

Efflorescence – Causes and Prevention

Abstract: This *Technical Note* describes the mechanisms leading to the formation of efflorescence, including probable sources of soluble salts and moisture. Conditions necessary to cause efflorescence to appear are presented, along with design recommendations and practices that reduce the potential for efflorescence.

Key Words: admixtures, chlorides, condensation, efflorescence, masonry, mortar, rain water, soluble salts, sulfates, trim.

SUMMARY OF RECOMMENDATIONS:

General

- Design and construct brickwork to maximize water penetration resistance
- Positively identify efflorescence
- Determine if the efflorescence is new building bloom
- Identify causes of efflorescence using the included troubleshooting list, and correct the causes before attempting removal
- Consider materials that contain fewer soluble salts
- Coatings are not recommended as the sole treatment to control efflorescence

Design

- Isolate exterior brick wythe with an air space
- Waterproof the exterior of walls that extend below grade
- For walls without an air space, separate the brick wythe from the backing with a dampproof coating

Construction Practices

- Store masonry materials off the ground and cover with waterproof materials to protect them from groundwater and precipitation
- Protect unfinished masonry from weather during construction

INTRODUCTION

Brickwork provides aesthetically pleasing structures. Occasionally, a white crystalline deposit will appear on its surface. These deposits are likely water-soluble salts referred to as efflorescence. Although undesirable, efflorescence is usually not harmful to brick masonry.

This *Technical Note* describes the mechanisms of efflorescence, including possible sources of salts and water, providing a basic understanding of the phenomenon of efflorescence that is essential to minimize its occurrence and prevent its reoccurrence. Although similar, sources of salts and the development of efflorescence on paving surfaces are discussed in the *Technical Notes* 14 Series on brick pavements.

A thorough program of efflorescence prevention or control may include identification of the type of efflorescence and investigation of its causes before options for correction are considered. This *Technical Note* is intended to serve as a guide in this process. Procedures for removal of efflorescence are discussed in *Technical Note* 20.

CAUSES OF EFFLORESCENCE

There are many mechanisms of efflorescence, often complicated. Simply stated, efflorescence occurs when water containing dissolved salts is brought to the surface of masonry, the water evaporates and the salts are left on the surface. The salt solutions may migrate across surfaces of masonry units, between the mortar and brick units, or through the pores of the mortar or brick units.

There are certain simultaneous conditions that must exist in order for efflorescence to occur:

- Soluble salts must be present within or in contact with the brickwork. These salts may be present in mortar ingredients, backing materials, trim, adjacent soil, brick, etc.
- A source of water must be in contact with the salts for a period of time sufficient to dissolve them.
- A pore structure must be present in the masonry that allows the migration of salt solutions to the surface or other locations where evaporation of water can occur. A driving force, such as a temperature or humidity gradient, directs moisture through the pore structure.

Individuals who have not previously observed efflorescence generally assume that it is caused by the material on which it appears—usually the brick. Soluble compounds that contribute to efflorescence on the surface of brick are most commonly found to have originated from the materials in contact with the brick, such as mortar, grout, concrete masonry, concrete, soil or other materials. However, soluble compounds can also originate within brick units. Since efflorescence is usually white, it typically is more visible against darker colors. As noted by John Sanders and Denis Brosnan:

The typically incorrect assumption that brick causes efflorescence is due to the fact that the soluble compounds are usually visible on the brick due to its darker color and the tendency of the brick to transport water due to its capillary porous nature [which is necessary] for the development of the bond between brick and mortar. [Ref. 6]

Efflorescence that appears on newly constructed brickwork, less than a year old, is referred to as “new building bloom.” New building bloom generally appears in a fairly uniform pattern across the wall surface and can be attributed to normal evaporation of water after construction is complete. In most cases, new building bloom will dissipate over time if the brickwork is allowed to dry after completion and if environmental factors such as wind and rain are given sufficient time to naturally clean the brickwork. When efflorescence occurs more than a year after construction is complete, it can generally be attributed to excessive water penetration or poor drainage and is often most severe in winter or periods of cold weather.

Under certain specific circumstances and conditions, it is possible for the crystals of efflorescence to form within the bodies of brick units. When this occurs, the growth of crystals and the resulting pressure may cause cracking and distress to masonry.

