


Salt resistant mortars: present knowledge and future perspectives

Dr. Barbara Lubelli

Assistant Professor
Delft University of Technology
Faculty of Architecture
Department Architectural Engineering + Technology

Research scientist
TNO Technical Sciences




TNO innovation for life

Salt damage – a worldwide problem

- Already known in ancient times
- Affecting most porous building materials
- Present all over the world, in arid and wet climates
- Expected to increase due to climate change

projects into the sea further than the neighbouring shores, and I observed that there were shells upon the hills, and that salt exuded from the soil to such an extent as even to injure the pyramids; and I noticed also that there is but a single hill in all Egypt where sand is found, namely, the hill above Memphis; and further,

Herodotus, The history of Herodotus, transl. of G. Rawlinson





Bedding and pointing mortar:
Scaling, sanding, alveolization



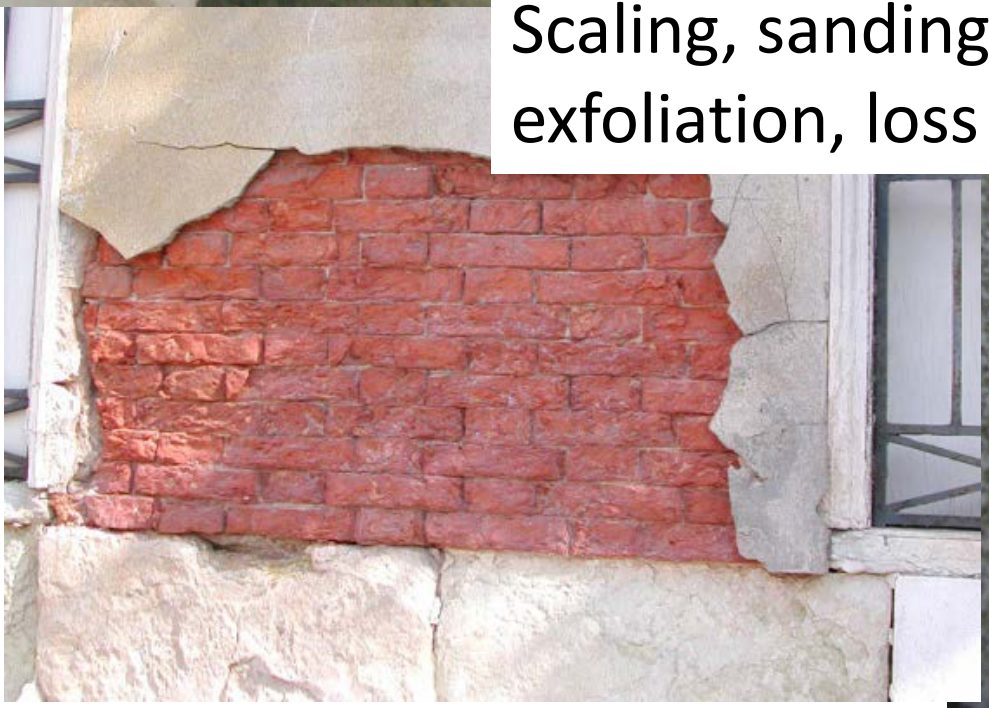






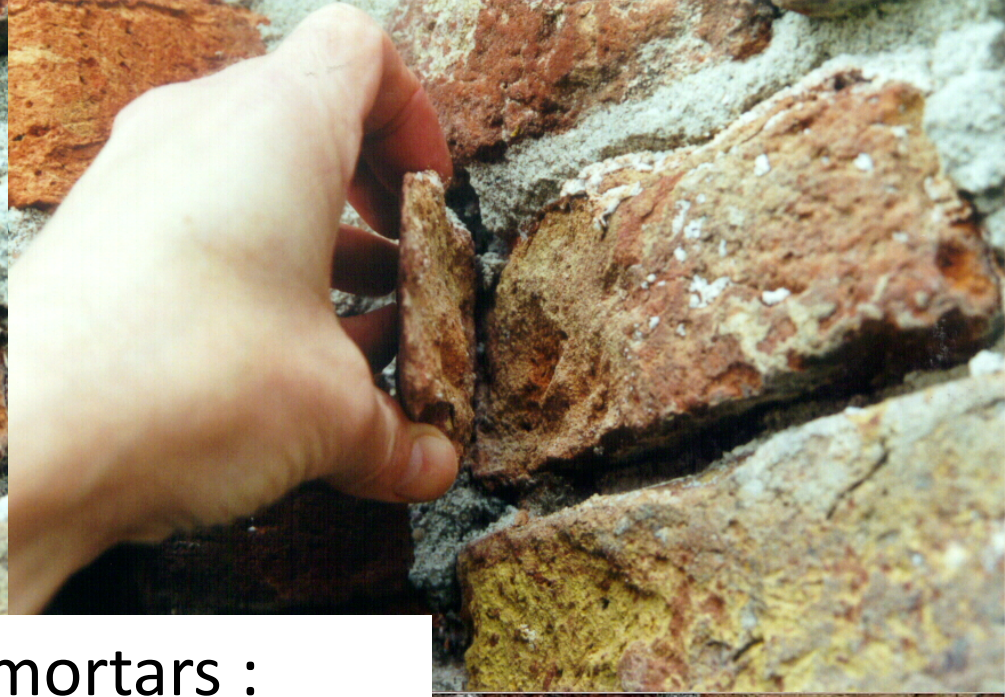
Plasters & renders:

Scaling, sanding, exfoliation, loss of adhesion





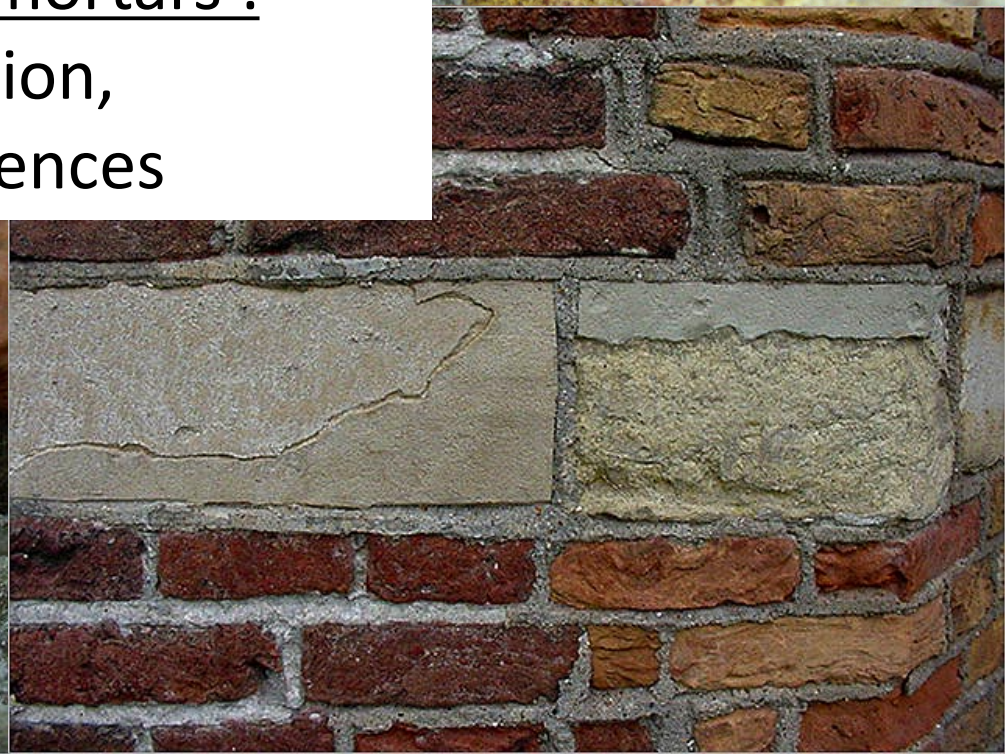




Stone repair mortars :

