9TH INTERNATIONAL SYMPOSIUM ON THE CONSERVATION OF MONUMENTS IN THE MEDITERRANEAN BASIN

Improvements in Conservation and Rehabilitation - Integrated Methodologies

PROCEEDINGS

Edited by E. N. Caner -Saltık,
A. Tavukçuoğlu, F. Zezza

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PREFACE

Dear Colleagues and Students,

It is a great pleasure for us to host you in Middle East Technical University in Ankara. We thank you very much for all of your efforts to participate in the Monubasin9 Symposium and share your knowledge and experience together with us. Our common interest and concern on the conservation of monuments belonging to humanity has brought us together. People from many disciplines: engineers, architects, restorers and conservators, archaeologists, art historians, geologists, scientists in the fields of chemistry, physics and biology, people from cultural institutions who work on heritage management, manufacturers of building materials and conservation treatment products will present their studies related to the conservation of monuments.

The thematic areas of the symposium are:

- physical and (bio)chemical processes in material deterioration
- historical, structural and technological aspects of monuments
- methodologies of damage assessment
- technologies for damage rehabilitation – conservation
- digital techniques for cultural heritage
- management of cultural heritage rehabilitation and conservation
- development of decision making tools for diagnostic studies, rehabilitation technologies in monuments

The main theme chosen for this symposium is “IMPROVEMENTS IN CONSERVATION AND REHABILITATION – INTEGRATED METHODOLOGIES”, with the aim of building up stronger links between scientific research results and conservation practice.

More than 200 authors from 18 countries from Algeria, Belgium, Chile, Egypt, France, Germany, Greece, Jordan, India, Iran, Italy, Malta, Poland, Portugal, Russia, Spain, Tunisia, and Turkey have contributed to this symposium. We are going to follow their presentations. The joint efforts will certainly be very fruitful for our goal on the development of monuments conservation.

Wishing us all an enjoyable and successful symposium.

Emine N. Caner-Saltık
Coordinator of Organizing Committee

THEMATIC AREA II

HISTORICAL STRUCTURAL AND TECHNOLOGIAL ASPECTS OF MONUMENTS

REFURBISHMENT BETWEEN TRADITION AND INNOVATION. THE CHURCH OF *"PIO MONTE DEI MORTI"* IN POMARICO (ITALY)

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***Keywords**: refurbishment, recovery intervention, conservation, suitability, values.*

ABSTRACT

To undertake a suitable intervention, three questions have to be answered: "whether", "where" and "how" to restore. The fourth question could be added, in which the economic aspect dominates: "when" to restore. To be able to respond adequately to these questions, it is necessary to proceed by developing specifications step by step, starting from a detailed knowledge of the entire building, the level and causes of degradation, and by finishing with the "operational" description of the proposed interventions as well as to define the functional organization of the liturgical space.

The preliminary data acquisition phase, the direct survey of the building characteristics and condition are accompanied by the research on the project documentation and the events that have affected the structure during its life. Then, it's necessary to plan the restoration of built heritage as a system in which technical and cultural variables create a balance between decisions and processes of conservation and transformation.

This methodological approach has been tested in the restoration intervention of the Church of "Pio Monte dei Morti" in Pomarico (Italy). The church, dated XVI century, is of great importance for the pastoral and social activities in Pomarico, becoming a key element in the story in the city. To use an application methodology, more respectful of the built heritage that do not attend a simple "uncritical transposition" of construction concept of building, it means to restore the monument its importance and value.

INTRODUCTION

The conservation intervention on a historic building, regardless of its architectural and/or artistic value, is generally more appropriate if informations on its construction, evolution to date, materials, construction techniques and structure is available [1].

In fact, it's no possible ignoring the importance of the diagnostic phase both for the intervention control and for the global behaviour of the building system, especially within a program of long-term building maintenance.

The problem of the consolidation and restoration of the monumental buildings is strongly articulated for the typological heterogeneity and structural and technological complexity [2] as well; sometimes also for the limited availability of adequate resources - including economical ones - for their safeguard.

Always, the issue of monuments conservation has been the subject of attention by technicians; in fact, in the Athens Charter (1931) it reads that *"the preservation of artistic and archaeological heritage involves all states that are guardians of civilization [...] and it hopes that they can express their interest for the heritage preservation that are expression of civilization"*.

Therefore, assumed the monument as an expression of a particular place [3], there is the problem of *"how"* to operate on them to protect themselves from the degradation action.

