

## Sacrificial mortars for surface desalination

N. Husillos-Rodríguez<sup>a</sup>, Paula María Carmona-Quiroga<sup>a</sup>, S. Martínez-Ramírez<sup>b,\*</sup>,  
M.T. Blanco-Varela<sup>a</sup>, R. Fort<sup>c</sup>

<sup>a</sup> Instituto de Ciencias de la Construcción Eduardo Torroja (IETCC-CSIC), C/Serrano Galvache 4, 28033 Madrid, Spain

<sup>b</sup> Instituto de Estructura de la Materia (IEM-CSIC), C/Serrano 121, 28006 Madrid, Spain

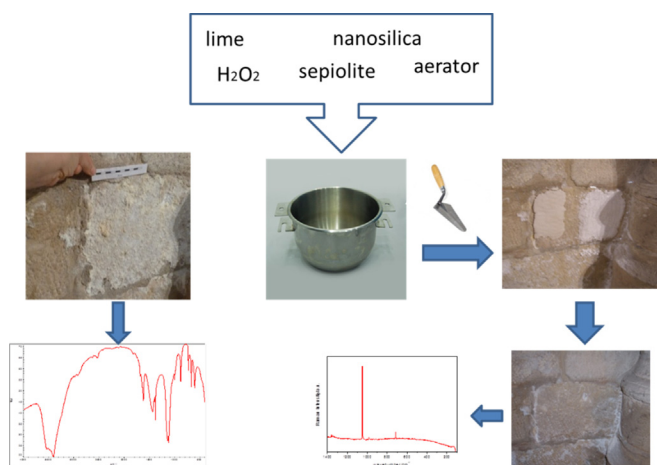
<sup>c</sup> Instituto de Geociencias (IGEO-CSIC, UCM), C/Doctor Severo Ochoa 7, 28040 Madrid, Spain



### HIGHLIGHTS

- Four absorbent mortars were designed and used as sacrificial desalinating media.
- The salts elimination was most effective in anions with a smaller ionic volume.
- Effectiveness increases with high superficial salt concentration.
- Three years later, the salt concentration was 50% lower than prior to treatment.

### GRAPHICAL ABSTRACT



### ARTICLE INFO

#### Article history:

Received 19 April 2017

Received in revised form 22 December 2017

Accepted 3 April 2018

Available online 24 April 2018

#### Keywords:

Desalination

Lime mortars

Sepiolite

Nanosilica

Dolostone

Heritage conservation

### ABSTRACT

Four absorbent mortars were designed in this study and used as sacrificial desalinating media. The mortars comprised lime, sepiolite, nanosilica (72/3/25 by weight) and three admixtures ( $H_2O_2$  and two commercial aerators) and had a liquid/solid ratio of 0.9, a mean porosity of 40% and a mean pore size of 0.8–0.7  $\mu m$ . These mortars were applied three times to ashlar exhibiting surface saline efflorescence on a church at Talamanca del Jarama, a town in the Spanish province of Madrid. The salts impregnating the wall were characterised with XRD, FTIR and Micro-Raman spectroscopy. The ion concentrations in the ashlar was studied with ion chromatography at 0.5 cm, 1.5 cm and 3.0 cm from the surface after each application and the inner and outer surfaces of the mortars were analysed with Micro-Raman spectroscopy to determine the desalinating efficacy of the mortars.

The mortars designed mobilised and absorbed the soluble salts in the ashlar; as a rule, elimination was most effective in anions with a smaller ionic volume and therefore greater ionic mobility and when the salt concentration was high and superficially located. Three years after application of the desalinating mortars, the salt concentration in the ashlar treated was 50% lower than prior to treatment.

© 2018 Elsevier Ltd. All rights reserved.

\* Corresponding author.

E-mail address: [sagrario.martinez@csic.es](mailto:sagrario.martinez@csic.es) (S. Martínez-Ramírez).

## 1. Introduction

One of the most prominent causes of built heritage decay is the presence of salts in the materials [1,2]. Such salts may crystallise on the surface of (saline efflorescence) or inside (sub- and crypto-efflorescence) materials, to the detriment of the value of the heritage asset. The effect of the former is essentially aesthetic, whereas the latter affects dimensional stability. When the crystallisation pressure exerted by a salt exceeds the mechanical strength of a material, the latter cracks, scales, flakes or crumbles.

Salts also hamper asset restoration and conservation, for they limit the effectiveness of consolidation and water-repellency treatments [3]. Hence the importance of establishing their presence in buildings, determining their origin, assessing their implications for decay and defining the most suitable elimination technique. Such techniques depend on the location of the salts in the walls, their chemical and mineralogical composition and the microclimate prevailing in the area surrounding the materials affected [4]. The petrophysical properties of the material housing salts must also be established, for factors such as porosity and pore size distribution affect salt concentration [5–8]. Some salts undergo mineralogical transformation when the relative humidity (RH) and temperature (T) of the surrounds vary. That, in turn, often induces volume change and the concomitant damage to the material [9–12]. Prior to any intervention, the superficial salts must be eliminated from the areas involved and their presence inside the walls must be lowered with the techniques presently available [13].

The origin of salts varies depending on their location and determines the most suitable desalinating technique. If the salts are found in depth, the origin may be attributed to human activity, certain types of mortars, underground water or the material itself. The desalination methods most commonly used in such cases are poultices, sacrificial mortars and immersion or electrochemical techniques.

If the salts are located near or on the surface, their source may be, in addition to the above, air pollution or microorganisms; in such cases they are eliminated primarily with mechanical, chemical or laser methods.