It is not practical to attempt to exclude all soluble salts from masonry materials, nor is it possible to prevent moisture from coming in contact with masonry exposed to the weather. However, reducing each factor that contributes to efflorescence is a realistic approach that will usually prevent efflorescence from occurring or reduce its severity.

The most effective means of preventing efflorescence is to minimize the amount of water that penetrates brickwork. This, as well as separating brickwork from sources of salts, is primarily accomplished through careful design and construction. To the extent possible, material selection should be used to minimize the salts present in the brickwork.

MATERIAL SELECTION

Material selection provides the first opportunity to reduce efflorescence potential. However, the ability to eliminate efflorescing salts is somewhat limited and less practical than minimizing water penetration. The following recommendations are presented to assist the designer in the selection of materials to limit the occurrence of efflorescence.

The chemical composition of efflorescing salts usually consists of alkali and alkaline earth sulfates and carbonates, although chlorides may also be present. The most common salts found in efflorescence are sulfate and carbonate compounds of sodium, potassium, calcium, magnesium and aluminum. The salts can come from a variety of sources, including mortar, groundwater, rainwater, improper use of chemical cleaners, or other miscellaneous chemical sources such as a nearby chimney or chemical plant. When chlorides occur as efflorescence, it is usually a result of the use of calcium chloride as a mortar accelerator, contamination of masonry units or mortar sand by saltwater, or the improper use of hydrochloric acids in cleaning solutions.

The content of water-soluble salt species, particularly the soluble sulfate content, is a good indicator of the potential of efflorescence to occur. Measurements of soluble salt species can be used to determine the source of efflorescence and to select appropriate building materials based on the potential to contribute to efflorescence [Ref. 6].

Brick

Since efflorescence appears on the face of the brickwork, it is often erroneously assumed to come from the brick. It is possible for brick to contain soluble salts, but it is much more common for efflorescing salts to originate from other materials that are in direct contact with clay brick, such as cement-based mortar, grout or concrete masonry.

The potential for brick to effloresce can be assessed using the efflorescence test in ASTM C67, *Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile* [Ref. 1]. This test consists of partially immersing brick in distilled water for a period of seven days. At the end of this period, the brick are allowed to dry and examined for efflorescence in comparison with brick that were not immersed. Based on visual observation, the brick are rated as either “not effloresced” or “effloresced.” Brick that receive a rating of “not effloresced” are readily available throughout the United States and Canada.

It is important to understand that this is a laboratory product test and not a test of the brick in service. The ASTM C67 efflorescence test is more severe than normal environmental exposures, as brick are dried at 220 °F (104 °C). At this temperature, the gypsum (calcium sulfate) transforms into a much more soluble salt, which is more readily transported to the surface. Because of the difference between service conditions and lab conditions, the test results do not predict whether efflorescence will or will not occur after brick are placed in a wall, veneer or pavement. Brick that are rated “effloresced” may not exhibit efflorescence in service; conversely, brick rated “not effloresced” may exhibit efflorescence in service. The National Brick Research Center (NBRC) is evaluating the accuracy of different efflorescence test methods to ensure that a brick unit that does not exhibit efflorescence in service will receive a rating of “not effloresced” when tested. Other testing conducted by NBRC determined the likelihood of efflorescence development from other sources by measuring water-soluble salts using ion chromatography. The results from various experiments concluded that in many cases the migration of salts from other sources, not the brick itself, was responsible for the efflorescence [Ref. 6]. Design and construction practices that minimize efflorescence potential are discussed later in this document.

Mortar and Grout

Mortar can be a significant contributor to efflorescence. W.E. Brownell, the author of a research report on efflorescence in brickwork [Ref. 2], states:

The primary and most obvious source of contamination of otherwise efflorescence-free brick is the mortar used in wall construction. The mortar is in intimate contact with the brick on at least four and sometimes five sides. It is applied to the brick in a wet, paste-like condition which provides ample moisture for the transfer of soluble salts from the mortar to the brick. If any appreciable soluble material is present in the mortar, it will be carried into the brick proportionately to the amount of moisture transferred.