In fact, both the protection and conservation of monumental heritage [4] show different - and sometimes alarming – aspects which help us to identify the commonly called *"the architectural emergency"*.

This approach, with its interconnections linked to the intervention suitability and durability, was applied on recovery intervention of a church called *"Pio Monte dei Morti"* in Pomarico (Italy).

In fact, to undertake a suitable intervention [5], three questions have to be answered: whether, where and how to restore. The fourth question could be added, in which the economic aspect dominates: when to restore. To be able to respond adequately to these questions, it is necessary to proceed by developing specifications step by step, starting from a detailed knowledge of the entire building, the level and causes of degradation, and by finishing with the *"operational"* description of the proposed interventions.

In fact, changes, modifications, partial demolitions as well as reconstructions are very usual in the life cycle of the monumental buildings and - as the reasons that have caused are not always respectful of the static characteristic of the monument - its efficiency could be compromised; a very high percentage of damage and instability in monumental buildings could be attributable to these changes; they could be not sufficiently respectful of the static balances (stabilized over time) and they could prompt new stress.

THE METHODOLOGICAL APPROACH

To increase the safety of a structure, it is possible to operate in two ways: remove the causes or contrast the effects.

The first type of intervention leads to a reduction of the loads imposed on the structure, reducing the existing structural imbalances. Examples are: (a) the adoption of tie beam for pushing structures, (b) the shielding of the vibrations induced by traffic using sound-proofing material, (c) the use of underpinning in the case of foundations settlement.

Moreover, there are interventions that involve the geometry of the structure (such as the realization of joints between adjacent buildings affected by differential settlement or the gradual correction of the overhangs) that are able to drastically reduce the stresses imposed to the structure.
The second type of intervention, which – as said above – tends to contrast the effects, involves integrations or modifications to the material or structures, preserving the geometry and loads, as it was the case study. It's convenient [6], when it is decided to restore, to operate using a

unified methodology that involves all the interventions over time. In fact, inserting much rigid material in the monumental building means to modify in a significant way the loads on the building; it could generates a possible localized failure, which may produce a widespread mechanism of collapse.

For this reason, it is often necessary to replace (if necessary) the degraded components with new elements with characteristics as similar as possible to the original ones [7].

Among the specific intervention techniques, which tend to contrast the effects of the material degradation [8], it can be considered two categories: the first concerns the actions that tend to restore or improve the characteristics of the degraded materials (preserving the static characteristics of the structures); the other concerns the interventions that add new structures to existing ones.

THE USABILITY AS A CONSERVATION INSTRUMENT

"To preserve means to use": this is a most important assertion that constitutes a fundamental condition for built heritage conservation debate.

It follows that the recovery intervention can and should be developed thorough a specific technical and scientific building knowledge, thorough the study of its constituent elements and the analysis of its values; in fact, it is necessary to relate interventions to their capacity to satisfy the functional and performance requirements expressed by the user.

So, among the conservation and preservation of historical built heritage and the requirements expressed by the users, there is not an "*irreconcilable"* conflict.

In fact, the requirements expressed by the users must be considered as normal elements of design like - for example – the structural stability. This process it could be possible when it accepts a progressive and critical idea of the recovery, as a characteristic act of the present time and not as a *"freezing action"*: the recovery, in fact, looks to the future and not to the past.

This was one of the specific aspects of the intervention design on the above said church; it was built as church and it could continue to preserve that function, even though in a revised *facies* that gives it an historic readability and, at the same time, the possibility of its reuse.

Therefore, the principle of the *"integrated refurbishment"* (defined by analogy with the *"integrated conservation"* as set out in the Charter of Amsterdam, 1975) highlighting the impossibility to realize a recovery intervention without emphasizing the close relationship between the intervention and the choice of a suitable function.

This function must be fully compatible with the historical and technological nature of building and at the same time open to the requirements that contemporary life imposes.

In this way, the function becomes an instrument (not an object) of conservation or – better - it will be the conservative instrument par excellence.

THE OPERATIONAL METHODOLOGY

The intervention procedures for restoration [4] refer to a *"traditional methods"* of intervention as well as to use *"modern"* materials, techniques and historical construction elements and innovative technological approaches (through the integration between tradition and innovation), as well [9]. There isn't a theoretical foreclosure for implementation of innovation in the restoration, whose role can be identified in the definition of a new balance between space, materials, new elements and technology; it is not a requirement of modernity, but a conservation tool, a way to reconnect the tradition (when it can not respond to specific needs) to the contemporary lifestyle [10]. So conservation, fruition, safety, functionality and maintenance efficiency have been the goal in the intervention design of the church *"Pio Monte dei Morti"*.