Despite the variety of methods in place to extract soluble salts [14–17], they are often scantily effective or inviable. None serves for all manner of materials, the results are questionable [18] and none is able to wholly eliminate salts deep within walls [19]. Very few studies have been conducted on the effectiveness of salt reduction *in situ* due primarily to the difficulty of assessing the findings, for the samples that would be needed cannot always be collected for analysis in light of the heritage value of the element to be conserved. To assess salt extraction efficiency, the pre- and post-treatment salt concentration must be determined. Efficacy is not the same on the substrate surface as at greater depths [19].

The environmental conditions (RH, T) that prevent salt mobility must also be established and the source of the salt eliminated, for otherwise it will re-impregnate the area to be protected [20].

One of the techniques for removing salt from inside walls is the application of sacrificial mortars [21–23]. Lime mortar porosity can be modified by adding appropriately structured inert or pozzolanic materials or admixtures. Sepiolite is known to be highly absorbent and to raise lime mortar porosity when added at concentrations of over 1% [24]. Lime mortars with 5% sepiolite have been shown to be more absorbent than the same mortars without the addition [25]. Other types of additions as amorphous silica added to lime mortars produce C-S-H gel by pozzolanic reaction, which modify the mortar microstructure as well as adherence and mechanical properties [26,27]. Finally, admixtures such as aerators are often used to increase the porosity of mortars and concretes [28]. From Keertana [29] a gas produced by hydrogen peroxide in the mortar improves the homogeneity of the void structure.

Based on the knowledge of the changes in lime mortar absorptivity and microstructure induced by sepiolite and nanosilica, this study was aimed at designing a sacrificial mortar able to absorb salts present in stone. Such mortars must be highly absorbent and exhibit low strength and suitable bondability while actively extracting salts, but must be readily removable with the least possible damage to the substrate after fulfilling their purpose.

The mortars designed were applied to dolostone ashlars located in the internal wall of the apse of a church at Talamanca del Jarama, a town in the Spanish province of Madrid. That stone, that is scantily resistant to salt crystallisation, has 15–150  $\mu\text{m}$  crystals, a porosity of  $16.2 \pm 3.4$ , an average pore size of 0.43  $\mu\text{m}$  and a pore size distribution ranging primarily from 0.1  $\mu\text{m}$  to 10  $\mu\text{m}$  being its water absorption coefficient of  $86 \text{ g}\cdot\text{m}^{-2}\cdot\text{s}^{-0.5}$  [30,31].

The mentioned ashlars were covered by saline efflorescences which not only result in aesthetical effects but also in surface cohesion less.

## 2. Experimental procedure

### 2.1. Materials, mortar optimisation

Tests were conducted on mortars containing different proportions of lime, sepiolite (with two particle size distributions, 15/30 and 6/30), nanosilica, and three modifiers of porosity, two commercial admixtures (SR and SG 500), and  $\text{H}_2\text{O}_2$ .

#### 2.1.1. Raw materials

- a) Hydrated lime (CL90-S).
- b) Two types of commercial sepiolite with the following information supply from the manufacturer: **15/30** with 95% ranging from 1.7 mm to 0.25 mm and 130% water absorption and **6/30** (70% pure), 14.7 wt% < 600  $\mu\text{m}$ ; 70 wt% from 600  $\mu\text{m}$  to 4.7 mm; 5.5 wt% > 4.75 mm; 95% water absorption and BET SS 240  $\text{m}^2/\text{g}$ .
- c) Amorphous nanosilica consisting primarily of amorphous  $\text{SiO}_2$  (~90%) with a loss on ignition at 1000 °C of 8.9% (free water and OH from silanol groups) [26].
- d) Aerators: a) SR (lignosulphonate base) and SG 500 (triisopropylamine base), both aerators used to add air to mortars, calling for 0.20–0.40 g per 225 g of mixing water to have a perceptible effect. B)  $\text{H}_2\text{O}_2$  (Panreac commercial hydrogen peroxide) with a molecular weight of 34.01 g; 0.5% non-volatile matter; 0.001% sulfates; 0.00005% As; 0.001% Ni; 0.001% Cu; 0.001% Pb; and 0.005% Fe. Aerators were incorporated in the mixing water.

#### 2.1.2. Optimisation of sacrificial mortars

Lime and sepiolite compositions were homogenised in the mixer-bowl before the incorporation of the water with aerators in solution. The mortars were obtained initially by mixing lime, the two types of sepiolite and  $\text{H}_2\text{O}_2$  (to improve the homogeneity of the void structure) in different proportions (M1, M2, M5, M6 in Table 1). The mortars were elaborated by moulding a series of six  $6 \times 7 \times 1 \text{ cm}$  prismatic specimens per composition, cured for 3 days at  $21 \pm 1$  °C and RH > 95%.

All the specimens shrank and cracked even under the high humidity conditions described, with greater shrinking at higher doses of  $\text{H}_2\text{O}_2$ . With a view to attaining dimensional stability and raising mechanical strength, nanosilica was added to the mortars and the moulds were sealed with a film during initial curing (M3, M4, M7, M8 in Table 1). After 3 days the moulds were taken from the chamber and after removing the film they were stored at laboratory temperature and a RH of 50–65% for 7 days. When

Download English Version:

<https://daneshyari.com/en/article/6713713>

Download Persian Version:

<https://daneshyari.com/article/6713713>

[Daneshyari.com](https://daneshyari.com)