

## DAMAGE ASSESSMENT AND DIAGNOSIS FORM

### SUMMARY OF DAMAGE DIAGNOSIS

<b>Name of the building – Location</b> Salvas Chapel – Sines, Portugal
<b>Type of damage – decay pattern</b> <ol style="list-style-type: none"><li>1. Cracking, sanding and crumbling. Detachment of the paint layer and of the superficial coats.</li><li>2. Efflorescences and detachment of the paint layer.</li><li>3. Powdering</li><li>4. Moisture spots, water flow marks and biological development</li></ol>
<b>Materials concerned</b> <ol style="list-style-type: none"><li>1. Render</li><li>2. Plaster</li><li>3. Red ceramic tiles of the pavement</li><li>4. External façades of the church</li></ol>
<b>Tests performed</b> <ul style="list-style-type: none"><li>▪ Moisture and hygroscopic moisture content (HMC) profiles, at two exterior locations</li><li>▪ Ion chromatography on four superficial samples of render</li><li>▪ XRD characterization of efflorescences collected at the interior of the church</li></ul>
<b>Diagnosis</b> <p>Capillary rise seems to be the main source of moisture.</p> <p>At the back façade, moisture contents are high, especially at the base. The salts contents are also very high, especially in the superficial coats, above the 0.5 m and below the 4.0 m (where damage is also higher). It is expected that the same happens at the other façades with similar degradation (front and lateral facing the harbour). Salts seem to be mainly chlorides (probably from the nearby sea, whether directly transported through the air or indirectly, after deposition in the soil), but also nitrates (probably from the soil). The relevance of the presence of carbonates is not yet established.</p> <p>At the lateral façade, which has an adjacent drain, the salts contents, as well as the moisture contents and the damage, are low.</p> <p>At the interior, the efflorescences are mainly constituted of carbonates.</p>
<b>Advice</b> <p>Further research seems necessary to detect the origin of the rising damp (superficial draining water or phreatic water). Measures to reduce the capillary rise should be taken, according to the results of this research.</p> <p>The new renders should respect the following general requirements: low alkali content, very low sulphate (and also chloride) content, sulphate resistant binders and aggregates, good resistance to cracking.</p>

## DAMAGE ASSESSMENT AND DIAGNOSIS FORM

### Date of inspection + description

2002-07-03 Preliminary inspection  
2003-10-30 Sampling and inspection  
2003-11-19 Sampling, by powder drilling

### Investigator / Institute in charge of the investigation

LNEC

### Reference Number

### GENERAL INFORMATION

<b>Name of the building</b> Salvas Chapel
<b>Address</b> Largo de Nossa Senhora das Salvas, Sines
<b>Owner of the building / Responsible authority of the building</b> IPPAR (Évora regional delegation) is nowadays the responsible authority.
<b>Construction phases + data (year)</b> The chapel dates from the beginning of the XVI century (by 1517 the church was already built). In the second half of the XVIII century, the front façade was rebuilt and the interior decorative wall ceramic tiles ("azulejo") panels were made.
<b>Relevant historical calamities</b> 1969 – Damage due to earthquake 1998 – During the winter, works were proceeding and the church was left partially unprotected (part of the roof was not there, the gutter was not yet waterproofed and the gargoyles were removed and not yet replaced). Penetration of water from the rain inside the church walls is very likely to have occurred.
<b>Function(s) of the building during time</b> The chapel has always been used for religious cult.
<b>Present function (use of installations)</b> Religious cult

**Pictures of the building**



Fig. 1 –Salvas Chapel, SW (front) façade (2002-07-03)



Fig. 2 – Salvas Chapel, SE façade (facing Sines harbour) (2003-10-30)



Fig. 3 –View of the Sines harbor and (back side of) Dona Bataça water fountain and reservoir (2003-11-19)



Fig. 4 – Dona Bataça water fountain and reservoir (ancient photo, prior of the most recent interventions) (DGEMN)