The methodological approach to restoration suggests, therefore, the consciousness that the human interventions can lead to irreparable separation between the historical process evolution of the area and the monumental buildings. The evaluation of the different components can be integrated in the general procedures of design, especially for those which (by their nature or characteristics) are highly susceptible to environmental conditions. In this context, it is necessary to define a methodological approach for the identification of operative rules for the evaluation of restoration intervention, starting from the preliminary definition of project.

THE INTERVENTION DURABILITY

The durability of a restoration intervention is determined by the material's ability to last over time, resisting to the aggressive actions of the environment, but ensuring the performance required [11]. This interdependence (durability and intervention) is strongly linked to the suitability (mechanical, physical or chemical) of materials used in the interventions. The material's suitability very important for the building; in fact, if it uses a unsuitable material, it can lead to pathological phenomena that could compromise the static equilibrium of the structure.

The material durability is necessary, but not sufficient to ensure the durability of the whole structure: there are causes of structural degradation that can not be attributed to a lack of material durability, but to the component defects. So, the restoration project became a complex tool both for the intervention management and for the design control during the building construction. To evaluate the durability in the design phase, it needs to provide solutions that are able to guarantee performance more than minimum required by the rule or customer; it is necessary, therefore, to propose solutions (regarding materials, techniques and technologies) that have an initial *"performance surplus"*; it could taking into account the decay curves and the possible maintenance interventions.

It also take into account the characterization of the building structure and - as it is clear in the case of the church *"Pio Monte dei Morti"* – the specificity of the surrounding environment, strongly characterized by a morphological complexity of the fabric of the city and, not least, by the reduced accessibility. The use of the same or a similar material, assembled with construction technique suitable with the original one, can improve the restoration intervention,

extending the usability and increasing the *"curability"* of a building [12]; this is the approach to restoration intervention of the church *"Pio Monte dei Morti"*. The evaluation is carried out by (a) establishing the relationship between technological performance and material's suitability and characteristics, (b) evaluating the behaviour of the solutions adopted over the time, (c) verifying the behaviour of the each building component in relation to the useful life of the building, (d) designing maintenance strategies, (e) allowing the evaluation of the project related to the user's needs over time.

INTERVENTION MATERIALS AND TECHNIQUES

The intervention technical and material choices are suitable with the contemporary debate about restoration of the built heritage. They regard the principles of *"minimum intervention"*, appropriateness and suitability, referred to the architectural context and methodological approach, above expressed. In fact, the recovery intervention is much more than the choice of way to guarantee the required performance; it becomes a careful research of the needs expressed by the user and of the alternatives for their satisfaction. A *"suitable"* restoration [13] allows, therefore, to test the appropriateness of the choices by overcoming the logic of the "*case by case"*: this means that the intervention hypothesis are not determined *a priori*, but through detailed observations and analysis; it also means to recognize a value to a building.

The restoration intervention of an architectural structure with strong historical and cultural value, must be understood not as a simple act but in a wider process which can be defined as *"the practice of conservation"* [14].

The mechanical properties of materials will be investigated to classify its mechanical properties, in order to carry out a load-bearing, constructive and structural qualification of the building structure.

THE CASE STUDY: THE CHURCH OF *"PIO MONTE DEI MORTI"*

Area characterization

The church of *"Pio Monte dei Morti"* is located in the city centre of Pomarico (a little town in the southern part of Italy) [16], close to the old church (now destroyed) of *"San Michele Arcangelo"* and near the ruins of the ancient castle as well; it is in an urban fabric strongly articulated and characterized (Figure 1) by narrow streets, according to the usual typology of the historical centres of the area.

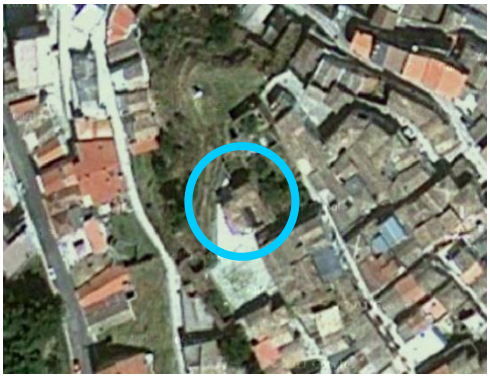

Figure l. Area characterization

The building has a very importance role in the history [17] of the city, although it was closed for many decades; it was abandoned and made the subject of repeated vandalism (in fact, it was removed the interior decorative ornament, the floor and the main altar, as well), assuming the appearance of a ruin. Inside, there was props and protection structures realized after the earthquake of November 1980.

