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EFFLORESCENCE OF MASONRY

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Preface

Over the years considerable research has been conducted on masonry mortar, some of which has been obscure or forgotten . . . and much of it contradictory in its conclusions and/or interpretation of the findings . . . and there is often disagreement among the researchers on the significance of tests, etc. Yet, preponderant or majority opinions on this collective research is often possible to glean. To this end the National Lime Association's staff has made a study of what appears to be the most significant research in the mortar field.

The results of this study are being summarized in a series of articles categorized into the principal properties and considerations of mortar, such as durability, efflorescence, bond, volume change, strength, and workability, along with selected bibliographies. The fourth article of this series deals with efflorescence, covering the effects of mortars, masonry units, construction practices, and environmental conditions. The earlier articles dealt with mortar durability, strength, and bond, respectively.

One inescapable general conclusion from this study is that an overwhelming majority opinion among the independent authorities consistently substantiated the need for *both* lime and portland cement in a well balanced, all-purpose mortar. The lime referred to is either hydrated lime or lime putty made from quicklime and may be either dolomitic or high calcium types. This should never be confused with pulverized limestone (calcium carbonate) that is sometimes erroneously called "lime," and which is inert in mortar and has none of the properties inherent with burned lime products. So, whether a conventional lime-cement mortar or a prepared one-bag mortar is used, be sure the mortar contains a bonafide lime that meets ASTM Specification C 207 or C 5—and enough of it.

Efflorescence of Masonry

Although unit masonry is a substantial, time-proven form of construction from both a sound structural and aesthetic standpoint, it is, like all types of construction, not devoid of problems. Undoubtedly, the most persistent and baffling problem attendant to masonry is efflorescence, popularly called "building bloom." It manifests itself as unsightly white coatings or scum that indiscriminately accumulates on the exterior walls of buildings. It is much more common and visually evident on the exterior of red-brick buildings, probably largely owing to the sharp contrast between it and the red brick. However, it also occurs on exposed stone, concrete, and calcium silicate facing units. Although some forms of efflorescence are temporary or short-lived, there is a permanent form that occurs, subsides or even disappears as a result of rains, only to recur again and again for many years. It is this latter type that constitutes the "problem," since in addition to marring the beauty of the structure, it often will, in time, cause the disintegration of the mortar and spalling of the masonry units. This resulting masonry "decay" leads to leaky masonry, which can severely damage interior walls and cause costly restorative maintenance. Although the occurrence of efflorescence cannot be predicted, it is more prone to appear suddenly, like a "disease," in a dry period during cool weather following a sustained rainy period. It is not as prevalent in hot, summer months due to rapid wetting and drying cycles. In northern states it is apt to occur most often in the late fall or late winter-early spring after rainy periods and when evaporation is slower and temperatures relatively low.

In spite of considerable research into the causes of efflorescence and ways to eliminate or minimize its occurrence, many of the research findings are conflicting and controversial. There are so many potential causes or contributors to efflorescence that this apparent disagreement is not surprising. Some of the researchers obviously failed to consider *all* possible factors and limited their investigations to certain combinations of materials or conditions. Nevertheless, it is possible to glean from the technical literature some consensus of opinion. (A bibliography follows at the end.)

On one point there is virtual unanimous agreement that, at least, the permanent form of efflorescence is composed primarily of soluble *alkali salts,* usually sodium and potassium sulfates, but expressed as Na_2O and K_2O equivalents, that exude from the masonry interior as a solution, and upon drying recrystallize as a supersaturated solution on the masonry facade. Less often these alkali salts are found in carbonate and even bicarbonate forms, such as Na_2CO_3 and $NaHCO_3$. In addition, in much lesser quantity, soluble chlorides and magnesium sulfate; insoluble calcium carbonate, calcium sulfate, and ferrous sulfate; and even traces of such rare metallic sulfates as vanadium, molybdenum, and others have been detected by chemical analyses in samples collected. There is disagreement on the chemical reactions occurring that perpetrate this phenomena, but not in the end-result.

