Cause of decay and intervention on external mortars of the S. Vittore Church - Stresa (Italy)

Causas de decaimento e intervenção nas argamassas exteriores da Igreja de S. Vittore - Stresa (Itália)

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Abstract

The ecclesiastical complex entitled to S.Vittore rises on the Pescatori Island in the Lake Maggiore in the northern Italy. The building was constructed in the X century and was afterwards widened in the XVII century. Inside the several steps in which the total plan of restoration of the church is divided (the diagnosis and the elimination of the causes of decay, the restoration of the external mortars and of the internal frescoes, the control of indoor environmental conditions), this work concerns the preliminary diagnostic and cognitive investigations and the subsequent intervention on the external mortars. The initial investigations have been addressed to understanding the causes of decay of the building and to the characterization of the external mortars. It was so verified that the main cause of decay is the water present in masonries coming from the meteoric water rather than from rising damp through the ground. The characterizations of the external mortars have shown that visible differences between the ancient (X century) and the more recent masonry parts result from the different binder-aggregate ratio, rather than from the mineralogical-petrographic composition. Following the results of this first step of the investigations, the rain water-drainage of the ground around the church has been carried out in order to collect and to remove the meteoric waters; the collection and removal system of the rain-waters has also been arranged. With regards to the external plasters, to ensure the visual, material and functional compatibility with the existing mortars it has been carried out the sealing and integration of existing mortars and plaster with compounds chosen on the basis of the analysis results and of the local constructive traditions. "Protected" in this way the external covering, the plan will continue with the internal restorations.

Keywords

Diagnostic investigations; external mortar; rising damp; drainage.

Resumo

O complexo eclesiástico consagrado a S.Vittore eleva-se na ilha dei Pescatori, situada no Lago Maior, no Norte da Itália. O edifício foi construído no século X e posteriormente ampliado no século XVII. No âmbito dos diversos passos nos quais se divide o plano global de restauro da igreja (diagnóstico e eliminação das causas de degradação, restauro das argamassas de exterior e dos frescos no interior, controle das condições ambientais no interior), este trabalho diz respeito ao diagnóstico preliminar e investigações cognitivas e à subsequente intervenção sobre as argamassas de exterior. As investigações iniciais foram dedicadas a compreender as causas de degradação do edifício e à caracterização das argamassas de exterior. Foi, deste modo, verificado que a principal causa de degradação se deve à presença nas alvenarias de água sobretudo proveniente da chuva (água meteórica), mais do que da humidade ascensional a partir do solo. A caracterização das argamassas de exterior mostrou que as diferenças visíveis entre as alvenarias mais antigas (século X) e as mais recentes resultam de rácios ligante-agregado diferentes, mais do que da composição mineralógico-petrográfica. De acordo com os resultados deste primeiro passo da investigação, foi efectuada a drenagem da água da chuva no solo que circunda a igreja, com o objectivo de recolher e remover as águas meteóricas; foi adicionalmente colocado um sistema de recolha e remoção das águas pluviais. No que diz respeito aos rebocos exteriores, para assegurar a compatibilidade visual, material e funcional com as argamassas existentes, foram efectuadas a selagem e integração das argamassas e rebocos existentes com compostos escolhidos com base nos resultados das análises e nas tradições de construção locais. Com o revestimento exterior "protegido" desta forma, o plano prosseguirá agora com os restauros no interior.

Palavras-chave

Investigações de diagnóstico; argamassa de exterior; humidade ascensional; drenagem.

Introduction

The restoration of an historical building must always be preceded by a careful and complete phase of instrumental diagnostic and historical-bibliographical search to estimate the state of decay of the building, to know the decay mechanisms and the materials and techniques used for its construction. To this first phase of knowledge, it will follow the elimination (or reduction) of the causes of decay of the building, the restoration of the building and, where it is possible or necessary, the indoor conservation conditions improvement of the building and of its contained works of art.

All these steps have been followed in the plan of restoration of the S. Vittore Church. The article describes the phases finished up to now: the research of the causes of decay, the intervention on main of these and the restoration of the external plasters of the church.

