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Performance of Single Materials Treated with a Water Repellent and Contaminated with a Salt Mix

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Abstract

One of the main causes of decay in porous materials is the growth of salt crystals within pores. Their presence in masonry is generally considered as a contra-indication for surface treatments. In the framework of a previous research, threshold values have been defined for sodium- and magnesium sulphate, sodium chloride and sodium nitrate tested out as single salt on samples treated with a water repellent product and compared to untreated ones. Knowing that building materials seldom contain one particular type of salt, but a complex mixture of ions, a research has been carried out as step forward using a mixture of salts consisting of sodium sulphate, sodium chloride and potassium nitrate. The selected substrates are an Italian soft brick and the French Massangis limestone. The results have shown that threshold values of salt contents up to which no damage is obtained, resulting from salt crystallisation tests on samples contaminated with single salts, generally are no longer valid in case of combination with other types of salts. Moreover, the prediction of the behaviour of salts in a mixture is complex due to the formation of double salts resulting from ion exchange.

1 Introduction

Deterioration of buildings and monuments, which are exposed to weathering and pollution, is becoming a serious life-cycle problem, causing economical and cultural damage [1].

One of the main causes of decay in porous materials is the growth of salt crystals within pores, generating stresses that are sufficient to cause disintegration. The material becomes weak and friable and the surface crumbles away or delaminates.

The presence of soluble salts in masonry is generally considered as a contra-indication for surface treatments. On the other hand, knowing that almost all building materials contain an analysable salt content, there are many examples of treated monuments where no damage is observed, even after 20 to 30 years [2].

In the framework of a European Project "SCOST" [3] a systematic research was carried out aiming to determine threshold values of salt contents, related to material properties, type of salt and treatment characteristics, up to which a surface treatment is allowed and related to untreated samples. Based on salt crystallisation tests, executed with sodium sulphate, magnesium sulphate, sodium chloride and sodium nitrate according to a protocol developed in this research, it was concluded that the type of salt plays a major role on the salt limit content, while the type of treatment plays a minor role. It turned out that sodium- and magnesium sulphate show a higher destructive index on treated and untreated samples than sodium chloride and sodium nitrate.

An inventory of the type of cations and anions in 936 samples taken from Belgian historic buildings proved that building materials seldom contain one particular type of salt, but a complex mixture of ions. More specific, 13 % of the samples were contaminated with one type of anion ($SO_4^{2^-}$), about 18 % contained a mixture of chlorides and sulphates while 69 % a mixture of chlorides, sulphates and nitrates. Concerning the type of cations, about 4 % of the samples were contaminated with only sodium salts, while most samples contained a mixture of sodium, potassium, calcium and magnesium salts, the latter being in minor quantity.

Therefore, as step forward, a research has been carried out in KIK-IRPA aiming to evaluate the performance of porous treated and untreated substrates contaminated with a mixture of salts. The surface treatment product is a solvent based water repellent applied on one type of brick and limestone. The water repellent properties of this product have been tested in previous projects from which its efficiency was concluded. The composition of the salt mix is based on the threshold values of sodium sulphate for these single materials obtained in the "SCOST" project [3], to which a varying amount of sodium chloride and potassium nitrate is added. This salt mixture represents an average contamination of building materials in Belgian monuments. Based on the results obtained after four salt crystallisation cycles, it is concluded that the performance, and hence the threshold values, in case of a mix generally differ from these of single salts due to the formation of double salts.

2 Experimental part

2.1 Substrates

Among the 20 materials tested in the project "SCOST", two have been selected for use as substrate for contamination with a salt mix. Their properties are presented in Table 1.

2.2 Treatment

The selected water repellent is an oligomeric methylsiloxane with ethoxy as reactive group diluted in white spirit in a way that the corresponding dry weight is 6.5 %.

The treatment is carried out by capillary rise during 10 seconds. The consumption is determined from the weight difference before and after treatment. After 1 week conditioning at 20 °C and 50 % relative humidity (R.H.), treated and untreated samples are contaminated with salts.

Substrate	Description	Prope determi Hg-poro	erties ned by simetry	Capillary wate prope	er absorption erties		
		Porosity <i>(%)</i>	Density (g [.] cm ⁻³)	Capillarity (A) (g ⁻ cm ^{-2.} h ^{-0.5})	C.M.C. (weight %) ^(a)		
Italian brick	Soft mud brick	40	1.60	1.97	21.7		
French limestone Massangis	Oolitic and crinoidal lime- stone	13	2.33	0.22	4.2		

Table 1:	Properties	of the	selected	substratea
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(a): amount of water that can enter a sample by capillary rise

The samples are cut in cubes of $10 \times 5 \times 10 \text{ cm}^3$.

