KÖSTER
Waterproofing Systems

HORIZONTAL BARRIERS

AGAINST RISING DAMP IN MASONRY

PATENTED SYSTEM

Why is rising damp a concern for building owners?

Rising damp is among the most frequently encountered causes of damage to masonry walls. The results are usually clearly identifiable through spalling of plaster, damaged joints and bricks but also through salt efflorescence and algae growth.

Change of colour, reduction of the thermal insulation.

Damaged plaster / render

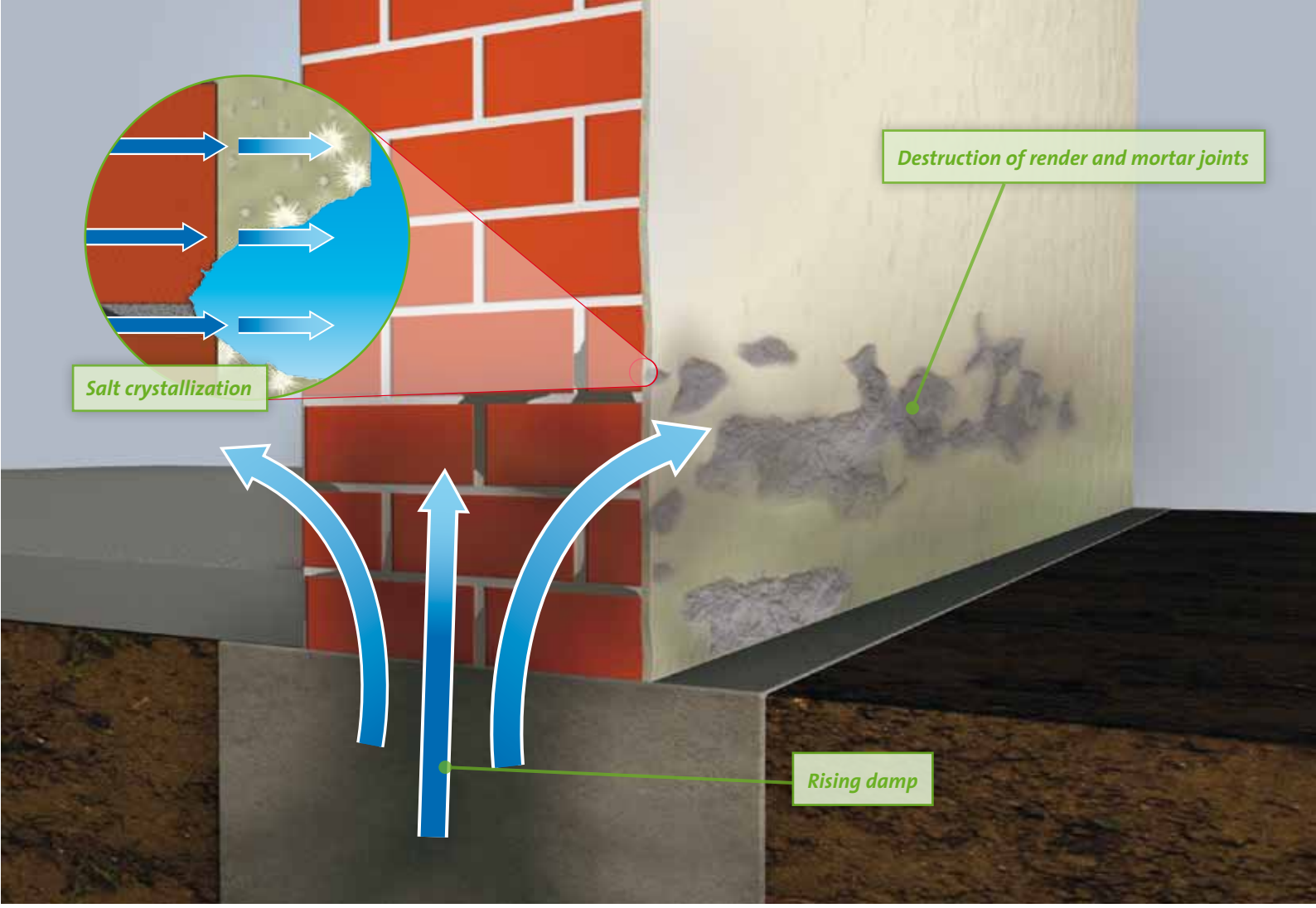
Destruction of render and mortar joints

Development of mould and damage to the fabric of the structure

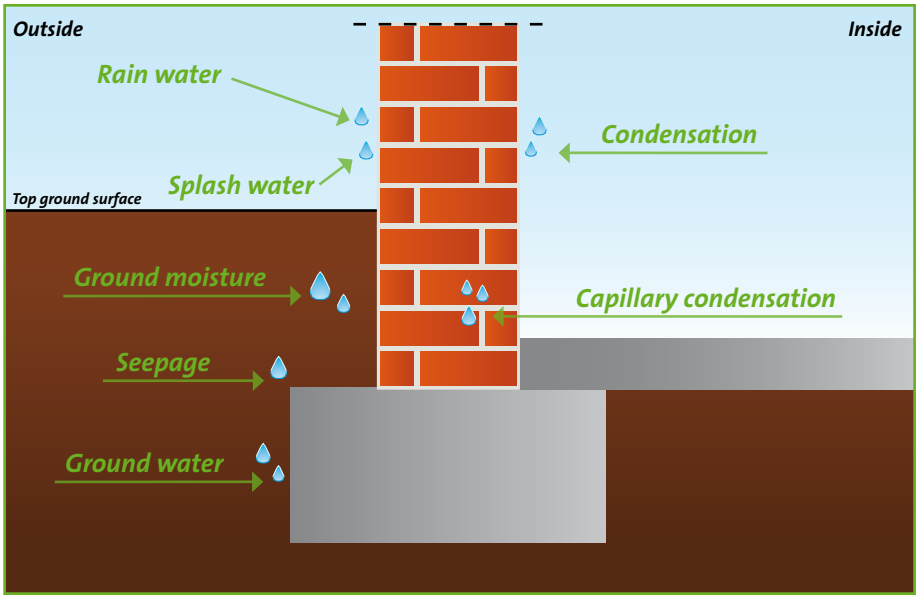
Over time rising damp in combination with salt contamination and / or frost can destroy masonry structurally. Taking into account the decrease of the remaining lifespans of such buildings, rising damp causes high financial damage every year.