This would also apply to grout, which is made with the same constituent materials as mortar and contains a greater amount of water. Brownell continues:

The simplest case of soluble salt contamination of efflorescence-free brick is the migration of “free-alkali” solutions from the mortar to the brick. This situation is not only the simplest mechanism, but it is also the most common. In the trade, it is known as “new building bloom.”

New building bloom tends to occur shortly after construction due to normal water loss during post-construction drying. Efflorescence that reappears after this initial period is likely due to water entering and remaining in the wall. Efflorescence can be more prominent when the mortar is not tempered with enough water. This can lead to poor hydration of the cement, which causes the alkali salts to be more mobile.

Mortar types and proportions should be selected on the basis of structural and exposure requirements for the particular project. Recommendations for mortar are contained in *Technical Notes 8* and *8B*.

Cement. The principal contributor to efflorescence in mortar and grout is the alkali content of portland cement. The tendency of cement to effloresce may be predicted with reasonable accuracy from a chemical analysis of the cement. Cements high in alkalies are more prone to produce efflorescence than cements of lower alkali content.

All cements contain some water-soluble alkalies. Those common in mortar and grout are sodium and potassium. It is suspected that the sulfate content of the cement may be as significant as the alkali content in contributing to efflorescence.

ASTM C150, *Standard Specification for Portland Cement* [Ref. 1], includes provisions for specifying low-alkali cement when required. In these cases, the optional compositional requirements limit equivalent alkalis ($\text{Na}_2\text{O} + 0.658\text{K}_2\text{O}$) to a maximum of 0.60 percent as measured using ASTM C114, *Standard Test Methods for Chemical*

Analysis of Hydraulic Cement [Ref. 1]. The alkalis referred to are the total of acid-soluble and water-soluble fraction alkalis. In general, the water-soluble alkali content will be on the order of 60 percent of the total.

Other ingredients for mortar and grout—i.e., lime, sand and water—should also be selected with care, although their contribution to efflorescence is typically less than that of cement.

Lime. It has been demonstrated that lime, clay or sand additions to a mortar generally do not contribute to efflorescence [Ref. 8]. In fact, these ingredients tend to dilute the deleterious effects of high-alkali cement.

On the other hand, lime is somewhat water-soluble. Its presence may serve to neutralize certain acids generated within the masonry. Under certain conditions, lime reacts with unbuffered hydrochloric acid to produce very soluble calcium chloride, which can migrate to the surface and become efflorescence. Nevertheless, lime improves the extent of bond between mortar and brick and thereby increases the water resistance of the masonry.

Sand. Sand used in mortar and grout is not water-soluble; however, it may be contaminated with material that will contribute to efflorescence. Sand for use in mortar or grout should be taken from sources free of contamination from saltwater, soil runoff, plant life and decomposed organic compounds, among others. Using clean, washed sand will reduce the potential for efflorescence.

Admixtures. Most admixtures are proprietary, and their compositions are not disclosed. In general, they are classified as workability enhancers, bond enhancers, water repellents, set retarders or set accelerators.

Chlorides that occur as efflorescence may result from the use of calcium chloride and compounds containing calcium chloride added to mortar as set accelerators. Because calcium chloride causes corrosion of metal embedded in mortar under certain conditions, TMS 602, *Specification for Masonry Structures* (TMS Specification) [Ref. 7], limits chloride ions to 0.2 percent for mortar admixtures. Normally, this amount of calcium chloride will not contribute materially to efflorescence.

Compressive strength, water retention and air content are generally the only properties included in reports on mortar. However, an admixture's effect on extent of bond and bond strength may also influence the efflorescence potential, as a reduction in either may make masonry walls more vulnerable to water penetration. Therefore, admixtures with unknown compositions are not recommended for use in mortars unless it has been established by experience or laboratory tests that they will neither materially impair mortar bond nor contribute to efflorescence.