Fig. 5 –Salvas Chapel, NW façade (2003-10-30)

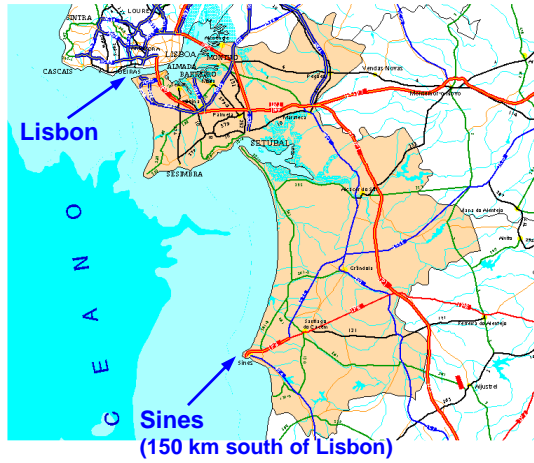


Fig. 6 –Salvas Chapel, NE (back) façade (2003-11-19)

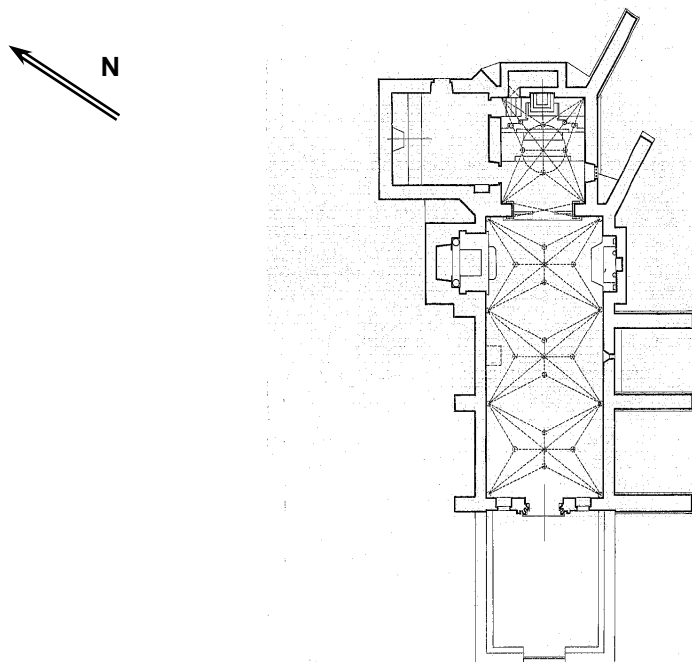


Fig. 7 –Salvas Chapel, interior (2003-11-19)

### Plan of the location of the building



### Building plan



**STATE OF PRESERVATION OF THE BUILDING**

	Type of damage	condition assessment					
		Excellent	Good	Reasonable	Not adequate	Poor	Very poor
Roof			X				
Facades							X
Structural elements			X				
Interior				X			
Floor			X				
Ceiling				X			

**RESTORATION OR MAINTENANCE INTERVENTIONS PERFORMED IN THE PAST**

<p><b>Type of restoration or maintenance:</b></p> <ul style="list-style-type: none"> <li>(a) demolition of town buildings adjacent to the chapel SE façade</li> <li>(b) repair of the SE wall (free from the demolished constructions) and of the roof</li> <li>(c) reconstruction of buttresses (probably the SE ones, which had been total or partially removed when the adjacent buildings were made)</li> <li>(d) rendering, plastering and painting (information needing confirmation)</li> <li>(e) repair of damage caused by an earthquake</li> <li>(f) rendering, plastering and painting</li> <li>(g) construction of a reinforced concrete belt, which encircled the chapel (we still don't have information of its exact vertical location)</li> <li>(h) rendering</li> <li>(i) a drain was built adjacent to the NE façade</li> <li>(j) repair of the chapel roof</li> <li>(k) renderings</li> <li>(l) plastering and repair of the ceramic tiles coverings (information needing confirmation)</li> </ul>
<p><b>Building part:</b></p> <ul style="list-style-type: none"> <li>(a) SE façade</li> <li>(b) SE wall and roof</li> <li>(c) SE façade</li> <li>(d) exterior and interior walls</li> <li>(e) roof; arches and domes, walls in the lateral SE side</li> <li>(f) exterior and interior walls</li> <li>(g) external walls of the chapel</li> <li>(h) exterior walls</li> <li>(i) NE façade</li> <li>(j) roof</li> <li>(k) external walls</li> <li>(l) walls, at the interior of the chapel</li> </ul>
<p><b>Date:</b></p> <ul style="list-style-type: none"> <li>(a) 1961</li> <li>(b) to (d) 1962</li> <li>(e) to (g) 1969</li> <li>(h) 1986</li> <li>(i) to (l) 1997</li> </ul>

