quaderni di assorestauro

QA

YEAR05NR05
DECEMBER 2016

SEMINAR
ICE-ASSORESTAURO
IN COOPERATION
WITH ISFAHAN
UNIVERSITY OF ART

اصفهان

RESTORATION & CONSERVATION OF DECORATIVE SURFACES (ORNAMENTS)

DECEMBER 10TH-12TH 2016

ISFAHAN | IRAN

عمارت خورشید
مهندسان مشاور معماری، مرمت و شهرسازی

ITALIAN TRADE AGENCY
ICE - Agenzia per la promozione all'estero e l'internazionalizzazione delle imprese italiane
1926 90 2016

assorestauro

Quaderni di Assorestauro

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INDEX

SPONSOR PRESENTATION

PRESENTATION OF ICE .... pag. 4
PRESENTATION OF AR .... pag. 5

PREFACE

Alessandro Zanini | *President of Assorestauro* .... pag. 6
Shahriar Nasekhian | *Dean of Faculty of Conservation & Restoration* .... pag. 8
Faramarz Parsi | *CEO at EK* .... pag. 9

SEMINAR SESSION

THE SURFACE OF HISTORIC BUILDINGS AS A RESTORATION ISSUE - Donatella Fiorani | *Full Professor of "Sapienza" University of Rome* .... pag. 10
RESTORATION OF MONUMENTAL FACADES. DESIGN PROCEDURES - Studio Berlucchi srl .... pag. 15
EXPERIMENTAL DIAGNOSTIC NON-DESTRUCTIVE ANALYSIS - PSC srl .... pag. 18
NANOLIME, NANOSILICA, BACTERIA. NEW TECHNOLOGIES FOR THE RESTORATION OF DECORATED SURFACES - Bresciani srl .... pag. 22
RESTORATION MADE IN ITALY - Italiana Costruzioni spa .... pag. 26
PALMYRA - Tryeco 2.0 srl .... pag. 30
RESTORATION BETWEEN TRADITION AND INNOVATION Michela Palazzo | *Ministry of Cultural Heritage and Activities and Tourism - Conservator-Restorer* .... pag. 38
FONDI CAL AQUILEIA RESTORATION - Ibix srl .... pag. 41
DIAGNOSTIC AS A TOOL FOR RESTORATION AND CONSERVATION OF WALL PAINTINGS, SCULPTURES AND DECORATIVE APPARATUS: APPLICATIONS - Cristellotti & Maffeis srl .... pag. 46
MOST ADVANCED TECHNIQUES FOR THE PRESERVATION OF DECORATED SURFACES - El.En spa .... pag. 52
MICROCLIMATE ANALYSIS: DIAGNOSIS AND MONITORING Carlo Cacace | *Director section microclimate models and data management IsCR* .... pag. 56
THE CHARLES BRIDGE IN PRAGUE - Mapei spa .... pag. 60
RESTORATION OF "CASALE DI PIAZZA ARMERINA" ROMAN VILLA. SICILY - Cooperativa Archeologia .... pag. 64
ELECTROPHYSICAL DEHUMIDIFICATION OF MASONRY - Tecnova Group srl .... pag. 72
HERITAGE ENHANCEMENT AND COMMUNICATION: FOLLOW-UP OF THE EXHIBITION PALAZZO TE AT THE MIRROR - ABAD Architetti Milano .... pag. 76

ITA

ITALIAN TRADE AGENCY

ICE - Agenzia per la promozione all'estero e l'internazionalizzazione delle imprese italiane

1926 90 2016

The Italian Trade Agency - ICE is the Government agency that supports the globalization of Italian firms, implementing the strategies of the Ministry of Economic Development.

The Italian Trade Agency - ICE helps to develop, facilitate and promote Italian economic and trade relations with foreign countries, focusing on the needs of SME's, their associations and partnerships.

The Italian Trade Agency - ICE sustains Italian firms in their internationalization processes, in the marketing of Italian goods and services while promoting the "Made In Italy' image around the world, and it is directly involved in attracting foreign direct investments.

The Italian Trade Agency - ICE provides information, support and consultancy to Italian companies on foreign markets, promoting and fostering exports and cooperation in all areas – industry (consumer and capital goods), agricultural technology and agri-food, services, and training - with the aim of increasing and making more effective their presence on international markets.

The Italian Trade Agency - ICE works closely with the Italian Regions, the network of the Italian Chambers of Commerce, business organizations and other public and private entities.

The Italian Trade Agency - ICE headquarters is in Rome and its network of offices around the world act as "Trade Promotion Offices and/or Sections" of the Italian Embassies or Consulates.

assorestauro®

associazione italiana per il restauro architettonico, artistico, urbano
italian association for architecture, art and urban restoration

Project coordinator:
Andrea Griletto

WHO IS ASSORESTAURO ?