Loss of adhesion, cryptoflorescences



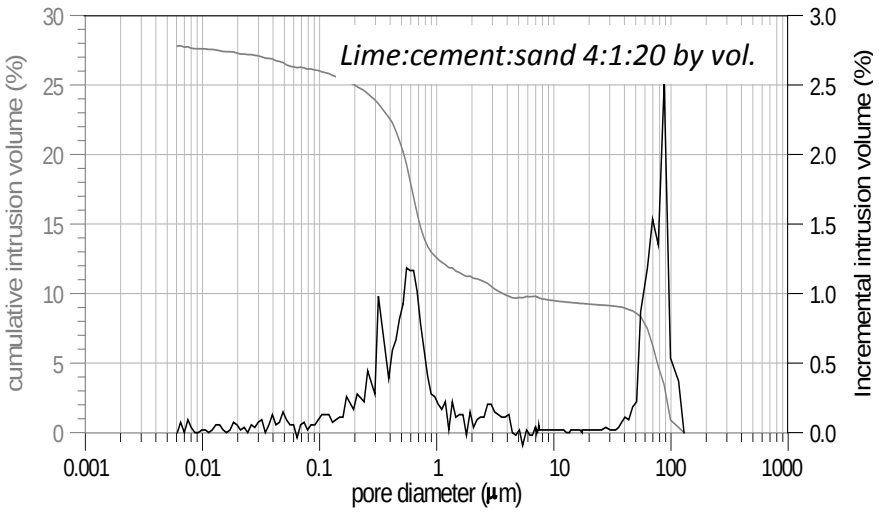


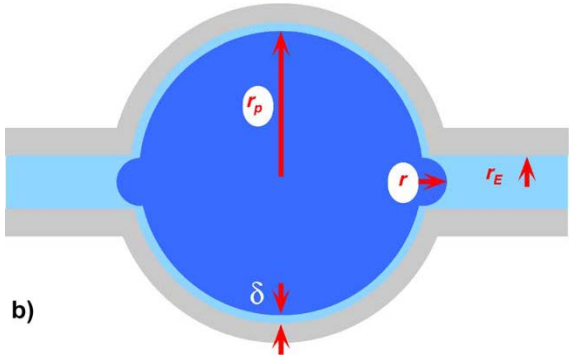



Weak points

- Mechanical strength
- Pore size distribution
- Evaporation surface (pointing, plasters and renders)

Bimodal pore size distribution





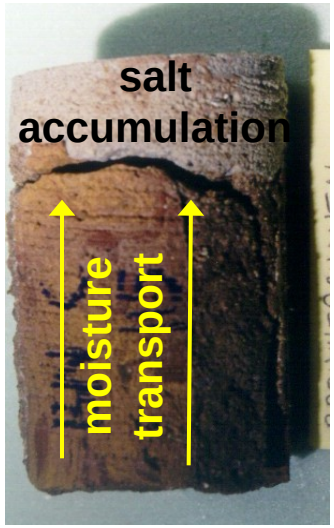
Bimodal pore size distribution

High susceptibility to salt crystallization damage

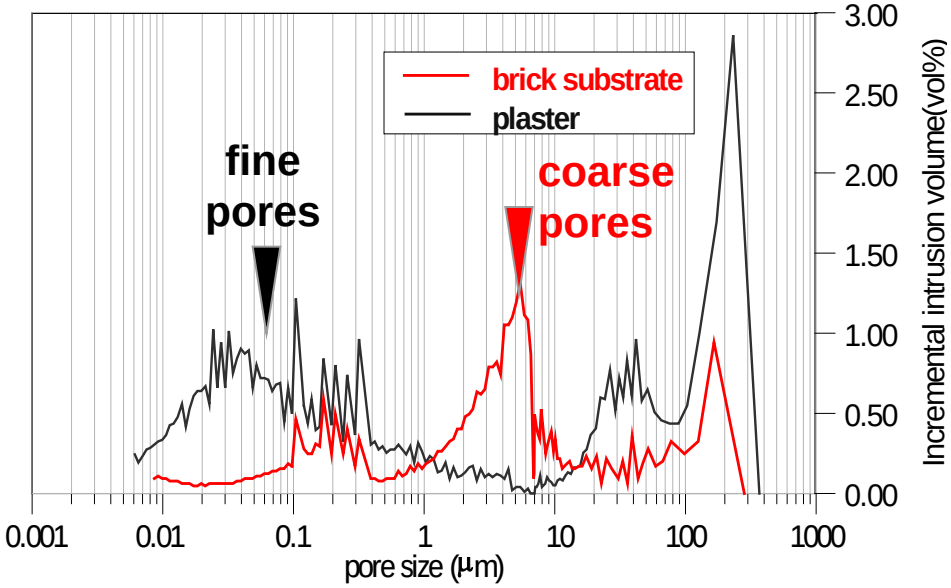
Scherer G., Cement and Concrete Research 34, (2004)

Small pore size

fine plaster



coarse substrate







Salt resistant mortars

Solutions up to now:

- Mortar with increased mechanical strength
(e.g. cement based mortar)

- Mortar (plasters & renders) with mixed-in water repellent additives (generally silicone based)

Compatibility

- Detachment of the mortar layer, often together with the outer layer of the substrate



- Damage moves to adjacent weaker materials (e.g. brick and stone)