Building characterization

The church has a single nave ending with the presbytery; in the nave, on the lateral walls, are located two altars. It has a length (Figure 2) of approximately 11.00 m and a height of about 6.50 m on the nave (whose cover is constituted by a barrel vault with groin) and about 8.50 m on the presbytery (whose cover is constituted by a cross vault).

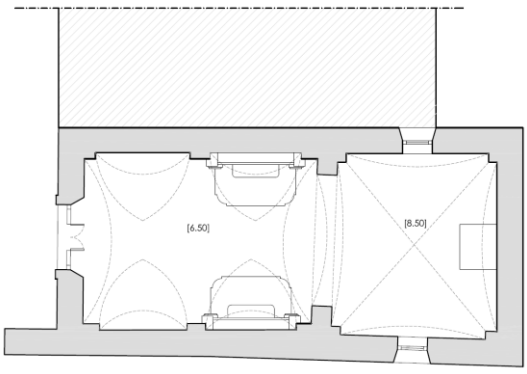

Figure 2. Church plant

Figure 3. Church conservation state

The church was built using masonry load-bearing in local stone very irregular (according to the traditional local construction systems) [15]. The main facade is onto a small, narrow urban street (Figure 3). The entrance is constituted by a mail door, which does not have decorations, but that is defined by simple sequence of clay bricks to form the architrave and door jamb; above the main door, there is a large window that is the natural light point for the nave; the facade ends with a double sequences of arches, that form the bell gable of the church (Figure 4).

Figure 4. Bell gable of the church - Particular

Regarding the lateral sides, the right one is close to a private garden, while the opposite one (left side) was on a private building that was built added to the church. The behind side shows a significant crack (in the vertical guideline); it is in an area heavily tampered, with two closed windows and a central ones, largest than the other but equally closed using brick. So, the masonry has modified several times the geometry of the loads (and of the formal type as well); it has reduced its resistance and load bearing capacity. The cover (Figure 5), as said before, consists of a barrel vault (nave) and a cross vault (presbytery) whose buttress was realized using topsoil (according to the local construction system) to form an inclined plane on which were placed the brick tiles to form the roof.

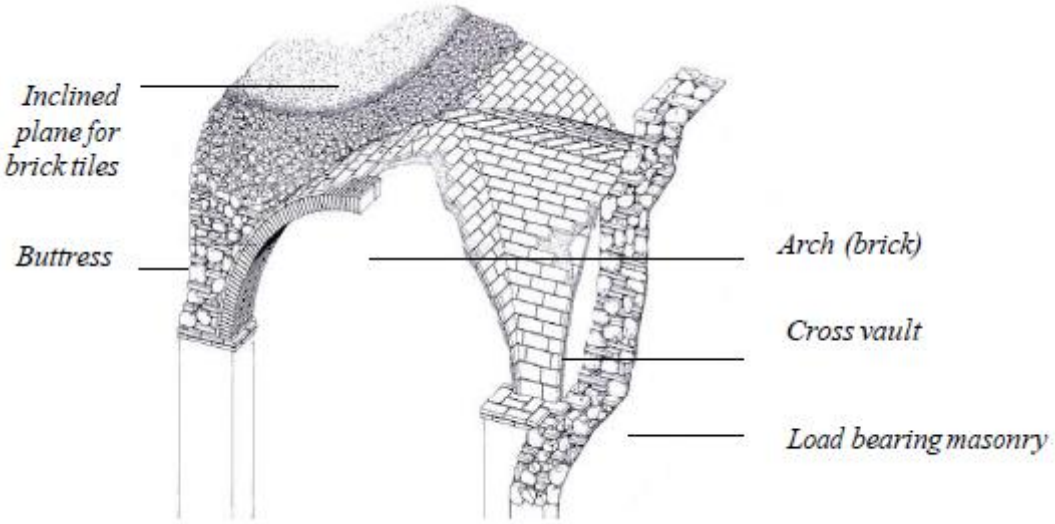

Figure 5. Presbytery cover structure - Particular

STATE OF CONSERVATION

The analysis of the state conservation, both crack and moisture, is fundamental to understand

the causes that have generated them; this analysis makes it possible to highlight the qualitative and quantitative characteristics of the building to determine the evolution of the damage over the time (Figure 7). However, this analysis is only the first element to identify the causes of damage and to determine the security status of the building; in fact, it is necessary to integrate that analysis studying the geological situation as well the foundation system, through tests of *in situ* monitoring. The church has a very important pathological condition that affects all the part and elements of the building. In fact, because of the total disconnection of the brick tiles on the roof and of the absence of a system for the draining of meteoric water, the vaults and the walls have undergone a process of pathological aging rather accelerated (Figure 6).