Established in 2005 as the first Italian association of manufacturers of materials, equipment and technology, suppliers of services and specialized companies, Assorestauro represents the Italian sector of restoration and conservation of material heritage. To date, it is the sole association and a reference in the domestic and international market for anyone willing to start working in the conservation sector in Italy, to be intended in its broadest sense, that is, as a synthesis of the various disciplines involved, of the professional specialists, of the available technology and of the growing business community. If examined as a whole, the sector accounts for a large market share and has a meaningful impact on tourism, industry and bioconstruction.

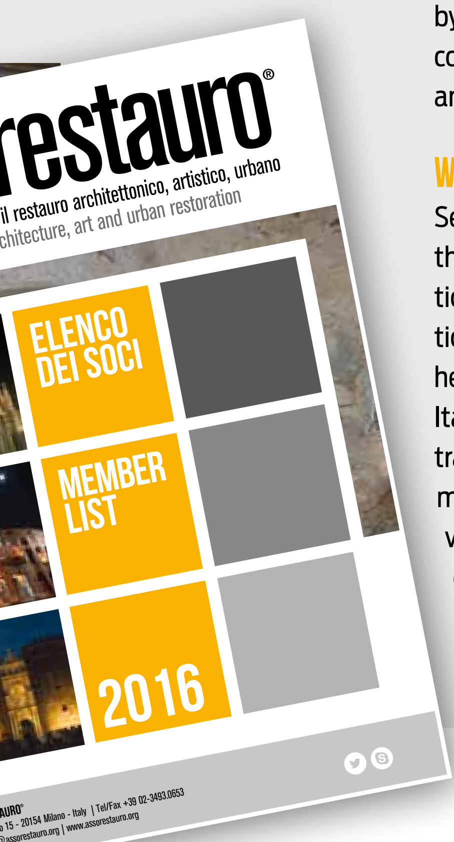
WHAT ARE ASSORESTAURO'S GOALS ?

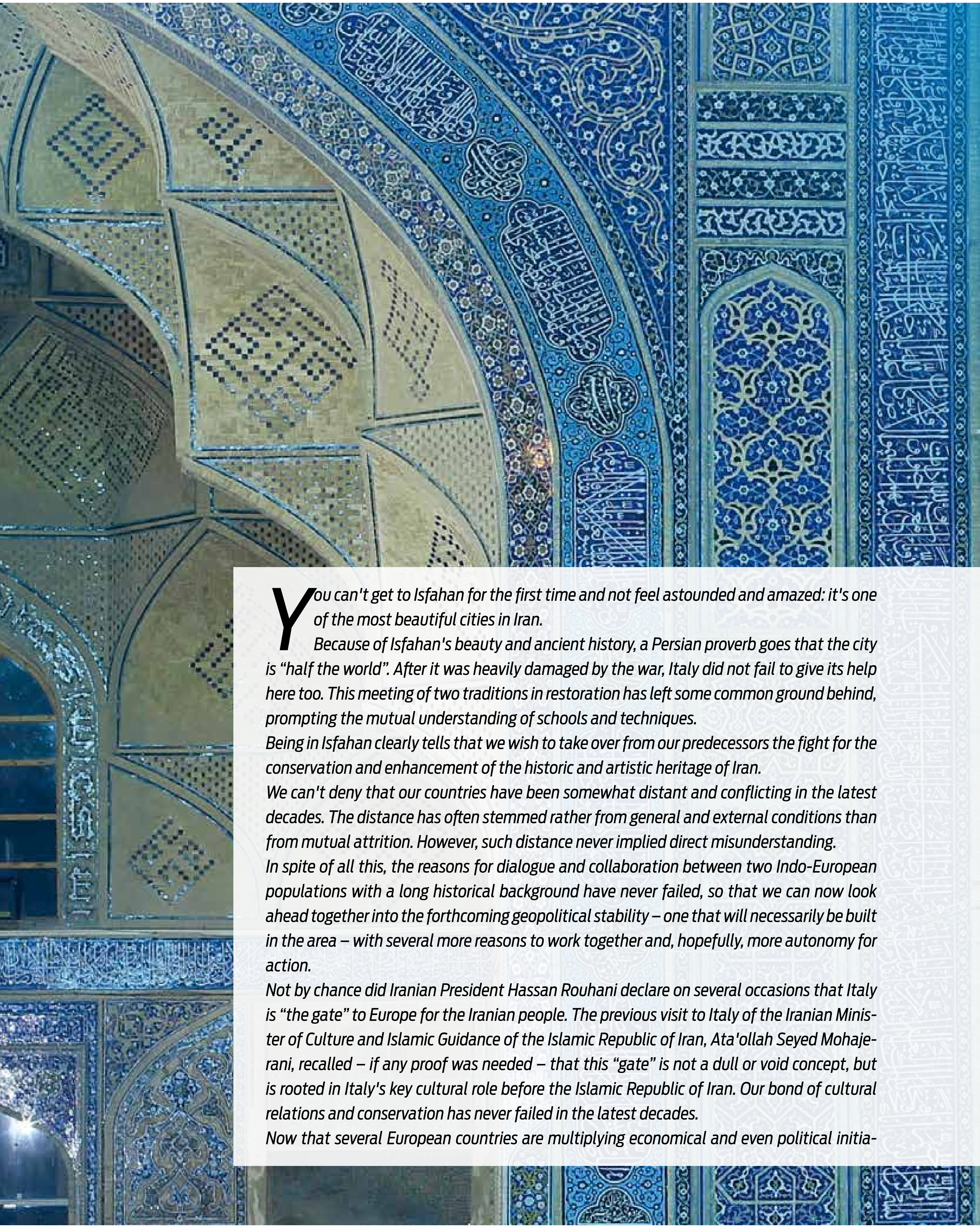
Assorestauro is the National Trade Association for the Restoration Sector, representing manufacturers of materials, equipment, technology, specialist companies, designers and suppliers of services for analyses, surveys and diffusion. The Association offers its members information, assistance, advice and training both directly and through its partners, with a view to building a consistent and unitary orientation to the different sectors of the restoration industry at national and international level.

