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Efflorescence — Prevention is Better than Cure

academic research report by
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What is efflorescence

Efflorescence is well known as the unsightly white deposits or stains that sometimes appear on the surfaces of motor, concrete or brickwork on buildings and block paving. Three categorites of efflorescence are commonly referred to(1)

· Lime bloom
· Lime weeping
· Crystallisation of soluble salts

White deposits of lime bloom usually become visible as thin sections when the structures concerned start to dry out. These deposits commonly disappear in the longer term by natural weathering. The effect of lime bloom upon mortar, concrete or brickwork is usually superficial.

Lime weeping is a much thicker localised build-up or encrustation of white deposits than lime bloom. Lime weeping is normally seen at cracks and joints where water appears to be coming from within the mortar, concrete or brickwork. This phenomenon is usually observed on more mature structures, where the originally light build-ups of efflorescence (lime bloom) have grown to a greater perceptible thickness. Lime weeping is generally permanent on account of its thickness and is unlikely to disappear through natural weathering. Even with lime weeping, the durability of the structure is not normally in question. Lime weeping (like lime bloom) is a manifestation of water flowing through the concrete, which is itself undesirable.

Crystallisation of soluble salts is the least common form of efflorescence and usually takes place where concrete has been produced with seawater or upon retaining walls. The deposits consist of soluble salts, like sodium chloride NaCl, that are not normally present in concrete. With weak or porous concrete, such salts can crystallise below the surface and give rise to disruptive stresses that cause swelling.

Where water can percolate through retaining walls, white deposits of trona Na2CO3.NaHCO3.2H2O are sometimes seen (1). Deposits of gypsum CaSO42H2O are also often found in efflorescence (2,3).

Efflorescence is ugly, but not normally damaging to the exposed concrete or brickwork (4). Photo 1* illustrates the effect of efflorescence on a domestic driveway/path. However, on relatively rare occasions the leaching effects of efflorescence may be sufficiently severe to cause some residual damage to the structure.

Should there be any uncertainty concerning the structural integrity, then the situation should be clarified through inspection by experts.

Causes of efflorescence

Primary efflorescence observed with lime bloom and lime weeping refers to uniform calcite deposits CaCo3 arising from transport of calcium hydroxide Ca(OH)2 in solution through capillaries within the structure to the external surface. Here the solution evaporates and leaves behind deposits of solid white calcium hydroxide. These in turn react with atmospheric carbon dioxide CO2 to form white deposits of calcite, the normal end product: Ca(OH)2 + CO2 ---------- CaCO3 + H2O.

Secondary efflorescence arises where water penetrates the surfaces and dissolves soluble calcium salts in a basically patchy way. The main chemical reaction is the same as that in primary efflorescence, namely namely conversion of calciium hydroxide to calcite. Secondary efflorescence originates from reaction in solution, usually caused by rain or condensation, and is thus of a more uneven nature, whereas primary efflorescence is caused by evaporation leaving behind the deposited salts.

It is important not to regard any white deposit on structures as always being due to efflorescence, particularly on hardened mortar and concrete. For instance, sodium silicate gel, indicative of alkali-silica reaction, and thaumasite (from thaumasite sulfate attack) are white deposits. Gypsum, often observed in efflorescence, can sometimes be found as a white deposit where ordinary sulfate attack has arisen. Normally the damage to structural integrity should be noticed, but if the attack is in the early stages, the situation may not always be clear-cut. If in doubt, the deposits should be examined further for clarification. There are numerous contributory factors to efflorescence (1).

Remedies for efflorescence

Efflorescence can be treated in practice by various means (1-5):

· Sandblasting the surface of the concrete
· Washing the concrete with an appropriate dilute acid like hydrochloric acid HCl
· Incorporating waterproofing admixtures/polymeric membranes into blocks, bricks and cladding panels to maintain their original condition upon prolonged exposure to the weather
· High pressure steam curing of concrete
· Reliance upon natural weathering - Here the calcite crusts either fall off by wind erosion, or by their progressive reaction with moist atmospheric carbon dioxide to form calcium hydrogen carbonate Ca(HCO3)2, a very soluble material, which can easily be washed away by rain: CaCO3 + CO2 + H2O ------- Ca(HCO3)2. It is essential that remedial treatments for removing efflorescence be always carried out by experts, so that any risk of damage to the structure can be avoided.