The intervention plan

The building and its state of conservation

The S. Vittore Church is a small dimensions building (width 10.8 m - length 16.2 m) that rises on the rocks bench that forms the small Pescatori Island in Lake Maggiore, always crowded by many visitors.

Of the first single nave Romanesque oratory of the last quarter of X century, originally dedicated to S. Gandolfo, remain the apse and parts of the boundary walls, pointed out towards the north-west and the south-west, then absorbed in the successive widening of the church.

The cover of the Romanesque portion had to be constituted from a hut roof of tile, supported by a wood truss (some tiles of remarkable dimensions are still visible on the fronton, absorbed in the more recent masonry).

Beginning from the 1500's, the Romanesque church was entitled to S. Vittore and underwent a series of transformations that reduced the apse to one of the lateral naves of the new church constructed on it, partially using its masonries. Between the 1600's and the 1700's, the church underwent further enlargements.

The external masonries of the church are plastered, except for a portion of the Romanesque part exposed to the north-west with cutstones at sight and only some traces of original plaster (Figure 1).

The church contains a series of frescoes, valuable marble altars, a pulpit in inlaid wood of walnut and four busts of Saints of the Church.

One of the main aim of the restoration is to bring back to light a series of frescoes, at the moment covered by a white washing layer, discovered in a small room on the south-west side of the Romanesque portion; the room (on whose external wall is recognizable the ancient opening of approximately 2 m overhang from an arc delimited by "roman bricks" emerging from plaster) has been up to now used as a warehouse. The plan previews the partial demolition of the dividing wall in order to allow the full fruition of frescoes as it had been thought to the age of their realization.

Fig. 1 The north-west side of the Romanesque part of the church.

The visual investigations and the observation of the macroscopic state of conservation of the building and its surfaces allow two reflections that have partially directed the following successive cognitive investigations. On one side, it is obvious the distinction between the more ancient part and the following interventions: testified by the comprehensive view of the whole building and the different renders of the external and internal walls. On the other side, the internal surfaces of the Romanesque part of the building show the greater decay, with plaster lacunae, rising damp with white efflorescence and the erosion of the columns of the two lateral altars and of the baptistery plaster. The external plasters show many concrete patches and a kind of decay due to the atmospheric and structural conditions: lacunae, small cracks, biological growth.

The plan themes

The aim of the plan is the conservative restoration of the monument. The interventions have been lead in the respect of the restoration guidelines, with special attention to the following disciplinary principles:

- respect of the existing for its documentary value;
- least intervention: the removal of every element of the building has been limited to the minimum indispensable;
- chemical-physical compatibility of all products used for the interventions;
- reversibility: the materials and the procedures have previewed, within feasible limits, the possibility to return to the status-quo preceding the intervention.

Diagnostic investigations: methodology of the measurements

Diagnostic instrumental investigations have followed three parallel paths: the measure of the hygrometric state of masonries, the monitoring of indoor microclimatic conditions and the characterization of the external plasters.

The hygrometric state of the masonries is characterized from the values (and their variations in time) of water content in walls and of the soluble salts content. The water content has been measured with the gravimetric method [1] applied to the samples extracted from masonries at two different depths from the surface and at various quotas from the floor level (sampling from the internal surfaces has been limited to the single quota of 10 cm). The measure, slightly invasive, has been carried out in 9 Points of measure on the internal walls and in 11 Points of measure on the external walls (Figure 2) and repeated in four days chosen like representative of the various seasonal periods: 29 September 2003 - 5 February 2004 - 28 May 2004 - 10 September 2004.

Between two subsequent water content measures, the Permanent Points of Measure (PPM) method has been applied; by a brick cylinder put in the hole made in the first day of measures with the gravimetric method, PPM method allows the qualitative estimation of the water content in masonries, avoiding to remove other material from the building. [2].

The contents in soluble salts with ionic chromatography were also analyzed [3].