As a national association, Assorestauro is aimed at coordinating, protecting and promoting the interests of the restoration sector and it represents before the outer market, in Italy and abroad, the common positions for technical and economic issues, as well as image, by carrying out targeted activities in such relevant fields of the sector as information and communication, protection of common interests (economy, image, standards), research and development, promotion.

WHAT DOES ASSORESTAURO DO ?

Several activities aimed at promoting the professional skills in the restoration sector fall in the scopes of the Association. They include diagnostic analysis, design and on site execution, producing technology and materials, as well as contributing technological innovation, with the support of Institutions, Universities, Agencies for the protection of cultural heritage and ICE, the Agency for the internationalization and the promotion abroad of Italian businesses. This type of action includes both promotion in Italy (conferences and training seminars, trade exhibitions, courses and similar initiatives) and abroad (foreign missions, training, b2b encounters, restoration sites), where member companies are involved and offered the chance to study and penetrate foreign markets through projects co-sponsored by national and international bodies.





You can't get to Isfahan for the first time and not feel astounded and amazed: it's one of the most beautiful cities in Iran.

Because of Isfahan's beauty and ancient history, a Persian proverb goes that the city is "half the world". After it was heavily damaged by the war, Italy did not fail to give its help here too. This meeting of two traditions in restoration has left some common ground behind, prompting the mutual understanding of schools and techniques.

Being in Isfahan clearly tells that we wish to take over from our predecessors the fight for the conservation and enhancement of the historic and artistic heritage of Iran.

We can't deny that our countries have been somewhat distant and conflicting in the latest decades. The distance has often stemmed rather from general and external conditions than from mutual attrition. However, such distance never implied direct misunderstanding.

In spite of all this, the reasons for dialogue and collaboration between two Indo-European populations with a long historical background have never failed, so that we can now look ahead together into the forthcoming geopolitical stability – one that will necessarily be built in the area – with several more reasons to work together and, hopefully, more autonomy for action.

Not by chance did Iranian President Hassan Rouhani declare on several occasions that Italy is "the gate" to Europe for the Iranian people. The previous visit to Italy of the Iranian Minister of Culture and Islamic Guidance of the Islamic Republic of Iran, Ata'ollah Seyed Mohajerani, recalled – if any proof was needed – that this "gate" is not a dull or void concept, but is rooted in Italy's key cultural role before the Islamic Republic of Iran. Our bond of cultural relations and conservation has never failed in the latest decades.

Now that several European countries are multiplying economical and even political initia-

اصفهان

HALF THE WORLD

tives in Iran, Italy's knowledge in the sector of cultural heritage conservation plays a key role in supporting the promotion of Italian skills in a wide scenario now experiencing fast growth. Assorestauro chose Isfahan to host the second workshop for collaboration between Iranian and Italian experts and to develop the topic that is more directly linked to restoration, that is, the conservation and treatment of prestigious historic finishes.

This way, we believe we will make the most of the two restoration schools and we will present our Iranian friends with the contribution that technological innovation can give to cultural heritage conservation.