Virtually all investigators readily agree that efflorescence is caused by multiple factors in combination, usually catalyzed by climatic and environmental conditions. Views are quite disconsonant on which factors are the major culprits in causing this building bloom. The resulting diagnoses, of course, are also frequently at odds. This is understandable since it is usually impossible to deduce the exact causes of a specific case with absolute certainty. Following is a complete list of the factors that can contribute to efflorescence.

Causes of Efflorescence

1. ***Construction Practices and Design***—There appears to be a majority opinion that faulty workmanship, construction practices, and design are the greatest contributors to efflorescence, and at least one or some of the following malpractices are invariably present when efflorescence occurs:

a. *Failure to protect piles of masonry units at the building site* with tarpaulins or polyethylene film from drenching rains. Units should be kept reasonably dry. Absorption of moisture tends to dissolve traces of soluble salts within the units, so that after being laid in the wall, upon drying, they effloresce. This coincides with the general recommendation that if at all possible, masonry units, even the absorptive types, should not be soaked before they are laid. To overcome this absorption problem, plastic mortars of very high water retentivity should be employed to resist the suction of porous units.

b. *Failure to cover and protect unfinished walls* during construction from rain. Again, the reasons are largely the same as in 1 (a): to prevent the bricks and freshly laid mortar from being saturated with water that will stimulate the dissolution of soluble salts from both the units and mortar.

c. *At roof level from inadequately flashed and unprotected parapet walls.* The latter, including chimneys, should be capped to prevent vertical absorption of water into the masonry interior.

d. *Lack of drips on cornices and sills.*

e. *Leaky gutters and downspouts,* which cause excessive wetting of adjoining wall sections.

f. *Failure to tuckpoint* cracked mortar joints or settlement cracks. The object is to impede as much as possible the penetration of water from driving rains into the interior of the wall.

g. A *common cause* is *poorly filled mortar joints* due to shoddy workmanship and/or the use of a harsh, unworkable mortar that is difficult to spread. The resulting voids in the mortar are most vulnerable to penetration from rains. So, only highly plastic, workable mortars should be employed.

h. *Use of dense masonry units and mortars* that upon becoming wet in the interior from rain penetration through cracks are paradoxically slow to dry out. In some cases such masonry never completely dries, so that this chronic damp condition is a "breeding ground" for salt concentrations. Masonry materials that are relatively porous dry out much more readily; they tend to "breathe" during wetting and drying cycles. As a result, capillary moisture penetration of masonry is not nearly as inducive to effloresce as water penetration through holes and cracks at the mortar-unit interface.

i. *Failure to use damp-proof courses,* such as metal foil, embedded between the foundation and masonry wall at or just above grade level, may be a cause. Groundwater that enters the foundation, unless impeded, may be absorbed upward vertically into the wall by capillary attraction or a "wicking" action. Again, the object is to keep as much water as possible from penetrating the interior of the wall.

2. *Masonry Units*—In widely varying degrees virtually all types of masonry units will possess, at least, a miniscule amount of efflorescence potential. The varying amounts of this potential are evident in certain geographic areas than other areas in spite of assiduously attempting to avoid the malpractices described in (1) above. This source is described as follows:

a. Certain *clay brick* derived from clay or shale containing a high total alkali salt content (Na_2O and K_2O equivalents) that are only soft to moderately burned into high porosity brick have an inherently high efflorescence potential. Clay and shale deposits vary greatly in the amount of alkali salts they contain. Use of chemical additives, like barium sulfate, by the brick manufacturer will reduce the tendency of some of these brick to effloresce, but this is no sinecure. Generally dense to moderately absorptive brick are least troublesome. Other sources of efflorescence may be derived from bits of limestone in the clay. When the brick is fired, the limestone is calcined into lime (CaO) or the resulting lime reacts with the sulfur from the fuel, forming calcium sulfate. The clay may also contain some gypsum ($CaSO_4$) in the native state. Nodules of lime or gypsum on the surface of the brick will hydrate and disintegrate, causing white streaking and pits to form in the brick surface. These two largely insoluble chemical compounds are usually temporary forms of efflorescence and upon a few cycles of wetting and drying are usually washed away. Nevertheless, clay devoid of limestone and gypsum should be used if possible as well as low sulfur fuels.