2.3 Salt crystallisation tests

After drying of the samples at 40°C, the salt solution, consisting of the defined salt mix (see part 4) dissolved in 80 % of the C.M.C., is introduced by capillary rise. If necessary, the top side of the container used for the introduction of the salt solution is closed to prevent evaporation. After introduction, the samples are put in a container with a layer of gravel (2 - 3 mm), in such a way that drying can only occur through the front face (5 x 10 cm²). For the Italian brick, the front face corresponds to its natural skin. The samples are conditioned at 20°C and 50 % R.H.. The drying is registered by periodic weighing till 90 % of the introduced water is evaporated. The front surface is cleaned with a soft brush. The collected material, consisting of salt deposit and loose material from the substrate, is analysed as described in 2.4.

For further salt crystallisation cycles, an amount of water equal to 80 % of the C.M.C. of the sample is introduced followed by conditioning at 20 $^{\circ}$ C and 50 $^{\circ}$ R.H. as described above.

For this research, four salt crystallisation cycles have been performed, corresponding with a total duration of 20 months.

2.4 Analysis of the material collected at the drying surface of the samples

The material collected after brushing the surface is analysed by X-Ray Diffraction (XRD, Philips PW1729). After that, the soluble salts are extracted from the loose material using demineralised water. The anions (Cl⁻, NO₃⁻ and SO₄²⁻) of the extract are analysed by ionchromatography (IC, Waters Model 510, eluent: an aqueous solution (pH 4.2) of KC₈H₅O₄ (4mM), flow rate: 1 ml·min⁻¹, detector: Waters Conductivity Detector Model 430) and the cations (Na⁺, K⁺, Ca²⁺ and Mg²⁺) by atomic absorption spectroscopy (AAS, Perkin Elmer AAS 300, Air/acetylene flame).

3 Threshold values of single salts

Among the types of salts combined in the mix subject of present research, threshold values have been defined for Na₂SO₄ and NaCl, namely the highest salt content at which no damage is obtained and the lowest salt content at which damage is obtained, systematically for treated and untreated samples. The threshold values are expressed as weight percentage of the dry material. For treated as well as untreated Italian brick and Massangis limestone, these values are presented in Table 2.

Substrate	Treated untreated	Highest o which no o obtaine	content at damage is d (w-%)	Lowest content at which damage is obtained (w-%)					
		Na ₂ SO ₄	Na ₂ SO ₄ NaCl		NaCl				
Italian brick	Untreated	0.25 ^(a)	0.50 ^(b)	0.50 ^(a)	> 0.50 ^(b)				
Italian Drick	Treated	< 0.50 ^(a)	0.50 ^(b)	0.50 ^(b)	1.00 ^(b)				
Massangis	Untreated	0.12 ^(a)	< 0.50 ^(b)	0.25 ^(a)	0.50 ^(b)				
limestone	Treated	0.12 ^(a)	< 0.50 ^(b)	0.25 ^(a)	0.50 ^(b)				

Table 2: Threshold values, expressed as weight percentage of the dry substrate,
of Na_2SO_4 and NaCl for the Italian brick and the Massangis limestone.

(a): determined within the "SCOST" project

(b): determined within present research

The threshold values for treated samples generally match well with those for untreated samples. In some cases, the highest content at which no damage occurs could not be defined because damage is obtained at the lowest tested salt content. This is as such for the treated Italian brick contaminated with Na₂SO₄. The remaining threshold values of Na₂SO₄, presented in bold in Table 2, form the basis for the set up of the research program with a salt mix.

4 Set up of the research program with a salt mix

The Na₂SO₄ limit up to which no damage is obtained forms the basis of part I of the research program with a salt mix while the lowest content at which damage occurs forms the basis of part II of the research program (Table 2). Starting from these threshold values, a varying amount of sodium chloride and potassium nitrate is added. For the treated Italian brick an additional part III is included for which the Na₂SO₄ content is twice that of part II.