Contractor: Company performing the restorations:  
There is no information

Reasons for restoration:

- (a) - create a public square surrounding the entire chapel.
- (b) to (d) - rearrangement of the chapel after the demolition of the adjacent buildings
- (e) to (g) - repair damage caused by an earthquake
- (h) - conservation
- (i) - solve moisture and salt problems in the walls and pavements of the chapel
- (j) - conservation
- (k) - replace salt damaged renders
- (l) - restoration of salt damaged ceramic tiles and replacement of salt damaged plasters

**Further information:**

- (h) – This was probably the first time in which cement-plasters and cement renders were used at the chapel but this hypothesis still needs confirmation.
- (k) – The salt damaged cement renders were removed and new lime renders (including also a small percentage of cement) were made
- (l) – The salt damaged cement plasters were removed and new pure lime plasters were made; the tiles cement bedding mortars were removed, the tiles were restored and re-bedded with pure lime mortars.



## DAMAGE

### Type of damage and architectural element affected

- 1 - Sanding of the render
- 2 - Crumbling of the render/paint system
- 3 - Cracking of the render/paint system (craquele)
- 4 - Detachment of the paint
- 5 - Detachment of render coats
- 6 - Moisture spots
- 7 - Biological development
- 8 - Efflorescences
- 9 - Powdering of pavement red ceramic tiles
- 10 - Water flow marks

### Location of damaged area

- 1 to 3 – Façades
- 4 – Walls, both at the interior and at the exterior of the church
- 5 to 7 – Façades
- 8 – Walls, at the interior of the church
- 9 – Interior pavement of the church
- 10 – Façades

### Extent of damaged área [%] abd depth (mm) – November 2003

- 1 and 2 – 12% of the façades surface (from superficial to a depth of 4 cm in some points)
- 3 – 60% of the façades surface
- 4 – 5% of the façades surface
- 5 – 5 % of the façades surface
- 6 – 5 % of the façades surface (may vary with the weather)
- 7 – 3% of the façades surface
- 8 – 1% of the walls surface, at the interior of the church
- 9 – 1% of the pavement surface, at the interior of the church
- 10 – 50% of the façades surface

### Evolution of the damage

Salt damage is nowadays spread through the entire height of the walls. However, according to IPPAR verbal information, before the works of 1997/1998, the damage was mainly concentrated at the bottom of the walls.

The following pictures show the evolution of the damage at the exterior of the chapel, between July 2002 and October/November 2003. Damage seems to be growing very quickly.