Backing

Materials commonly used as backings or inner wythes of masonry walls, such as concrete and concrete masonry units (CMUs) may contain large quantities of soluble salts. As with mortar, the cement in concrete and concrete products is the principal contributor to efflorescence. Measurements of the soluble salt contents of clay and concrete masonry units and their efflorescing tendencies have shown that concrete products can contain two to seven times as much soluble material as the fired clay material [Ref. 4]. Such salts found in backing materials may contribute to efflorescence on the face of the brickwork if sufficient water is present to dissolve the salts and there is direct contact between the brick and backing or a pathway for the solution to reach the masonry surface.

As with mortars, concrete and CMUs made with low-alkali cements decrease the quantity of salts available for efflorescence. Design suggestions and construction practices that prevent absorption of these salts by brick are presented later in this document.

Masonry Trim

Masonry trim elements, such as caps, copings, sills, lintels, keystones, etc., are often built into the brick veneer. These items may be natural stone, cast stone, precast concrete, etc.—any of which may contain soluble salts. Such materials may contribute significantly to efflorescence on the face of adjacent brickwork. As the amount of soluble salts contained in these materials cannot usually be controlled, their effects on brickwork should be carefully considered during material selection. Careful attention to detailing and consideration of these effects will help minimize their contribution to efflorescence occurring in brickwork.

DESIGN AND DETAILING

The most meticulous design and detailing can be thwarted by the selection of improper or inappropriate materials or by poor workmanship. The converse is also true: The use of appropriate materials and good workmanship will

not in themselves ensure a successful and permanent structure if the design is improper.

As previously discussed, the mechanism of efflorescence is dependent upon the presence of free water in the masonry wall assembly to dissolve any available soluble salts. The primary source of moisture for the occurrence of efflorescence is rainwater that penetrates or comes in contact with masonry. Rainwater will penetrate all masonry walls to some degree, more so if they are improperly designed or detailed.

Limiting available moisture helps to suppress the development of efflorescence. Therefore, much depends on the design and attention to certain critical details, particularly those associated with preventing moisture entry into the brickwork and directing water away from wall tops and horizontal surfaces. See **Photo 1**.

A general discussion of water penetration resistance is provided in the *Technical Notes 7 Series*. The following paragraphs present design measures that minimize the potential for efflorescence by improving the water resistance of brickwork. Workmanship employed during construction of a masonry wall also has a significant effect on the amount of water penetrating the wall and is discussed later.

Air Space

Drainage walls are recommended for maximum resistance to rain penetration and minimum efflorescence. The drainage wall system provides a cavity or air space that separates the exterior brickwork from other elements in a wall assembly, as shown in **Figure 1**. This separation impedes the development of efflorescence in two ways: It allows water to travel down the back of the brick veneer and exit the wall without wetting other materials within the assembly and prevents the migration of salts from backing materials to the brick by isolating the veneer from the materials containing soluble compounds. To the extent possible, the air space must be kept clear of mortar and mortar droppings during construction to allow adequate drainage and to minimize the amount of water bridging the air space and transferring soluble salts from other sources.

Photo 2 illustrates the transfer of soluble salts from CMU backing units to brick when the two materials are in direct contact. This result was obtained by placing the CMU in pans of water with five brick units on top of each block. The brick units had previously been subjected to the efflorescence test and rated “not effloresced” [Ref. 1]. The potential for backing materials to effloresce can be determined by using the