The set up of the research program is presented in Table 3. From this table it can be remarked that for some salt combinations of the Massangis limestone, the NaCl-content corresponds to the threshold value at which damage is obtained when tested as single salt (Table 2). These have been presented in bold in Table 3.

Table 3: Set up of the research program

Substrate	Part	Untreated/ treated	Salt contamination Na ₂ SO ₄ -NaCI-KNO ₃ content ^(a)						
	I	Untreated	1-1-1	1-1-1 1-2-1					
Italian brick	II	Untreated Treated	2-1-1	2-2-1	2-1-2				
		Treated	4-1-1	4-2-1	4-1-2				
	1	Untreated	1-1-1	1-2-1	1-1-2				
Massangis limestone	I	Treated	1- 4 -1	1-1-4					
	II	Untreated Treated	2-2-2	2 -4 -2	2-2-4				

(a) : A value of 1, 2 and 4 corresponds for the Italian brick to respectively 0.25, 0.50 and 1.00 w-% while for the Massangis limestone to respectively 0.12, 0.25 and 0.50 w-% of the dry material.

Prior to the salt crystallisation procedure on salt contaminated samples, the types of salts formed by evaporating an aqueous solution containing Na₂SO₄, NaCl and KNO₃ are examined.

5 Results and discussion

5.1 Consumption of the water repellent product

The consumption of the water repellent product is presented in Table 4. The uptake of water repellent product of the Italian brick is at least three times higher than that of the Massangis limestone.

5.2 Types of salts formed by evaporating an aqueous solution of Na₂SO₄, NaCl and KNO₃

Prior to the salt crystallisation procedure, the salts formed by evaporating an aqueous solution containing Na₂SO₄, NaCl and KNO₃ in different ratios are determined by XRD. The results are presented in Table 5.

The results presented in Table 5 show that NaCl and KNO₃ are crystallising as such, while Na₂SO₄ tends to combine with nitrates to form darapskite $(Na_3(NO_3)(SO_4).H_2O)$ or, at higher KNO₃ contents, to form a double salt with potassium.

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Table 4: Consumption of the water repellent product

Substrate	Consumption (g.m ⁻²)
Italian brick	459 (±68)
Massangis limestone	132 (±17)

 Table 5: Types of salts formed by evaporating an aqueous solution containing

 Na₂SO₄, NaCl and KNO₃

Salt ratio of Na ₂ SO ₄ , NaCl and KNO ₃ (weight ratio)	Types of salts formed							
	halite							
3-1-2	niter	KNO ₃						
	darapskite	Na ₃ (NO ₃)(SO ₄).H ₂ O						
	niter	KNO ₃						
3-1-6	potassium sodium sulphate	K ₃ Na(SO ₄) ₂						
3-1-0	halite	NaCl						
	darapskite	Na ₃ (NO ₃)(SO ₄).H ₂ O						

5.3 Salt crystallisation tests on samples contaminated with a salt mix

The results obtained for the Italian brick and for the Massangis limestone are presented in Table 6 and 7 respectively.

Similar as described in 5.2, NaCl is efflorescing as such and shows no exchange with potassium. Generally the sulphates are deposited in the form of darapskite and this already in the beginning of the salt crystallisation test together with KNO₃ and NaCl. Despite their global lower solubility [4], Na₂SO₄, K₂SO₄ and K₃Na(SO₄)₂ are deposited at a later stage of the salt crystallisation test. K₃Na(SO₄)₂ is mainly formed when the amount of KNO₃ is at least twice that of Na₂SO₄.

All samples of part I of the research program remain undamaged, except for the untreated Massangis limestone containing 0.12 w-% of Na₂SO₄ and 0.50 w-% of NaCl (1-4-1). It is supposed that damage results from the activity of NaCl since 0.50 w-% is the threshold value from which damage occurs when tested as single salt.

Table 6: results of salt crystallisation tests for the Italian brick : main components of the salt deposit (XRD, IC and AAS).
For part I, the Na₂SO₄ content corresponds to the highest value at which no damage is obtained when tested as single salt (Table 2); for part II, the Na₂SO₄ content corresponds to the lowest value at which damage is obtained. For part III, the Na₂SO₄ content corresponds to the lowest value at which damage is obtained. For part III, the Na₂SO₄ content corresponds to the lowest value at which damage is obtained. For part III, the Na₂SO₄ content is twice that of part II. The salt contamination is presented as "Na₂SO₄-NaCl-KNO₃" in such a way that a value of 1, 2 and 4 corresponds to respectively 0.25, 0.50 and 1.00 w% of the dry material.
The results are presented in *italic* in case damage is obtained.