Indoor microclimatic conditions monitoring has been carried out to estimate both the eventual negative winter heating effects and to collect reference data to check if the future interventions already planned (the installation of a walls dehumidification system and the elimination of the wall of the frescoed room of the

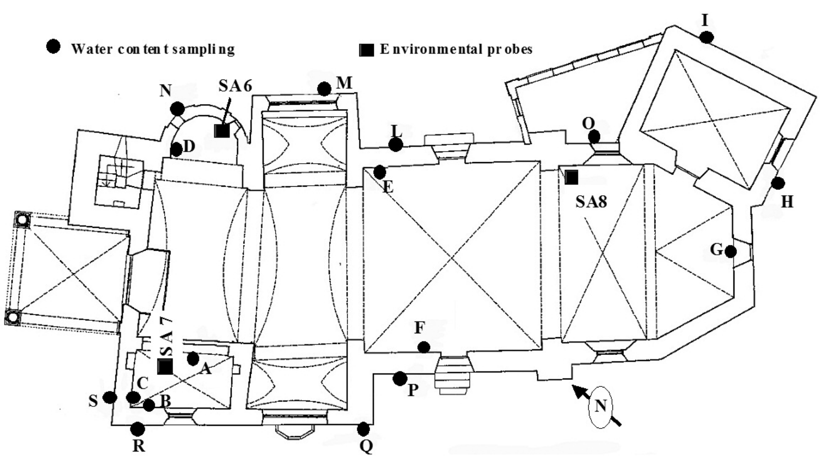

Fig. 2 Position of the zones of masonries water content measures (in some zones sampling has been carried out at various quotas from the floor plane) and of the probes for the indoor conditions monitoring.

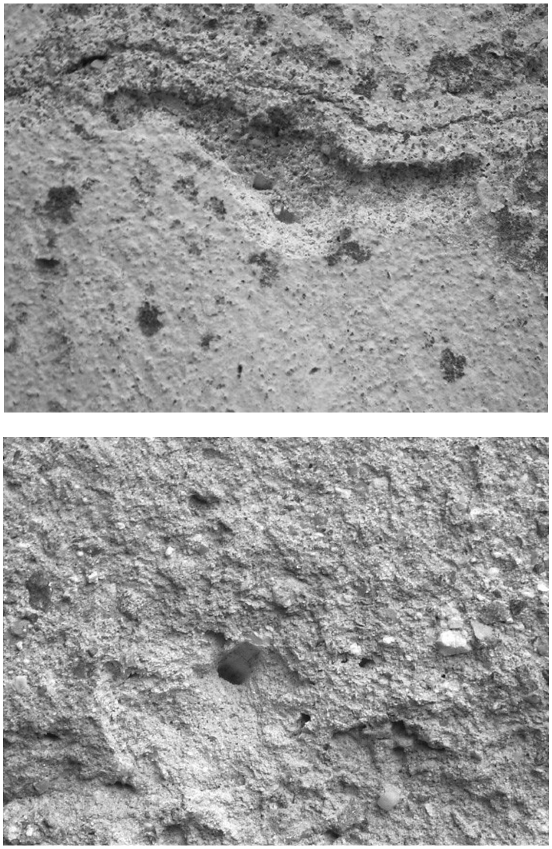

Fig. 3 The different appearance of the older plasters (above) and recent one (below).

Romanesque portion) will have effects on the environmental air conditions.

The analyses on the external plasters had analytically to explain the visible difference between the older plaster (in the Romanesque part of the church) and those most recent in the rest of the building (Figure 3) and to characterize the bedding mortars of the Romanesque part. Sampling was carried out taking into account minor damage to the walls; for this reason, rendering pieces were obtained at edges where detachment was initiating on three sides of the church (excluding the facade). In order to obtain as complete as possible a characterization so as to enable later execution of similar mortars based on the information gathered, X-Ray diffraction (to determine the mineralogy) and observation of thin section by optical microscopy with transmitted and polarized light (to check mortar's microstructure) were carried out.

