

EFFLORESCENCE

– *prevention is better than cure*

What is efflorescence?

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

- Lime bloom
- Lime weeping
- Crystallisation of soluble salts.

White deposits of lime bloom usually become visible 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 more perceptible thickness. Lime weeping is generally permanent because 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 sea-water 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 ($\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$) are some-

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Figure 1: The unsightly effects of efflorescence on a domestic driveway/path.

times seen⁽¹⁾. Deposits of gypsum $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ are also often found in efflorescence^(2, 3).

Efflorescence is ugly but not normally damaging to the exposed concrete or brickwork⁽⁴⁾. Figure 1 illustrates the effect of efflorescence on a domestic driveway/path. However, on rare occasions, the leaching effects of efflorescence may be enough to cause residual damage to the structure. Should structural integrity be in doubt, the situation should be clarified by expert inspection.

Causes of efflorescence

Primary efflorescence observed with lime bloom and lime weeping refers to uniform calcite (CaCO_3) deposits arising from transport of calcium hydroxide ($\text{Ca}(\text{OH})_2$) in solution through capillaries within the structure to the external surface. Here, the solution evaporates, leaving behind deposits of solid white calcium hydroxide. These then react with atmospheric carbon dioxide to form white deposits of calcite, the normal end product: $\text{Ca}(\text{OH})_2 + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O}$.

Secondary efflorescence arises where water penetrates the surface and dissolves soluble calcium salts in a

patchy way. The main chemical reaction is the same as that in primary efflorescence, namely conversion of calcium hydroxide to calcite. Secondary efflorescence originates from reaction in solution, usually caused by rain or condensation, and so is more uneven, 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 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 its early stages, the situation may not be clear-cut. If in doubt, the deposits should be examined further. 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
- Reliance upon natural weathering. Here the calcite crusts either fall off by wind erosion or react progressively with moist atmospheric carbon dioxide to form calcium hydrogen carbonate $\text{Ca}(\text{HCO}_3)_2$, a very soluble material that is easily washed away by rain: $\text{CaCO}_3 + \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{Ca}(\text{HCO}_3)_2$.

It is essential that remedial treatments for removing efflorescence be carried out by experts, to avoid any risk of structural damage.

Preventing efflorescence

Prevention is better than cure. This is true in cost terms and where repeated remedial treatment is needed for new appearances of efflorescence, since this could result in longer-term structural damage.

To prevent efflorescence, 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 permeability. To lower permeability in cementitious structures, the water/cement ratio should be kept as low as possible commensurate with good workability by incorporating superplasticisers. In addition, extenders like pfa, ggbs, metakaolin and microsilica allow additional calcium silicate hydrate C-S-H binder to form, lowering the internal permeability of hardened structures and hindering internal transport. These extenders have a good record in preventing or at least minimising efflorescence, since much or even all of the calcium hydroxide is consumed in the pozzolanic reaction to form more C-S-H binder.

An effective method for preventing efflorescence is to treat the structure with an appropriate polymeric system that covers it in a film, blocking the transport of dissolved salts to the exposed surfaces. This can apply to cementitious systems like concrete

as well as to systems based on clay bricks. With blocks, bricks and cladding panels, for instance, their original condition can be maintained on prolonged exposure to different weathers.

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 penetration comes about by evaporation of the solvent. Polymerisation of the urethane-based material occurs by the atmospheric and residual moisture in the substrate that effects the curing. The result is an in-situ bond that stabilises the jointing sand and prevents its erosion, while maintaining the normal flexural properties of the pavement. The key factor is the stabilisation of the jointing sand⁽⁶⁾. High-quality manufacture is necessary to produce an effective polyurethane-based membrane. These membranes tend to enhance colour and give an attractive wet-look two-coat system.

These specially prepared polyurethane systems can prevent:

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

Figure 2 shows the difference between untreated blockwork and blockwork treated with a polyurethane-based system.

Both new and old pavers can be treated but applying the membranes by roller is a specialist activity. The surface temperature needs to be around 3–30°C. The surfaces should be clean and free from oil, algae, dust



Figure 2: Contrast between untreated blockwork and blockwork treated with a polyurethane-based preparation.

and efflorescence and the substrate must be dry. Any efflorescence can be removed by an appropriate proprietary efflorescence removal fluid before 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 and can readily spoil the look of mortar, concrete or brickwork, particularly where the decorative properties are important. However, it is not normally deleterious to long-term durability. Although there are a number of remedial treatments – which must be applied expertly – prevention is better than cure. Special polyurethane membranes can stop efflorescence forming, in both concrete materials and in brickwork, by cutting off the water flow to the surfaces. Blended cements containing pfa, ggbs, metakaolin or microsilica are 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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References

1. BENSTED, J. Efflorescence – a visual problem on buildings. *Construction Repair*. Vol. 8, No. 1, January/February 1994. pp. 47–49.
2. KRESSE, P. Coloured concrete and its enemy: efflorescence. *Chemistry & Industry*. No.4, 20 February 1989. pp. 93–95.
3. NEVILLE, A.M. *Properties of concrete*. Longman, 4th edn 1995. pp. 139, 184, 373, 513–514.
4. BENSTED, J. Changing concrete's colour. *Urban Renewal*. Vol. 1, No. 1, 1990. pp.29–32.
5. RIXOM, M.R. and MAILVAGANAM, N.P. *Chemical admixtures for concrete*: Second Edition. E. & F.N. Spon, London, 1986. pp.141, 239–240.
6. EMERY, J.A. Erosion of jointing sand from concrete block paving. *Proceedings of 4th International Conference on Concrete Block Paving*, University of Auckland, New Zealand, 1992.