Desalination of historic masonry. From pre-investigation to after-care

Rob P.J. van Hees[1,2], Barbara Lubelli[1,2]
[1]TNO Built Environment and Geosciences, Delft, The Netherlands
[2]Faculty of Architecture, Delft University of Technology, Delft, The Netherlands

Abstract
Salt crystallization constitutes one of the most widespread decay mechanisms affecting historic buildings. Desalination is a conservation treatment of growing importance in the case of historic masonry.
This paper describes the approach from pre-investigation and treatment to follow-up care as the basis for a successful preventive conservation of monuments suffering from salt decay.

Introduction - assessment and description
Salt crystallization constitutes one of the most widespread decay mechanisms affecting historic buildings. Desalination is a conservation treatment of growing importance in the case of historic masonry. However, it is an intervention that needs a thorough analysis of the situation in order to guarantee success.

In practical cases the following steps should be taken:
-Historical assessment of the building, including past interventions; historic events or interventions that may have contributed to the damage should be taken into consideration as well
-Assessment of the technical state of conservation, including:
- Damage assessment
- Conditions of exposure
- Description, identification and characterization of materials (total porosity, pore size distribution)

-Diagnosis, including risk assessment and description of the mechanism of decay; which salts are present and in what concentration, the salt distribution, is moisture present and what is the source
-Decision regarding the (technical) requirements for the treatment on the basis of substrate properties and salt distribution
-Decision on the poultice mix, fitting in the above framework [1]
Decision on how to assure quality control on applied materials and skilful execution
-Decision on side measures (dealing with moisture sources, indoor climate,...)

-Monitoring and after-care
The Monument Damage Diagnostic System (MDDS), see fig.1 and [2] is an example of a decision support system that assists this way of assessing (damage in) historic buildings.

Analysis and diagnosis

An assessment of the state of conservation is the first and necessary step in order to define the problem to be solved. This step includes also the decision on which investigations have to be performed. The investigations should lead to a clear diagnosis, which includes the assessing the cause of the damage, i.e. the process leading to the damage. It should become clear whether there still is an active source of moisture and or salts. After the pre-investigation a decision should be made on the intervention, i.e. the treatment to be used and under circumstances on side measures.

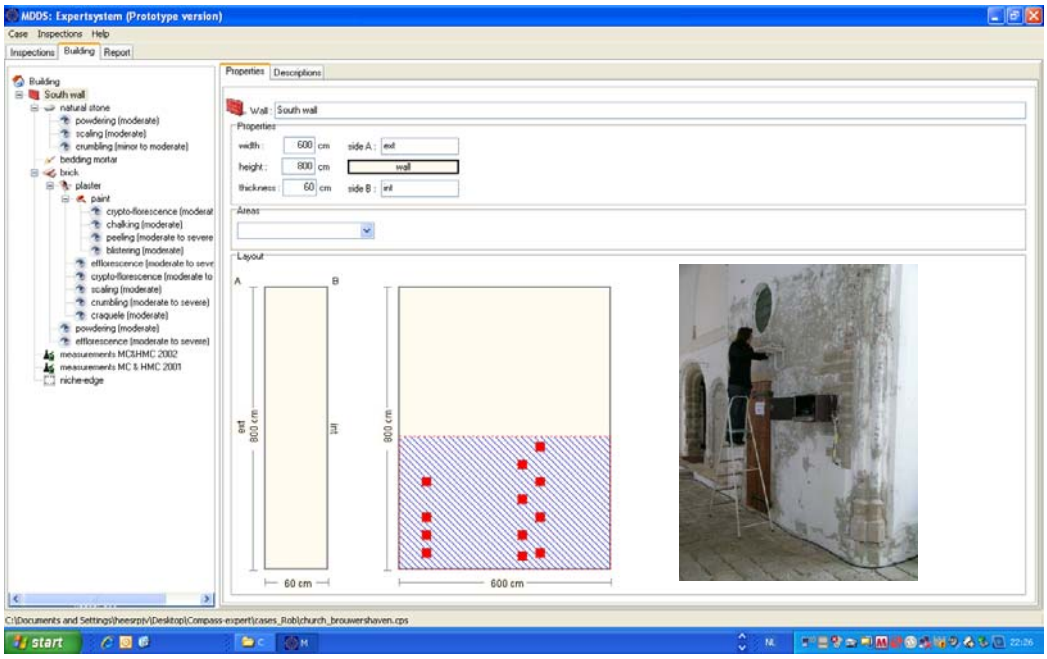

Figure 1 Location of salt damage and sampling in damaged wall section of a historic building.

Intervention

The use of poultices for the extraction of salt constitutes a well established technique in the field of conservation of valuable art objects (frescos, statues, ect.), and, recently, also of masonry surfaces. However, the obtained results appear often variable and unpredictable.
The used desalination poultices (commercial products and/or self-made recipes) are generally chosen on the basis of experience and not tuned to the properties of the substrates. In the EU project desalination [3], a modular system of

poultices was developed to optimize the desalination: tuning the pore size of the poultice to that of the substrate improves the efficiency of desalination (table 1 and figure 2).