Figure 6. Church cover state of conservation

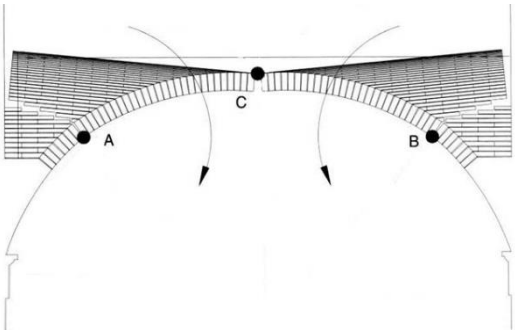

Figure 7. Kinematic mechanism of damage

To the above said reasons it is added the age of the material and technological elements, the very irregular form of the masonry, the topsoil on the buttress of the vault (that saturated with the meteoric water increasing its volume and weight); it is clear that the structure of the cover was set to undergo a collapse by crushing (Figure 8), generating a damage state extremely evident. The same situation characterizes the load-bearing masonry with evident crack produced by crushing.

Figure 8. Collapse by crushing – Particular

Consolidation Intervention

The recovery intervention involved the consolidation of the masonry, using (a) low pressure injections of mortar containing pozzolan (to improve load-bearing structure); (b) the static

consolidation of the barrel and cross vault through the application of resins in the extrados (armed with high strength woven carbon fiber) (Figure 9).

That intervention consisted in a (1) plastering of the vault intrados to eliminate the presence of any micro-cracks, (2) cleaning the extrados with total elimination of incoherent parts (and any other material that could affect the anchoring of the resin, as well) and (3) cleaning the surface with brushes and aspirator, (4) applying by brush or roller of high penetration epoxy resin and finally (5) applying with spatula of adhesive resin (average thickness 2 mm).

The resins (Figure 10) used are highly adhesive to the materials; it will have a good flexibility to be able to follow small dynamic movements over the time.

Figure 9. High strength woven carbon fiber

Figure 10. Adhesive resin - Particular

Figure 11. Connections with bars in carbon fibers and improved adherence bars pultruded in glass fiber

The intervention of improvement of masonry connections, instead, has been realized by alternating the reinforcement of connections (Figure 11) with bars in carbon fibers and improved adherence bars pultruded in glass fiber. Subsequently it was reconstituted the buttress of the vault using lightweight concrete as well as the coverage system and brick tiles, restored and integrated with new ones similar for colour, shape and material to existing ones.

The intervention evaluation

At the end of the intervention were compared to the results deriving from the tests *in situ* using single and double jack (Figure 12) to evaluate the performance of the masonry of the church before and after the intervention, according to the Italian regulations for seismic verification (DM 14/01/2008). From the verification *ante operam*, the structure was not verified if subjected to seismic actions (also very modest); while it was verified only for the static condition, according to the operating loads.

Figure 12. Double jack - Particular

While, *post operam*, as a result of the above described consolidation interventions of masonry, the structures are verified to seismic actions, even if only in terms of limit state and damage ones.

The breaking strength (determined by a test *in situ* - jack double), in fact, is strongly improved compared to the same value measured with the same test before the intervention; this leads, therefore, an improvement of the resistance of the masonry structure of about 200%. The operating strength is conforming all over the building, reaching the same value for all masonry. So the consolidation intervention, in addition to increasing the breaking strength of the building, has contributed (through improved connections with masonry and the cover system) to rationalize the load on the entire building structure, distributing strengths in more uniform way.

CONCLUSIONS

The presented analysis, enriched by the description of the intervention, leads us to deeper considerations (and perhaps most radical) on the concept of recovery. It is crucial, then, to point out that any intervention can not disregard a careful evaluation of the past (and of the users needs, as well) leading to design an intervention that is able to transmit to posterity an heritage no less than what we have received from the past (Figure 13).

The idea is to provide the tools for the definition of a system that, through the determination of the technological and functional elements, are able to reduce the risk to compromise the historical heritage and, at the same time, that are able to ensure a buildings formal, morphological and *"philological"* preservation.

Figure 13. The Church after intervention

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