4	3	2		4		ω	1	2		number/salt content	Cycle
(d)	(d)	(b)		(a)	Na ₃ (NO ₃)(SO ₄).H ₂ O	NaCI,	Na ₃ (NO ₃)(SO ₄).H ₂ O	KNO ₃ , NaCl.		1-1-1	
(d)	(d)	(d)		Na_2SO_4	NaCl, KNO ₃	Na ₂ SO ₄ ,	(~)	(a)		1-2-1	Part I
(d)	(d)	(d)		KNO₃, NaKSO₄	Na ₃ (NO ₃)(SO ₄).H ₂ O NaCl	KNO ₃ ,	Na ₃ (NO ₃)(SO ₄).H ₂ O	KNO3. NaCI.	Ľ	1-1-2	
(a)	(a)	(a)	Treate	Na ₂ SO ₄ KNO ₃		(a)	(=)	(a)	ntreated	2-1-1	
	Na_2SO_4	(a)	đ	Na₂SO₄		(a)	Na ₃ (NO ₃)(SO ₄).H ₂ O	NaCI, KNO ₃ ,		2-2-1	Part II
(a)	(a)	(a)		K ₃ Na(SO ₄) ₂ , Na ₂ SO ₄	Na ₃ (NO ₃)(SO ₄).H ₂ O	NaCI, KNO ₃ ,	KNO3	Na₂SO₄. NaCl.		2-1-2	
		Na_2SO_4		(d)		(d)	1~1	(b)		4-1-1	
		Na_2SO_4		(b)		(b)	1-1	(b)		4-2-1	Part III
	Ma_2SO_4	(a)		(d)		(b)	(~)	(b)		4-1-2	

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(a): no efflorescence nor damage on the sample (b): not tested

		2-2-4		(a)		K ₃ Na(SO ₄) ₂	KNO3, NaNO3, NaCI	K ₃ Na(SO ₄) ₂ ,	Na ₂ SO ₄		NaCI, KNO3,	Na3(NU3)(SU4).H2U	NaCI, KNO ₃	CaSO4.2H2O	Na ₃ (NO ₃)(SO ₄).H ₂ O	NaCI,K ₃ Na(SO ₄) ₂ ,	Na ₃ (NO ₃)(SO ₄).H ₂ O KNO ₃			
(XRD. IC and AAS). In tested as single salt (Table 2); contamination is presented as and 0.50 w% of the dry material.	Part II	2-4-2		NaCI, KNO ₃ ,	Na ₃ (NO ₃)(SO ₄).H ₂ O	NaCI,	Na ₃ (NO ₃)(SO ₄).H ₂ O, Na ₂ SO ₄ . K ₂ SO ₄	Na ₂ SO ₄	NaCI		(a)		NaCI, KNO3,	Na ₃ (NO ₃)(SO ₄).H ₂ O		NaCI, Na ₂ SO ₄ ,	K ₂ SO4			
		2-2-2		NaCI, KNO ₃ ,	Na ₃ (NO ₃)(SO ₄).H ₂ O	NaCI	Na ₃ (NO ₃)(SO ₄).H ₂ O	Na ₂ SO4.	CaSO4.2H2O		(a)		NaCI, KNO ₃ ,	Na ₃ (NO ₃)(SO ₄).H ₂ O		Na ₂ SO ₄ , K ₂ SO ₄				
nts of the salt depos nage is obtained wh e is obtained. The s. espectively 0.12, 0.3		1-1-4		NaCI, KNO ₃ ,	NaNO3	KNO ₃ ,	K ₃ Na(SO ₄) ₂	KNO ₃ ,	Na ₃ (NO ₃)(SO ₄).H ₂ O		KNO ₃ , NaCI, NaNO ₃	Na ₃ (NU ₃)(SU ₄).H ₂ U	NaCI, KNO ₃ ,	Na₂SO₄		KNO ₃ , Na ₂ SO ₄				
lisation tests for the Massangis limestone : main component 4 content corresponds to the highest value at which no dama 4 content corresponds to the lowest value at which damage - 1 ^e in such a way that a value of 1, 2 and 4 corresponds to res nted in <i>italic</i> in case damage is obtained.	Part I	1-4-1	Untreated	Untreated	Untreated	Untreated	NaCI, KNO3	Na ₃ (NO ₃)(SO ₄).H ₂ O	NaCI, Na ₂ SO ₄		NaCI, Na ₂ SO ₄		treated	NaCI, KNO3	Na3(NO3)(SO4).H2O	NaCI, KNO ₃			NaCI,	Na ₃ (NO ₃)(SO ₄).H ₂ O
		1-1-2		NaCI, KNO ₃ , NaNO ₃ ,	Na ₃ (NO ₃)(SO ₄).H ₂ O	K ₃ Na(SO ₄) ₂ , KNO ₃		K₃Na(SO₄) ₂ ,	NaNO ₃		KNO ₃ ,NaNO ₃ ,NaCl	Na ₃ (NU ₃)(SU ₄).H ₂ U	NaCI, KNO ₃ ,	Na ₃ (NO ₃)(SO ₄).H ₂ O		K₃Na(SO₄) ₂ ,	KNO ₃ , NaCI			
		1-2-1		NaCI, KNO ₃ ,	Na ₃ (NO ₃)(SO ₄).H ₂ O	NaCI, KNO ₃ ,	Na₂SO₄	(a)			NaCI, KNO3,	Na ₃ (NU ₃)(SU ₄).H ₂ U	NaCI, KNO ₃ ,	Na ₃ (NO ₃)(SO ₄).H ₂ O		NaCI,	Na ₃ (NO ₃)(SO ₄).H ₂ O			
sults of salt crystal or part I, the Na ₂ SO. r part II, the Na ₂ SO. Ia ₂ SO ₄ -NaO-KNO ₃ ie results are prese		1-1-1		NaCI, KNO ₃ ,	CaSO4.2H ₂ O, Na ₃ (NO ₃)(SO4).H ₂ O	NaCI, KNO ₃ ,	Na ₂ SO4	Na ₂ SO ₄ .	CaSO4.2H2O		NaCI, KNO3,	Na3(NU3)(SU4).H2U	NaCI, KNO ₃ ,	Na ₃ (NO ₃)(SO ₄).H ₂ O		NaCI, KNO ₃	Na ₃ (NO ₃)(SO ₄).H ₂ O			
Table 7: re Fc *N *N	Cycle	number/salt content		2		З		4			2		e			4				

