Efflorescence in Brickwork

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Introduction:

Efflorescence on brick masonry building is a source of concern to owners, embracement to builders and frustration to architects. The aesthetically objectionable salt deposits are the results of migration of aqueous solutions of soluble salts from within the walls to the surface, with subsequent evaporation of the water. During periods of warm, dry weather the transformation from liquid to vapours may occur before the solution reaches surface, leaving behind the salt deposits within the walls. Paradoxically, although the surface deposits are of great concern because they are unsightly, however deposits left within the walls are generally ignored because they are not obvious but they are main source of masonry deterioration. These salt deposits build up and they gradually exert pressure that eventually become great enough to spall away the surface of the bricks and the mortar.

Depending on their nature, distribution and quality of materials, soluble salts may produce one or more of the following defects;

- Unsightly appearance
- Lime staining
- Surface disruption
- Coloured stains
- Hard glossy skin
- Sulphate attack
- Loss of adhesion

This article will through light on understanding the chemistry of efflorescence and remedial measures.

Factors Essential for Occurrence of efflorescence

The following factors are essential for its occurrence

- Water
- A well structured conducive passage for water
- A source of water solvable salts
- Suitable weather conditions

Water may enter masonry in several ways:

- During construction process
- As a result of wetting during rain storm
- By migration of water vapours into the walls from high humidity area within enclosure

During the construction process water is deposited in the structure in masonry mortar and plaster, and as the new wall dry out efflorescence often appear. This initial efflorescence usually disappears after the construction water has evaporated, and if the wall is resistant to rain penetration it probably will not reappear.

It is inevitable that masonry walls will be subject to wetting during rain storm. The amount of water entering the walls will depend on:

- The effectiveness of the design details and the degree of workmanship obtained during construction and
- The nature of the masonry materials used in the structures.

Important considerations at the design stage are:

- The type of wall structure
- Adequate flashings, particularly around openings
- Sills and copings that project sufficiently to throw water clear to wall necessitating a properly designed drip

The best procedure for ensuring a wall with maximum resistance to rain penetration must be insisted upon. Inferior workmanship inevitably results in ready paths for water to enter and travel through masonry walls. Initial efflorescence may be prolonged by rain falling over partially completed walls that have not been covered adequately at the end of the work.

Even if the above precautions have been observed, the nature of the microstructure of the bricks mortar used may promote efflorescence. Highly porous materials with high absorption potentials permit the entry of water in to the wall and facilitate its circulation through interior. It is reported that a ceramic body with zero per cent absorption cannot produce any efflorescence. However, some practical limits between zero and 6 per cent have been reported at which efflorescence will not occur.

A variety of salts have been identified in efflorescence deposits. Commonly efflorescence creating salts include sulphates and carbonates of calcium, magnesium, sodium and potassium. Presence of nitrates and chlorides is usually indicative of salt derived from ground water, although sulphates and carbonates may also be present. Chlorides may also originate Efflorescence on brick masonry building is a source of concern to owners, embracement to builders and

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Nature of Soluble Salts

1. Composition

Some common salts which may be encountered in dealing with efflorescence problems are:

$CaSO_4$ $MgSO_4$ Na_2SO_4 K_2SO_4 $Fe_2(SO_4)_3$
$CaCO_3$ $MgCO_3$ Na_2CO_3 K_2CO_3

2. Solubility of Sulphates and Their Effects

a. $CaSO_4$, because of low solubility does not normally give rise to efflorescence. However its presence induces sulphate attack under prolonged damp conditions. The solubility of $CaSO_4$ is appreciably increased in presence of K_2SO_4 due to the formation double salt, which is more soluble, thus appreciable quantity may be found in efflorescence.

b. $MgSO_4$ is mainly responsible for most of the failures caused by soluble salts, despite the fact that it is rarely present in appreciable quantities. In stone work $MgSO_4$ results from the decomposition of $MgCO_3$ exposed to environment, this salt may crystallise out at or near the surface of a material. On external surfaces, because of its solubility, $MgSO_4$ is easily washed away. This does to a large extent, minimise the possibility of destruction of materials. Thus sheltered parts of buildings are more vulnerable. Decorations may be impracticable as disintegration of the surface may occur when $MgSO_4$ appears on the surface of plaster. Under certain conditions, when lime is present in plaster, crystal growth at the plaster may exert sufficient pressure to separate out the plaster.