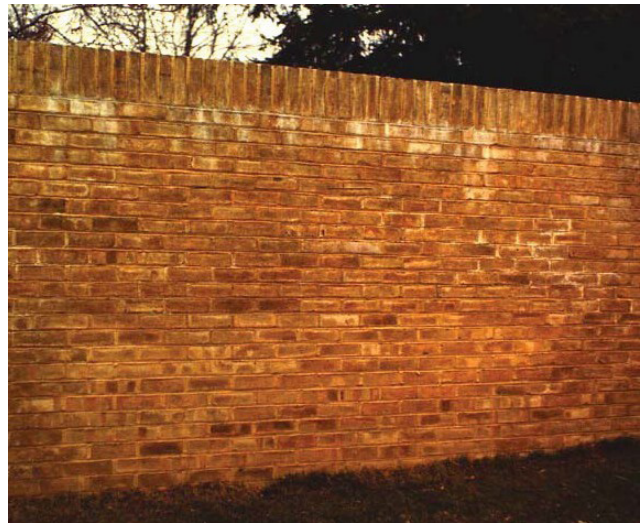


Photo 1
Efflorescence from Water Penetrating Wall Top

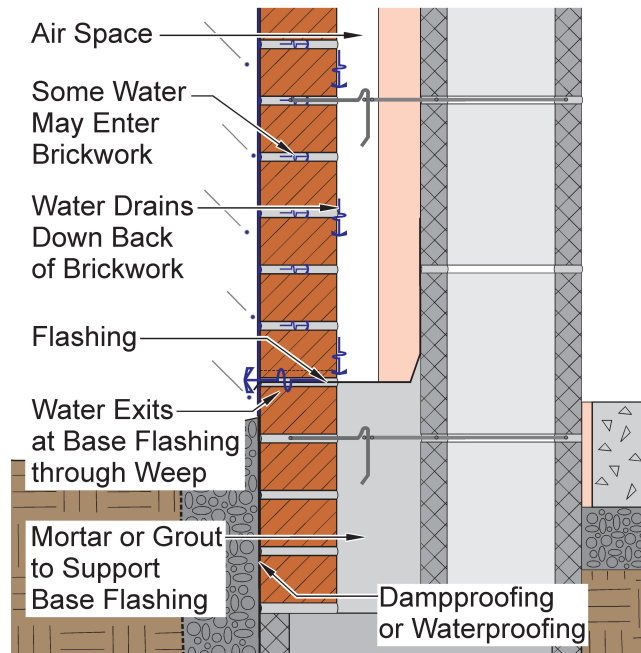


Figure 1
Drainage Wall System

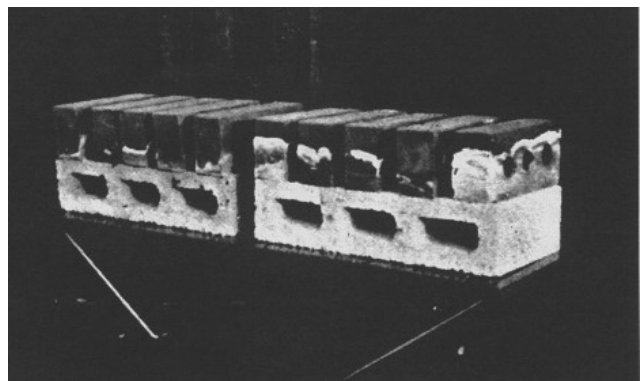


Photo 2
Migration of Soluble Salts from Backing to Brick

same efflorescence test method used for brick. The barrier wall strategy of filling a collar joint between masonry wythes with mortar or grout to provide a continuous barrier to water penetration is not recommended. Because mortar and grout contain cement, collar joints increase the potential for efflorescence by placing a source of salts in direct contact with the brickwork.

Providing a dampproof coating on the exterior surface of concrete and concrete masonry backings of drainage and barrier walls may reduce the potential for brick veneer to effloresce. These coatings limit the passage of salts and moisture between backing materials and the brick wythe. Dampproof coating materials for concrete masonry walls are typically bituminous and applied by spraying or brushing. The compatibility of through-wall flashing materials and adhesives with the dampproof coating should be verified. If an air barrier with water-resistive properties is installed on the concrete or CMU, this can serve the same purpose.

Masonry Trim

Because masonry trim elements, such as copings, sills and water-table caps, are in direct contact with brickwork, any salts they contain may contribute to efflorescence. These elements are frequently used in locations that are most vulnerable to water penetration. Therefore, all three of the conditions necessary for efflorescence are met almost anywhere trim is used. However, there are various ways to reduce the potential for efflorescence from these elements, such as the following:

- Incorporating slope into the top surface of the trim elements to shed water and avoid accumulation or ponding.
- Selecting trim materials that require fewer joints than traditional rowlock sills, caps or copings. Fewer joints will minimize water penetration into the brickwork below the trim elements. Common examples include architectural precast concrete, cast stone, stone and metal.
- Placing flashing or other materials to act as a capillary break between trim elements and brickwork. This reduces the contribution of trim materials to efflorescence by preventing contact and the migration of salts. The flashing also serves to direct any moisture that penetrates the trim out of the system, preventing saturation of the brickwork.

