0.36	0.31	0.27	0.24	0.22	0.20	0.18
			40	0.40	0.34	0.29	0.25	0.22	0.20	0.18	0.17
			35	0.37	0.31	0.26	0.23	0.20	0.18	0.16	0.15
			32	0.35	0.29	0.24	0.21	0.19	0.17	0.15	0.14
			22	0.27	0.22	0.18	0.16	0.14	0.12	0.11	0.10
Lightweight concrete solid masonry 1000 kg/m³	0.46	1.36	45	0.48	0.40	0.34	0.29	0.26	0.23	0.21	0.19
			40	0.45	0.36	0.31	0.27	0.24	0.21	0.19	0.17
			35	0.41	0.33	0.28	0.24	0.21	0.19	0.17	0.15
			32	0.38	0.31	0.26	0.22	0.20	0.17	0.16	0.14
			22	0.29	0.23	0.19	0.16	0.14	0.12	0.11	0.10
Normal-weight concrete hollow block 1800 kg/m³	0.92	2.11	45	0.55	0.44	0.37	0.32	0.28	0.25	0.22	0.20
			40	0.50	0.40	0.34	0.29	0.25	0.22	0.20	0.18
			35	0.45	0.36	0.30	0.26	0.22	0.20	0.18	0.16
			32	0.42	0.34	0.28	0.24	0.21	0.18	0.16	0.15
			22	0.31	0.24	0.20	0.17	0.15	0.13	0.12	0.10
Cellular concrete slab GP6	0.27	0.91	45	0.41	0.35	0.30	0.26	0.24	0.21	0.20	0.18
			40	0.38	0.32	0.28	0.24	0.22	0.20	0.18	0.16
			35	0.35	0.29	0.25	0.22	0.20	0.18	0.16	0.15
			32	0.33	0.28	0.24	0.21	0.18	0.16	0.15	0.14
			22	0.26	0.21	0.18	0.15	0.13	0.12	0.11	0.10
Vertical coring light-weight brick 800 kg/m³	0.33	1.06	45	0.44	0.37	0.32	0.28	0.25	0.22	0.20	0.19
			40	0.41	0.34	0.29	0.25	0.22	0.20	0.18	0.17
			35	0.38	0.31	0.26	0.23	0.20	0.18	0.16	0.15
			32	0.35	0.29	0.25	0.21	0.19	0.17	0.15	0.14
			22	0.27	0.22	0.18	0.16	0.14	0.12	0.11	0.10

*) As per EN ISO 7345 "Thermal insulation – Physical quantities and definitions"
**) All wall structures have 1.5 cm of plaster and 2 cm of render (existing render)

Glossary

Efflorescences
As a result of penetrating moisture (e.g. in the form of driving rain or rising damp), water-soluble salts dissolve in render substrates or coatings and migrate to the rendered surface. When the moisture evaporates, the salts are deposited on the rendered surface. This leaves behind visible salt crystals that look like ugly white flecks on the surface of the building. If the salts crystallise in the dividing layer between the masonry and the render, this may cause the mechanical destruction of the rendered surface.

Blower-door test
A test to determine the airtightness of the building envelope using a fan to generate a difference in pressure between the interior and the surroundings. This method is generally used in building shell work.

Dynamic stiffness (MN/m³)
Characteristic of the spring behaviour, e.g. of an insulation board. In EWIS, the use of insulation boards with low dynamic stiffness on the external wall results in an improvement to the airborne sound insulation values.

Environmental Product Declaration (EPD)
The voluntary "Environmental Product Declaration" (EPD) documents the entire life cycle of a construction product – including potential health risks as well as any environmental impact that may arise as a result of its manufacture and use.