c. During crystallisation K_2SO_4 tends to assume a hard glossy form, while sodium sulphate gives a fluffy deposit. Decay is usually likely to be most severe where the salts concerned can exist in more then one state of hydration. Externally, the transition temperature between the two states is within the range of outdoor temperatures, sodium sulphate for exampleat temperature below 32.5^0 C crystallises with 10 molecules of water of crystallisation. This compound changes into the anhydrous salt Na_2SO_4 even at this temperature but at reduced humidity. Heat from sun can change it to the anhydrous form, which will occupy 4 times the initial volume. Consequently, if the salt is deposited in the pores of a material, the dimensional Changes can lead to destructive pressure in the pores and powdering the surface.

d. Rusting stains particularly on mortar joints in brick work are usually due to iron salts, which are changed to ferric oxide by oxygen and lime. Yellowish green stains are due to an efflorescence of a coloured salt, which contains vanadium.

Sources of Soluble Salts

Sources of salts causing efflorescence can be broadly grouped in two classes:

1. Internal Source(Salts originally present in the construction materials)
   A salt from internal sources broadly comes from construction materials used e.g. bricks, tiles, cement etc.

2. External Sources(Salts derived from external sources)
   Salts from external sources includes jointing materials, backing materials, decomposed materials, ground and other hardcore materials below paving, atmosphere, user's activities, cleansing and maintenance methods followed during use.

Physical Processes Involved in Efflorescence

The formation of efflorescence deposits, a number of physical processes of salts and transfer of water in and out of pores of material are involved in this. Some of the key factors involved in the process are as under:

1. Effect of Pore Structure of Construction Materials

In fact porous materials may have two distinct types of structures wiz fine pored and coarse pored. In which the fine pored structure (closely textured bricks) capillary forces will tend to draw the solution so that the free water surfaces in pores are near the face exposed to the evaporating environment. Visible deposits of salt crystals will take place, as evaporation and thus crystallisation, will tend to occur at exposed face. With a coarse pored structure (open textured bricks) the larger dimensions of pores will cause the free water surfaces to fall below the exposed surface. Nevertheless, evaporation by diffusion and by pore ventilation could take place. Resulting in crystallisation occurs below the exposed surface, I.e. crypto efflorescence. Some apparent anomalies may be explained through above said approach. Efflorescence tends to appear more readily on more dense bricks than on common bricks, mainly because of former are fine pored and and later coarse pored.

Sometimes, however, efflorescence may only appear on certain area of materials. This may be explained by fact that these areas are probably fine pored than the remainder of material. Thus in addition to the factors already outlined, the salt solution would be drawn to the finer pored areas due to stronger capillary action, which they are capable of exerting.

Mortar or the pointing is dense; drying out at the mortar joints will be either prevented or restricted. Drying out of the wall therefore takes place mostly through the bricks. Consequently, soluble salts will tend to concentrate on bricks. The lesson to be learnt from this are two fold. First, pointing should not be denser than the mortar and mortar should ideally match the porosity of the unit it is jointing. This is yet another reason for avoiding, wherever possible, the use of mortar which is stronger than units being jointed. It should also be noted where the building unit is impermeable, salts might be deposited on the mortar joints, if this is porous and permeable.

2. Effect of Crystal Form of Salts

The readiness with which efflorescence forms depend on the shape of the crystals of the salt or mixture of salts that are deposited from solution.

3. Effect of Hygroscopic Nature of Salts

Highly hygroscopic materials like hydroxides of alkalis are left in solution, when Portland cement is mixed with water. These are not likely to form efflorescence initially, being hygroscopic in nature. However, efflorescence could appear with such salts also, after their chemical intersections and atmospheric CO_2/ SO_2 to form carbonates / sulphates.

General Precautions for Selection of Various Building Materials

1. Bricks

Well fired bricks should be used in construction particularly in exposed parts. Such bricks have high strength, low water absorption and low salt contents. Bricks with black core (where salts concentrate) or with lime nodules (which cause lime bursting) should be avoided. Soluble salts get evaporated at higher temperature of firing giving low porosity and high strength.