In addition, at locations where there are transitions between cladding materials, such as at the top of water tables, flashing should be installed at the base of the non-brick cladding above the water table to prevent excess moisture from saturating the cap or entering the brick air space/drainage cavity.

Below-Grade Walls

Soluble salts in soil are dissolved by water that percolates through the ground. Consequently, most groundwater contains a high concentration of these salts. When masonry is in direct contact with the earth, groundwater may be absorbed by the masonry and may rise through capillary action several feet above the ground. An accumulation of efflorescing salts on the surface of the masonry is then possible, as shown in [Photo 3](#).

To eliminate these salts as a source of efflorescence, applying a waterproof membrane on the earth side of the masonry that extends below grade and installing flashing within 10 in. of grade is recommended. The waterproofing membrane prevents the masonry from absorbing dissolved salts from the adjacent soil, and the flashing acts as a capillary break, preventing any absorbed salts from rising higher in the wall. In addition, mortar or grout should be used to fill the air space below the base flashing, as shown in [Figure 1](#).

As noted, the solidly filled air space places a source of soluble salts in contact with the brick; however, the potential risk of efflorescence is outweighed by the risk of leaving the air space unfilled.



Photo 3
Migration of Soluble Salts from Soil

Condensation

In addition to rainwater and groundwater, water may accumulate within a wall assembly through condensation of water vapor. Air movement within walls and differences in humidity between inside and outside air can move water vapor to areas where condensation can occur, resulting in wetting of wall elements. On occasion, accumulation of condensed water within a wall may provide enough moisture to cause brickwork to effloresce. However, in most cases, moisture within the brick due to condensation typically evaporates before causing any damage.

Condensation typically contributes to efflorescence when moisture that originates inside buildings travels to the exterior of the brickwork. Indoor air may have a particularly high moisture content due to a building's use (e.g., swimming pool) or certain activities that take place inside the building, such as cooking, bathing, washing and other operations employing water or steam. During cold weather, building interiors conditioned to normal comfort settings may contain enough moisture to cause condensation at lower temperatures. If this water vapor reaches a vapor-resistant surface at a temperature below the dew point temperature, then the vapor will condense and can provide the moisture necessary to contribute to efflorescence on the wall surface.

Condensation is typically controlled through design that considers the possibility of its occurrence. Using materials with the appropriate water vapor permeance and preventing the transfer of air through the building envelope reduce the possibility of condensation. Refer to *Technical Note 47* for a more detailed discussion on causes and prevention of condensation.

CONSTRUCTION

Construction practices and workmanship employed in building masonry walls can significantly affect the amount of water within masonry materials and the completed construction. Some discussion and recommendations for proper construction practices follow.

Storage of Materials

The method of storing materials at a construction project site may influence future occurrence of efflorescence. Masonry units, cementitious materials, sand and water should be stored off the ground, in such a manner as to avoid contact by rain or snow, or contamination by dirt, plant life, organic materials or groundwater, any of which may contribute to efflorescence. These materials should also be covered by a non-staining waterproof covering to protect them from the weather.

Water

Water used in mortar or grout, for wetting brick, cleaning or other applications, can also be a source of contaminants. Clean, potable water free of salts, deleterious acids, alkalies or organic materials should be used at all times. Water from external sources should be checked for alkali content to ensure that no efflorescing salts will be introduced into materials intended for use in masonry construction.

Workmanship

It is critical for the mason to completely fill all mortar joints intended to receive mortar and to minimize mortar droppings in air spaces. Attention to both of these items is of primary importance in preventing efflorescence. Full mortar joints are more effective at reducing water penetration, and cavities with minimal mortar droppings help masonry dry faster and separate brickwork from backings containing salts. *Technical Note 7B* discusses recommended workmanship practices for masonry construction. Brick masonry with workmanship characterized by partially filled joints, deep furrowing of the mortar beds, and improper execution of flashing and sealant joint details is subject to increased rain penetration.

Unfinished Brickwork

Partially completed brick masonry walls exposed to rain and other elements during construction may become saturated with water and, depending on climatic conditions, can require weeks or even months to dry. This prolonged saturation may cause soluble salts within masonry to go into solution. Such conditions may also contribute to the contamination of the masonry with soluble salts from elsewhere in the construction (concrete, masonry trim, plaster, etc.).