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(a): no efflorescence nor damage on the sample

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The results show that, in case the Na₂SO₄ content corresponds to the threshold value for damage in case of contamination as single salt (part II), the addition of NaCl and KNO₃ generally results in a decrease of the destructive activity. Especially for the treated Massangis limestone, no damage is obtained for all tested salt combinations. Moreover, treated as well as untreated limestone end up undamaged in case the content of both Na₂SO₄ and NaCl corresponds to the threshold value for damage when tested as single salt (Table 3). The combination 2-2-1 results in a destructive activity for treated and untreated Italian brick. For the untreated Massangis limestone, this is the case for the combination 2-2-2. This result indicates that damage might appear for a contamination characterised by equal weight contents of NaCl and Na₂SO₄ and equal or lower amounts of KNO₃.

Damage on untreated samples can be described as powdering and crumbling, while on treated samples it varies from powdering and crumbling to scaling and spalling. Its occurrence is generally linked with the deposition of Na₂SO₄ which causes spalling of the water repellent layer of treated samples as illustrated in Figure 1 for some samples of the Italian brick of part III. For the untreated Massangis limestone, the ionic composition of the efflorescence, determined by IC or AAS, has been compared with that of the introduced salt mix. Some results, expressed as ratio of ion content in the salt efflorescence to that in the introduced salt mixture, are presented from Figure 2 to 4.

Figure 2 presents the results obtained after the second crystallisation cycle for a contamination of which the NaCl content equals that of Na₂SO₄ (0.12 w-%) while the amount of KNO₃ increases gradually from 0.12 to 0.50 w-%. This figure shows that the efflorescence of chlorides is favoured regardless the KNO₃ content. The content of deposited nitrates is experimentally higher than that of K⁺ which is explained by the formation of darapskite. The efflorescing sulphate content is in all cases lower than theoretically expected. A declining profile is obtained for NO₃⁻, K⁺ and SO₄²⁻.This indicates that increasing the amount of KNO₃ in the mix is not causing an equivalent increase of its content in the efflorescence as well as that of darapskite.