How does rising damp damage masonry?

In masonry that is affected by rising damp, moisture is continuously transported upward through the capillaries. The water evaporates on the surface and more moisture follows. This process will usually lead to an increase in the concentration of salts on the surface. Most evaporation takes place in the area between the dry (top) and the damp part of the wall (bottom). In these areas, there are often the first signs of damage.



Where does the water come from?



There are many sources from which water can get to a wall such as rain water, ground water and condensate (see graphic). Also leaking gutters or drainage pipes can be sources of water. If the water which is entering a wall is constantly replenished then a continuous transport of water through the capillaries of the building material will take place. The water rises upwards against gravity due to a mechanism called capillary action.

Is it rising damp?

A wall with damage apparently attributable to rising damp should always be analyzed by a specialist before any renovation measures are undertaken. Determining the cause of the damage is always important. Information such as the type of damage, the characteristics of the building, as well as the salt and moisture contents of the building materials all have to be taken into consideration when determining how to repair the damage and remove its cause. The source of damage may not always be rising damp. Other possibilites are: splash water above a functioning horizontal barrier, hygroscopic action or just leaking pipe installations. If it is rising damp, the restoration has to take into account the salt and moisture content of the building material. Therefore, a salt and moisture analysis is recommended.

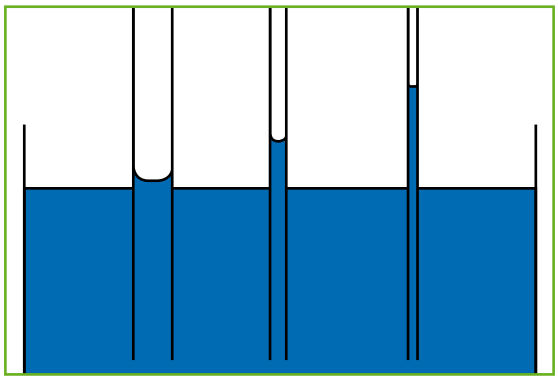
Why does moisture rise in masonry?

Interfacial tension of liquids (adhesion)

Surface tension of water (cohesion)

Rising damp is an effect created by the surface tension of a liquid (cohesion) and the interfacial tension (adhesion) between the liquid and the solid surface. Generally a liquid has the tendency to spread when it comes in contact with a surface. On the other hand liquids like water have a surface tension. These two forces together, lead to the effect that water rises in a narrow pipe (see graphic).

Example for rising damp



Rising of liquids in capillaries

Building materials like bricks absorb water in a similar way to a sponge (see photo). This occurs because masonry as well as concrete contain small pores. Depending on the diameter of the pores, they can tranport water upwards against gravity (rising damp). Pores with a radius between 10^{-7} m and 10^{-4} m show the most distinctive water transport and are referred to as capillaries. Between 20 % and 50 % of the pores in the building materials concrete, brick and mortar fall into that category. Pores with a radius of below 10^{-7} m are called micro pores and are too small for capillary water transport, where as pores with a radius of above 10^{-4} m are too large.

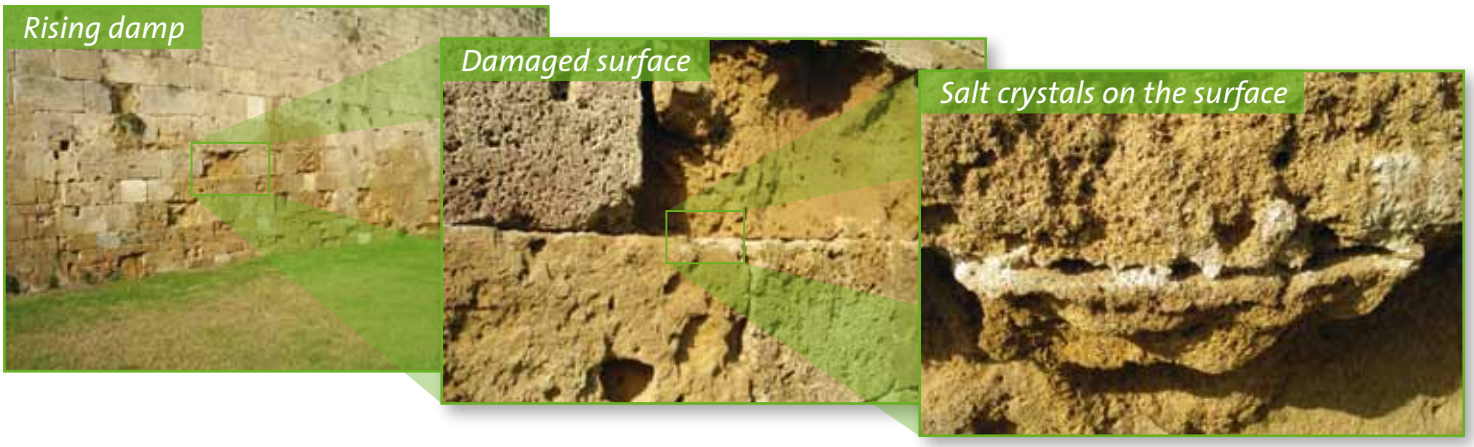
The smaller the diameter of the capillary, the larger the capillary pressure and the higher the capillary elevation. A capillary with a diameter of 1 µm (10^{-6} m) can theoretically create a suction pressure of 1.5 bar which corresponds to a capillary elevation of water of approximately 15 m.