Results

Water content in the walls

The water is distributed in a non uniform way in the various inquired walls. The average water content values (measured in all points of measure of the Figure 2 at 10 cm height from the floor plane) are shown in Figure 4.

The Romanesque portion of the church shows the greater water contents in masonries (Figure 5) without

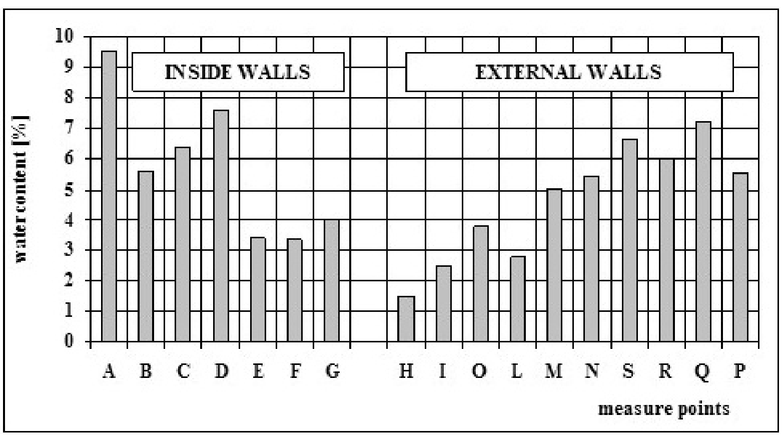

Fig. 4 Average water content.

difference between the different sides of the building. The result is in accordance with the greater decay of this part of the building drawn above.

PPM method has allowed to verify the variations in time of the values up to here indicated in absolute terms. The Romanesque part of the church has also the greatest water content values: the water in the walls keeps high and almost constant for great part of the year. In the rest of the church, on the contrary, the water contents are low. The outdoor walls show a greater variability in accordance with the unsteady evaporation caused by air movement (Figure 6).

The geologic inspections leave out the hypothesis of water stagnations or phenomena of capillarity in the cliff below the church. The water distribution in the masonries and its variations in time can then be explained by the different hygrometric behaviour of the materials of the Romanesque part regarding the rest of the building and by the presence of an "external source" of water fed by meteoric water that falls in the strip of land that runs along the building.

The "external source" is also deducible by salts contents analysis. The eighteenth-century portion of the church shows high nitrate contents that, by way of the water transport, come from the outside cemetery that completely encircles the apse.

Also in this case, a difference between the two constructive ages of the building is found, since the walls of the Romanesque portion have a higher content of sulphates: the efflorescences taken from the surface of the

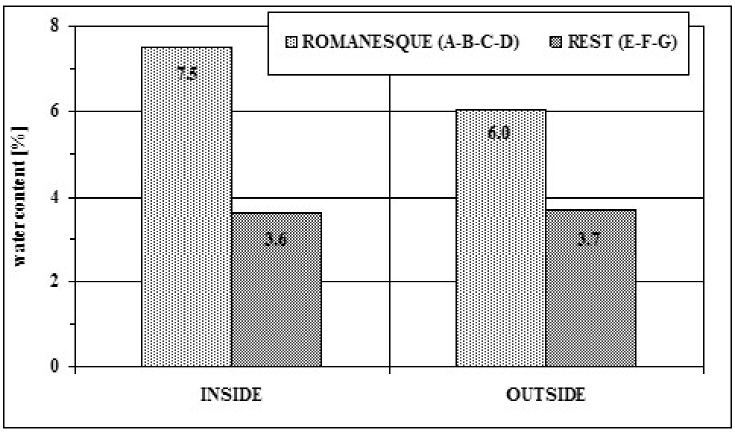

Fig. 5 Comparison between the average values of water content of masonries measured in the Romanesque part and in the rest of the building.