Table 1. Modular system of poultices : Each poultice category is suitable to desalinate certain categories of substrate pore sizes. A = appropriate extraction poultice; P = possible extraction poultice

Poultice principle and type		**Substrate**			
		micro pores < 0.1 µm	small pores 0.1 – 1 µm	meso pores 1-10 µm	macro pores 10-100 µm
Advection	1.		A	P	P
	2.			A	P
	3.				A
Diffusion	4.	A	P	P	P

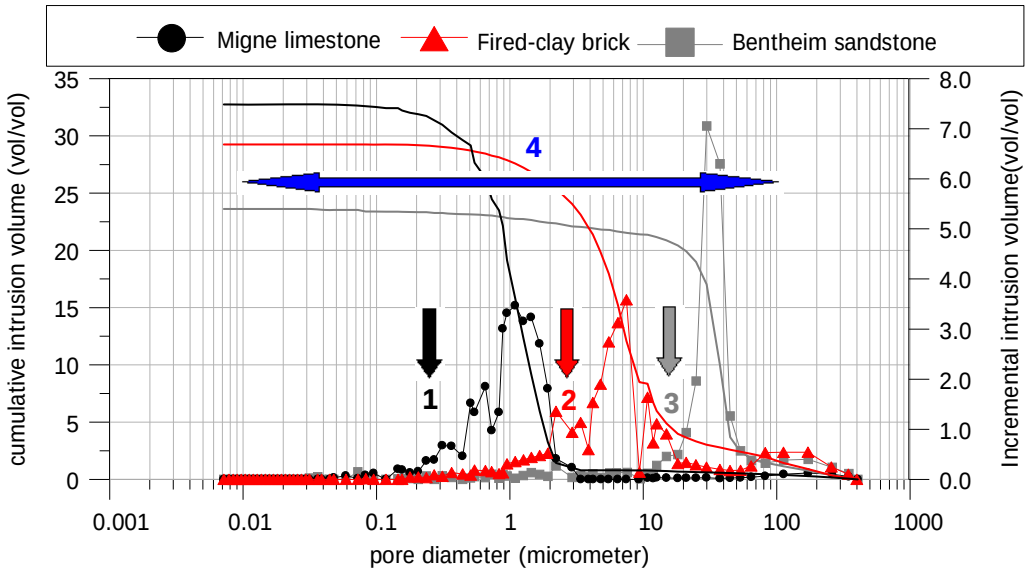

Figure 2 Modular system of poultices. The number sindicate the class of desalination poultices. The arrows indicate the pore size the poultice should have for each class of pore size of the substrate. A poultice has to be tailored to the substrate which has to be desalinated.

In order to have a sound basis for the choice of the poultice, the following information should be collected on the substrate:

-Pore-size distribution and total open porosity

-Moisture source, quantity and distribution
-Salt type, quantity and distribution

Before and after desalination the moisture and salt content and distribution in the wall (and not only in the desalination poultice) should be measured to evaluate the efficiency of salt extraction. Eventually, side measures (as for example climate control) might be considered too. The state of conservation (and eventual damage development) of the treated structure on the long term should be monitored.

After-care

It is of great importance that decisions and measures are properly described and archived, so that in future an evaluation of any measures taken, whether the effect is positive or negative, can be performed.
Regular control of the effectiveness of the intervention in combination with a maintenance planning should be carried out. In this way the intervention fits in the cost effective concept of preventive conservation [4].
Table 2 gives a complete overview of the steps in the decision process.

Table 2 Steps ideally to be taken in the case of a desalination intervention

Phase	Steps	
Assessment and description	Assessment of the history of the building	
	Assessment of the state of conservation	Identification and characterization of materials
		Damage description (types / patterns)
Analysis and diagnosis	Hypothesis on the damage process	Measurement of moisture and salt load
		Determination of the salt types, amount and distribution
		Monitoring of the climate
	Verification of the damage process	Identification of the moisture and salt sources
		Description of the damage process
	Risk analysis	Activity of moisture and salt sources
		(Indoor) climate
Intervention / execution	Possibility and applicability of desalination treatment	
	Technical requirements for the desalination treatment	Choice of desalination principle
		Choice of poultice mix
		Pre-wetting
		Pre-consolidation
	Quality control during execution	
	Monitoring of the desalination process	
	Sampling and salt distribution measurements	
	Planning eventual side-measures	Climate control
		Measures against moisture sources (for example rising damp)
After care	Documentation of diagnosis and intervention	
	Planning of future maintenance	
	Monitoring of the state of conservation	

References

[1] Lubelli B., Hees van, R.P.J., Desalination of masonry structures. Fine tuning of poultice pore size distribution to substrate properties, Journal of Cultural Heritage (2009), on line: http://dx.doi.org/10.1016/j.culher.2009.03.005

[2] Rob P.J. van Hees, Silvia Naldini, Barbara Lubelli, The development of MDDS-COMPASS. Compatibility of plasters with salt loaded substrates, special issue Compass - Construction and Building materials, Vol 23, No 5, May 2009, pp. 1719-1730

[3] EU project Desalination - *Assessment of Desalination Mortars and Poultices for Historic Masonry*, Contract no.: 022714 (2006-2009)

[4] EU specific support action (7th FP), project SPRECOMAH 2006 - 2008