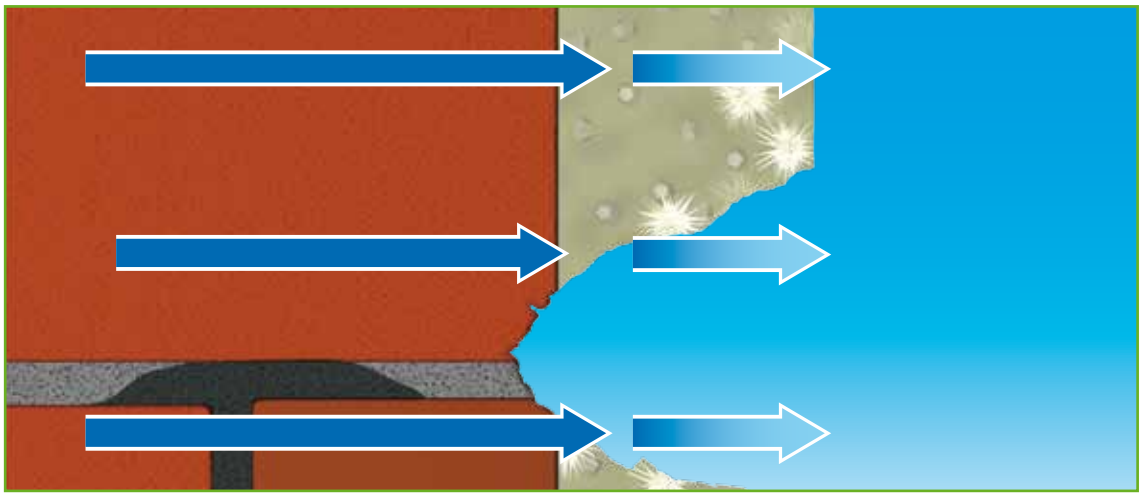
What have salts got to do with rising damp?

Usually, the water which is transported into and through a wall contains salts. These salts can have different sources:

- *Salts are present in the ground. They can be dissolved in ground water or ground moisture and can then be transported with the ground water into the wall.*
- *Salts are present in the brick itself. These salts can be dissolved by the rising damp in the masonry.*
- *Salts have other sources such as deicing salt, fertilizer or feces which are transported by rain water, splash water or ground water into the wall.*

When the salt containing water evaporates in the surface area of the wall, the salt remains in the wall or on its surface, leading to an increase of the salt concentration. The salt crystallizes on the surface or in the pores of the building material. This process is characterized by directed growth, an increase in volume and high strength of the crystals. When salt crystals form in the pores of a building material over a longer period of time, a high crystallization pressure builds up. This eventually leads to a destruction of the pore. Once this process has proceeded far enough, the surface of the construction material becomes brittle and starts to fall off.





Destructive crystallization process

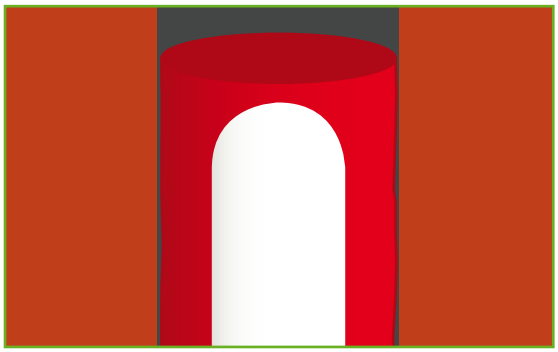
Frost has a very similar effect. The ice crystals that form when a specific amount of liquid water freezes have a much larger volume than the same amount of liquid water. If water freezes in the pores, the expanding ice crystals build up a high pressure and can lead to the destruction of the building material.

How can rising damp be stopped?

There are two fundamental ways to stop rising damp: Blocking capillary active pores or hydrophobing their surfaces. Hydrophobing the surface of a pore means to modify the surface so that it becomes water repellent (hydrophobic). Thus, the capillary action of that pore is stopped.

Blocking a pore means to partially or totally fill the pore in order to stop the transport of water. It is crucial to bring enough material into the pore so that the diameter of the pore is narrowed far enough and no more capillary action can take place.

Hydrophobing : Making the building material water repellent



Narrowing/blocking the capillary, forming an elastic film in the capillary

KÖSTER Crisin® 76 stops rising damp with three effects: It lines the capillary with a water repellent film. Secondly it narrows the pore so much that capillary action cannot take place any more. Finally, KÖSTER Crisin® 76 can cure to form a membrane over the complete diameter of the capillary.

These effects together ensure that KÖSTER Crisin® 76 works every time, irrespective of pore structure, salt or moisture content. The first buildings were treated more than 25 years ago and those horizontal barriers are still intact and working. KÖSTER Crisin® 76 has a very low viscosity and is not water soluble. It penetrates deeply into even the smallest capillaries in building materials where it stops capillary action permanently.

Due to the hydrophobic effect of KÖSTER Crisin® 76, the drying process in the wall begins immediately, creating an active horizontal barrier as soon as the material has been installed.