- Introduction of new salts



Compatibility

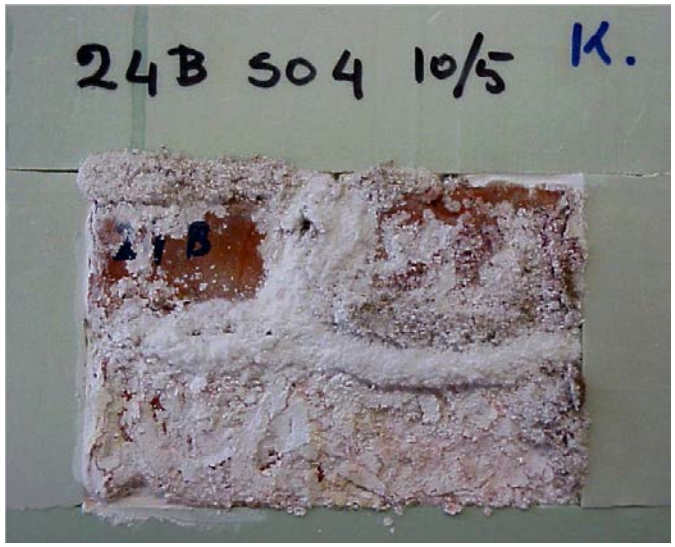


Old plaster: lime based

New plaster: Cement based plaster with mixed-in water repellent

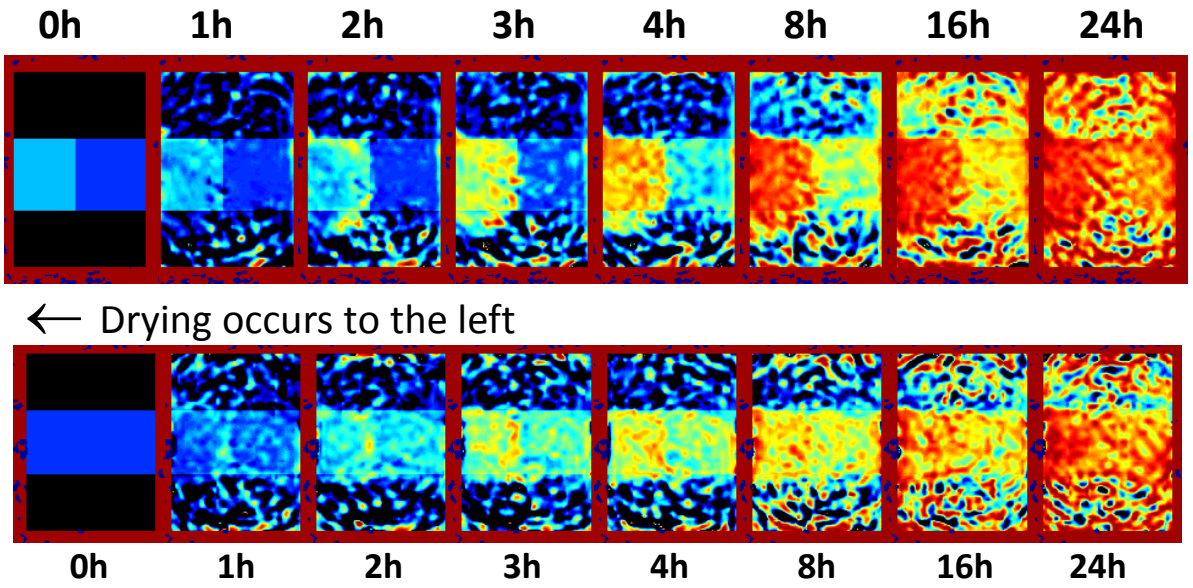
Compatibility





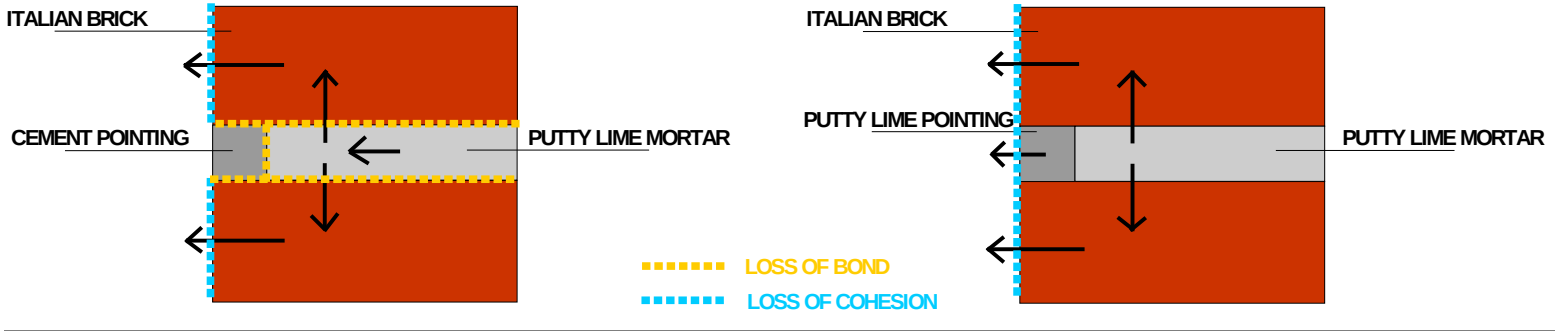
The compatibility of a mortar should also be evaluated in combination with the existing materials.

Compatibility



- IT brick
- putty lime bedding mortar
- **cement pointing**

- IT brick
- putty lime bedding mortar
- **putty lime pointing**







Salt resistant mortar for the future

- Mortar with engineered pore size
- Mortar with mixed in crystallization inhibitors
- Mortar with enhanced self-healing capacity
- Slightly water repellent mortars (natural wr)





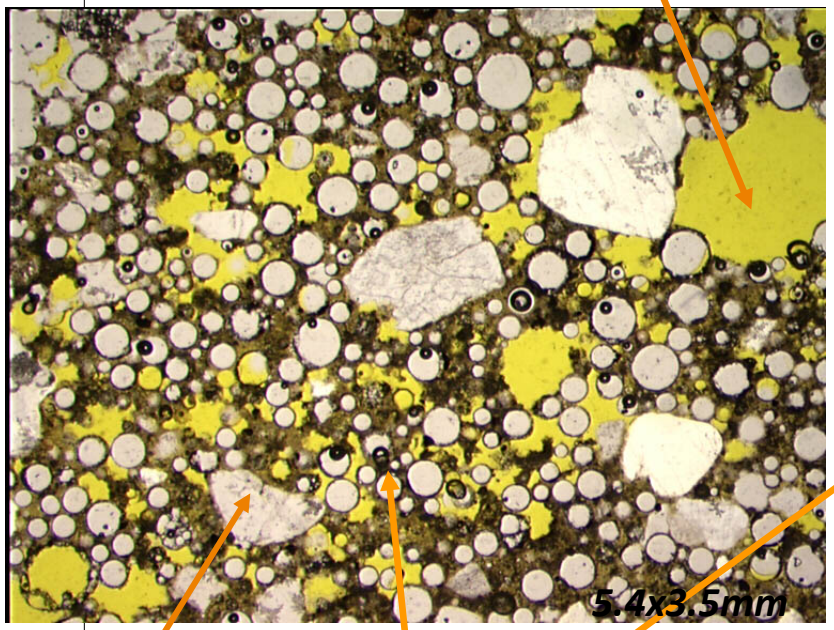
TNO innovation for life

Controlling the pore size

- By the ratio between components and the grain size of the sand
- By the use of light aggregates
- By the use of air entraining agents