European Technical Approval (ETA)
The European Technical Approval (ETA) is proof of a building product's usability in the sense of the Building Products Guideline. The ETA is based on tests, inspections, and a technical assessment performed by authorised bodies approved by the EU member states. It covers all product features that may be considered relevant to ensure that statutory requirements in the member states are complied with, whereby the performance level required in each case may differ depending on the country and the intended purpose. A European Technical Approval can be issued for building products that do not (yet) have harmonised standards according to the Building Products Guideline, or for those considerably differing from a harmonised standard. The approval for usability is based on either approval guidelines (European Technical Approval Guideline – ETAG), which have been created by the EOTA for the corresponding product areas, or on assessment criteria especially for an application for approval that have been agreed upon with other EOTA bodies. The ETA allows the manufacturer to label their construction product with the CE marking, thus opening the way into the European market. With this CE marking, the manufacturer confirms that they have carried out the mandatory procedures to prove the conformity of the product with the approval.

Expanded polystyrene (EPS)
Expanded polystyrenes (EPS), also known as foam, are low-density, man-made materials with a cell-like structure. Building elements made of foam are virtually free of internal stress and are characterised by their extremely low density (apparent density) and thermal conductivity.

Heating degree days
You can calculate the amount of heat consumed within a heating period by taking the number of heating days and multiplying that by the difference between the average outside temperature and the average ambient room temperature.

Light reflectance value
The light reflectance value is important when choosing the colour for the facade. As a measure for the reflectance of a colour shade, it indicates how far away its brightness is from black (minimum reflection = value 0) or white (maximum reflection = value 100).

High-rise level
The high-rise level is between 22 m from the ground to the floor of the highest storey people are living on. This value may vary in different countries.

Hydrophobisation
Hydrophobisation (adding water-repellent properties) describes the treatment of a building surface with a coating or impregnating agent that reduces the capillary absorption of the building material.

Capillary action
During capillary action, the water reaches the hydrophilic wall of the capillaries due to the surface tension in narrow capillary tubes. As the capillary diameter decreases, the exerted forces and transport speed in a capillary full of water increase dramatically and encroach on the surrounding building materials due to the pressure that develops.

Core insulation
The insulation between two walls (load-bearing wall and masonry). Mineral wool or polystyrene are generally used as the insulating material.

Convection
The transfer of heat owing to the flow behaviour of liquids and gases (fluids) Fluids are heated up by warm objects and give off heat to cold ones.

If there are differences in the temperatures in a room, the air will be circulated automatically (free convection). The flow will stop once a consistent ambient room temperature has been reached.

Airborne sound

The transmission of sound waves in the air.

Low energy house

There is not one standard definition for the term "low energy house". It refers to buildings that undercut the statutory regulations for the maximum energy expenditure for heating and supplying hot water. These maximum values are determined for Germany in the Energy Saving Ordinance, for example.

Osmosis/capillary action

Osmosis enables water to be transferred in building materials when areas with different salt concentrations adjoin each other. Water attempts to move from zones containing less salt to those containing more in order to equalise the salt concentration.

Perimeter insulation

Thermal insulation that is installed so that it is protected against mechanical damage or pressing water in the soil. This is only possible with suitable insulants that have been designed specifically for this purpose and that comply with the building inspection requirements.

Rain protection

Measures taken to protect a building material used on the building envelope against moisture caused by rain.

Relative air humidity

Air normally contains just a part of the highest possible humidity. The relative air humidity is the water vapour mass divided by the highest possible water vapour mass. It is expressed as a percentage.

Sound attenuation

The sound attenuation of a building element is calculated by carrying out comparative measurements on finished elements: a high sound attenuation means that the level of transmission is lower and that the element has good sound insulation properties. With respect to solid external walls, the mass per unit area is crucial: the heavier (concrete, calcium silicate masonry unit, solid brick) and thicker the wall is, the better (= higher) the sound attenuation that it achieves will be.

sD value/diffusion-equivalent air layer thickness

The resistance which one layer of a building element applies to oppose water vapour diffusion.
sd [m] = μ x d
d = layer thickness of the building material [m]
μ = water vapour diffusion-equivalent air layer thickness [non-dimensional]

Solar energy generation (windows)

Heat generated as a result of solar radiation.