b. *Concrete products,* while generally not as prone to effloresce as clay products, can do so under certain conditions from the free lime that is liberated in the hydration of the cement, the lime carbonating on the surface of the unit. Usually such efflorescence is only temporary and will wash off after the first prolonged rain. Often such efflorescence is not noticeable, due to camouflaging effect of the units. Since it is not usually recurrent, it is not regarded as efflorescence, but simply as "lime streaking." Since in the U.S. most lightweight concrete products that might contain some degree of soluble salts are largely used in the back-up, their efflorescent generating potential would probably be less and more difficult to appraise than clay face brick. Dense concrete facing units generally present no problem because of low capillary action, and they possess only traces of these deleterious salts. Most stone and calcium silicate facing units would behave similarly, although no masonry unit would be completely devoid of soluble salts—at least a few parts per million.

3. *Mortar Materials*—Again, similar to masonry units, virtually all mortar materials will possess at least a faint amount of efflorescence potential, since none would probably be completely devoid of at least bare traces of soluble salts.

a. *Portland and masonry cements* vary greatly in their contribution to efflorescence because of the many varying raw materials from which they are made. Some cements are made from clay or shale with relatively high alkali contents of over 0.25% and up to 1%+ total Na_2O and K_2O. In the finished cement total salts will approximate these same percentages. These resulting cements when used in conjunction with some of the malpractices cited in (1) above can cause serious efflorescence; in contrast, other cements, low in these salts, may cause little or none when employed under the same circumstances. A few cement companies produce special "low-alkali" cements which alleviate this problem. The impure limestones and calcareous materials used generally to make portland cement may also contribute an excessive amount of alkali salts and sulfur to the cement. Less serious and largely temporary sources of efflorescence may be derived from the gypsum, which is admixed as a retarder into the cement as well as from the small amount of free lime which is generated as the cement hydrates in mortar making. Thus, selection of raw materials is important in cement manufacture. Special non-staining and white portland cements, made from carefully selected materials, possess near zero potential.

b. Most *limes* are extremely low in soluble salts as well as in sulfur content—much lower than cement on an average. In the U.S. and Canada, practically all lime is made from pure, high calcium or dolomitic limestone, assaying over 95% total carbonate content (and averaging over 97%). Total Na_2O and K_2O contents in the limes average between 0.05 to 0.1%, with many of the dolomitic mason's limes much less than this (about 0.01%). In contrast, most cement is derived from limestone or marl of 70-90% total carbonate content, much of which is argillaceous and earthy. As a result, limes on an average contain about 4-10 times less efflorescence potential than cement.

In Europe where hydraulic limes are still widely produced, alkali contents are usually much higher, approximating cement on an average, since these limes are made from impure, siliceous limestones. However, there is only one hydraulic lime manufacturer in the U.S. Therefore, lime is one of the lesser sources of efflorescence, along with well-washed sand and potable water.

c. Theoretically the *sand aggregate* might contribute to efflorescence if the sand was not thoroughly washed or if it was dredged from areas contaminated with brackish or sea water. In the abscence of this, most clean, well-graded commercial mason's sand has near zero potential.

d. *Water* that is brackish or extremely hard could contribute to efflorescence; sea water should never be used as mixing water. But most clean or potable waters present no problem.