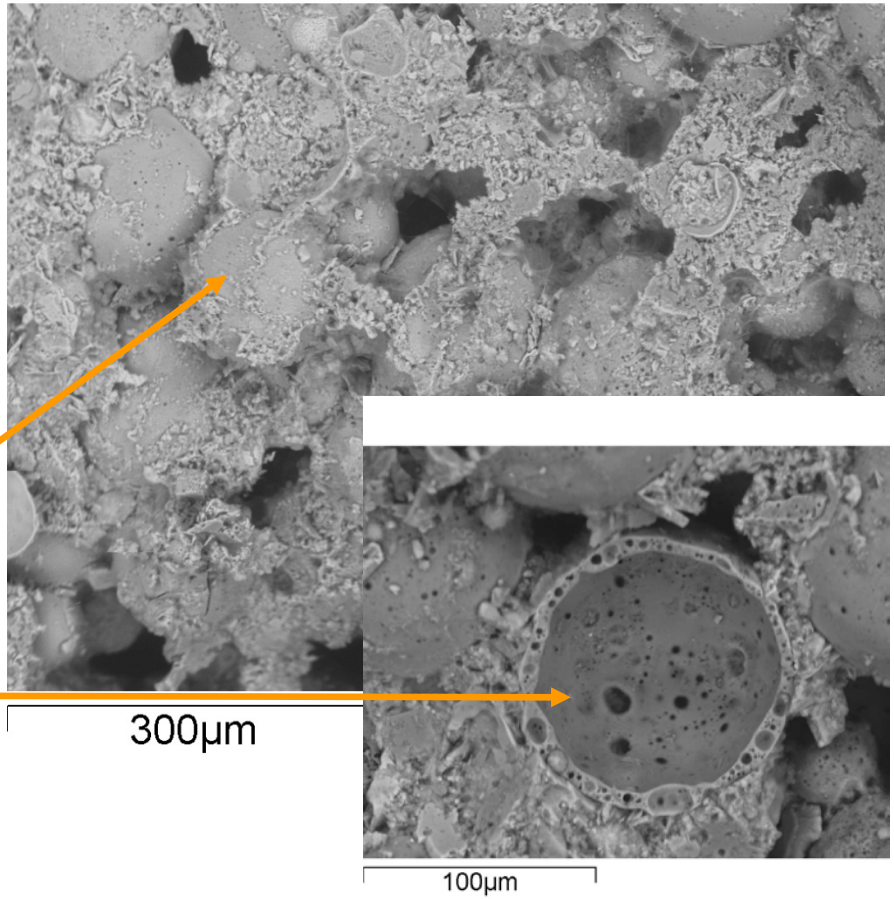
Light aggregate - mullite

large voids



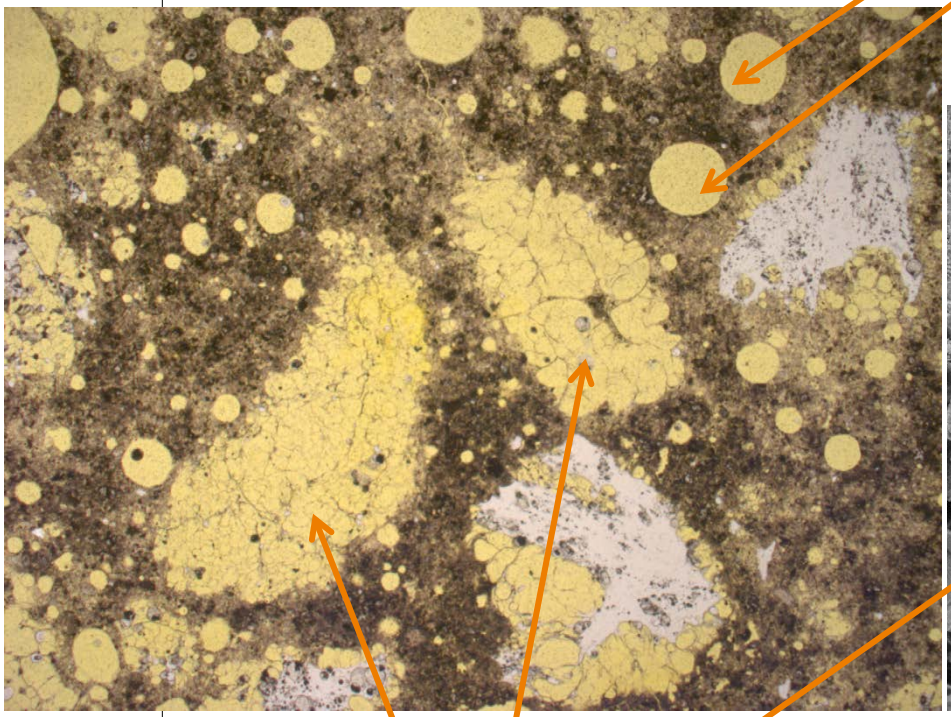
aggregate

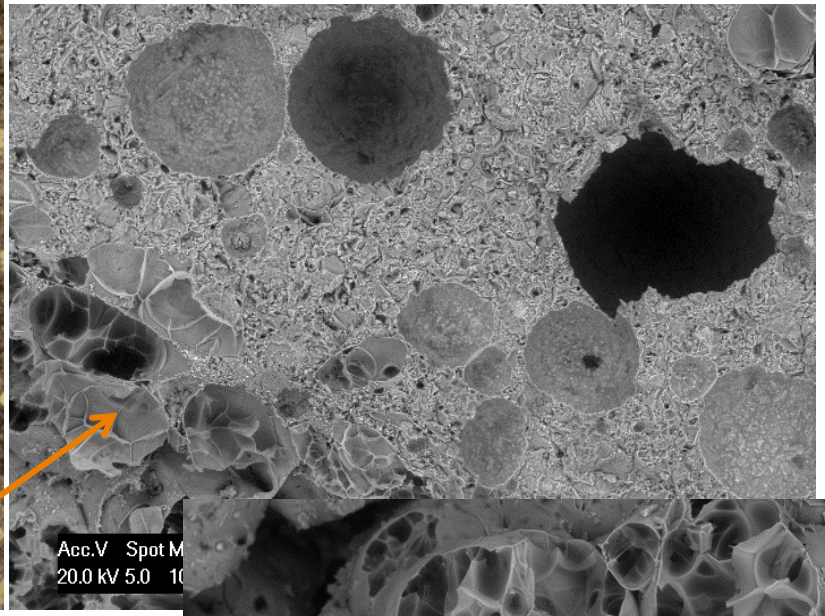
hollow closed
light aggregate



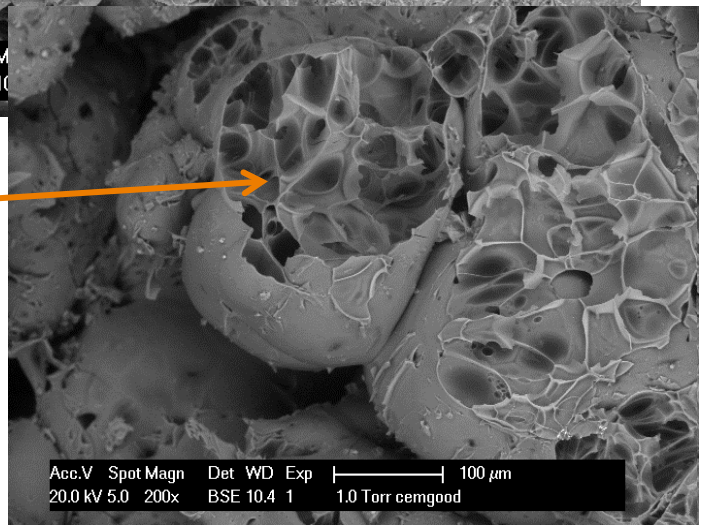
Light aggregate - perlite

Air bubble due to air entraining agent

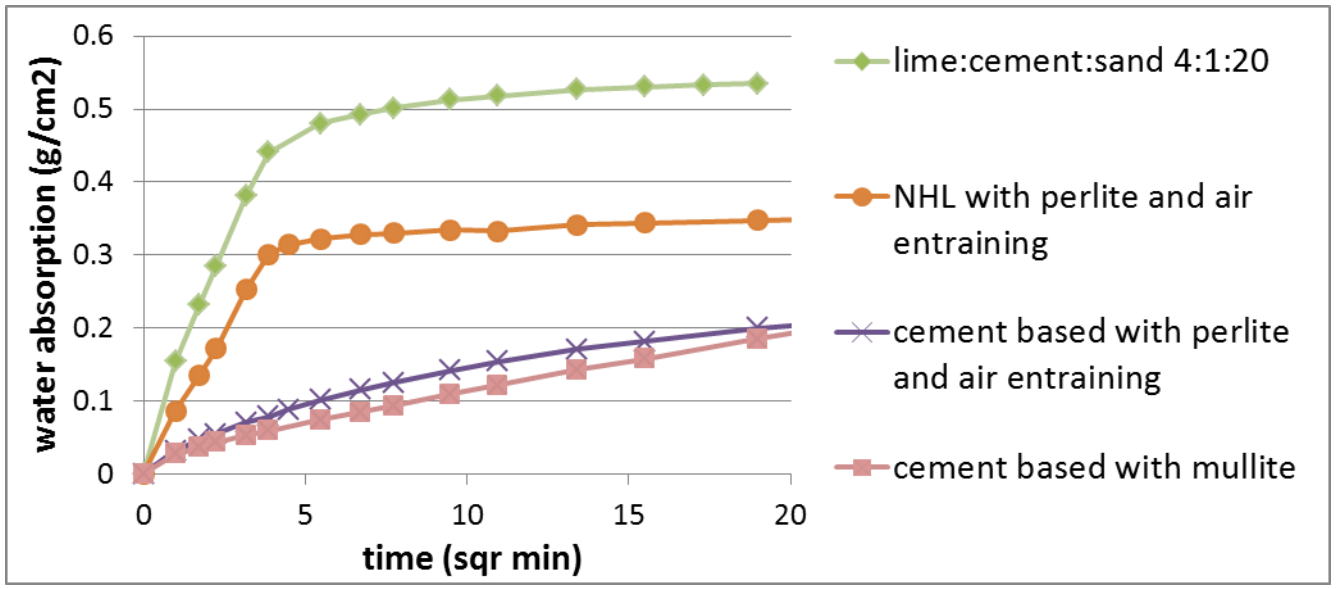




(partially) open light aggregate



Water absorption



Crystallization inhibitors

EU project SALT CONTROL (2005-2008)
Prevention of salt damage to the built cultural heritage by the use of crystallisation inhibitors



NaCl on brick