2. Mortars

Portland cement used in mortars contains tricalcium aluminate. Sulphates added at the time of manufacturers cement or from bricks or ground may be carried to the mortar by water, where calcium sulphonamide - aluminate hydrate is formed. This compound has a large specific volume. Hence expansion occurs and mortars disintegrate. The damage caused depends on the amount and nature of sulphate present. More soluble sulphates of sodium, potassium and magnesium produce grater damage than less soluble calcium sulphates.

Mortars used should, therefore be sulphate resistant and should prevent rain penetration. Use of very rich mortars should be discouraged as these develop shrinkage cracks. Mortars with plasticisers offer higher resistance to rain penetration and also offer higher resistance to movement to soluble salts. But use of such mortars is not common till date.

1:1:6 cement: lime: sand mix. mortar is suitable for external walls. Care should be taken that sand itself is not source of salts. For internal use 1:2:9 mix. may be used. Use below damp proof course 2:1:9 cement: lime: sand or 1:3 cement sand mortars or resin mortars preferably.

3. Plastering

Due weightage should be given to the choice of materials; particularly sand. It should be tested for salt contents. Obviously, sand from sea side or river estuaries should be avoided.

Mixes suitable for external plastering on clay bricks or blocks are:

1:1:6 (cement: lime: sand) for undercoat

1:1:6 or 1:2:9 (cement: lime: sand) for finish

Where there is definite possibility of migration of sulphates from the background, either from brick or soil (inadequate DPC) exists, it is advisable to use sulphate resisting cement for rendering.

For internal plaster of brick or block surface 1:6 cement: sand mortar with plasticisers or mixes suggested for exterior plaster may also be used. Very rich mixes should again be avoided.

4. Stone

Some tomes bricks are used in conjunction with stones. Lime stone reacts with sulphurous atmosphere producing calcium sulphate, which may affect the masonry and may also be leached out as efflorescence. Hence lime stone and bricks should not be used together. Use of sand stone with lime stone should also be avoided as calcium sulphate from lime stone may be carried to sand stone by water.calcium sulphate flakes off sand stone surface.

If porous stones are used in sea side buildings their surface gets eroded. It is best to use granite or basalts under such conditions. Porous stones should not be used near ground level due to obvious reasons.

Construction Methods

It is essential to prevent water getting access to brick work. Few general points are that water used in construction should be free from salts and bricks should be soaked to a minimum. Over burnt bricks may be used below C.P.C. level. Such bricks have high strength, low water absorption and are practically free from salts. Bricks of compressive strength less than 7.5 N/ mm2 should not be used in exposed parts of a building. Under fired low strength bricks should also not be used in combination with lime stone.

Two coats of bitumen cut back comprising hot bitumen five parts and kerosene oil one part by weight should be applied on both the sides of foundation walls up to D.P.C. level. This checks continuous rise of underground moisture.

While applying rendering on a wall the surface should be cleaned. Joints should be ranked out and cleaned and the whole surface should be wetted so as to avoid excessive suction of water from the finishing coat. Heavy troweling and skimming of the surface should be avoided as these lead to greater incidences of efflorescence.

Sealing coats are some times applied on plastered surface before giving a decorative finish. Such coats efflorescence in early stage but lead to serious difficulties later. They should therefore be avoided. Plasters should be allowed to dry adequately before applying decorative finish. Internal waterproofers should not be depended upon to prevent efflorescence. They do not act as vapour barriers and can't withstand flow of water even a small pressure heard.

Details of Design

Details of design are primarily concerned with methods, which aim to exclude as much water as possible (DPC's and other water excluding features are significant). However an equally important consideration is the relationship of different materials in the same construction.

As regards exclusion of water special care is required with those parts, which are likely to be more heavily exposed than others. It is important that the body of a construction is prevented from becoming saturated by water percolating through horizontal surfaces may require weathering and flashings, while even rainwater outlets need suitable detailing. It is probably axiomatic that care in the design of D.P.C and damp proof mortars in the walls and floors is necessary as to limit the rise of salts from the soils to predetermined (designed) level.