Advantages of KÖSTER Crisin® 76

- *suitable even in cases of high moisture contents > 80 %*
- *suitable even in cases of high salt contents*
- *suitable for most types of salts (sulfates, nitrates, chlorides)*
- *the treated substrate does not have to be alkaline for the material to react*
- *no prior or subsequent drying of the wall necessary, even in case of high moisture contents*
- *application possible even at temperatures below +5°C*
- *can not be diluted with water / is not water soluble*
- *resistant against most ordinary aggressive substances that are encountered in masonry such as acids, alkalis and salts*
- *fast reaction, immediately effective*
- *not bio-degradable*
- *not frost sensitive*
- *does not cause or promote corrosion of steel reinforcements*
- *density (0,76 g/cm³); penetrates deeply even into the smallest capillaries of the construction material*
- *the cured material and thus the horizontal barrier is elastic*
- *can be applied to perforated brick and cracked or hollow masonry without having to fill the voids beforehand*
- *no subsequent injection necessary, one time installation, guaranteed success*
- *patented system*
- *easy installation, horizontal drilling*
- *proven to be effective for more than 25 years*
- *10 years warranty**

KÖSTER Crisin® 76 ist chemically neutral and does not cause efflorescence. It is furthermore resistant against most ordinary aggressive substances that are encountered in masonry like diluted acids and alkalis.

** Under the condition that the material is applied by a certified applicator.*

The patented KÖSTER Suction Angle System is the result of decades of experience in combating rising damp, involving extensive research and development by KÖSTER BAUCHEMIE AG. The horizontal barrier is installed solely through utilization of capillary action which is itself the cause for rising damp. Thus, rising damp is stopped with the aid of its cause.

The system consists of the KÖSTER Crisin® 76 cartridge, the KÖSTER Capillary Rod and the KÖSTER Suction Angle.

KÖSTER Crisin® 76

KÖSTER Capillary Rods

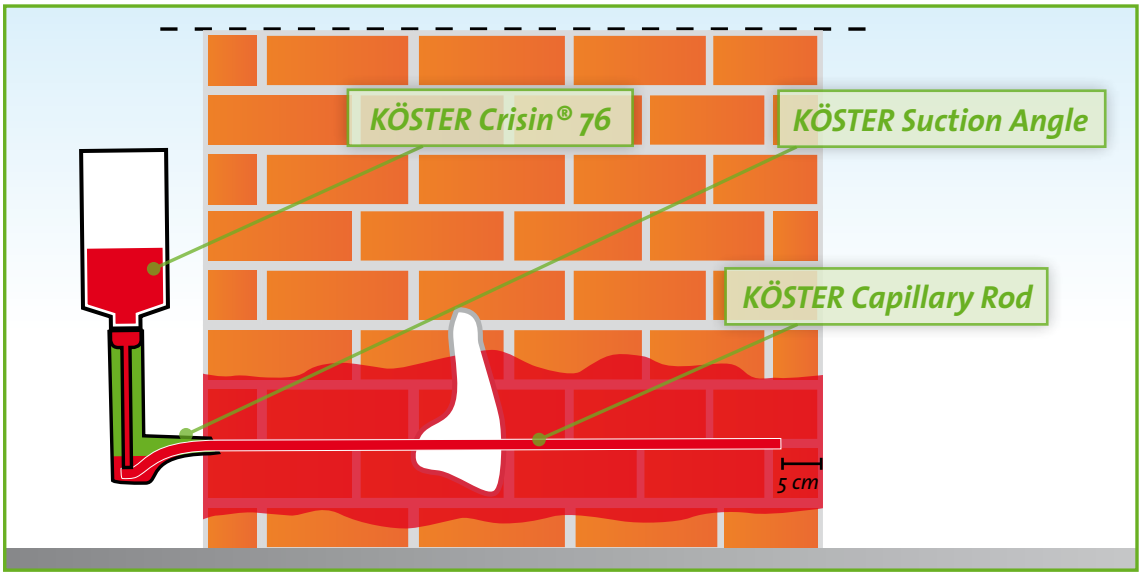
KÖSTER Suction Angle

The KÖSTER Capillary Rod acts like a wick, one end is inserted into the wall and the other end into the KÖSTER Suction Angle. From there, the it draws the injection liquid into the wall. The KÖSTER Capillary Rod is available in a length of 45 or 90 cm.

This is a crucial advantage not only when installing horizontal barriers into hollow bricks, vertically perforated bricks or old and cracked masonry, but also for all other conditions. The method allows easy control of the distribution of the injection material in the wall. It also gives security in the calculation of costs for the installation of a horizontal barrier since the amount of material needed can be easily determined.

How to apply KÖSTER Crisin® 76

- *Remove the plaster and any loose materials completely from the wall.*
- *Drill the boreholes at the required distance (see table). The length of the borehole is the thickness of the wall minus 5 cm. Clean the boreholes, preferably with pressurised air in order to remove the dust.*
- *After that, the KÖSTER Capillary Rod is cut to the required length (depth of the borehole + 7 cm) and inserted into the borehole.*
- *Then the KÖSTER Suction Angle is installed and the supply chamber of the KÖSTER Suction Angle is filled with water. This has the effect that the KÖSTER Capillary Rod swells a little bit and thereby makes good contact with the wall of the borehole. Then, the cartridge filled with KÖSTER Crisin® 76 is set into the KÖSTER Suction Angle. KÖSTER Crisin® 76 flows into the supply chamber of the KÖSTER Suction Angle where the liquid is absorbed by the KÖSTER Capillary Rod. The injection liquid is transported through the KÖSTER Capillary Rod. It is only released into the wall where the KÖSTER Capillary Rod has contact with the wall of the borehole. In those places where the KÖSTER Capillary Rod does not have contact with the wall of the borehole – like cracks and voids in the masonry - no injection liquid is released and thus no injection liquid is lost into cracks or voids.*



- *Once the cartridge is empty, the cartridge and the suction angle can be removed. Both can be reused.*
- *After the installation of KÖSTER Crisin® 76 the boreholes are closed using e.g. KÖSTER KB-Fix 5.*
- *As an ideal combination KÖSTER Restoration Plaster is applied afterwards.*

The consumption depends on the thickness of the wall. With the following table the consumption can easily be calculated.