After the topic of antiseismic prevention and structural conservation and after the second workshop about the conservation of decorated surfaces, we think we made our best to deal exhaustively with two main issues in conservation and to promote the widest participation of all possible stakeholders from Italy and Iran.

We expect these two encounters will be helpful to start projects and related activities next year. The more we will make joint efforts in the field of cultural heritage conservation by erecting solid foundations for scientific cooperation and business for our companies, the less the international political scenario will be likely to impair direct relations between Italy and Iran.

The conservation and promotion of cultural heritage are not only aimed at preserving material monuments and their intrinsic history, but are terrific instruments to make history in the first place. Meeting the expectations of today's generations and promoting hope for the future ones means promoting an international scenario that will be more respectful of the rights and traditions of all peoples.

Alessandro Zanini
Assorestauro President

Faculty of Conservation and Restoration in the Art University of Isfahan, having been established in 1975, is the oldest school of conservation in Middle-East; it is located in the historic Safavid houses of David and Soukias with an infrastructure area of 4700 square meters and is equipped by various specialized laboratories and studios, and has provided a very rich library materials with specific focus on the domains of conservation and restoration. Moreover, this faculty is being supported by approximately 20 fixed faculty members and 20 invited professors each semester. Also, there are currently 600 students studying towards Bachelor's and Master's degree and Doctor of Philosophy (PhD) in the fields of Architectural conservation, Urban conservation, Conservation and restoration of historic relics and properties, Archaeometry, Archaelogy.

Art University of Isfahan and specially the department of Conservation is pleased to organize and host this seminar in cooperation with Assorestauro, Emarat-e Khordshid engineering consultant as well as ITA in this historic city on December 10-15 2016.

The seminar will receive some of the most experienced Iranian and Italian academics and professionals in the field of conservation and restoration and will particularly address those professionals with prominence in restoration and conservation of decorative surfaces and ornaments.

Shahriar Nasekhian
Dean of Faculty
of Conservation & Restoration

عمارت خورشید
مهندسان مشاور معماری، مرمت وشهرسازی

Emarat Khorshid (EK) Consulting engineers was established in 2000, as an individual company, specialized in architecture, restoration & urban design, focuses on historic buildings of Iranian architecture to restore & revitalize them as responsive environments for now-day's needs. With more than 250 projects (Architecture, Restoration & Urban Design) all over Iran, EK expand its job area to Iraq, Uzbekistan, Afghanistan and some other countries. Cooperation with Iran Cultural heritage Organization (ICHTO) in preparing of two documents for world heritage list (UNSECO), EK try to opens new windows to research projects in international scale. These projects lead to documentation of Tabriz Grand Bazaar and Sheikh Safi (Ardabil) holy shrine in UNESCO world heritage list. Today, EK is one of the best companies in Iran, acts as a reference both in governmental organization and Individuals who willing to start a project. In last 5 year we focused on public restoration and do projects in Masoudieh Historic Palace (Tehran), Farahzad eco-tourism valley (Tehran), Isfahk historic village rehabilitation design, (Tabas, south Khorasan), Tabriz city hall (Tabriz) &... to indicate that restoration is a social trends that need social vision. Also EK as one of pioneer's in Iran to use modern restoration, use new material and techniques on some of its project. Tehran Tejarat Bank (main branch), Sanaati Museum & Naser el-din-Mirza House in Emam Khomeini Sq, and Baghcheh Jough Garden in Maku refers to this kind of restoration. Collaboration with international companies and institute such as Assorestauro (The Italian Association for Architectural, Artistic and Urban Restoration) to held international discuss on "Seismic Reinforcement and structural rehabilitation of historical buildings" in Tabriz (October 2016) and "Restoration and conservation of historic surfaces" in Isfahan (December 2016) represents EK's scientific and technical potential. Due to starting of two-way scientific cooperation, we would like to declare our great interest to develop sustainable collaboration between Italian companies and EK Consulting Engineer's in the field of scientific research, design and implementation of restoration projects. Obviously, presence of valuable monuments and buildings in two countries & great experiences of restoration in each side and a long history of cooperation between scientific institutions and specialized professionals, new partnerships can be in the form of; "Joint- venture co-operation", "exchange of experts and specialists" and "exchange of experience and technology" between two sides.