Fig. 8 - SW (front) façade, July 2002



Fig. 9 - SW (front) façade, October 2003



Fig. 10 - NE (back) façade, July 2002

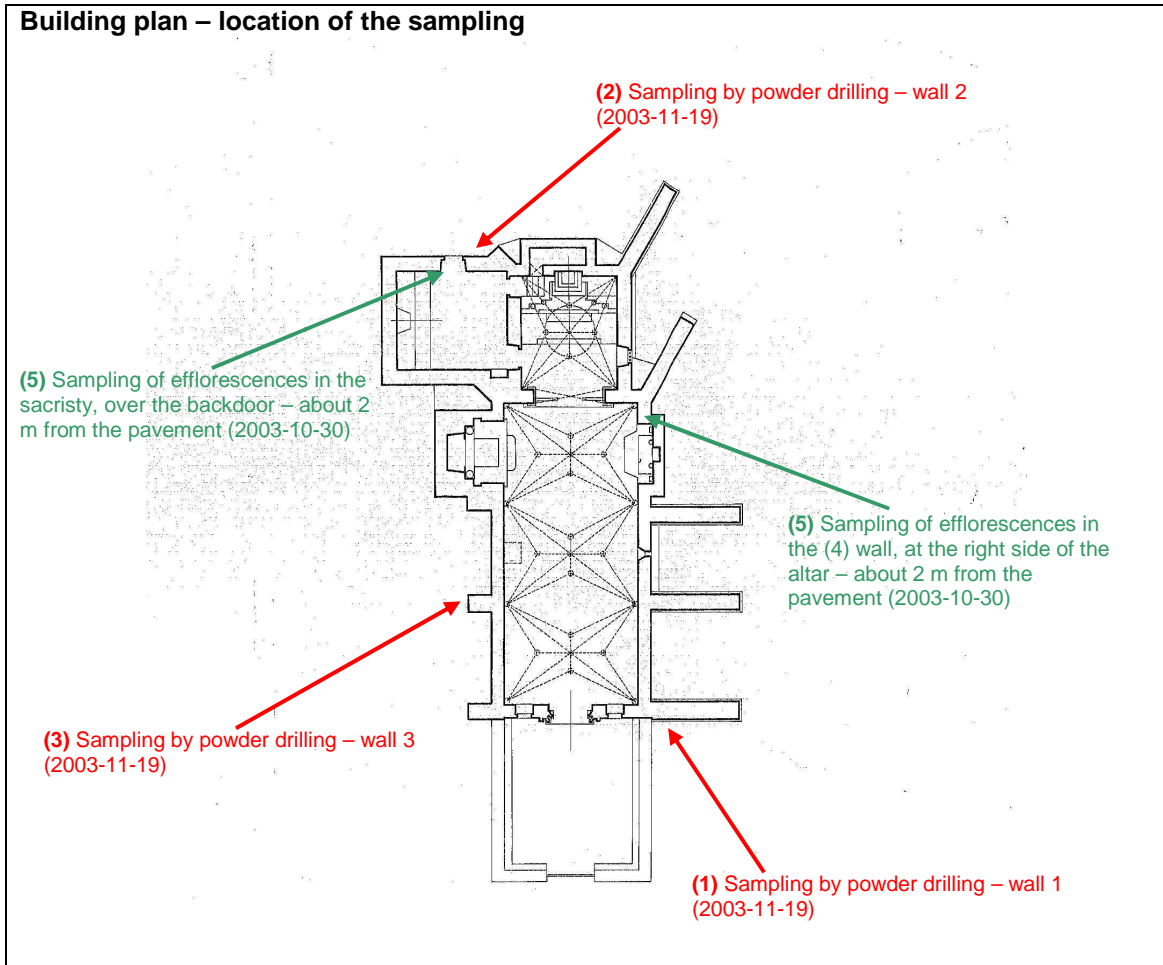


Fig. 11 - NE (back) façade, November 2003

<b>Type of damage and material(s) concerned</b>
Wall as a whole Moisture spots, water flow marks and biological growth at the exterior of the church.
Masonry elements (brick or stone)
Mortar
(Re)Pointing
Renders/plasters Cracking, sanding and crumbling of the render. Detachment of the paint layer and of the render superficial coats. Efflorescences on the plaster and detachment of the plaster paint layer
Other coverings Powdering of the pavement red ceramic tiles.