Prevention of efflorescence

Prevention is better than cure, both in cost terms and in those situations where repeated remedial treatment is needed for new appearances of efflorescence. The accumulated effects of the latter cycles might give rise to some longer term structural damage in certain instances.

In order to prevent efforescence the transport of water through the structure should be hindered, so that calcium hydroxide and other salts cannot gravitate towards the exposed surfaces. This can be achieved by increasing the hydrophobicity with waterproofing admixtures and/or by lowering the permeability. For lowering the permeability in cementicious structures, the water/cement ratio should he kept as low as possible commensurate with good workability by using superplasticisers in the mix. In addition, extenders like fly ash, ground granulated blastfurnace slag, metakaolin and microsilica in allowing additional calcium silicate hydrate C-S-H binder to form the internal permeability of the hardened structures is lowered thus hindering internal transport. These extenders have a good record in preventing or at least minimising the extent of efflorescence, since much or even all of the calcium hydroxide is effectively used up in the pozzolanic reaction to form more C-S-H binder.

A very effective method for preventing efflorescence is to treat the structure with an appropriate polymeric system that effectively covers it in a film and so stopping the transport of dissolved salts to the exposed surfaces by a blocking effect. This can apply to cementitious systems like concrete as well as to clay brick-based systems. With blocks, bricks and cladding panels, for instance, their original condition can be maintained upon prolonged exposure to different weather conditions.

For example, urethane-based low viscosity prepolymer in an appropriate hydrocarbon or aliphatic solvent can penetrate jointing sand and bind the sand particles together and to the sides of concrete or clay-based pavers. The actual penetration comes about by evaporation of the solvent. Polymerisation of the urethane-based material is created by the atmospheric and residual moisture in the substrate that effects the curing.The result of this is to produce an in-situ bond, which stabilises the jointing sand and prevents its erosion, whilst maintaining the normal flexural properties of the pavement. The key factor is the stabilising of the jointing sand (6). A high quality manufacturing standard is necessary for producing an effective polyurethane-based membrane. These membranes tend to enhance colour and give an aesthetically attractive wet look two-coat system.

These specially prepared polyurethane systems can prevent the following:

· Water ingress
· Efflorescence
· Staining by oil
· Algae, lichen and general plant growth
· Frost attack
· Chipping or peeling
· Soiling by drink, foodstuffs etc.

Photo 2* shows the difference between untreated blockwork and blockwork treated with a specially prepared polyurethane-based system. Application of these membranes by suitable rolling is a specialist activity. Both new and old pavers can be treated. The surface temperature needs to be ca. 3-30oC. The surfaces should be clean and free from oil, algae, dust and any existing efflorescence and the substrate must be dry. Any efflorescence can be removed by cleaning off with an appropriate proprietary efflorescence removal fluid prior to sealing, so that the white patches can be removed from both the surfaces and the upper layers of the blocks as well.

Concluding remarks

Efflorescence is ugly in appearance and can readily spoil the look of mortar, concrete or brickwork, particularly where the decorative properties are very important. However, it is not normally deleterious to long term concrete durability. There are a number of remedial treatments, which must be applied expertly. Prevention is better than cure. Special polyurethane membranes can stop efflorescence from forming in the first instance in both concrete materials and in brickwork, by effectively cutting off the water flow to the surfaces. Blended cements containing pfa, ggbs, metakaolin or microsilica are very useful for dealing with efflorescence by lowering the permeability in cement-based structures. Waterproofing agents can be applied to bricks, mortars and concretes.

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** For photographs associated with this report please contact mail@resiblock.com*