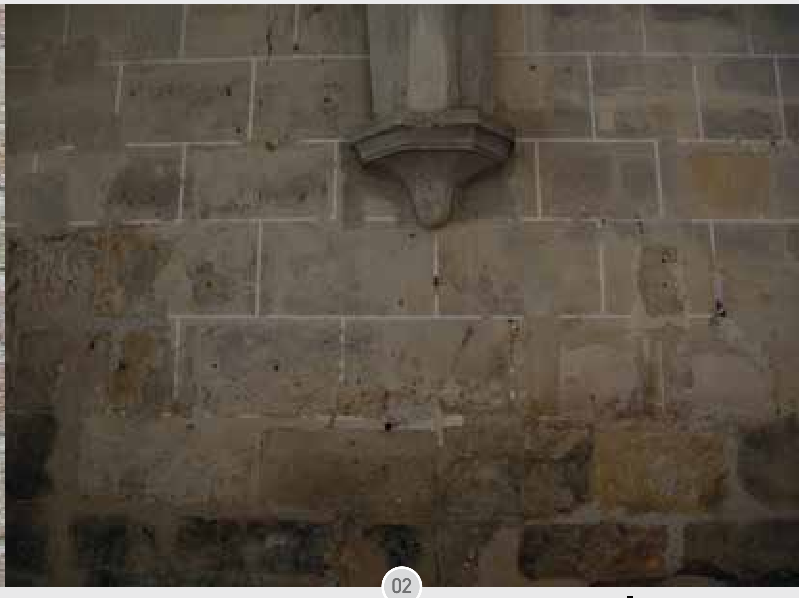
Faramarz Parsi
CEO at EK

Donatella Fiorani
Full Professor of "Sapienza" University of Rome

THE SURFACE OF HISTORIC BUILDINGS AS A RESTORATION ISSUE

The reason why the conservation of the surface ornamentation of historic buildings is dealt with as a separate issue – unlike other forms of figurative expression (e.g. the conservation of sculptural or painted surfaces usually comes with the general topic of the conservation of sculpture and painting and, as a general rule, is a prevailing issue in any restoration decision) – is that architectural surfaces represent the interface between space and construction and entertain with them a fairly complex relationship.
Although the look of a historic building entirely relies on that external "half an inch deep" layer the English critic John Ruskin solicited to safeguard as early as in the 19th century, architectural surfaces often pay the heaviest toll during restoration works, in Europe and elsewhere in the world.
Because of the nature of its own heritage, Italy is particularly committed to studying and enhancing historic building. While the most recent standards issued in Italy have aimed at improving its protection by introducing the notion of "decorated surfaces" ("Code of cultural heritage and landscape", Leg. Decree 22.1.2004, n. 42, art. 9, paragraph 6), a thorough definition of "decorated surfaces" is still missing. Also, the scenario of the skills required in the restoration sector is so blurred that the conservation of historic surfaces is widely dependent on the sensitivity and expertise of restorers and clients.
As a matter of fact, architectural surfaces make the substrate for nature and man-induced events to pile up since the edifice was built and, at the same time, they represent the perceivable image of an architecture.
Any competent study will consider surfaces as an essential record to understand the original look of the construction and to infer the methods used in working the materials. No other source can offer any comparable data. When surfaces are carefully studied, impor-

01 Ronzano



02 Royaumont

03

NewYork. EllisIsland

tant information can be gathered about traditional working tools, how and why some techniques were used to finish stone (straight chiselling, claw chiselling, anathyrosis, etc.), bricks (surface grinding, scratching, etc.) (figure 1), plaster (smoothing, claw chiselling, graffiti, painting, etc.), mortar joints (smoothing, pointing, etc.), clay soil. As a consequence, a historic construction has been gradually endowed with new important connotations. Such information helped restorers reproduce in some cases, or conserve in some other cases.
Similarly, studying architectural surfaces can help recognize some elements that had nearly totally disappeared, like the paintings on Roman marble, on Medieval slabs and on stuccowork of all epochs (for instance, the colourful stuccoes of the underground Basilica di Porta Maggiore and the paintings on limestone in the churches of Abruzzo, e.g. the parapets in the church of S. Pellegrino in Bominaco).
Studying architectural surfaces also makes a precious source to recognize how an edifice was altered over time and to identify any repairs, replacements, restyling in the whole edifice. Often, surface finishings are given the role of adding a coherent and consistent wrap to the multiple layers of a building that has been successively adapted to the needs of different epochs. For instance, the ruins of Royaumont Abbey in France (figure 2) caused by the destructions during the French Revolution were restored by accurately rebuilding the masonry and an etched false curtain wall: this is the current outlook of the building, which is in most respects the result of the 19^{th} century feeling of how a Medieval architecture should look like.
By patiently matching the information collected about different buildings, one can make up a stratigraphy of the traditional local construction, which may be useful to date other buildings and their elements in future. In the city of L'Aquila, for instance, the finishing methods used for the surfaces (and, of course, the masonry layout itself) offer useful indications about the succession of construction techniques over time: more or less regular limestone blocks or regular limestone ashlars, either exposed or covered with a very thin layer of plaster, were widely used in the Middle Ages; limestone blocks and evenly spread mortar prevailed in the 15th century; smaller and more irregularly arranged blocks coated with thick plaster characterize the most recent buildings. This precious material and ornamental heritage is now endangered by post-earthquake reconstruction works, which are too exclusively focused on structural rehabilitation only.

