Restoration of San Petronio Basilica: four-year project between innovation and eco-sustainability

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1. Introduction: the Felsinae Thesaurus project

The Basilica of San Petronio is one of the most important and significant parts of our heritage. Ended the long construction history that has gone through four centuries of history (1390-1663), Basilica administrators and city community have paid increasing attention to the conclusion and enrichment of his considerable artistic heritage and to the maintenance of the monument in all its complexity. This activity has gradually intensified from the late nineteenth century to the present day, focusing on the conservation of tangible and intangible memories of the Basilica, as part of its religious identity, history and culture. In this perspective, in order to accomplish what has been achieved and to plan future maintenance according to a unified plan, it was developed in 2009 an overall project called “Felsinae Thesaurus” focused on giving answers to different aspects - economic, financial, organizational, scientific and cultural - that the combination of activities necessary for the conservation of a monument, among the largest and most complex such as San Petronio Basilica, requires to deal with¹. Procurement of financial resources and financial planning are thus went hand in hand with the project of the restoration, from the analysis of the conservation status to the study of the most appropriate modes of operation. The cognitive campaigns conducted on the material value, the study of historical archival sources, documentation of the restoration and development of operational protocols, experimental and innovative, permitted the collection and systematization of vast amounts of data, in many cases unpublished, useful both scientifically both for the planning of future maintenance. At the same time, the set of activities and the renewed attention to the monument and its meanings has created an articulated series of communication initiatives, participation and divulgation that have strongly influenced the project from the cultural point of view. Starting then from a general view of the monument, the conservative intervention was particularly targeted to those parts mostly affected by materials and structures degradations, which differ in location, extent and matter and artistic character, but assimilated by the common need to stop in time and with the most appropriate methodologies its natural decay. The complex characteristics and the extension of the proposed works have advised their overview in a unified plan divided into six functional steps, in order to optimize the methodological, organizational and financial aspects.

2. Project Felsinae Thesaurus restoration interventions

2.1. The restoration of the exterior façade

The facade conservation project is compared first with the operational diffi-
cultures due to the need to extend the restoration site to the entire surface of the facing, up to 58 meters level reached for the first time with the appropriate temporary works. To this was added to the complexity of the methodological problems, in particular due to the heterogeneity of materials (brick, marble, stone, wall paintings, coatings and dyes, metals) and their state of preservation, the latter in part inherited from previous interventions restoration.

STEP 1 - Restoration of the façade, top: brick facing

The first phase of intervention, realized out between July 2010 and August 2011, has contemplated the construction of the scaffolding and, subsequently, diagnostic and preparatory reliefs for restoration of facing brick, plasters, the gable upholstery and side buttresses, the iron cross and the large window.

STEP 2 - Restoration of the façade, bottom: stone veneer and sculptures

The second intervention phase began with the formulation of a diagnostic and cognitive plan to identify, through the execution of preliminary non-invasive and non-destructive analysis and instrumental metric survey, the state of conservation and the morphological, matter and structural characteristics of stone veneer and decorative and sculptural system of portals.

Conservation, consolidation and cleaning interventions of stone materials and sculptures have been outlined as a result of the preliminary analysis and samples executive taken, then verified with periodic analysis and critically evaluated during works.

The restoration, which began in 2012 and still being a work in progress, cannot ignore the conservation history events that preceded it. The first major restoration of the façade which was subjected in modern times dates back to the seventies and had as protagonists Ottorino Nonfarmale, Eugenio Riccomini and Raffaella Rossi Manaresi at the center of a lively debate; in the course of the nineties were also carried out a series of maintenance operations. These data are essential when you consider that most of the intervention focuses on the current dialogue with what has been done in the past.

Façade conservation was overall discrete, the consolidating protective used, known as “mista bolognese”, an acrylic-silicon resin, has fulfilled its function in the stone veneer and took only a few timely and limited interventions of consolidation or bonding of spare parts with epoxy bicomponent. The more consistent operation was certainly the cleaning articulated in a series of successive and progressive stages that have allowed a constant control. At a first stage of removal of surface deposits made with brushes and soft brushes and with the aid of an aspirator, followed a pack cleaning with demineralized water supported, depending on the areas on which intervened with paper pulp, or with Carbogel (derived by the acid polyacrylic) or with rigid agar or gellan gel admixed with chelators.