## ILLUSTRATIONS



## Picture of damaged area



Fig. 12 - Sanding of render and crumbling of render/paint system (2002-07-03)

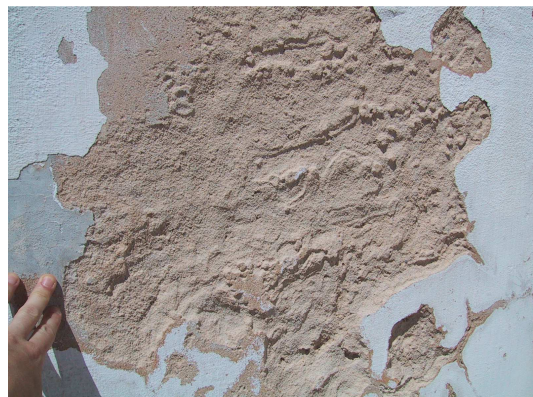


Fig. 13 - Erosion of render/paint system (2002-07-03)



Fig. 14 - Cracking and erosion of render/paint system (2003-11-19)



Fig. 15 - Cracking of render/paint system (2002-07-03)



Fig. 16 - Detachment of paint and cracking of render (2003-10-30)



Fig. 17 - Cracking of render (2003-10-30)



Fig. 18 - Damage seems to start from the cracks (2002-07-03) ... and from other singularities (2003-10-30)



Fig. 19 - Detachment of paint and of render superficial coat (2002-07-03)



Fig. 20 - Moisture spots and other degradation of render/paint system (2003-10-30)





Fig. 21 - Biological development at the base of the northern façade (2003-11-19)



Fig.22 - Water flow marks from the tiled roof and biological growth (2003-11-19)



Fig.23 - Detachment of paint at the interior of the church (2002-07-03)



Fig. 24 - Efflorescences and detachment of paint on an internal wall (2002-07-03)



Fig. 25 - Efflorescences, detachment of paint and sanding of render at the base of an internal wall (2003-10-30)

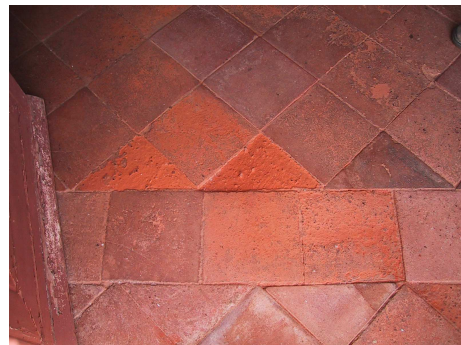


Fig. 26 - Powdering of internal pavement ceramic red tiles at the chapel main entrance (2003-10-30)

## ENVIRONMENT

### **Climatologically circumstances**

The church is very close to the Atlantic ocean (about 100 m from Sines harbour).

### **Exposition (rain, wind, etc.)**

The church is located in the top of a clifty cape, adjacent to the Sines harbour and so, it is very exposed to wind and rain. The SE façade is the one facing the harbour. The opposite NW façade, is the most sheltered one.

### **Surrounding environment (urban/rural/industrial, coastal/interior)**

Urban / coastal.

### **Additional data**

**DIAGNOSIS**

**Hypothesis(es)**

Damage is due to salts crystallization.

**Tests performed**

- Moisture content profiles and hygroscopic moisture content (HMC 80% RH and 95% RH) profiles, at two locations:
  - Back façade
  - Lateral (NW) façade (at a buttress)
- Ion chromatography on two superficial samples of each one of the two HMC profiles
- XRD characterization of efflorescences collected in the two places, at the interior:
  - Wall, at the right side of the altar (about 2 m from the pavement)
  - In the sacristy, over the backdoor (about 2 m from the pavement)

**Tests results**

Table 1 – Main type of materials found at the back façade (visual observation of powder samples)

Height (m)	Depth (cm)								
	0-2	2-5	5-7.5	7.5-10	10-15	15-20	20-25	25-30	30-35
4.0	LM	LM	LM	S	S	LM + S	LM	S + LM	LM
3.0	LM	S	S	S	S	S	S + LM	LM	LM
2.0	-	LM	LM	LM	LM	-	?	LM	LM
1.0	LM	LM	LM	LM	S	S	S	S	S + LM
0.5	LM	B + LM	B + LM	B + LM	LM + B	LM + B	LM + B	LM + B	LM + B
0.2	LM	LM	LM	LM	LM	LM	LM	LM	-