Thickness of wall incl. Plaster	ø of bore holes	boreholes per meter	Distance between drilling holes from center to center (horizontal)	Cartridge per borehole	Cartridge per meter	Maximum consumption of capillary rod (45 cm)	(90 cm)
	[mm]		[cm]	[piece]	[piece]	[maximum pieces per m]	
up to 30,0 cm	if necessary proportionally less than one cartridge can be applied						
up to 40,0 cm	14	8	12,5	1	8	8	4
up to 50,0 cm	14	10	10	1	10	12	6
up to 60,0 cm	14	11	9	1	11	16	8
up to 70,0 cm	14	13	7,5	1	13	21	11
up to 80,0 cm	14	15	6,5	1	15	28	14

Installation

The following pictures show the installation of a new horizontal barrier with KÖSTER Crisin® 76 in a historic building.

The masonry is from 1750, the existing plaster is damaged. The salt and moisture contents are high.

Boreholes are drilled into the interior walls at a distance of 10 cm from each other (wall thickness 45 cm) up to a depth of 40 cm.

The boreholes are cleaned from dust by blowing the dust out of the borehole with pressurised air.

KÖSTER Capillary Rods are installed so that they protrude 7 cm from the borehole.

The KÖSTER Suction Angles are installed so that the KÖSTER Capillary Rods reach into the supply chamber of the KÖSTER Suction Angles.

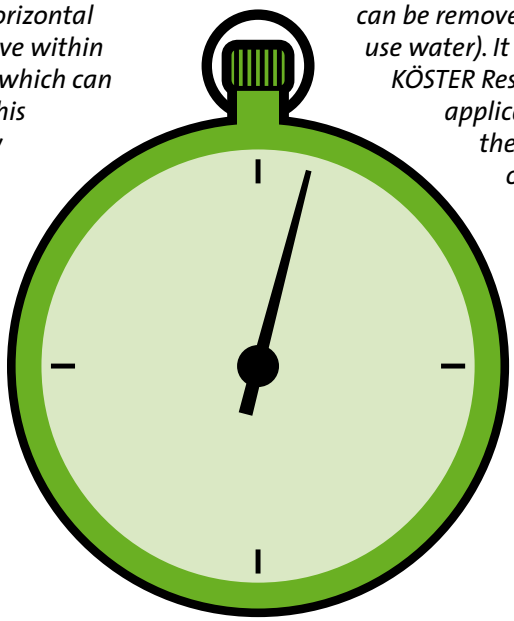
The supply chambers of the KÖSTER Suction Angles are filled with water in order to pre-water the KÖSTER Capillary Rods.

The KÖSTER Crisin® 76 cartridges are installed.

The pressureless injection of KÖSTER Crisin® 76 into the masonry starts immediately after the installation of the cartridges.

How fast does KÖSTER Crisin® 76 become active?

Generally, the KÖSTER Crisin® 76 cartridges empty within 48 hours after they have been installed. Now the horizontal barrier has been successfully installed. Due to the hydrophobic characteristics of KÖSTER Crisin® 76, the reduction of rising damp starts immediately after the installation. The horizontal barrier becomes fully effective within the curing time of the resin which can take up to 10 days. During this period, the masonry already begins to dry. The drying time depends mainly on the moisture content and the thickness of the walls. The moisture content can be determined by taking core samples which are then weighed and dried according to the kiln-dry method.