This was followed by a solvent superficial and localized cleaning made with swab to lighten the areas in which the protective lying in previous interventions resulted altered to natural decay of the same or because he had incorporated part of the atmospheric particulate matter. This cleaning, based on concepts such as the gradualness and selectivity, has finally found its completion in laser technology, used only on particularly tenacious deposits with the aim of selective removal of only the deposits and the conservation of oxalate patinas.
and traces of previous treatments. The operation of stucco works filling of joints and more or less firm cracks has played a leading role for its conservative appearance bringing them to the level of the stone in order to facilitate the flow of meteoric water. In the same vein were made the covers of mortar made of lime, cocciopesto and sand, pull to iron to make the surface almost waterproof and reinforced with a honeycomb mesh net. The last step will be the drafting of the protective specially formulated to be laid out on a surface treated with acrylic-silicone resins. The three sculpted portals and the major decorative elements of the façade were subjected to a general three-dimensional relief made by structured light scanner of high precision useful to the acquisition of a perfect virtual model of the entire complex, made with digital techniques and without direct contact with the elements. Through the model it is possible to reconstruct a real scale of material, for development, study, or exposure or for full prototyping of partial elements to replace the original in case of loss of the same.

2.2. Completion of the restoration of the exterior and its chapels. The Chapel of St. Vincent Ferrer: a pilot project for interventions in facing side

STEP 3 – Restoration of the elevation on Via Archiginnasio, 4 chapels and counters

The third phase of the work concerns the counter and the chapels of S. Vincenzo Ferrer, S. Rocco, S. Michele, S. Rosalia-S. Barbara, and outside, the corresponding elevation on via dell’ Archiginnasio, extending the restoration site to the adjacent parts of the facade in order to complete and standardize the work already done in the course of interventions taken at different times and in different ways.

The works to realize for functional areas in consecutive batches will be about, as a result of investigations and preliminary samples, the structural consolidation, restoration of plastered and painted surfaces, plastic and pictorial decorations, altars, facing brick and stone veneer, the windows, paving and maintenance of the system of collection and disposal of stormwater.

Of this site, is nearing completion the restoration of the Chapel Ferrer which can be a valuable methodological starting point for intervention on vestments side of the Basilica.

In the exterior, in addition to marble, for which were used the same methods in the course of the intervention at the same time on the facade, there are portions of plaster, in which were found traces of a decoration, portions of brick “unfinished” which also characterizes the upper part of the facade, and finally there is the brick “sagramato”, not present in other subject areas of recent interventions, but particularly important as a surface to be treated preserving the traces of the original finish. The sagramatura has characterized much Bolognese medieval building but it is still present only in a few original examples.

Careful diagnostic campaign has allowed the knowledge of materials and pathologies and causes of degradation that characterize both the stone material
that the brick.
For the stone a special mention must be made to the experiment carried out thanks to the indication of Opificio delle Pietre Dure, of sulfate reducing bacteria which have the advantage, also in a sustainable perspective, to carry out a cleaning extremely controlled in accordance with the object, of the operator and the environment in which it operates.
At a structural level there were no significant problems except for a large lesion existing on the second capital from left that, being a hole and parallel to the surface, has made it necessary the application of a bandage tapes in carbon fiber stacked in three layers, glued with epoxy resins bi components, then treated with inert for grain size and color conformed to the original.
To give greater stability at the anchoring of the windows we proceeded with the replacement of old iron rods and of T-shaped and L-shaped profiles with new elements in burnished stainless steel so as to conform to the context of the ancient artifact.
In the segments resulting from the intersection of the upper portion of the frame of the windows and the rose window above, there are two portions of plaster above which were found traces of an old polychrome decoration; we proceeded with the consolidation of the paint layer and of the support to recovering residual fragments, then stucco works filling the gaps and with the chromatic rearrangement.
Instead on facing brick, after consolidating portions of sagramatura with micro injections of diluted acrylic resin, we proceeded with a cleaning with atomizer system which combines the mechanical action obtained by washing, even the chemistry of the water that dissolves slowly chalk or secondary calcite, of redeposition, which act as binders of the black crust and causes the removal.
In the lower part of the windows on some black crusts created in correspondence of the brick parts was used the laser. The use of this nanotechnology has allowed a controlled cleaning of the surface without the risk of damaging the protective coating present. The joints in the portions that required it, were grouted with mortar made of lime and sand, in accordance with the original.
STEP 4 – Restoration of the roof of the central nave
The fourth phase will concern the roof and the sticked out parts on the side of the central nave. The interventions are complementary to the restoration of the wooden decks of inside of the roof, already realised in the past, and will be about, in two consecutive batches, the construction of service scaffolding from Piazza Galvani and the restoration of the roof and of the sticked out parts, with the ‘inclusion of security products (life line) for access to and routine future maintenance of the building.
STEP 5 - Restoration of the elevation on Via De ‘Pignattari and 4 chapels
The fifth phase of the work will affect the chapels of S. Girolamo, S. Lorenzo, of the Cross, St. Ambrogio, and outside, the corresponding elevation on Via de ‘Pignattari, extending the restoration site to the adjacent parts of the facade in order to complete and standardize the work already done in the course of interventions taken at different times and in different ways.
STEP 6 - Restoration of the apse front of Piazza Galvani
The sixth and final phase of the work will concern the front apse facing the
Fig. 1 - San Petronio Basilica, Bologna; Fig. 2 - San Petronio Basilica, Bologna, particular cleaning with laser method; Fig. 3 - San Petronio Basilica, Cappella S. Vincenzo Ferrer, particular cleaning with water spray of the facing brick "sagramato"
apse of the Basilica overlooking Piazza Galvani.