Roma. Palazzo Falconieri

04

Borris House

05

Not only do architectural surfaces keep record of man's time, but also of nature's time: deposit accumulation, scars induced by wind, subsidence and peeling off, colour alterations caused by the sun. Time adds a patina but also degradation.
All what is collected as a record is also, at the same time, an image. The patina mirrors the aesthetic sense of history, but even alteration and degradation can contribute to the visual quality of a surface.
There is an aesthetic value in what is unaccomplished, which fascinates the artists and architects of the Western world. Not necessarily does it trigger a conservative sensitivity, but it can also work towards innovation. In the first case, restoration will emphasize a particular event (for instance, the worn-out surfaces maintained in some German buildings survived after the second world war), but it can also simply play with the contrast of modern and ancient, like in the interior decoration of some edifices meant for cultural or commercial destinations in the historic city centres in Europe. In the latter case, while recognizing the value that Alois Riegl would define 'of what is ancient', the interventions have introduced some modifications: some examples can be found in the works of Portuguese Alexander Farto, who carves worn-out historic surfaces with new patterns, or in the solutions offered by French architects Lacaton & Vassal, e.g. at the Palais de Tokyo in Paris.
There is, however, a prevailing aesthetic value of what is accomplished, which leads to the rehabilitation of the façades of historic buildings in Europe and in America alike, but also – sporadically – to the development of new creative colour patterns, like in Dublin castle in Ireland or in Tirana city centre, Albania. It is exactly when a total remake is made that we

learn that changing a surface means radically changing the perception of a building. For example, after the recent application of a new very smooth and white plaster, the Moritzkirche in Augsburg, Germany, now appears the result of a contemporary minimalist design and hides the previous layers of what was a medieval church decorated in the Baroque period, damaged by the war and rehabilitated in the second half of the 20^{th} century.

If recognizing the historic value of a surface helps conservation, the aesthetic fruition can also lead to innovation. In all cases, considering an architectural surface as a record only can cause it to become alienated from the surrounding space, like in the graffiti-covered pillars inside the Immigration Museum of Ellis Island, in New York (figure 3). On the other hand, considering it exclusively as a figurative element on its own can lead to the annulment of the perception of the whole and to the loss of the patina, as it happened in several recent restorations of European historic buildings (figure 4).

If, on the contrary, no value is recognized to the surface, the results of the intervention can be really ill-fated, as it is unfortunately evident in the surfaces of some historic buildings of L'Aquila after they have been consolidated after the earthquake, where the original relations of depth between plaster and stone frames has been overturned.

A restoration project, then, must stem from the understanding of the value of historic surfaces, be based on an assessment capable of synthesizing their historic and figurative quality and be developed with an appropriate technical methodology.

Assessing the conditions of architectural surfaces is based on the codified description of the pathologies found. These pathologies were formally described, as far as stone materials are concerned, with a lexicon standardized in UNI 11182:2006 standard in Italy and in the Illustrated Glossary on Stone Deterioration Pattern issued by the International Scientific Committee for Stone of Icomos (2010) worldwide. The same definitions are used, with the necessary adjustments, to characterize the state of conservation of plaster and stuccowork.

Using these codes has enabled to share the analyses of degradation in a clearer and easier way, and to perform more efficient conservation interventions. Sometimes, however, these codes have accidentally created misunderstanding, and caused to reduce such a complex issue as the interpretation of historic surfaces to a mere technical assessment. This "engineer's" approach to degradation assessment has sometimes favoured the one-to-one correspondence of pathology and type of intervention and generated scarcely convincing results in terms of conservation and, more generally, perception.

A technical analysis, in fact, cannot be performed with a merely mechanical approach, and is something an architect cannot passively delegate to scientists and restorers. The deep knowledge about architecture and its history must accompany every diagnostic step, including the selection of samples, the identification of the appropriate testing method, the identification of the causes, and the final choice of the type of intervention. If this does not happen, then the correct control over the whole architecture is lost and restoration will only be the sum of a number of interventions conducted on different and separate elements.