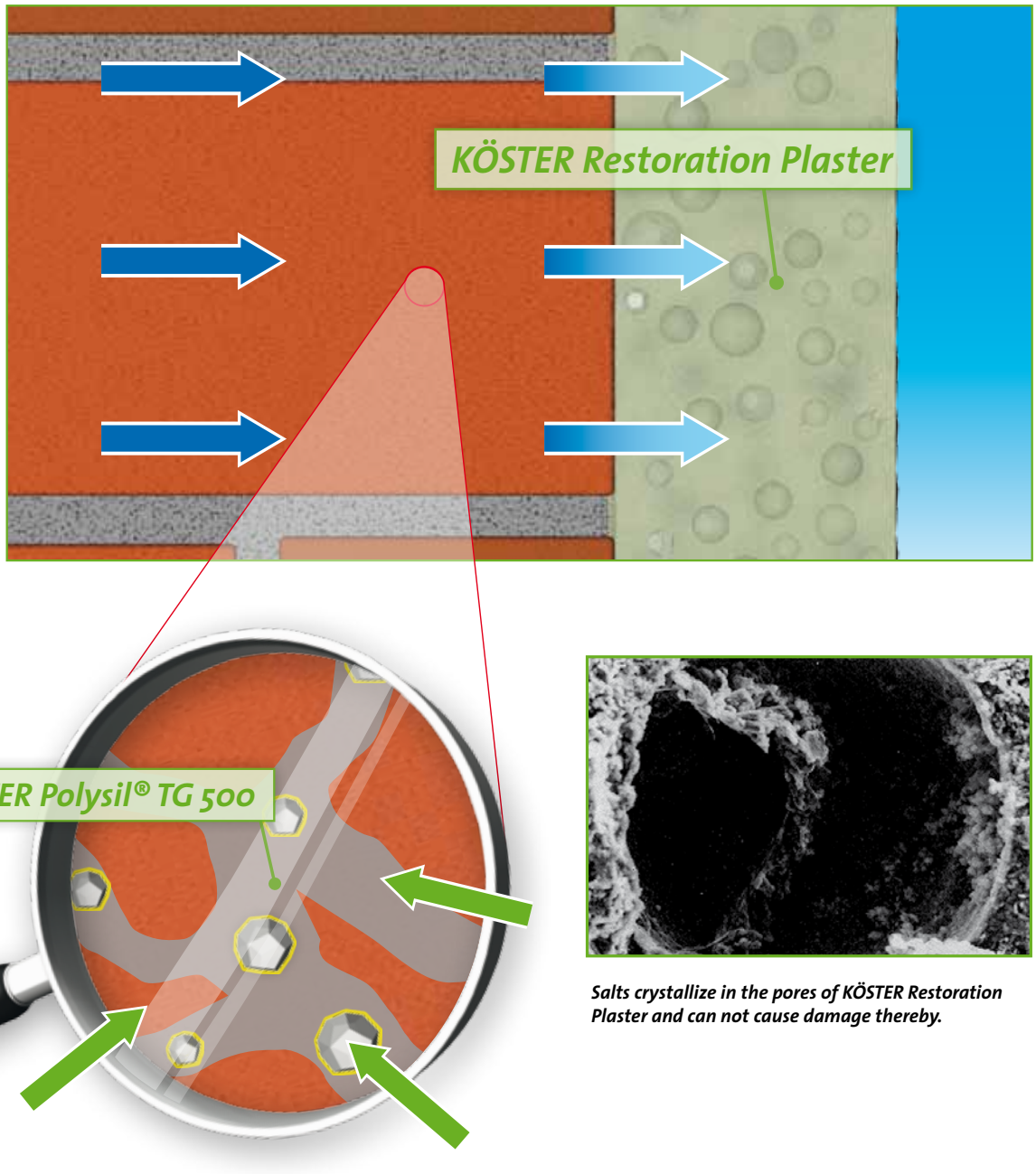


Often masonry burdened by rising damp contains high salt concentrations. Therefore, during the first weeks of drying after the installation of a horizontal barrier, salts may diffuse to the surface causing salt efflorescence. This is part of the drying process. The efflorescence can be removed mechanically (do not use water). It is recommended to apply KÖSTER Restoration Plaster after the application of KÖSTER Crisin® 76 thereby preventing any effects of salt efflorescence.

The perfect system: KÖSTER Crisin® 76 and KÖSTER Restoration Plaster

KÖSTER restoration plasters are especially designed for the restoration of masonry with high salt and moisture contents. When rising damp is stopped with KÖSTER Crisin® 76, KÖSTER restoration plasters help to dry out the wall and it absorbs remaining salts. KÖSTER restoration plasters withstand moist conditions since they do not contain lime or gypsum. They are open to water vapour diffusion and help to create a healthy and comfortable room climate. They are also not effected by high salt contents and prevent salts from diffusing to the surface. Apply KÖSTER Polysil® TG 500 as a primer in order to strengthen the substrate and reduce the mobility of the salt molecules. KÖSTER restoration plasters are available in grey or white. In historic buildings they can be used as a decorative plaster even without painting. They are suitable for interior and exterior use.

The interior walls of these buildings were restored with KÖSTER Restoration Plaster 2 White.



Salts crystallize in the pores of KÖSTER Restoration Plaster and can not cause damage thereby.

Installation

Remove old plaster. Fill breakouts and holes with KÖSTER Repair Mortar. Spray KÖSTER Polysil® TG 500 onto the surface to block salts and strengthen the substrate.

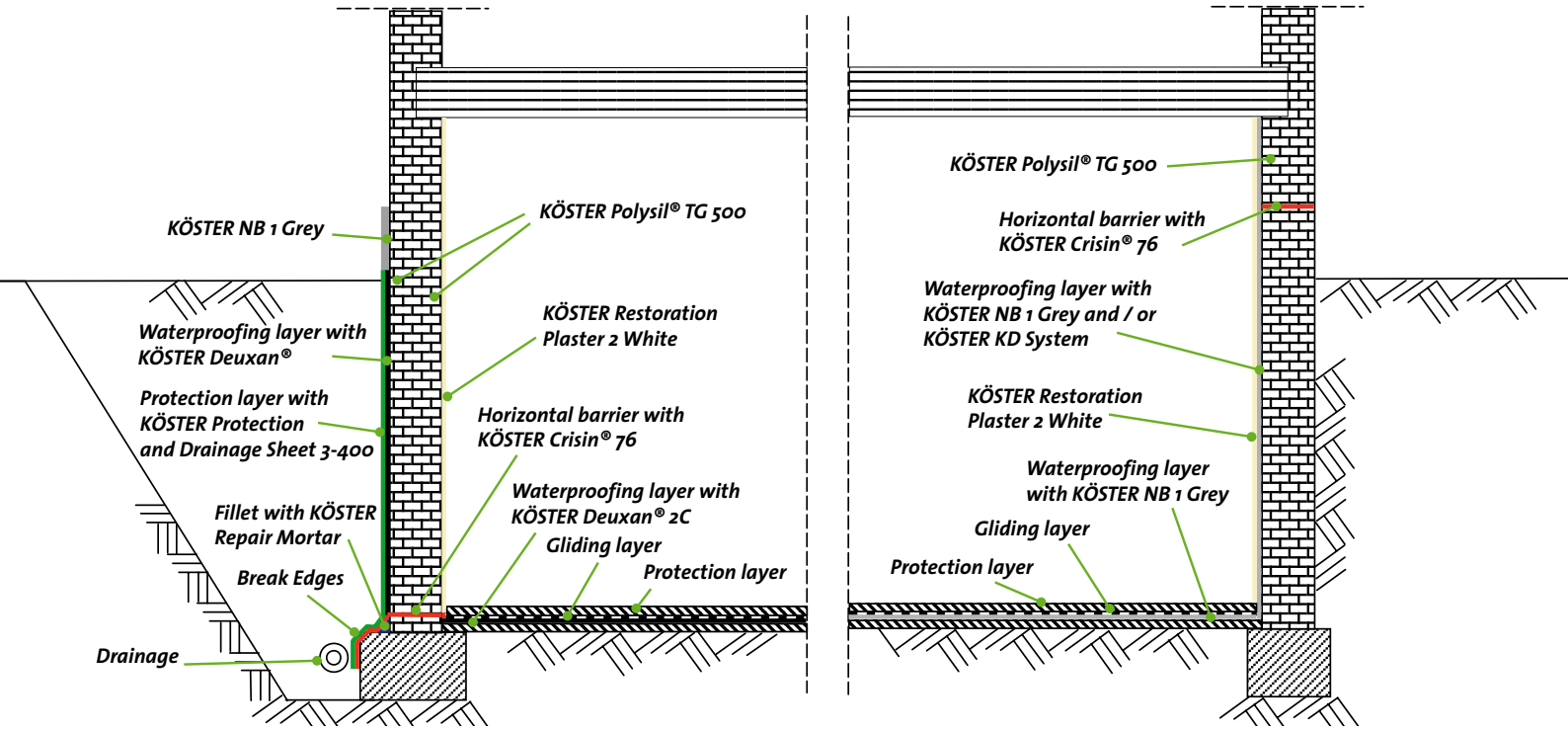
At the earliest after 30 minutes apply a plaster key to ensure optimal bonding of KÖSTER Restoration Plaster.