3. Other restoration works made recently

3.1. The Chapel of Santa Brigida and some structural problems

Particularly significant for the purposes of intervention methods is the work of dismantling and restoration realized before the project Felsinae Thesaurus on the Chapel of Santa Brigida during the restoration of the decorative interior. The first monitoring campaign of the fractures found in the stems of twisted columns of the window of this chapel, dates back to November 2007. In early 2009, the damage previously founded, accelerated, in fact the four central columns appeared hopelessly fractured at the ferrules and fractures were also identified in all the other columns of the apparatus window. We proceeded therefore urgently for the safety and subsequent removal of all the columns and their glass parts. To proceed with disassembly was conceived and designed a galvanized metal structure able to support the upper portion of the windows and the loads acting on the columns from the upper stone portion. The groins of the arches have been protected with lightweight material in blocks. In this way the weight of the structure has been fully unloaded on the architrave maintaining all elements decorated in safety. So it has been possible to disassemble the columns thanks to a cutting blade made to act in proximity of the joints of the elements.

Before the disassembly phase, it was made the catalogation and accurate documentation of all elements; an accurate diagnostic phase has been realized through a Tomografia Ultrasonica e Magnetometrica, as well as chemical-physical analysis, have preceded the realization of the actual restoration. After the restoration of the columns, made in a lab created inside the chapel, we proceeded to the replacement of the columns following the original layout structure, using as binding agent an epoxide bi-component resin at high elasticity that would allow a good resistance to compression and bending; the problem of poor reversibility of this type of product has been exceeded by treating pre-emptively the surfaces with a protective based on fluorinated copolymers that worked as sacrifice-layer between the adhesive and artifact.

3.2. After the Earthquake: some additional monitoring and safety measures interventions

Following the earthquake of May 20 to 29, 2012, was carried out a campaign of monitoring and consolidation of unsafe parts inside the Basilica with the aim to secure the surfaces of the walls and vaults and interior architectural elements. The intervention was performed using two baskets elevators which have enabled us to reach areas located at different altitudes in the aisles and chapels up to almost 60 meters high.

The intervention has been structured in a preliminary analysis, functional to define in detail the actual condition of the surfaces by means of an analysis in raking light and reflected light, performed with manual typing and / or rubber hammers to identify any lifting, decohesion and detachment; with the aid of a portable covermeter it was possible to verify the presence, location, and the diameter of eventual reinforcement inside of sculptural elements and then get useful information to verify the efficacy of anchors; finally surveys were
conducted using portable infrared thermal camera, for the detection of any anomaly on the surface. The possibility to perform simultaneous analysis and restoration, made immediate and effective the interventions performed. The most serious degradation phenomena encountered consisted of a series of cracks and fissures of different extension and entities present on the plastered surfaces both in correspondence of the walls of the vaults of the aisles and chapels. In some cases they were connected to previous restorations, old fillings that were then partially reopened as a result of seismic events. The lesions most obvious concerned the walls that divide the Bolognini Chapel and the Chapel of S. Sebastiano on the east side and those that divide the chapels of St. Girolamo and the Immacolata and S. Lorenzo and the Holy Cross on the west side. In principle we intervene on all the situations requiring an immediate safety measures operation but the monitoring and interventions campaign continues.
today on a scale of priorities it has put first all the situation that required immediate action proceeding hand in hand with detailed and timely interventions of the whole church.

4. The GREEN RESTORATION ® project
The Basilica of San Petronio restoration was conducted according to the Green Restoration®: a particular approach that considers environmental sustainability and energy conservation. This concept, born with the growing awareness of problems related to environmental issues, develops from architecture. The architect Mario Cucinella sustains that “the architecture should be good as well as beautiful” and we believe that also the restoration should be “good”. So, as in architecture, we think that also the field of restoration should follow this new discipline to create a sustainable conservation of cultural heritage.