This applies to monuments as well as to diffused historic building: the existence of a bituminous layer found on the interior walls of the dwellings in Castelvecchio Calvisio, a mountain village in the neighbourhood of L'Aquila, could be explained and dated only after a detailed study of the construction history of the buildings was performed. This helped identify an empirical and quite unusual habit, a peculiar maintenance method aimed at preventing the disaggregation of plaster owed to the crystallization of sulphate in the masonry. In the late 19th century, the waste material from the processing of oil schist available on site was widely used as an insulating material on top of plaster, then whitewashed with lime, which was renewed at frequent intervals. After the reasons for the use of bitumen were understood and the absence of salts in masonry was verified (because rubbish was no more discharged into the gaps between the houses), it was eventually decided to remove the material and repaint the walls, so that these medieval terraced houses could become fit for residential use again.

Diagnostics, historic understanding and aesthetic assessment must therefore converge in restoration design, which in turn cannot be reduced to the mere choice between replacement or conservation. Generally speaking, when confronted with surfaces, a conveniently wide range of solutions is always viable: the Roman plaster cornices in the Borris House of Kilkenny (figure 5), in Ireland, are prone to different degrees of integration; the succession of the façades of Palazzo Carli-Benedetti of L'Aquila, in Italy, can be adequately harmonized without losing the traces of stratification by the reasoned use of a thin coat of plaster (figure 6); the clay soil surfaces of Alqueria Tower, in Spain, have been efficiently preserved by carefully repairing the missing portions. Often, different solutions can be adopted in the same building, depending on the problems arising from the existing materials and the specific conditions of degradation. For instance, the restoration works of the 19th century Neues Museum in Berlin vary from ultimate conservation (including dirt) of the surfaces to the complete recovery of the original colours.

Restoration, also of the outer skin of historic buildings, is not the result of a precise and unique formula, but the result of a process of thorough understanding, technical skills and figurative sensitivity. It is a work that requires depth, even when dealing with the surface.

06

L'Aquila.
Palazzo Carli Benedetti

Nicola Berlucchi
Civil Engineer,
Architect and Restorer

Article based on:
AA.VV. "Scuola di Restauro – Heritage conservation in Italy and Russia" – Nardini Editore, Firenze 2015

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RESTORATION OF MONUMENTAL FACADES. DESIGN PROCEDURES

If we look at the restoration of the facades of Procuratie Nove in Venice (St. Mark's Square) or at the restoration of St. Peter's Basilica in Vatican we see that the level of cleaning of the monumental stone surfaces ranges from being very respectful of the patinas and black crusts to a deeper cleaning approach depending on the approval of the local authorities and the region where the restoration is held.
So even in Italy the restoration approach is not univocal, but in any situation and any place one thing is unambiguous: the respect of old surfaces and of different phases and modifications submitted by the monument during its life.
The methodology in the restoration of monumental Facades is well defined and can be resumed into the next steps that are necessary to obtain a good and reliable detailed project:

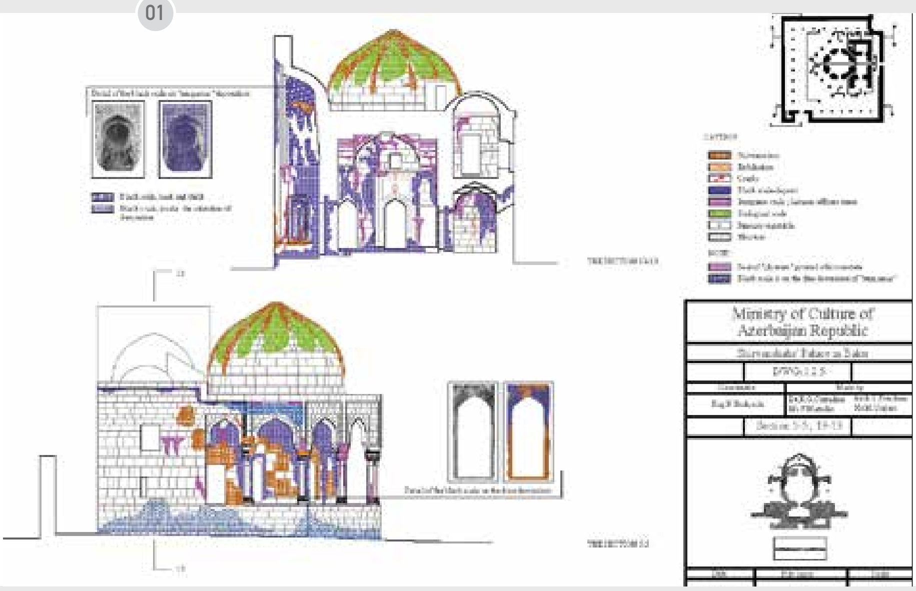
REPORTS OF THE PROJECT AND TENDER

The project report describes in a comprehensive and very analytical way all the processes required for the restoration, but also the approach adopted in the project.
It is a critical step to make the reader aware of the theoretical framework of the project (eg purely conservative, with integrative restoration, in-style recovery or respectful of all periods); the approach can be therefore very different, and consequently also the final result can vary considerably even within a same design philosophy. The report will be primarily written with a general introduction and a following descriptive detail which is the performance specifications.