Figure 3 presents the results obtained after the second crystallisation cycle for a contamination of which the KNO_3 content equals that of Na_2SO_4 (0.12 w-%) while the amount of NaCl increases gradually from 0.12 to 0.50 w-%. The content of chlorides in the efflorescence approaches that in the introduced salt mix. The efflorescing sulphate content is, similar as described above, lower than theoretically expected. The profiles of K⁺ and

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Figure 1: Damage on the Italian brick contaminated with a Na₂SO₄ –NaCl-KNO₃ mixture of, from left to right, 4-1-1, 4-2-1 and 4-1-2. A value of 1, 2 and 4 corresponds to respectively 0.25, 0.50 and 1.00 w-% of the dry sample

 NO_3^- decline indicative for a suppression of the efflorescence of KNO₃ as the amount of NaCl increases.

After cycle four, an opposite tendency is obtained, in such a way that the efflorescence of chlorides and nitrates is much lower than theoretically expected from the composition of the mix while that of sulphates is favoured. The influence of the salt crystallisation cycle number on the types of ions deposited on the drying surface of the Massangis limestone containing equal amounts of Na₂SO₄, NaCl and KNO₃ is illustrated in Figure 4 which confirms that the efflorescence of nitrates and chlorides decreases with increasing crystallisation cycle number while that of sulphates increases.



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Figure 2: Ratio of ion content in the salt efflorescence to that in the introduced salt mixture after the second crystallisation cycle for the untreated Massangis limestone contaminated with a Na₂SO₄ - NaCl - KNO₃ mixture corresponding to 1-1-1, 1-1-2 and 1-1-4. A value of 1, 2 and 4 corresponds to respectively 0.12, 0.25 and 0.50 w-% of the dry material.



Figure 3: Ratio of ion content in the salt efflorescence to that in the introduced salt mixture after the second crystallisation cycle for the untreated Massangis limestone contaminated with a Na₂SO₄ - NaCl - KNO₃ mixture corresponding to 1-1-1, 1-2-1 and 1-4-1. A value of 1, 2 and 4 corresponds to respectively 0.12, 0.25 and 0.50 w-% of the dry material



Figure 4: Influence of the salt crystallisation cycle number (2, 3 or 4) on the ratio of ion content in the salt efflorescence to that in the introduced salt mixture for the untreated Massangis limestone containing 0.12 w-% of Na₂SO₄, NaCl and KNO₃ (1-1-1)

6 Conclusion

This research has shown that threshold values of salt contents up to which no damage is obtained, resulting from salt crystallisation tests on samples contaminated with single salts, generally are no longer valid in case of combination with other types of salt. Moreover, the prediction of the behaviour of salts in a mixture is complex due to the formation of double salts resulting from ion exchange. In case NaCl and KNO₃ are added to Na₂SO₄, it turned out that NaCl is generally deposited on the sample as such at an early stage of the salt crystallisation test, while KNO₃ partially tends to combine with Na₂SO₄ resulting in the formation of Na₃(SO₄)(NO₃)·H₂O (darapskite). Hence, the actual amount of Na₂SO₄ acting as such is diminished resulting in higher acceptable contents up to which no damage is obtained.

The sequence at which the salts are deposited at the drying surface is not conform with the indications formulated by Arnold [5], who states that, for a wall suffering from rising damp, the deposition of salts is governed by their solubility. This difference in sequential salt deposition stresses the importance of a sufficient amount of crystallisation cycles prior to a final evaluation of the salt compatibility of a material.

7 References

- [1] Les hydrofuges: produits de protection de la Pierre, Section Française du Conseil International des Monuments et des Sites (ICOMOS), Direction du Patrimoine, Ministère de la Culture et de la Francophonie, Laboratoire de Recherche des Monuments Historiques, Paris 26 mars (1996)
- [2] Evaluation of the performance of surface treatments for the conservation of historic brick masonry, EC Report No 7, Ed R.P.J. van Hees (1998)
- [3] Salt Compatibility of Surface Treatments (SCOST), ENV4-CT97-0710, final report edited by Eddy De Witte (2002)
- [4] CRC, A Handbook of Chemistry and Physics, 69th edition, CRC Press (1988)
- [5] A. Arnold, Rising damp and saline minerals, Proceedings of the Fourth International Congress on Deterioration and Preservation of Stone Objects, July 7-9, 11-28 (1982)