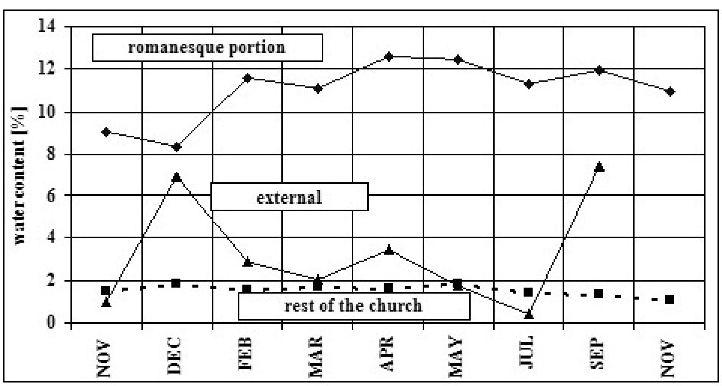

Fig. 6 Water content vs. time.

Romanesque part are in fact constituted by calcium sulphate bi-hydrate (gypsum - $CaSO_4 \cdot 2H_2O$) and magnesium (hexaedrite - $MgSO_4 \cdot 6H_2O$ - and epsonite - $MgSO_4 \cdot 7H_2O$).

The results of the diagnostic measurements and their analysis have therefore addressed the plan towards a first outdoor intervention of water-drainage of the strips of land that encircle the foundations of the building (upon the cliff).

The characterization of the external plaster

The sampling and the analyses have been lead in order to estimate the visible difference between the plasters of the two parts of the Church, the "ancient" Romanesque part and the eighteenth-century "recent" part.

Samples indicated as "ancient" are characterized by mortars with weakly magnesian lime binder with micritic texture and with irregular shaped cavities. The aggregate is made of silicate sand with angular quartz rounded metamorphic rock The aggregate show a variable granulometry from 0.2 to 1.0 mm (cliff fragments have greater dimensions that can arrive to 3-4 mm). The binder-aggregate ratio is approximately 3: 2.

The "recent" plasters have the same mineralogicalpetrographic nature of the "ancient" one, but show a minor percentage of the aggregate, with a binder-aggregate ratio 1:1 (Figure 7).

The samples of bedding mortar show the same composition and binder-aggregate ratio of the samples of the "recent" plasters group.

The analytical analyses therefore have indicated that the plasters settled on the external walls of the church (surely during the subsequent maintenance of the building) have been obtained with the same materials, probably coming from nearby quarries (the near Valley of Ossola has certainly been an historically testified source of supplying for the buildings of the lake Maggiore) mixed in different ways.

Subsequent stratigraphical-archaeological plasters sampling in the Romanesque apse have allowed to find a lime coming from furnaces from the neighbouring Caldè, recognizable for the light rose coloration. The presence of the furnace for the lime production from local stones is testified beginning from the XIII century from annals of the "Fabbrica del Duomo" (Milan Dome Factory) with a seasonal production alternated with fields working. The production became stable in the 1800's. The furnace has been then stopped after the Second World War; currently the rests of the furnace make a little port for the navigation on the Lake Maggiore.

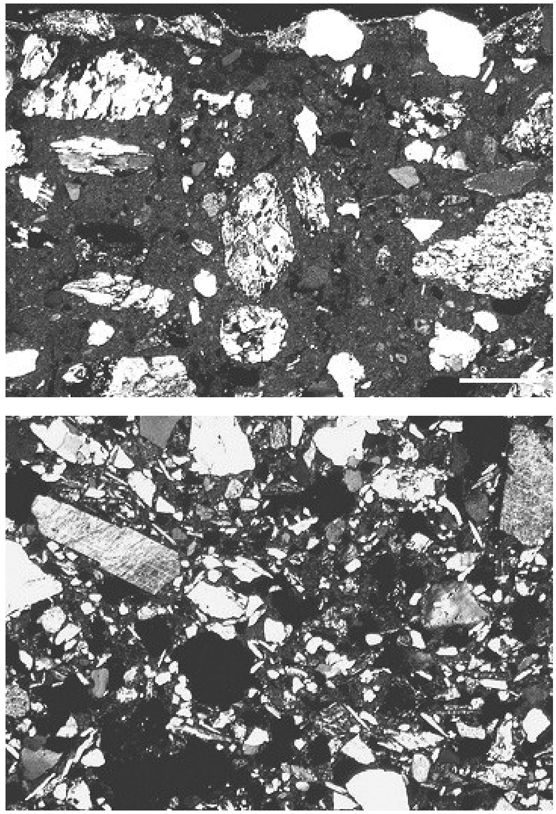

Fig. 7 Thin sections of a sample of "ancient" (above) and "recent" (below) plaster observed with the optical microscope in polarized light (bar = 100 μm).