NaCl + inhibitor on brick



NaCl + inhibitor on brick - detail

Inhibitors can reduce salt crystallization damage provided they are supplied to the solution before crystallization occurs.

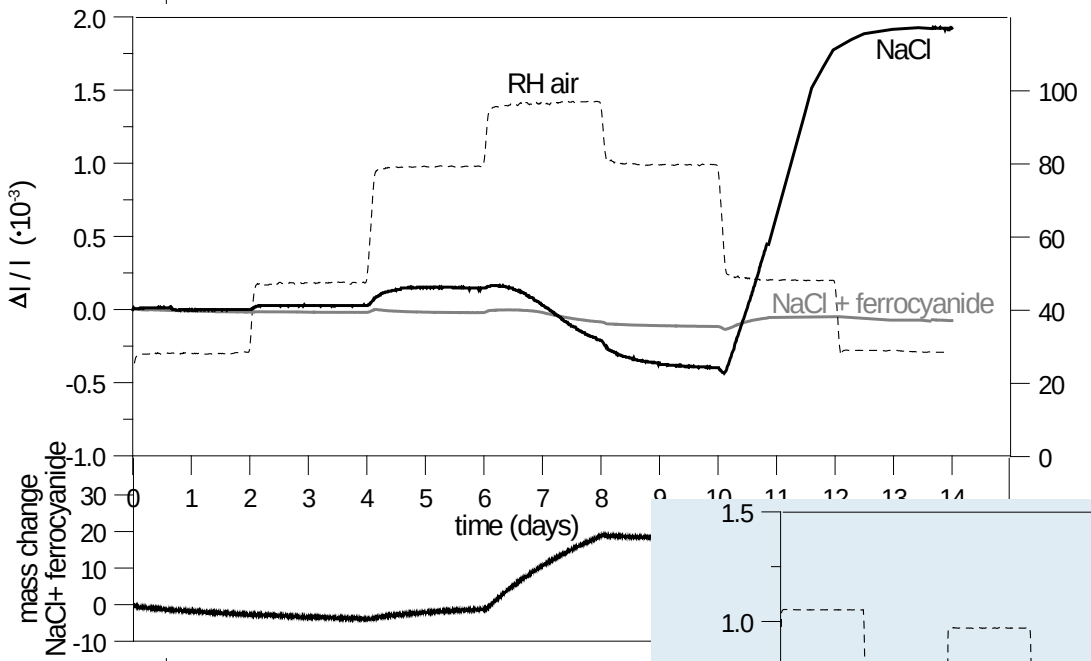
Effect of the inhibitor on the drying

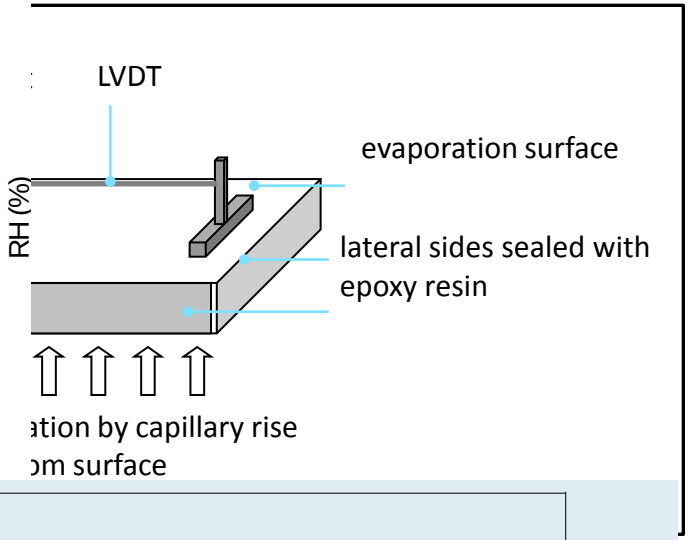




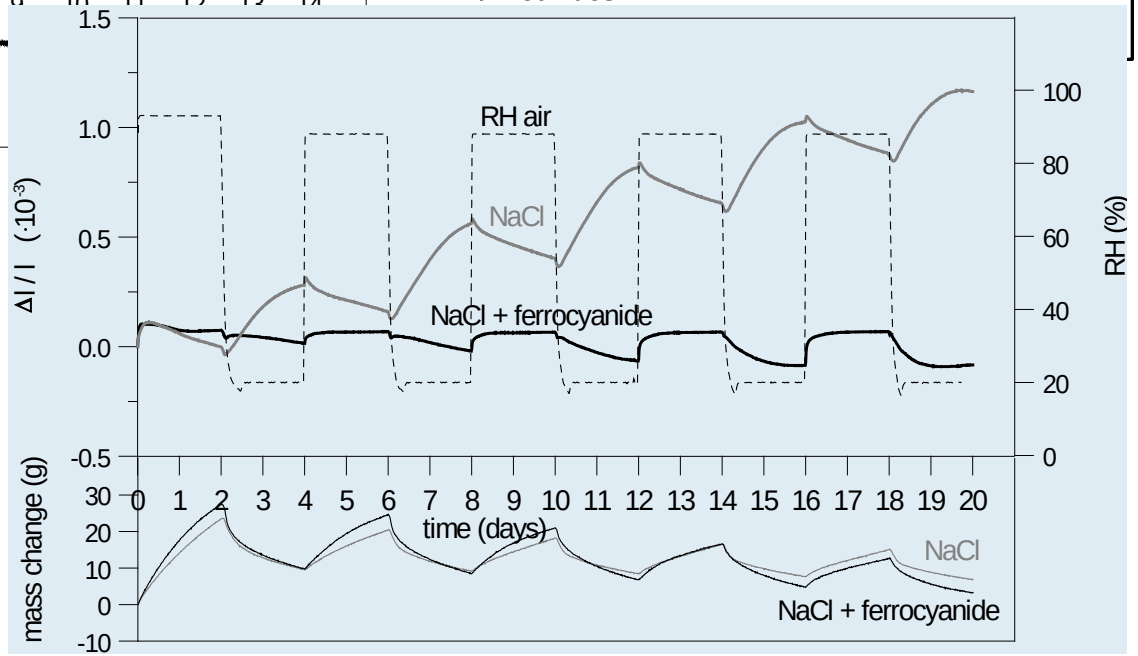
- The salt remains longer in solution →this facilitates its transport to the surface
- The branched crystallization habit of the salt and its large drying surface enhances evaporation.
- Efflorescences are favoured, instead of cryptoflorescences