4. *Environmental Conditions*—Even certain climatic and atmospheric conditions are influencing factors.

a. Areas of high *rainfall* are more likely to induce efflorescence than dry, arid climates. Its appearance is relatively rare in the latter climate.

b. *Smoke and industrial fumes* frequently are laden with sulfurous gases (SO_2 and H_2S), and in addition to being a cause of smog and an air pollutant, they can cause efflorescence. The sulfurous gases, particularly under damp conditions, will decompose the surface of mortar joints, forming calcium sulfate crystals. This white, insoluble salt is washed onto the brick facing after it rains. Both lime and portland cement are vulnerable to such attacks. In some intensely industrial sections this type of efflorescence is almost a chronic condition with the red brick stained both black from soot and white from the calcium sulfate streaking—a drab sight that epitomizes slum conditions. As an extreme in one industrial area daily tests over a year period revealed that the average SO_2 content in the air was 0.3 ppm and at times, was as high as 2.5 ppm. Under the most severe sulfurous atmospheric concentrations, it is doubtful if masonry composed of materials of the least efflorescent potential would be immune from attack. Smoke abatement is the only preventive measure against this source of efflorescence.

DISCUSSION

The most recent researcher who has studied efflorescence in depth is Ritchie of Canada (1). In studying the effect of mortar on efflorescence, he employed representative limes, portland cements, and masonry cements of various salt contents, as revealed in Table 1. Widely varying proportions of these materials were mixed with the correct amount of sand and water, and the resulting mortars were molded. Ceramic wicks, specially designed for measuring efflorescence, were embedded one-third of the way into each mortar specimen before hardening. After each mold had been cured, the samples were subjected to ten cycles of wetting and drying. The wicks were then broken off flush to the surface of each mortar mold and the amount of soluble salts absorbed through capillarity was computed. Some wicks were encrusted with heavy efflorescence; others were free of it or only slightly marked. As Figs. 1-4 indicate, the amount of efflorescence tended to increase as the proportion of portland cement in the mortar increased. (Proportions of lime and cement ranged from 100% lime to 100% cement, with four intermediate proportions of both.) Fig. 1 also shows that mortars with one portland cement contained appreciably

Table I. Analysis of Mortar Materials (%)

Component	Lime A	Lime B	Lime C	Portland cement A	Portland cement E	Masonry cement M	Masonry cement N
Na_2O	(*)	0.02	0.05	0.41	0.09	0.28	0.01
K_2O	(*)	0.01	0.06	0.49	0.53	0.41	[illegible]
SO_4	(†)	(*)	(*)	3.38	1.92‡	[illegible]	1.25
Cl	(†)	(*)	(*)	(*)	(†)	(*)	(*)
CO_2	0.05	2.14	0.44	0.24	(†)	25.5	1.57
MgO	0.99	11.64	1.72	2.62	4.1	[illegible]	[illegible]
CaO	97.15	64.00	90.50	62.77	62.2	[illegible]	[illegible]

* None. † Not determined. ‡ As SO_3.

less efflorescence than another cement with the same lime, sand, and equivalent proportion. Similarly, as Fig. 5 depicts, the two masonry cements behaved completely differently: one (the M series) generated heavy efflorescence; the other (the S series) had scarcely any. Invariably, the greatest efflorescence stemmed from those mortar materials possessing the greatest amount of alkali salts (see Table I).

In other research Ritchie built a series of capped brick piers with different combinations of brick, lime, and portland cement (mortar in varying proportions from high lime to high cement content (2)). He also confirmed the importance of proper design and workmanship cited earlier. However, he also confirmed his research findings on mortar, described above, with the ceramic wicks; i.e., generally efflorescence was "more extensive and pronounced for mortars of higher proportions of portland cement." He revealed, however, that the quality of the brick affected efflorescence to as great an extent as cement. A high portland cement content mortar, when used with three different bricks of different degrees of absorption (porosity), yielded much efflorescence with the brick of high absorption; a slight amount with brick of moderate absorption; and none with a dense brick. Mortar proportions used in the above studies by Ritchie are contained in Table II.