Handling, Storage and Protection of Materials

Contamination of materials can take place very easily either during handling or storage, particularly on a building site, although the works or the yards of manufacturers and builders merchants can not be exempt. Care should always be taken that the in compatible materials are not stored in contact with one another, particularly in damp conditions. In general materials should not be stored in contact with the ground. Some form of raised platform of damp proof mortar should preferably used. Polythene sheet has proved invaluable for this purpose. Materials should be protected from becoming saturated by rainwater while stacked or stored at site and later when they have been incorporated in the construction.

Drying out

Some applications such as adhesive and paints cannot be successfully applied either on damp surface or on surfaces which have deposits of soluble salts. The later should always be removed prior to use of applications, which rely on adhesion. If still there is sufficient water left in the body of the construction, efflorescence may still form. However the salts are likely to be deposited under the adhesive or paint film causing loss of adhesion.

Removal of efflorescence

The way efflorescence may be removed from a surface depends on the type of efflorescence and the nature of the surface.

(a) White Powdery Deposits

There is a simple rule for the removal of white deposits from the surface of brickwork that chemical methods should never be used. On new brickwork the efflorescence should first be allowed to weather away naturally during the warm drier months.

The residual deposits may be removed by brushing with a stiff bristle brush. The deposit should be collected as it is being brushed away, care being taken to ensure that it does not enter the brickwork at lower levels. Any deposits still remaining may be removed or reduced by using clean cold water. The washing down may cause the salt to re-absorb by the brickwork, as the salt is water soluble. Using the clean, damp sponge, rinsed frequently in clean and cold water may minimise the amount of reabsorption. Where a deposit appears on old brickwork the cause of efflorescence should be investigated and remedied before removing it as described above.

(b) Yellow or Green efflorescence

Washing the the brickwork with inorganic acid solution often produces a dark coloured strain. In the first instance the efflorescence should be allowed to weather away naturally.

Concluding Remarks

There is no perfect remedy for efflorescence except complete isolation of the construction from water. This is however, not always practical. Some of the remedial measures useful, in particular circumstances and are given below.

(I) Careful dry brushing and washing repeatedly can remove efflorescence on brickwork traceable to salts in the materials. Patches of salt on isolated bricks in building provided with adequate D.P.C. may be removed likewise. Intensity of efflorescence diminishes after each washing.

(II) Water penetration in stone construction may be checked by using water repellent surface treatments such as silicon treatments. It is successful if the surface is free from cracks or fissures. Similar treatment can also be given to brickwork.

(III) Efflorescence in old building, internal or external, is a potential danger to such buildings. The cause can be traced ti the ingress of water into the building. Usually the D.P.C. Is at fault or it has not been provided at all. This has to be properly rectified.

(IV) Providing plinth protection should prevent accumulation of water close to walls. Other possible sources of water ingress should be carefully checked and rectified.

(V) Continuous wetting and drying of walls causes' regular dissolution of soluble salts present either in brick, concrete or plaster. These soluble salts get deposited over surface or weaken the plaster after drying. If source of water is contaminated with soluble salts it also causes the same effect. Hence continuous wetting and drying should be checked as soon as possible.

(VI) Internal efflorescence in old buildings sometimes pushes out the plaster leaving the brickwork bare. Such surfaces should be given a heavy coat of bitumen based material (cold sticker) and the surface should be rendered with gypsum plaster.

(VII) Efflorescence and erosion problems are often encountered in buildings near the sea. Under such situations, adequate D.P.C. measures are sufficient to prevent erosion as well as efflorescence. Re-plastering of the eroded wall surface with rich mix. has been found inadequate.

(VIII) Electro-osmosis and latex-silicon injection treatments are claimed to have prevented efflorescence in exiting building without D.P.C. Both the methods aim at damp-proofing the walls and both need handling by specialists.

References

1. BIS specifications for common building clay bricks IS: 3495 : 1995

2. BS: 3921 : 1985 British Standard Specification for clay bricks

3. BS: 5628: 1985 British Standard Code of Practice for use of Masonry, Part 3. Materials and Components, Design and workmanship.

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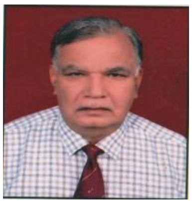
BIOGRAPHIES



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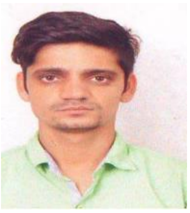

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