Effect on damage

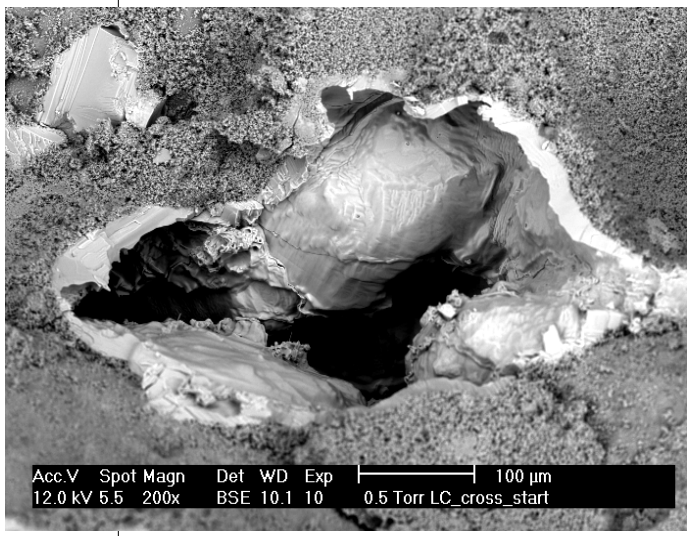


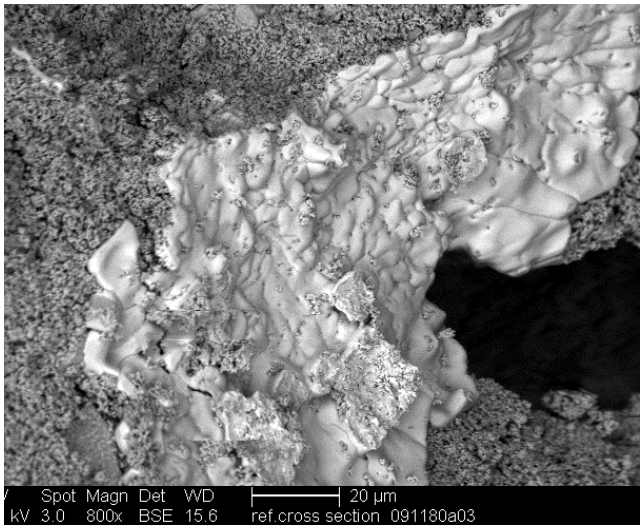


ation by capillary rise
om surface

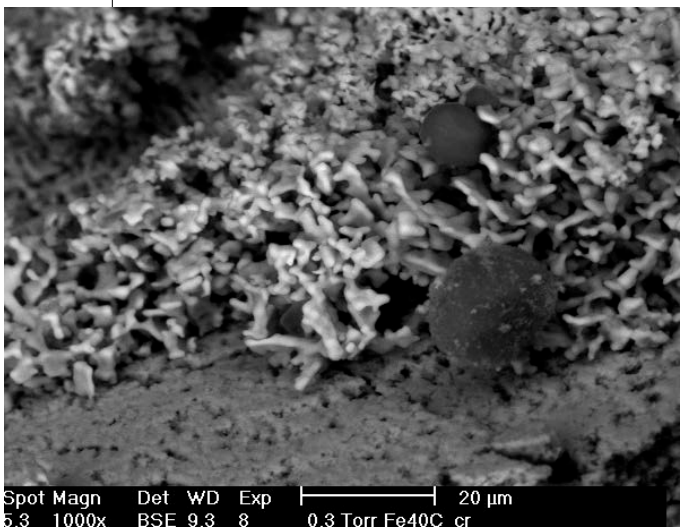


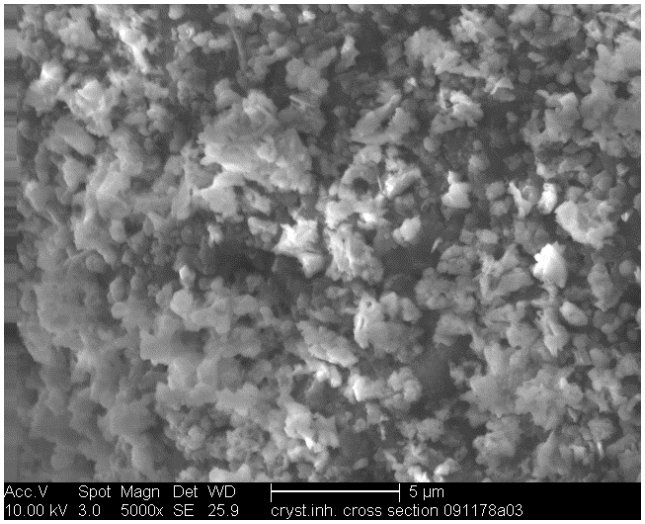
Effect on crystal habit and damage





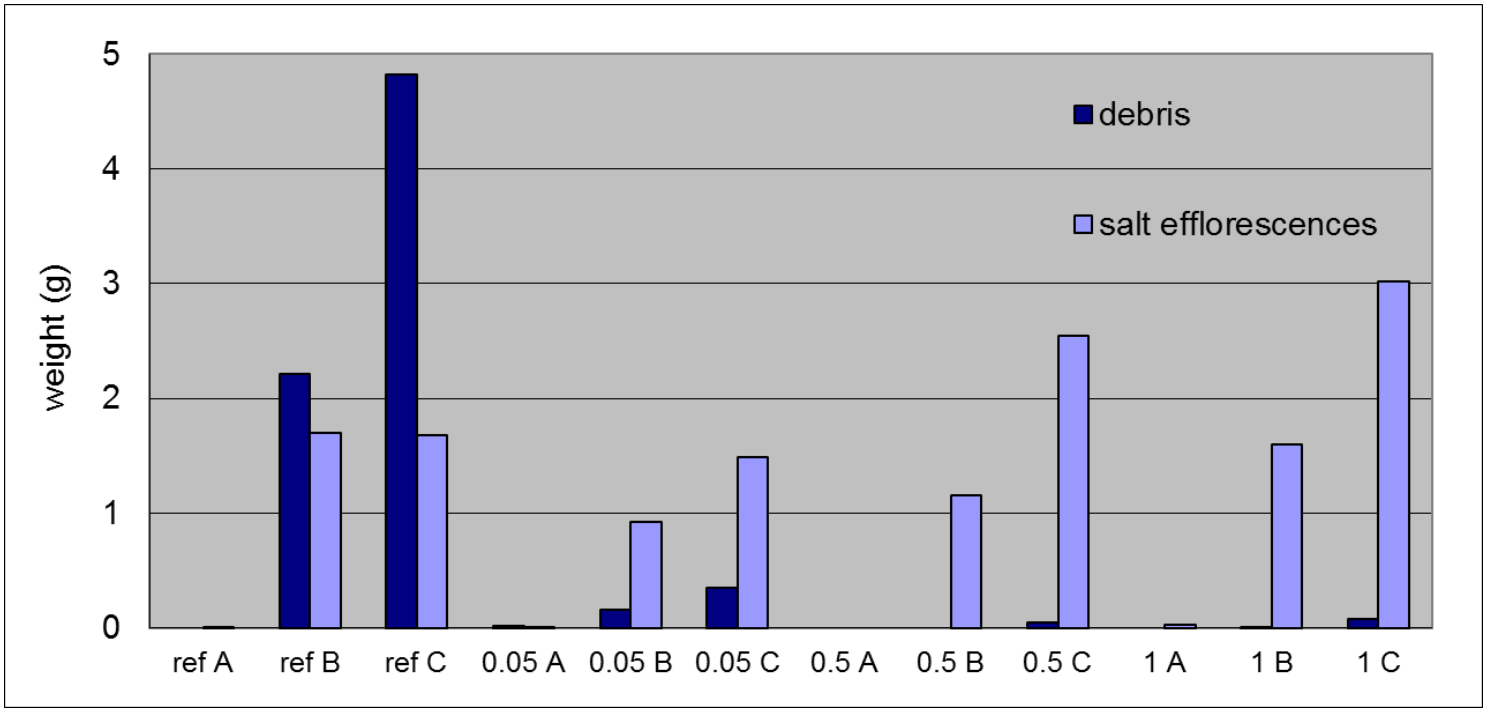
NaCl





NaCl + inh.