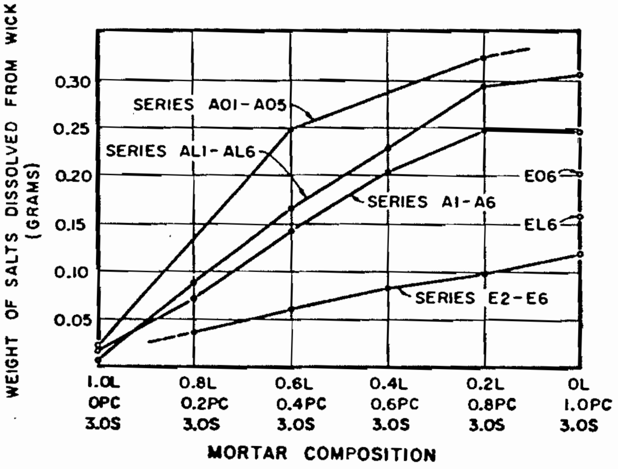


Fig. 1. Comparison of amounts of salts dissolved from wicks used with mortars of lime A and various sands and Portland cements. (L) indicates lime, (PC) Portland cement, and (S) sand. Proportions are by volume.

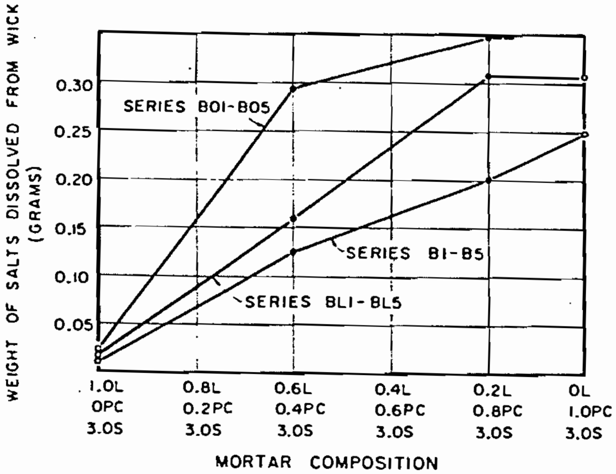


Fig. 2. Comparison of amounts of salts dissolved from wicks used with mortars of lime B, Portland cement, and various sands. (L) indicates lime, (PC) Portland cement, and (S) sand. Proportions are by volume.

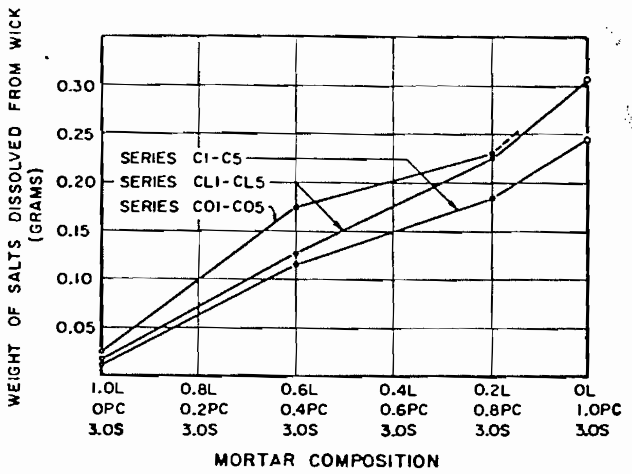


Fig. 3. Comparison of amounts of salts dissolved from wicks used with mortars of lime C, Portland cement, and various sands. (L) indicates lime, (PC) Portland cement, and (S) sand. Proportions are by volume.

