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Influence of Salt Content on the Drying Behavior of Brick

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ABSTRACT

We know that the drying behavior of brickwork is affected by hygroscopic salts. Slightly soluble salts like gypsum affect brick similarly when they crystallize beneath the fired surface. Tests were carried out to study these phenomena.

Results show that a layer with a thickness of a few hundred micrometers of crystallized gypsum in the pores of a brick near the surface is enough to influence the drying behavior strongly. After capillary water transport from inside the bricks, evaporation and vapor diffusion are dramatically reduced.

INTRODUCTION

Damage to brick caused by salts has been examined and described in detail in the literature. Deterioration is a result of hydration and crystallization pressures and the effects of hygroscopic salts (WTA 1992; Winkler 1994). This paper discusses the influence of salts on the drying behavior of bricks. The starting point for this work was determination of the salt distribution in brickwork as a function of pore volume and pore-size distribution. As gypsum often appears to be the damaging salt in historic brickwork, our aim was to induce an enrichment of this compound by capillary uptake of saturated solutions of the salt, and then to let the water evaporate over the brick surface. We thought that this could be achieved within a few days, since capillary uptake of pure water and gypsum solutions do not differ. Unexpectedly, these initial tests were not successful. Thus, systematic investigation of this effect was undertaken.

EVAPORATION OF SALT SOLUTIONS

The experimental setup for these tests is shown in Figure 7.1. The sides of the brick samples were sealed with a water-tight sealant so that uptake could only proceed from the bottom. Evaporation was only possible through the top surface of the sample.

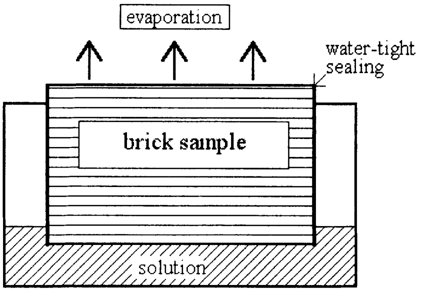

Figure 7.1 Experimental setup for evaporation tests.

The specimens were then put into one of three test solutions:

- pure water,
- magnesium sulfate solution (concentration 0.012 mol/l),
- saturated gypsum solution.

The amount of evaporated water was determined over different time intervals by gravimetry. The tests were conducted for three weeks.

Figure 7.2 shows the results for bricks without fired skins. The evaporation rate is plotted as a function of time.

During the first few days, all samples behaved similarly: after water saturation, as a result of capillary suction, the evaporation flow was nearly constant. Eventually, a significant decrease (down to about 10% of the initial value) in the evaporation rate could be detected with the gypsum-soaked samples, whereas the flow remained unchanged in the other solutions. Similar results were obtained from bricks with a fired surface. A

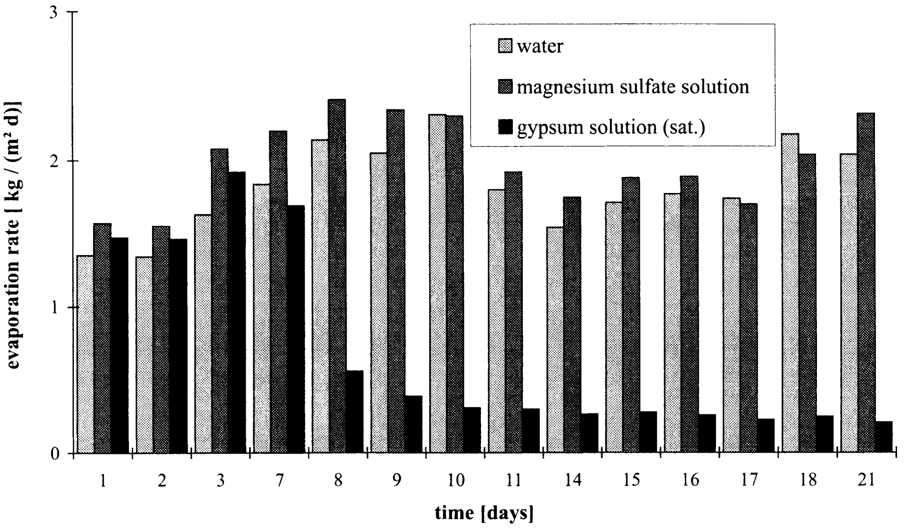

Figure 7.2 Evaporation rates of different solutions for brick without fired surfaces.

blocking effect could also be detected in bricks with the magnesium sulfate solution, but only after a longer test time.

Several experiments were conducted to establish the cause of this phenomenon. The sulfate contents of the bricks were determined. The values were in the range of about 0.5 to 1 wt.% in the first 2 mm of the samples. No sulfate enrichment could be detected at depths greater than 2 mm.

Pore blocking, examined by mercury intrusion porosimetry, could not be proven as the calculated effects of changes were in the same order of magnitude as the uncertainty of the measured quantity. It was possible to get relationships between salt content and changes in pore volume and pore-size distribution when analyzing other samples with higher salt contents after natural weathering.

Using a scanning electron microscope (SEM), more accurate information on salt distribution in the sample was obtained. Salt enrichment could be detected within the first 100–200 μm of the samples. This was confirmed by X-ray fluorescence (XRF) analysis using the SEM.

Figure 7.3 shows the relative XRF peak intensities relative to silicon plotted as a function of different depths.

As the signals (and therefore content) of aluminum, iron, and potassium are nearly constant over a depth of about 400 μm, a strong calcium enrichment can be detected within the first 150–200 μm of the sample.

Thus, there is a change in the pore structure that strongly reduces the capillary transport but which does not completely obstruct water evaporation.

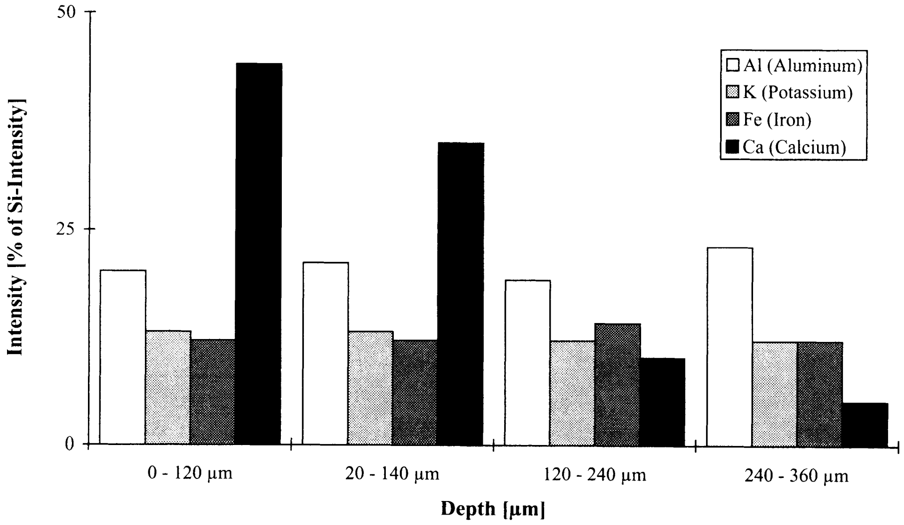

Figure 7.3 Salt distribution by XRF analysis results relative to Si.