Apply KÖSTER Restoration Plaster onto the cured plaster key by trowel or use the KÖSTER Variojet.

After approximately 60 minutes, smooth the surface.

How is a horizontal barrier installed in combination with negative side or positive side waterproofing?

Subsequent waterproofing normally includes various measures such as the installation of area waterproofing for walls and floors and the installation of a horizontal barrier within the masonry. The installation of a horizontal barrier is a key element in any restoration waterproofing project.

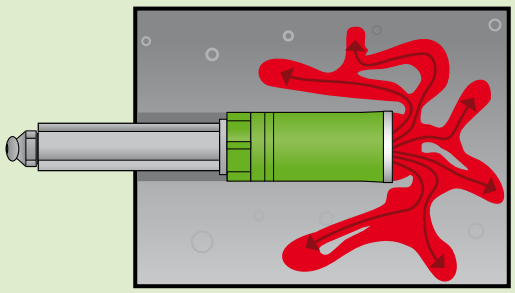


The left side of the drawing shows the solution with positive side waterproofing. It requires that the ground on the outside of the basement wall is excavated and the waterproofing is installed on the outside of the wall. The advantage is that the wall is dry after the waterproofing has been installed. This solution can be implemented by using the KÖSTER Deuxan® system. In this case, the horizontal barrier with KÖSTER Crisin® 76 is placed as low as possible. The purpose of the horizontal barrier here is to ensure that moisture can not rise from the foundation into the masonry wall.

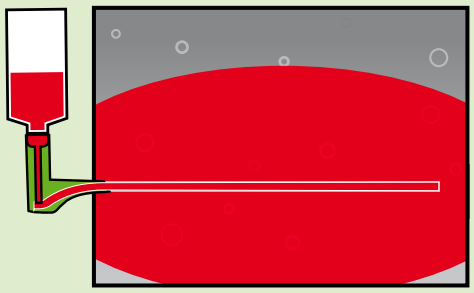
The right side shows negative side waterproofing. It is usually the cheaper and faster possibility because it is carried out from the inside. The KÖSTER KD-System together with KÖSTER NB 1 Grey is the perfect choice for such a solution. The horizontal barrier with KÖSTER Crisin® 76 is placed 30 cm above ground level. The waterproofing layer on the inside of the wall ensures that no water can penetrate into the basement. The purpose of the horizontal barrier in this case is to ensure that moisture can not rise into the constuction members above.

Pressurised or pressureless injection?

Generally, horizontal barriers can be installed with high pressure injection or with pressureless injection. High pressure injection requires the use of injection ports or so called "packers", which are fixed in the boreholes. With a high-pressure injection pump, a suited material is then injected into the wall through these packers. With this method the injection material can be applied very fast. This advantage is offset though, if the masonry contains voids because these voids would be filled with the injected material during high-pressure injection and thus be lost. To avoid wasting injection material in voids and cracks, the boreholes are injected with a borehole suspension in a preceding work step in order to fill voids and cracks in the masonry. The boreholes are then drilled open again and now the material for the horizontal barriers can be injected. Additionally, even with very high pressure, the finest capillaries cannot be filled.