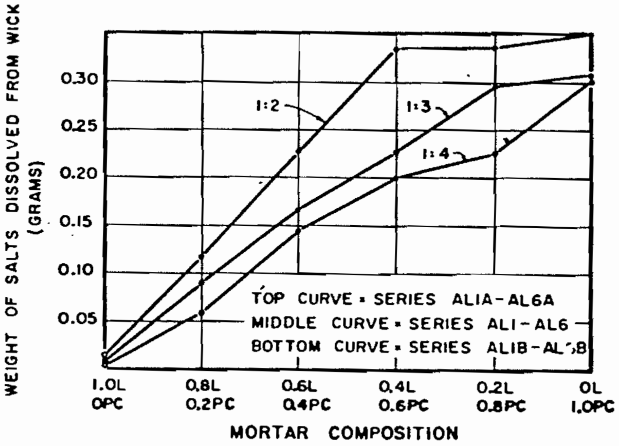


Fig. 4. Comparison of amounts of salts dissolved from wicks, in relation to changes in mortar composition and ratio of cementing material to sand. (L) indicates lime, (PC) Portland cement. Proportions are by volume of lime; ratios by volume of cementing material to sand.

Berriman of Stanford Research Institute studied efflorescence, and his findings generally confirmed Ritchie's on the diverse influence of different mortars (3). His research was based on studying the weathering effect on brick piers. Certain portland cements, possessing high alkali salt contents, effloresced badly, much more than other cements. His conclusions that alkali salts are the manifestation of efflorescence is supported by data collected on sodium sulfate additions to mortars. A mortar that tested nearly zero in alkali salts was given increasing increments of sodium sulfate. In brick

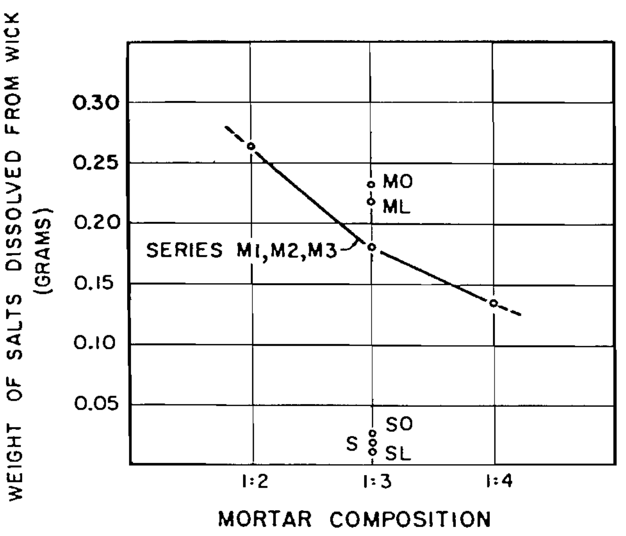


Fig. 5. Comparison of amounts of salts dissolved from wicks used with mortars of masonry cements M and S and various sands for different ratios by volume of cementing material to sand.

Table II. Compositions of the Mortars

Components (by volume)
0.0 PC:1.0 L:3.0 S
0.2 PC:0.8 L:3.0 S
0.4 PC:0.6 L:3.0 S
0.6 PC:0.4 L:3.0 S
0.8 PC:0.2 L:3.0 S
1.0 PC:0.0 L:3.0 S

PC = Portland cement; L = lime; and S = sand.

panels built with these mortars, those containing sodium sulfate effloresced badly. Increasing increments of lime as replacement for cement in mortars generally reduced efflorescence significantly.

Butterworth of England has written extensively on efflorescence (4). He acknowledges that certain porous brick have high efflorescence potentials, but he has developed a foolproof test that exposes the vulnerable bricks. He stresses the importance of proper design and workmanship and infers that when these factors are performed perfectly, almost any type of brick can be used safely. He favors use of a 1:2:9 mortar (cement, lime, and sand, respectively, by volume) for general work as possessing the lowest average efflorescence potential; superior bond leading to greater watertightness in joints, however, is the principal reason for this recommendation.