LM – lime-mortar; S – stone; B - brick

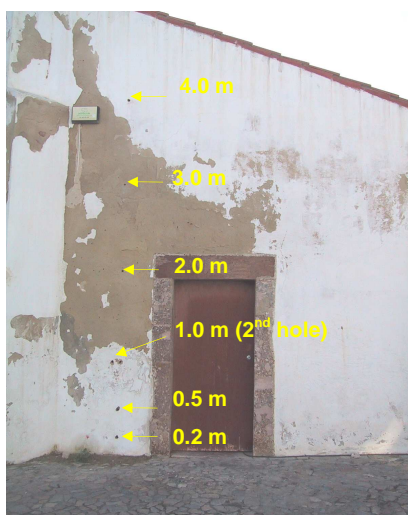


Fig.27– Location of sampling at the back façade

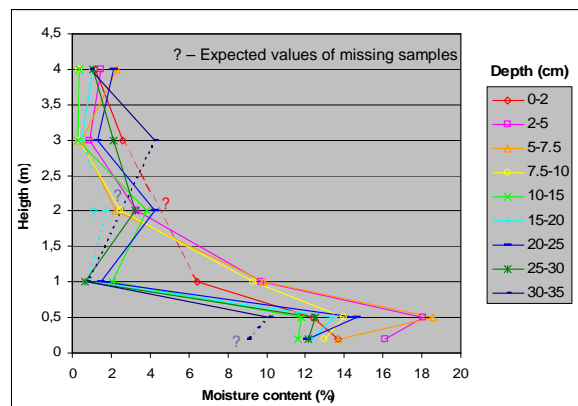


Fig. 28 – Moisture distribution in the back façade

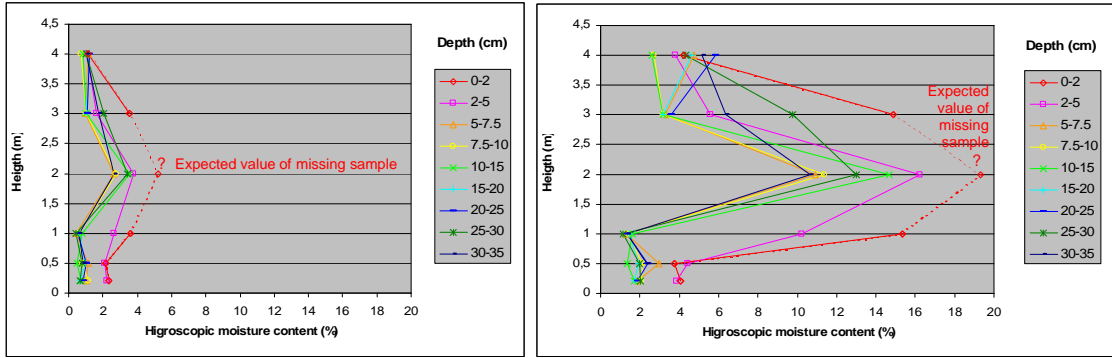


Fig.29 – Back façade: HMC at 80% RH (left) and at 95% RH (right)

Table 2 – Main type of materials apparently found at the lateral façade (visual observation of the powder)

Height (m)	Depth (cm)								
	0-2	2-5	5-7.5	7.5-10	10-15	15-20	20-25	25-30	30-35
3.2	LM	LM	LM	LM	LM	LM	LM	LM	LM
2.0	LM	LM	LM	LM	LM	LM	S	S + LM	S
1.0	LM	LM	LM	LM	LM	LM	LM	LM	LM
0.5	LM	LM	LM	LM	LM	LM	LM	S	S
0.2	LM	LM + B	LM	LM	LM	LM	LM + B	LM + B	-