During construction, the TMS Specification requires the tops of all unfinished masonry to be protected from the weather. At the end of each workday, shutdown period or times of inclement weather, unfinished walls should be covered with water-resistant membranes or tarpaulins, securely fastened or weighted in position. Protective coverings are recommended to extend 24 in. (610 mm) down the vertical face on each side and should be maintained until the wall construction is completed or protected by adjacent materials. Mortar boards, scaffold planks and light plastic sheets (less than 10 mils thick) weighted with brick should not be accepted as suitable cover. Additional recommendations and construction procedures for protecting walls during inclement weather are discussed in *Technical Note 1*.

Sealant Joints

Sealant joints should be integral elements of construction, designed and installed with the same care as other elements of the structure. Sealants and caulk should not be used as a means of correcting or hiding poor workmanship that would permit water penetration.

Joints between the brickwork and door and window frames, expansion joints, and other locations where sealants are required are the most frequent sources of water penetration into the wall assembly. These vulnerable locations should be given careful attention during design and construction to prevent the excessive moisture ingress that may lead to efflorescence. Sealants and caulk do not have service lives as long as buildings. Maintenance programs should be established to identify and replace sealants and caulk that have dried or become ineffective, as shown in [Photo 4](#).



Photo 4
Sealant Joint in Need of Repair

POST-CONSTRUCTION

Troubleshooting Efflorescence

In addition to the information already presented, the following measures can be used to help determine the cause and extent of the efflorescence problem, and to suggest methods for repair and alleviation:

1. Determine the age of the structure at the time when the efflorescence first appeared. If new building bloom is involved (structures less than 1 year old), then the source of the salts is often the cement in the mortar, and the source of moisture is the water that was used for or otherwise entered during construction. If the structure is over 1 year old, construction details should be examined to identify possible leaks in the wall or in the surrounding construction. The appearance of efflorescence on an established building that had previously been free of efflorescence is usually attributable to a new source of water in the masonry.
2. Observe the location of the efflorescence, both on the structure and on the individual units or mortar joints. The location on the building may offer some information as to where the water is entering. The recent use or occupancy of the building should also be noted. For example, has it been vacant for some time, or has there been new construction? In short, what has occurred that might cause, or trigger, the appearance of the efflorescence?
3. Examine the condition of the masonry. The profile of the mortar joints, the condition of the mortar, the quality of workmanship employed, the condition of caulking and sealant joints, the condition of flashing and drips, obstructed weeps, and any deterioration or eroding of mortar joints in copings or in sills should all be carefully noted. This information should offer clues as to the entry paths of moisture into the construction.
4. Review wall sections and details of construction for an indication of possible paths of moisture ingress, and for possible sources of contamination by soluble salts. A careful examination of roof and

wall juncture and flashing details should be made. If available, a comparison of contract drawings with as-built drawings may be helpful. This examination will also be useful for determining steps for repair or alleviation of the efflorescence.

5. Review laboratory test reports on the materials of construction if they are available. This may help determine the source of the soluble salts, as well as other contaminants, and may be of use in analyzing and making repair judgments.
6. Identify the efflorescence. Knowing the composition of efflorescing salts is useful for determining proper removal methods. **Table 1** lists the most probable sources of efflorescing salts [Ref. 2]. If the composition is unknown, testing laboratories can use X-ray diffraction, petrographic analysis, ion chromatography or chemical analysis to determine the types and amount of salts present. The results of these tests can also be helpful in determining an appropriate cleaning solution.
7. Consider miscellaneous sources of water when all obvious sources have been eliminated. Some of these sources are condensation within the wall, poorly directed landscape sprinklers, leaky pipes, faulty drains, and condensation on heating or plumbing pipes. If necessary, condensation analysis methods are described in *Technical Note 47*.

When the mechanisms causing the efflorescing salts to appear have been established and the sources of salts or moisture are identified (usually the latter), suitable corrections must be addressed. Solutions to efflorescence problems usually involve reducing water penetration into the masonry prior to removing the efflorescence from the wall. Recommendations for the correction of water penetration in masonry walls can be found in *Technical Note 46*.