Palmer also researched efflorescence in depth (5). His writings tended to implicate all masonry materials about equally as being potentially contributive. He found certain absorptive brick that would not effloresce when tested alone, but would effloresce in masonry panels, indicating that the mortar was to blame. (Ritchie reported the converse of this.) In 288 brick panels he found only slightly less efflorescence with lime as compared to cement. He advocated the use of 2% calcium stearate in all mortars as a preventative. Yet, in other writings, Palmer (6) contended that the greatest deterrent to efflorescence was tight mortar joints and proper design to prevent as much as possible the penetration of water into the walls. To achieve watertight masonry he favored the use of high lime mortars (1:2:9—cement, lime, and sand, respectively, by volume) because their high plasticity and water retentivity provide greater extent and intimacy of bond at the mortar-unit interface. The stronger, higher cement-content mortars, he felt, were too vulnerable to separation cracking from the masonry unit due to shrinkage, which leads to leaky masonry.

Anderegg wrote voluminously but rather inconclusively on this subject (7). He recognized all of the possible additive causes, and felt that a combination of these causes was necessary to precipitate "building bloom."

In research sponsored by the clay products industry, Wilson tended to exonerate clay brick from causing efflorescence (8). His findings indicated that mortars were much more to blame. Experimentally, he found at least traces of efflorescence in all mortars tested. The worst efflorescence occurred when straight cement mortars were used or when brackish water was employed in the mixing water. He claimed lime contributed less to efflorescence than cement, and favored the use of a 1:1:6 mortar as causing the least trouble. Of lime types he noted less efflorescing with hydrates than with lime putty from quicklime. Unlike other investigators, he concluded strongly that the efflorescence from cement was largely caused by the gypsum content of cement and secondarily from the free lime that is liberated during hydration and not the soluble alkali salts. As a result, he did not distinguish between the permanent and temporary forms of efflorescence, cited above. In his research findings, he tended to minimize the vital influence of construction practices on this problem.

Some interesting research on this subject was conducted at Yale University (9), in connection with the University's own construction program. In order to secure a foolproof design against efflorescence, 54 masonry panels were built with several types of clay brick and mortars and subjected to saturated conditions. The findings revealed that straight portland cement mortars and proprietary masonry cement mortars effloresced much worse than a 1:1:6 portland cement-lime mortar. Contrary to Wilson (above) they found that a high calcium quicklime putty effloresced slightly less than a high calcium hydrate. They also found that dense, low water absorption brick was best. The masonry material specification that they selected was: dense brick and a 1:1:6 mortar of quicklime putty and a special non-staining cement of very low soluble salts. They report a building that is free of "bloom."

Empirically, Newman (10), a specialist in masonry construction, observed that the most destructive, permanent form of efflorescence is the type one rarely or only periodically sees. It exists hidden within the interior recesses of the masonry, but can reappear suddenly under certain temperature and climatic conditions. But what concerns Newman the most is its internal destructive effect on mortar and the integrity of the masonry by causing severe leaks, as a result of crumbling mortar and eventual spalling of the units. He advocates tight joints to keep as much water out of the masonry as possible; use of porous masonry units and mortars because such materials dry out completely and more easily. To achieve this he prefers a 1:2:9 (high lime) mortar for its tighter bond and its greater porosity.

Nowhere in the technical literature is lime blamed for efflorescence. Unfortunately, it has been erroneously indicted as "the culprit" by a few well-meaning architects and builders. Their accusation is predicated on the rather unprofound theory that since efflorescence and lime are both the same degree of whiteness and no other material entering masonry is the same hue, that lime must be the cause. The foregoing by the technicians who have studied this problem in greatest depth proves how irresponsible such utterances are.

SUMMARIZATION

1. There are a great many factors that contribute to efflorescence in widely varying degrees. Virtually any material used in masonry possesses at least a trace of efflorescence potential that in itself is inconsequential but may produce a very minor additive effect.

2. No single factor can cause serious efflorescence. It is caused by multi-factors working in combination.

3. The serious forms of efflorescence are caused by soluble alkali salts, mainly sodium and potassium sulfate. Efflorescence from other soluble salts and insoluble substances, like calcium carbonate, calcium sulfate, and other metallics, are less troublesome and tend to be temporary in occurrence.