Mortar with mixed-in crystallization inhibitors



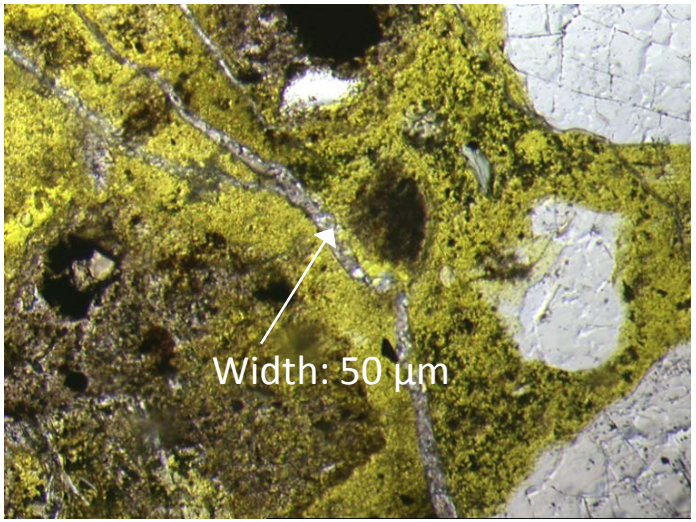
- More efflorescences
- Less damage



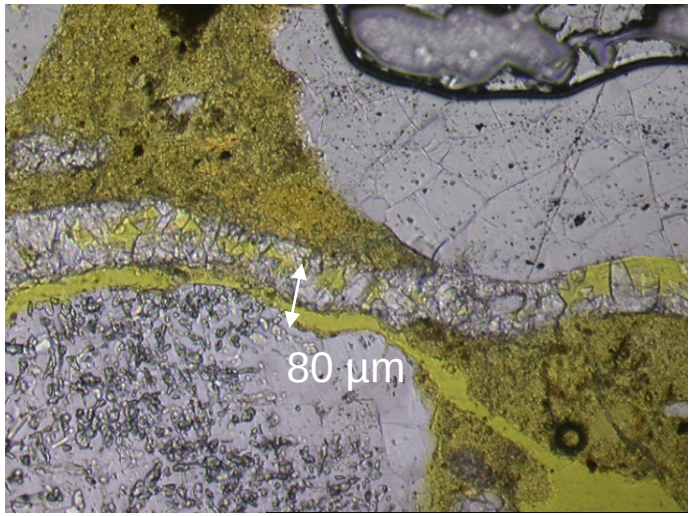

Questions left

- Suitable inhibitors for salts other than NaCl
- Effect of inhibitor on salt mixtures
- Leaching of inhibitor in time
- Environmental and health issues

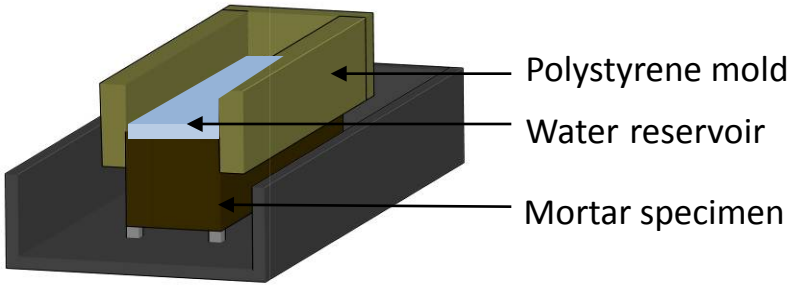
Mortars with enhanced self-healing capacity



Quay wall, Den Bosch
(magnification 100x, 1.4x 0.9 mm)



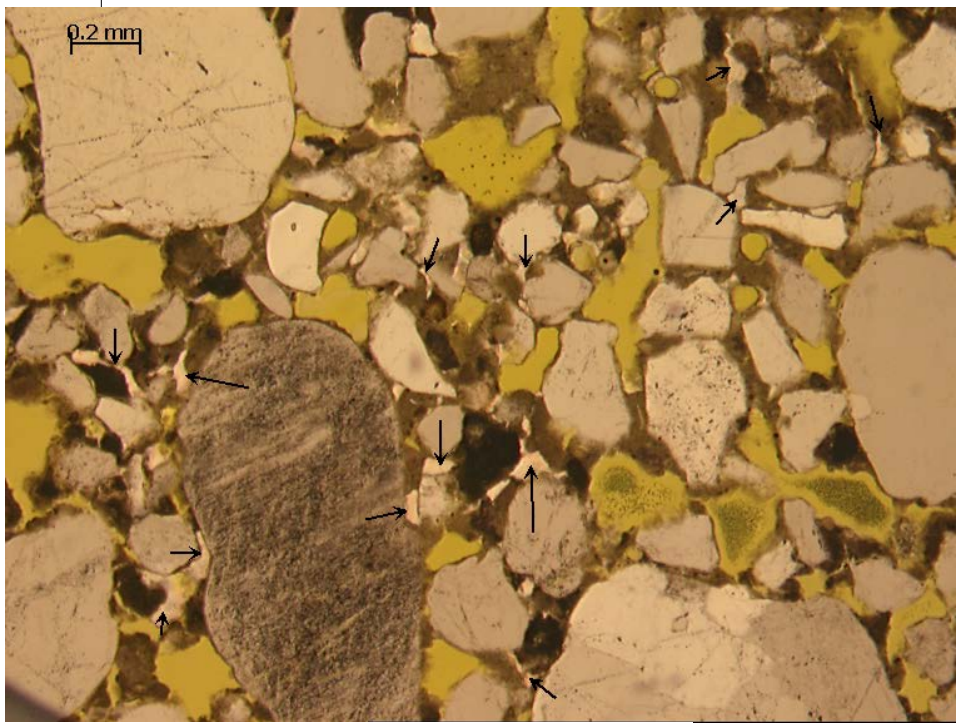
Quay wall, Den Bosch
(magnification 200x, 0.7 x 0.45 mm)



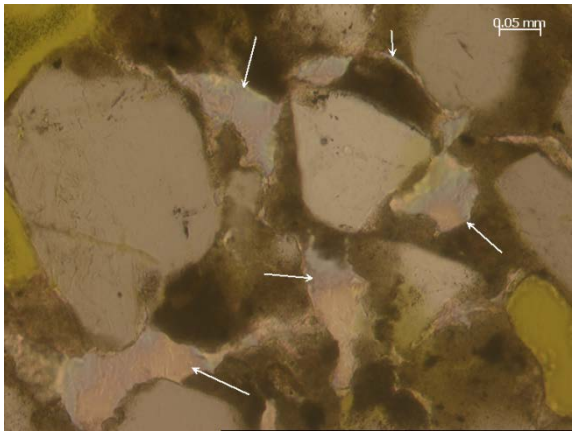
Test procedure

- Immersion in water (5 °C, pH 5) for about 3 months → leaching
- 10 wet-dry cycles (each 2 weeks) → re-precipitation