The interventions

The interventions against water

Following the indications of the diagnostic investigations discussed in chapter 4.1, the first outside intervention on the building had the aim of removing from the church the meteoric water that falls in the proximity of it. In an excavation carried out around the building, a drainage

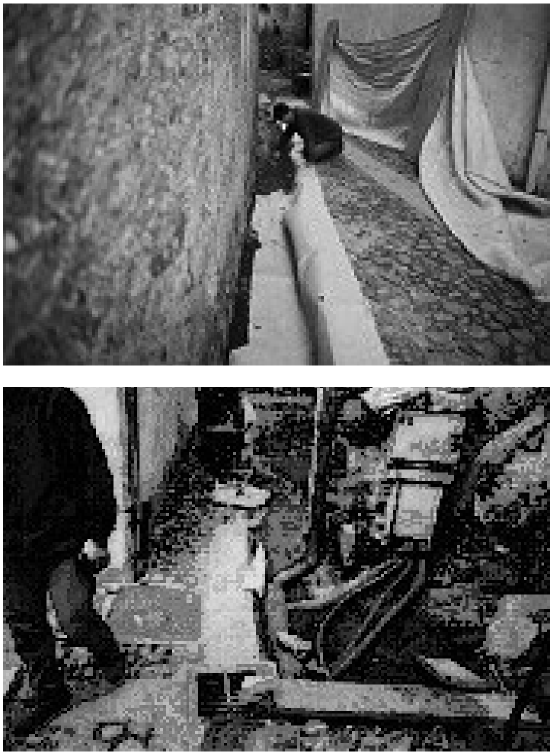

Fig. 8 The excavation and the drain strip around the church.

pipe has been put down and connected to the public water discharging; all the down-pipes of the meteoric waters collection plan have been connected to the same canalisation. The excavation has been then covered with a gravel layer of various diameters in order to obtain an effective water-drainage (Figure 8).

The interventions on external plaster

After the first phase of cleaning and consolidation (with injections of hydraulic lime and micronized binder) of the plasters, the phase of integration of gaps has been carried out following the diagnostic indications: using therefore the same compounds (seasoned air lime and different granulometry aggregates: fine sand, sand with diameter 1 mm, gravel from 5 to 9 mm, quartz crystals with size from 3 to 7 mm, micronized "cocciopesto" with diameter from 1 to 6 mm) for every single integration their ratio has been varied so as to integrate it with the existing plaster to match its granulometric and chromatic appearance (Figure 9). When necessary, a chromatic veiling with watercolour has been executed to better meet the original plaster colour.

Fig. 9 An example of integration of gaps of the external plaster (above) and of the bedding mortar (below).

The same procedure and materials have been adopted for the integration of the bedding mortar of the Romanesque portion of the church.

Conclusions

Because the described diagnostic analyses and the intervention on the external mortars are a part of a diffuse procedure of restoration, the authors wish to emphasize the integration of these procedures within a wider plan that has placed diagnostic investigations as an essential step to define every intervention of restoration of an historical building. After the described intervention, other works are previewed for the church indoors: the installation of a masonry dehumidification system (whose effectiveness will be measured in time), to bring back to their original context the frescoes contained in the warehouse of the Romanesque portion after their restoration, to remove soluble salts from walls. All these interventions will be controlled and supported by new measurements carried out to control the effectiveness of the masonry dehumidification, to help the restorer in the choice of the better salts removal technique and to check the new microclimatic indoor conditions in order to verify the possible necessity of a further plant intervention on the thermo-hygrometric air conditions.

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