TABLE 1
Common Sources of Efflorescence

Principal Efflorescing Salt	Chemical Symbol	Most Probable Source
Calcium sulfate	CaSO ₄ * 2H ₂ O	Brick
Sodium sulfate	Na ₂ SO ₄ * 10H ₂ O	Cement-brick reactions
Potassium sulfate	K ₂ SO ₄	Cement-brick reactions
Calcium carbonate	CaCO ₃	Mortar or concrete backing
Sodium carbonate	Na ₂ CO ₃	Mortar
Potassium carbonate	K ₂ CO ₃	Mortar
Potassium chloride	KCl	Acid cleaning
Sodium chloride	NaCl	Seawater
Vanadyl sulfate	VO ₂ SO ₄	Brick
Vanadyl chloride	VOCl ₂	Acid cleaning
Manganese oxide	Mn ₃ O ₄	Brick
Iron oxide	Fe ₂ O ₃ or Fe(OH) ₃	Iron in contact or brick with "black core" or "black heart"
Calcium hydroxide	Ca(OH) ₂	Cement

Removal of Efflorescence

The removal of efflorescence from the face of masonry is generally a relatively easy operation. Most efflorescing salts are water-soluble, and many will disappear of their own accord with normal weathering. This is especially true of new building bloom. In cases where efflorescence is not removed by normal weathering, it usually can be removed by dry brushing. Specialty cleaners formulated specifically for use on brickwork are effective in removing heavy accumulations or stubborn efflorescence. It is important to test all cleaning solutions on a small area prior to full-scale application.

It is usually not advisable to wash efflorescence off the brickwork except in warm, dry weather, since washing results in the presence of considerably more moisture, which may bring more salts to the surface of the brickwork. Special care should be exercised in cleaning new masonry, since improper procedures and errors can contribute to or cause efflorescence.

For additional recommendations concerning cleaning efflorescence, see *Technical Note 20*.

Coatings

Clear water repellents, silicone and acrylic coatings are among the solutions often suggested for preventing efflorescence. A coating may prevent efflorescence from recurring by reducing the amount of water absorbed by an exposed masonry surface. However, applying a coating to brickwork that has a tendency to effloresce, without stopping the mechanisms causing that efflorescence, may lead to degradation of the masonry. Further, applying a coating that inhibits evaporation of water from the masonry may also lead to degradation.

As water and dissolved salts within masonry travel toward a coated exterior surface, they may be stopped at the inner margin of the coating (usually $\frac{1}{8}$ to $\frac{1}{4}$ in. [3 to 6 mm] below the surface). At this point, the water will evaporate, passing through the treated area as vapor, and soluble salts in the water will be deposited within the masonry. Known as cryptoflorescence or subflorescence, salts that crystallize within masonry can develop tremendous pressures which may result in brick spalling. For this reason, coatings are not recommended as the sole treatment for efflorescence problems.

OTHER STAINS

A number of stains that affect brick masonry are white in color and may be confused with efflorescence. There are still other stains that are different in color but have a mechanism of development similar to that of efflorescence. Discussion of these stains is outside the scope of this *Technical Note*. Identification of these stains, their causes and prevention are addressed in *Technical Note 23*.

SUMMARY

The development of efflorescence requires the presence of soluble salts and moisture. To prevent or minimize efflorescence, the elimination of either will suffice. Design, detailing and construction practices that promote resistance to water penetration are the most effective methods of preventing efflorescence. When efflorescence does occur, careful observation is valuable in determining and correcting sources of water entry or salts prior to removal.

The information and suggestions contained in this Technical Note are based on the available data and the combined experience of engineering staff and members of the Brick Industry Association. The information contained herein must be used in conjunction with good technical judgment and a basic understanding of the properties of brick masonry. Final decisions on the use of the information contained in this Technical Note are not within the purview of the Brick Industry Association and must rest with the project architect, engineer and owner.

REFERENCES

1. *Annual Book of Standards*, ASTM International, West Conshohocken, PA, 2018:
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C114 Standard Test Methods for Chemical Analysis of Hydraulic Cement
Volume 04.05
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