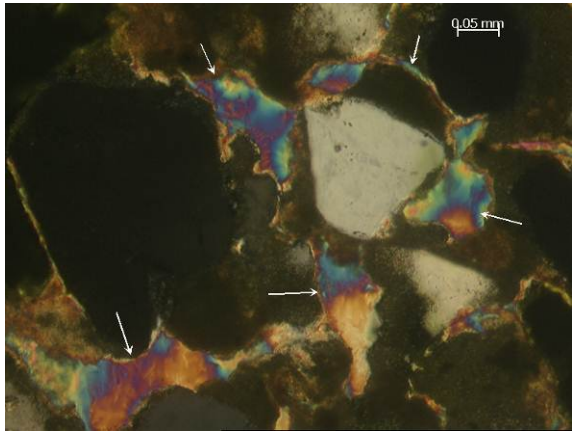
Autogeneous self-healing in dolomitic lime mortar



view 1.4 x 0.9 mm, plane polarized light

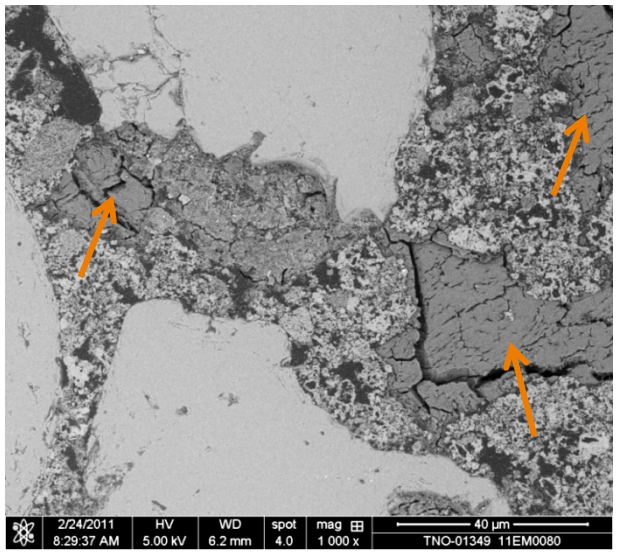


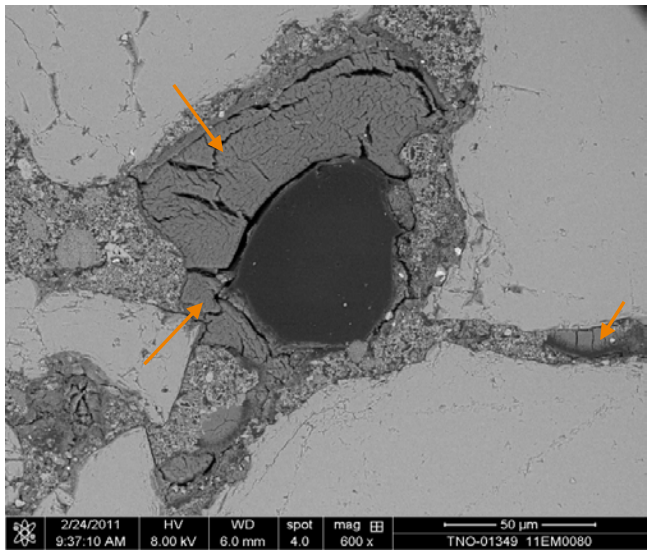
view 0.7 x 0.45 mm, ppl



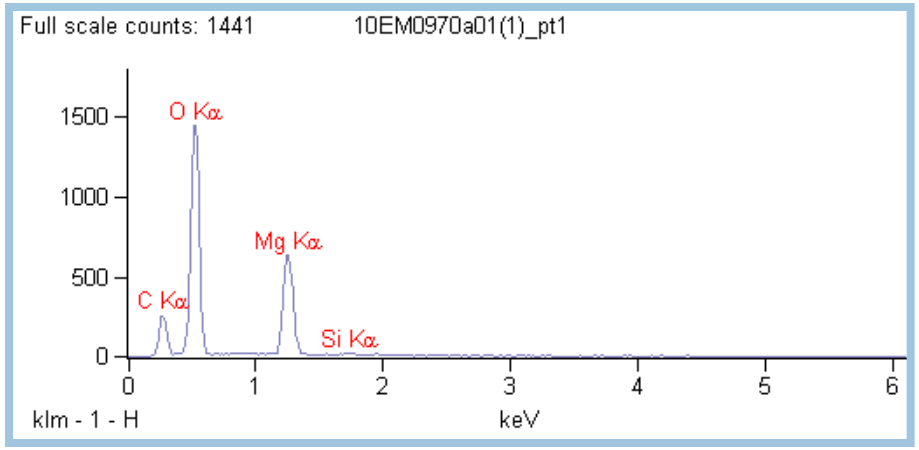
view 0.7 x 0.45 mm, xpl

SEM-EDX on thin section





Voids (partially) filled by the re-precipitated compound



Re-precipitated Mg compound (probably hydromagnesite)

Natural water repellents mixed in mortar



Selected natural water repellents:

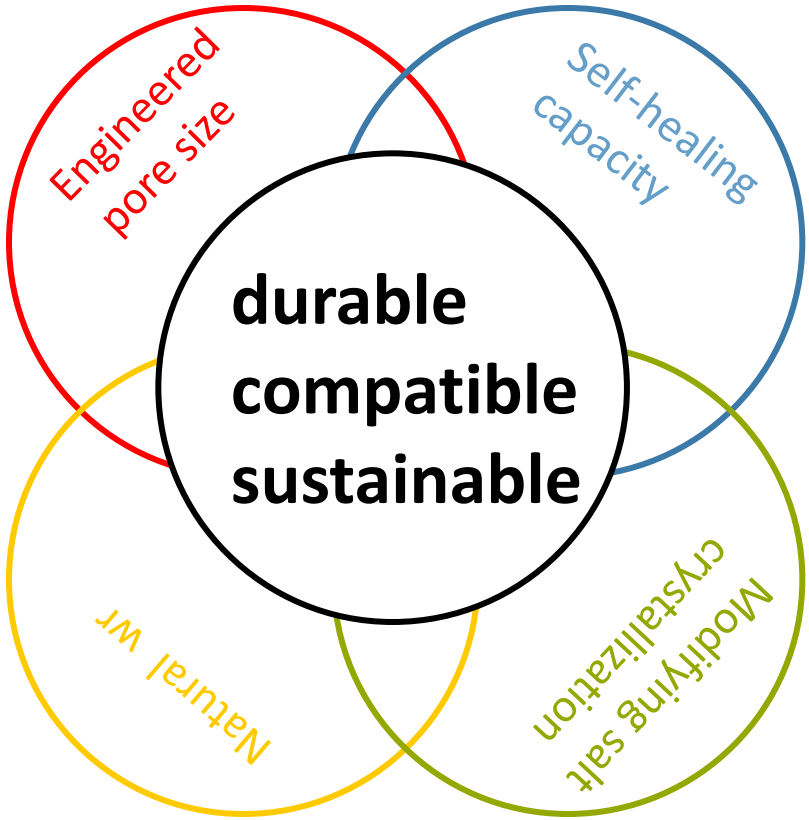
- Raw linseed oil
- Boiled linseed oil
- Stand linseed oil
- Rapeseed oil





TNO innovation for life

Salt resistant mortar for the future






TNO innovation for life

Thank you for your attention