Enhancing self-healing of lime mortars by built-in crystallization inhibitors

Salt crystallization is a common cause of weathering of porous building materials. Mortar is one of the building materials most affected by salt damage (figure 1) due to its pore size distribution (with both coarse as fine pores), and its relatively low mechanical strength. Replacement of mortar (pointing mortar, plasters and renders) constitutes a large cost in restoration works. Salts present in masonry can originate, amongst others, from sea salt spray, rising damp, road salt, salt storage and the building materials themselves.

Salt crystallization inside the pores (crypto-fluorescence) causes severe damage, crystallization at the surface (efflorescence) is relatively harmless. Crystalization pressure is generally recognized as the main mechanism of damage. Pressure is exerted by a crystal on the pore wall, when the crystal is in contact with a supersaturated solution but it has no more space to grow. When the pressure exceeds the tensile strength of the material, cracks appear. Due to dissolution/crystallization cycles, damage occurs.

Mitigation of salt damage can be obtained by promoting efflorescence, or by lowering the supersaturation level of the solution at the moment of crystallization. This can be achieved with crystallization modifiers. These ions or molecules prevent or delay nucleation (inhibitors), promote nucleation of a certain polymorph (promoters) and/or modify the habit or the crystals (habit modifiers) (see figure 2 and 3). By mixing the modifiers into the mortar, they will be present when salts penetrate the material. When the crystallization sets in, the modifiers will alter the crystallization behaviour and limit the damage.

Selected publications


Figure 1: Salt damage in plaster (Church in de Rijp, the Netherlands) and pointing mortar (building in Oostkapelle, the Netherlands)

Figure 2: Images showing the effect of sodium ferrocyanide on NaCl growth. Inhibitor added to the salt solution. (tl) SEM picture of a cross-section showing non-cubic crystallization in a pore, 10000x magnification. (bl) SEM picture showing crystallization at the surface of a porous material, 500x magnification. (tr) Macroscale picture of dendritic, feather-like crystallization at the surface of a mortar.

Figure 3: Inhibition mechanism of ferrocyanide on NaCl. \([\text{NaCl}_5]^4- \approx [\text{Fe(CN)}_6]^4-\), therefore there is no incorporation of \([\text{Fe(CN)}_6]^4-\) due to charge difference with \([\text{NaCl}_6]^5-\) in bulk. The charge difference causes the blocking (Bode et al. Crystal Growth & Design, 2012, 12, 1919–1924).