Stability verification

The stability verification of EWIS must always be carried out in the entire system. The individual components are checked to ensure that they are fit for purpose. The loading cases to be checked are dead load, hygrothermal deformations, and wind suction.

Dew point/formation of condensation

The dew point is the exact air temperature at which the relative air humidity reaches a value of 100 %. Whenever this limit is exceeded, condensation water forms.

Thermal imaging

The non-contact method for determining thermal bridges on completed building envelopes using an infrared camera.

Transmission heat loss

Heat loss from fixed structures or building elements, such as roofs, ceilings, cellars, windows, and external walls.

Rainscreen cladding facades (RSC)

Rainscreen cladding facades (RSCs) are multi-layered external wall constructions. They consist of a facade cladding, a ventilation zone, and the insulation of the substructure. The outermost layer, which is used to protect the facade from driving rain, is separated from the layers behind by a cavity.

Thermal bridges

Localised points in walls and ceilings, which exhibit higher heat loss due to lower thermal insulation, such as window lintels, columns, roller shutter boxes, and corners of the building.

Insulating render

Render with lightweight aggregates (e.g. polystyrene pellets, perlite) to boost the thermal insulation properties.

External wall insulation systems (EWIS)

External wall insulation systems (EWIS) refer to systems that provide external insulation for the external walls of buildings. The insulating material (insulant) is fixed to the existing substrate in the form of boards or lamellae using adhesives and/or anchors and then provided with a layer of reinforcement and external render.

Thermal expansion
The phenomenon of a fixed building element's length changing due to the heat.

Total thermal resistance (R_T)
Total thermal resistance R_T (measured in m²K/W) is the total of the individual thermal resistances of the various layers and the heat transfer resistances for the interior and exterior.

Thermal transmittance/ U-value
Currently applicable across Europe, the U-value or thermal transmittance (measured in W/m²K) indicates in watts the extent of the heat flow that passes through a surface of 1 m^2 at a temperature difference of 1 kelvin (1 °Celsius).

Thermal resistance (R)
Thermal resistance R (measured in m²K/W) is calculated from the layer thickness of the material (d), divided by the thermal conductivity λ:
$R = d/\lambda$

Thermal conductivity
The better a building material is at conducting heat, the more adept the heat is at escaping to the exterior. Thermal conductivity is the amount of heat (in Ws) that flows through a layer of material measuring 1 m in thickness and with a surface area of 1 m2 in 1 s when there is a temperature difference of 1 K. It is measured in W/mK.

Heat conduction
The transfer of kinetic energy (= heat) from one molecule to another. The ability to conduct heat depends on the material in question and its structure.

Thermal radiation
The transfer of energy from a warmer to a cooler body as a result of the emission or absorption of electromagnetic waves in the invisible infrared range.

Heat transfer/heat flow
Flowing thermal energy (generally from the interior to the exterior) due to a temperature drop from the warm to the cold side of a building element.

Water absorption coefficient (W)
The water absorption coefficient (known as the w-value for short) indicates how much water a material takes in within a certain period of time.

Water vapour diffusion
The gaseous water molecules (water vapour) contained in the air migrate (diffuse) in the direction of lower vapour pressure, e.g. from the humid room air through building elements to the drier outside air.

Water vapour diffusion-equivalent air layer thickness (μ)
The water vapour diffusion-equivalent air layer thickness (as per EN ISO 12572: 2001 CDI) specifies how much more resistant to water vapour a material is than a layer of stationary air of equal thickness. The greater the μ value (non-dimensional), the more resistant to vapour a building material is. The water vapour diffusion-equivalent air layer thickness of a material is determined largely by the sd value, which is calculated as the product of the μ value and the layer thickness of the building material.

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