LM – lime-mortar; S – stone; B – brick

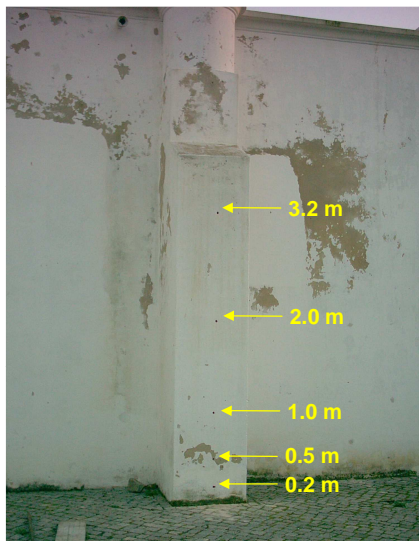


Fig.30 – Location of sampling at the lateral façade

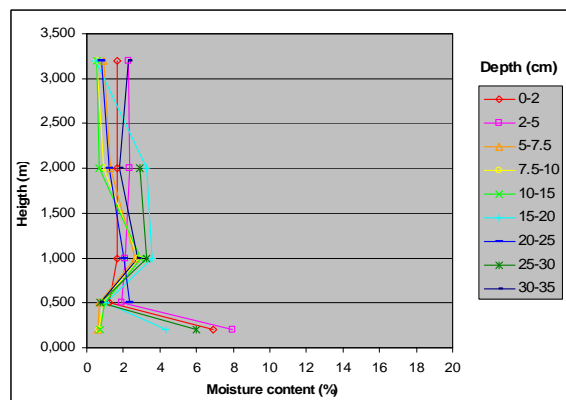


Fig. 31 – Moisture distribution in the lateral façade



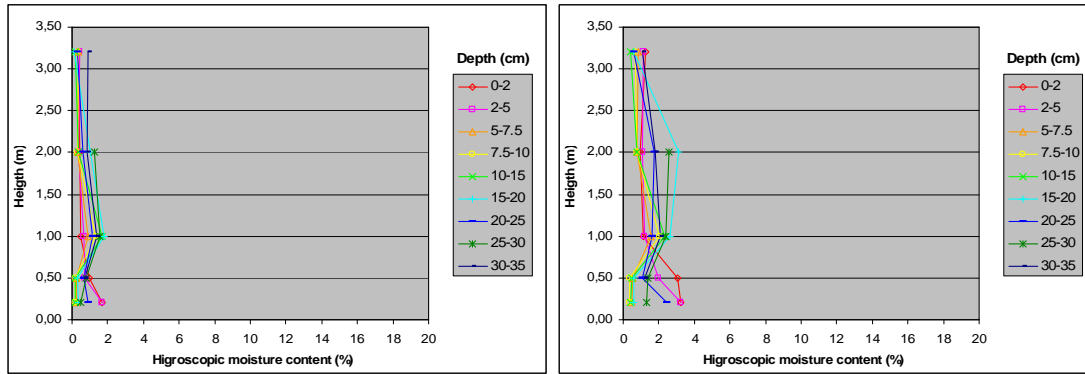


Fig. 32 – Lateral façade: HMC at 80% RH (left) and at 95% RH (right)

Table 3 – Ion chromatography on some of the superficial samples (0-2 cm) collected by powder drilling

Façade	Height (m)	Na <sup>+</sup>	K <sup>+</sup>	Mg <sup>2+</sup>	Ca <sup>2+</sup>	Cl <sup>-</sup>	NO <sub>3</sub> <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	CO <sub>3</sub> <sup>-</sup> (1)
Back	3,0	0,33	0,07	nd	0,73	0,60	0,33	0,08	*
	0,5	0,05	0,04	nd	0,51	0,16	0,04	0,09	*
Lateral	1,0	0,05	0,04	nd	0,43	0,07	0,02	0,06	*
	0,5	0,13	0,08	nd	0,44	0,08	0,07	0,14	*