Pressurised injection



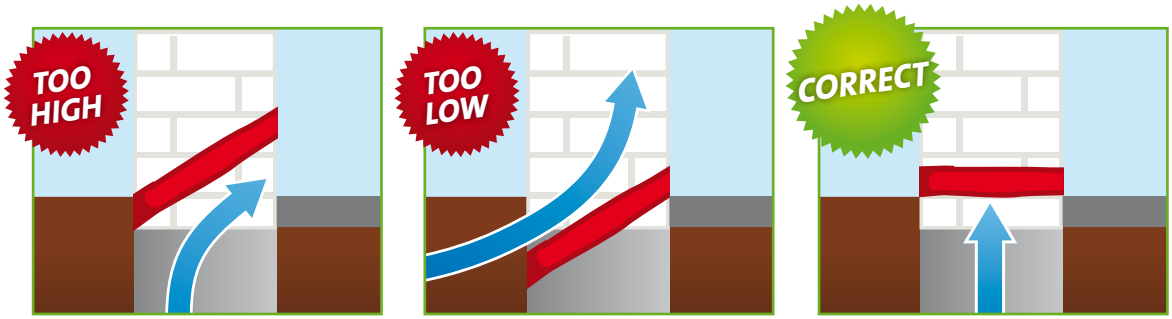
Pressureless injection

The KÖSTER pressureless injection method with KÖSTER Crisin® 76 in contrast utilizes the wall's capillary action. The remedy is injected using the source of the problem. Advantages of injection without pressure are:

- *The injected liquid is transported effectively into the capillaries which are part of the mechanism that causes rising damp. No material gets wasted in cracks or voids.*
- *The amount of material that is injected into the masonry is easily controlled. The pressurised injection does not allow such good control of the amount of injected material.*
- *Damage of the masonry and derogation of the statics are avoided.*

Angled or horizontal placement of the boreholes?

With the KÖSTER Suction Angle System, the boreholes are positioned horizontally. The obvious advantage over diagonal drilling is that with horizontal positioning the length of the boreholes is considerably lower. It is also easier to calculate the required length of the boreholes (wall thickness minus 5 cm). A further problem of diagonal drilling is that the installed barrier has different levels on the inside and on the outside. This is due to the angle of the boreholes and is illustrated in the following graphic. The practical result of this can be that moisture can still "overflow" or "underflow" the installed barrier.



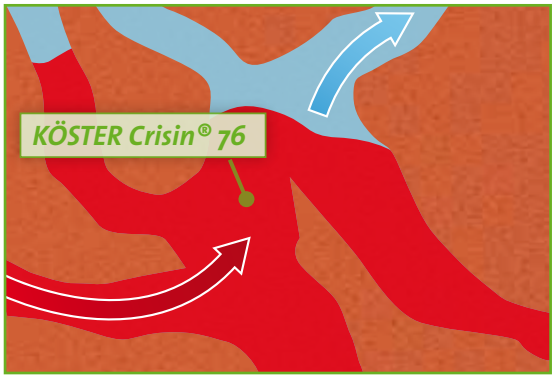
The horizontally positioned system in contrast has the same height level on both sides of the wall and can thus be easily positioned correctly.

How can KÖSTER Crisin® 76 be injected in a wall that is already saturated with water?

A pore filled with water is not like a bottle but more like a pipe. Therefore even a highly saturated wall can be treated with KÖSTER Crisin® 76. The water flows continuously through the capillary system from bottom to top. When KÖSTER Crisin® 76 is installed, the active substances use this same transport mechanism to enter the finest capillaries. With its hydrophobic effect, it stops the flow of water from the bottom and penetrates deeply into the pore structure.

KÖSTER Crisin® 76 is a water insoluble injection material and is therefore not in danger of being diluted with the water that is already present in the masonry. If an injected material can be diluted, the material can fail to function properly. KÖSTER Crisin® 76 cures and develops its full functionality even if the wall is completely saturated with water. KÖSTER Crisin® 76 does not require a prior or subsequent mechanical drying of the wall to become effective.

KÖSTER Crisin® 76 cannot be diluted with water



KÖSTER Crisin® 76 penetrates into the capillaries and pushes out the fluids.

Why is the chemical composition of KÖSTER Crisin® 76 so important with regard to salts?

The stream of water that is transported as rising damp through a porous building material often contains dissolved salts. Salts are chemically active, therefore it is very important that the reaction of the injection material is not influenced by salts. Due to its unique combination of active ingredients, KÖSTER Crisin® 76 remains completely unaffected by high salt contents of the substrate. Due to the fact that KÖSTER Crisin® 76 is not an emulsion, the ingredients do not flocculate when they come into contact with salts but remain fully effective.

How does KÖSTER Crisin® 76 penetrate so deeply into the structure?

A liquid installed horizontal barrier must penetrate deeply into the capillary system of a masonry in order to function properly. For this purpose, a very low viscous liquid is required. In order to achieve a widespread wetting of the capillary walls, the injected material has to possess a low surface tension. KÖSTER Crisin® 76 is a resin based liquid with a very low viscosity. Due to its low surface tension it is able to penetrate deeply into the pore structure of a building material. Additionally, KÖSTER Crisin® 76 contains special additives that promote its penetration into the building material.

KÖSTER Product Range

1. External basement waterproofing
2. Internal basement waterproofing
3. Horizontal barriers/ Restoration of masonry
4. Crack and hose injection
5. Concrete protection and repair
6. Sealing of expansion joints
7. Bathroom and wet room waterproofing
8. Mould control
9. Floor coatings
10. Façade protection
11. Balcony and terrace waterproofing
12. Roof waterproofing
13. Water tank and reservoir waterproofing

KÖSTER BAUCHEMIE AG develops, produces and supplies a comprehensive range of special construction materials in the areas of waterproofing and concrete repair. Being founded in 1982 in Germany, the KÖSTER Group consists meanwhile of 24 companies which are represented in more than 45 countries. It is our policy to offer construction materials of highest quality, durability and general performance.

Service you can depend on

With our service and distribution network in many countries world-wide we can offer you professional advice and technical support immediately and on the spot. Your required waterproofing materials can be delivered promptly and will protect your property efficiently and lastingly.

For further information, please contact:

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Waterproofing Systems

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