4. Use of brackish water or sea water will contribute substantially to it. Only clean or potable water should be used in mixing mortars.

5. The best prevention against efflorescence is to keep as much moisture as possible from penetrating into the wall. Tight mortar joints are particularly important.

6. The greatest cause of efflorescence is faulty design and construction practices. It is doubtful if serious or permanent forms of efflorescence can occur, regardless of the masonry materials used, including those of the highest effloresencing tendency, without the occurrence of some construction malpractices.

7. Certain types of clay brick and portland cement have the greatest efflorescence potential of all masonry materials, particularly soft-burned, highly absorptive brick and cement that contains a high alkali content. Other types of brick and cement contain much less soluble salts and have low to intermediate potentials.

8. Limes, such as the relatively pure types that are produced in North America, have a slightly varying but generally very low potential—much lower than cement on an average. Many limes have near zero potential, approximating well-washed sand and clear or potable mixing water as far as soluble salt content is concerned.

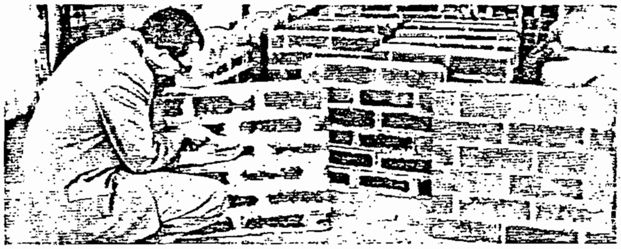
9. Hydraulic limes, made from impure, siliceous limestone, would have a much higher potential than the pure, "fat" limes, approximating portland cement on an average. Such limes are mainly used in Europe.

10. To construct masonry that is as efflorescence-proof as possible, the following materials are recommended:

   a. Use only hard-burned brick of low to moderate moisture absorption or test the brick for its efflorescence potential with the wick test, described earlier.

   b. Use only "low alkali" portland cements or non-staining or white cements in the mortar.

   c. Use high lime content mortars, such as a 1:2:9 proportion (cement, lime, and sand, respectively, by volume). Such a mortar promotes watertight masonry due to its greater extent of bond, high plasticity, and very low soluble salt content.



Researcher scrapes off some of the powdery crust (efflorescence) from a test brick panel. The substance was identified as soluble alkali sulfates, particularly those of sodium and potassium.

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Appendix

What is lime?

The term, "lime," in spite of being used broadly and loosely, *only* embraces burned lime products, quicklime and hydrated lime, and *not* pulverized limestone, which is used in many masonry cements. Limestone is a *carbonate* form of calcium or calcium-magnesium—a sedimentary rock, possessing completely different properties than lime, which is an *oxide* or a *hydroxide* of calcium or calcium-magnesium. Lime is a manufactured product (basic chemical), made from limestone or oyster shells by calcination at high temperature (2000° F.) in kilns. The resulting product, quicklime (unslaked lime), is used as a mortar material after slaking into putty—or is converted to hydrated lime. The hydration process disintegrates the lump, pebble, or granules of quicklime into an extremely fine, white powder by adding a controlled amount of water, enough to satisfy its chemical affinity.

Limestone has no cementing value, whereas lime contributes some strength to mortar by recarbonation, i.e., absorbing carbon dioxide from the atmosphere and reverting to its original carbonate form.

Hydrated limes are divided into two classes, as described in ASTM Specification C-207—Type N and Type S hydrated limes, applicable to both high calcium and dolomitic (high magnesium) hydrates. The Type S (Special hydrated lime) is differentiated from Type N (Normal hydrated lime) principally by its ability to develop high early plasticity, higher water retentivity, and by its limitation on unhydrated oxide content.

Lime putty, derived from slaking quicklime, generally possesses most of the Type S properties.

In this series of NLA Technical Notes, a "high lime mortar" is generally considered as comprising one part cement, two parts lime and approximately nine parts sand. The National Lime Association recommends this 1:2:9 proportion as an excellent mortar for general use.