The restoration is in fact a part of the construction industry, which is at the heart of the global sustainability problems. The first input came from the Green Building Council to which we adhere and with which we are working to define the Historical Buildings protocol. The protocol, however, cannot be used for the interventions that not include the whole building but which represent the most part of the work taking place on construction history. Often the restoration is restricted to a single part of the building (the facade, the porch or the indoors) and only in a few cases the restoration can include the whole complex. For this reason we thought the definition of a system of rules that represents an intervention philosophy, characterized by the constant concept of awareness, which can guide daily decisions and modify the work method going toward eco-sustainability and energy saving direction.

In this system it is possible to classify three areas of key development: the testing of materials/techniques, the reduction of waste and improvement of internal processes, the management of each intervention with a constant attention to the most correct procedure for the environment and the operators. The system, as regards the choice of methods and techniques, can be redesigned for each individual case with the Building Site Supervisor and the government department involved. This means that it does not exist a unique method that can be simply applied but there are many different options, which can be examined case by case.

First, much attention is paid to minimizing the environmental impact generated by the activities of restoration, with the purpose to reduce the pollution caused by any intervention. In particular the reduction of the production of dust and noise, the proper transport management of persons and goods to and from the yard, the re-use of original materials (where it is possible) and the control of the emission of pollutants are carried out. The subject of water management, particularly important for the building of new construction, takes more importance, even in the context of the restoration. The efficiency of water use, which is a key element in the most restoration works, is increased with a particular attention to the use and the disposal of the productions water also, where possible, with shares reuse. The most consumption of water is usually related to cleaning interventions. For this reason alternative systems as the use of laser or sprinkler systems, were used to decrease the water con-
assumption by increasing the effectiveness and thus improve the final results. Another key theme in the restoration are the use of materials and resources in construction sites. In the last decades the use and the diffusion of chemical products increase in all the intervention stages on historic buildings and more generally on the historical and cultural heritage. In consideration of the foregoing we decide to give priority to the use of natural and traditional materials, closer to the building nature and more friendly for the environment. We also chose to select through the new technologies, those that more fulfill requirements of environmental sustainability as, for example, the biotechnology and the laser, steam-based or water-based systems. Particular attention is paid to the management of waste, that is organized at the central level. Furthermore the separate collection and the proper disposal of special and hazardous waste are keep in high esteem. However everything has just been reduced with the less use of chemicals.

An integrated energy saving is used in business processes with the use of vehicles with low emissions and with a constant focus on reducing waste in all our operations, even with small and constant everyday practice. The whole RESTORATION GREEN ® system is calibrated case by case basis due the industry analysis, which is related to restoration and allows in all circumstances to make the correct choices as described in the paragraphs above.

5. Conclusions
The restoration interventions of a building complex as the Basilica of San Petronio are numerous, varied and also an important opportunity for study and research. The synergy between different public and private actors that it was possible to put in place in this project has allowed us to transform these works in important opportunities for discussion and growth to the benefit of both the quality of work of that knowledge through enrichment with execution interventions both static and conservative created specifically for this factory, and the details of the mode of intervention arranged will be useful also in high application cases. In conclusion we would like to thank all those, institutions and practitioners who have contributed to the conduct of these operations under the leadership of Monsignor primicerius Oreste Leonardi assisted by the construction supervision and by the association of Amici di San Petronio.

Notes
1 The entire project defined and directed by Cavina Terra Architects study of Bologna has been shared and supervised by the architect Paola Grifoni director of the Superintendent of Environmental and Architectural Heritage of Bologna and the official in charge architect Franca Iole Pietrafitta as well as the architect Carla Di Francesco to the Director of the Regional Directorate for Cultural and Landscape Heritage of Emilia Romagna that we would like to thanks in this occasion.
2 The restoration of the portals of the facade was made by the Opificio delle Pietre Dure in Florence under the guidance of Prof. Dr. Maria Cristina Improta director of the section restoration of stone materials. The Opificio has also performed all the preliminary diagnostic campaigns and in work in progress as well as developed the intervention
system then applied in other stone parts. The restoration of the remaining parts was performed by Leonardo srl and Laboratorio degli Angeli s.r.l as a consortium of Il Consorzio del Restauro, a consortium of custodial works.


5 This intervention was realised by Leonardo srl under the direction of arch. Silvio Vianelli. On glass components has attended Camillo Taron’s individual company.

6 The Green Restoration project was conceived by the company Leonardo, that registered the trademark in 2011 and then started the implementation of the project in various restorations, through several collaborations and research projects with Italian and foreign institutions and organizations to test products and systems.

7 These systems, based on the atomisation of the water jet, can often replace the absorbent cleaning packs, which use chemical products and therefore they can significantly contain the environment impact. An application of these systems can be seen, for example, in the Ferrer Chapel.

References


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