(1) The carbonates were qualitatively detected by titration: \* - Present Nd - non-detected  
 The colours indicate the classification of the chlorides, nitrates and sulphates content, according to the WTA specification E-2-6-99/D: low content, medium content, high content

Table – XRD characterization of the efflorescences

Crystalline compounds	Efflorescences	
	Altar	Sacristy
Natron (Na <sub>3</sub> H(CO <sub>3</sub> ) <sub>2</sub> .2H <sub>2</sub> O)	++	++
Hydrous Sodium Carbonate (Na <sub>2</sub> CO <sub>3</sub> .7H <sub>2</sub> O)	++	+
Trona (Na <sub>3</sub> H(CO <sub>3</sub> ) <sub>2</sub> .2H <sub>2</sub> O)	+	vtg
Gaylussite (Na <sub>2</sub> Ca(CO <sub>3</sub> ).5H <sub>2</sub> O)	+	vtg

## Diagnosis

Analysis of the moisture content profiles (general decrease of the moisture contents with height) points for capillary rise being the main source of moisture (although it is not clear the reason why, at the back façade, the moisture content at the height of 0.2 m is lower than at 0.5 m).

The increase (very clear at the back façade, less clear at the lateral façade), towards the surface of the wall, of the moisture content at the base of the wall suggests that superficial water is the main responsible for the capillary rise. However, more profiles, namely at interior walls, would be necessary to be sure of this fact.

A certain irregularity of the moisture content profiles does exist but is not enough to ensure the existence of another simultaneous source of moisture, namely accumulation of rain water, inside the walls, during the works of 1997/98. Anyway, even if this other source does exist, the profiles are clear in pointing capillary rise as the most relevant one.

Moisture content is very high (between 12% and 18%) at the base of the back façade and it is expected that the same happens at the other areas with similar degradation (namely, at the front and at the lateral façade facing the harbour). At the buttress of the lateral façade (opposite to the harbour), moisture content (and also degradation) is not so high (a maximum of 8% at the base), but a general decrease with height also exists.

At the back façade, the salts contents are very high, especially in the superficial coats, above the 0.5 m and below the 4.0 m (where damage is also higher). Salts seem to be mainly chlorides (probably from the nearby sea, whether directly wind blown or mediated by deposition in the soil), but also nitrates (probably from the soil). The relevance of the presence of carbonates is not yet established for the exterior façades.

At the buttress of the lateral façade, which has an adjacent drain, the salts contents, the moisture contents and the damage are low.

At the interior, the efflorescences are mainly constituted of carbonates.

Visual observation of the chapel façades in the several inspections (see Evolution of Damage and Pictures of Damaged Areas), indicate that salt damage starts at the mortar cracks and other singularities.

## ADVICE

Further research seems necessary to detect the origin of the rising damp (superficial draining water or phreatic water). Apart from other moisture profiles, done at both the interior and at the exterior of the chapel, it is necessary to evaluate;

- The possible contribution for the superficial draining water of the eventual water-tightness of the pavement adjacent to the chapel;
- The real effectiveness of the existing drain;
- The existence of a high phreatic level in the area of the chapel;
- The possible relation between the nearby fountain and the high amounts of moisture that reach the base of the chapel walls.

Measures to reduce the capillary rise should be taken, according to the results of this research.

A total absence of moisture is not however expected to be achieved, namely due to the present accumulation of moisture inside the walls. The new renders should, therefore, respect the following general requirements:

- Low alkali content (the alkali ions, usually from the hydraulic binders or from poorly washed sands, may originate very soluble alkali carbonate salts).
- Very low sulphate (and also chloride) content (common portland cement is many times responsible for the introduction of sulphates in the walls of ancient buildings and that may also result from the use of poorly washed sands).
- Due to the presence of moisture and sulphates (even if in a low quantity), it is also advisable the use of sulphate resistant binders and aggregates (cement with low aluminates content and aggregates without reactive alumina).

The new renders should be resistant to cracking, namely to cracking due to the drying shrinkage.