DESIGN DRAWINGS

Graphic documentation of the project can be highly variable from case to case, but you can find, schematically speaking, three different design approaches:

01



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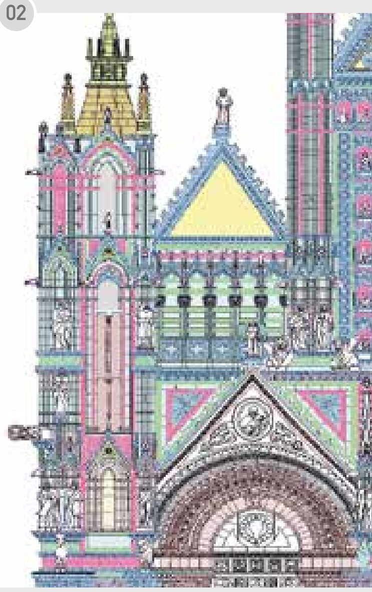


Fig 1. Detailed project for restoration of Divanhane palace in Baku (Azerbaijan): mapping of interventions on the basis of existing decay.

Fig 2. Detailed project for restoration of Siena's Cathedral façade: mapping of single materials, different degradation states of conservation and different percentage of incidence of degradation for surface unit.

a_Through mapping of interventions on the base of the different alterations (figure 1). By this term I mean a project that relies heavily on previous mapping of surface alterations, identifying interventions based replacing almost automatically, whenever possible, the list of decays with a new list of interventions. For example you can think of replacing with "extraction of soluble salts" the voice of alteration "efflorescence" to visualize the area and the quantities of surfaces to be treated with this work.
Experience has shown that such an approach tends to underestimate the real work to be performed, resulting in substantial changes during construction phase.

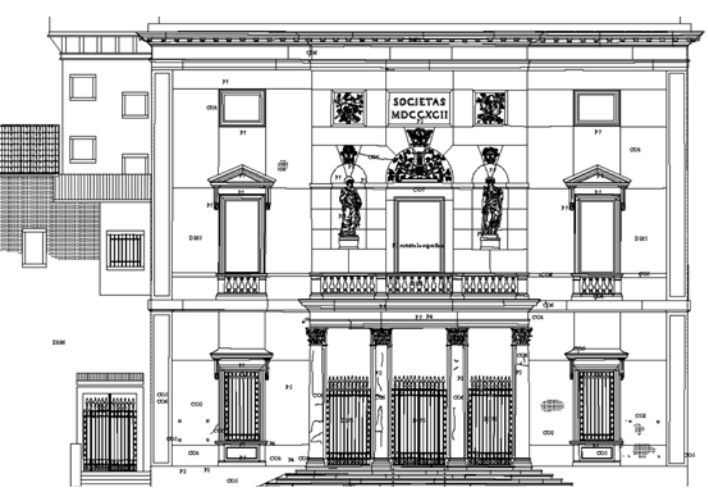
b_Through mapping of interventions on the base of materials and their conservation status (figure 2). A second approach may be to define the restoration works upon the mapping of all materials and their state of conservation; this method has the advantage of covering all surfaces of the monument and not to be tied to the preliminary assessment of the degradation, however, requires a careful description of all operational phases of restoration provided on each single material (phases which may differ depending on the materials and on the forms of degradation) and requires a considerable experience in the assessment of the unit costs of interventions for each material.
In the reported example of Siena's Cathedral façade restoration design to each color corresponds a different marble or, within the same marble, a different degree of protrusion or complexity of decoration or incidence of degradation.

c_Using drawings with abbreviations or codes (figure 3). A third method of representation of the restoration project can be considered to draw up design tables based on the geometric survey inserting symbols or codes that refer to the single decay or work specifications.

d_Using detailed descriptions that cover all eventualities in case of relatively small size artifacts (figure 4) (statues, marble elements, furnishings) At last there is the possibility of basing the design on the single survey of materials and alterations, referring for the intervention only to detailed complete descriptions of the work, considering such a contract inclusive flat rate for a fixed amount, independent of the measurements of the

Fig 3. Detailed project for restoration of Teatro La Fenice façade: use of abbreviations and codes.

Fig 4. Detailed drawing with single marble slabs related to a fixed price contract with detailed descriptions of complete restoration works



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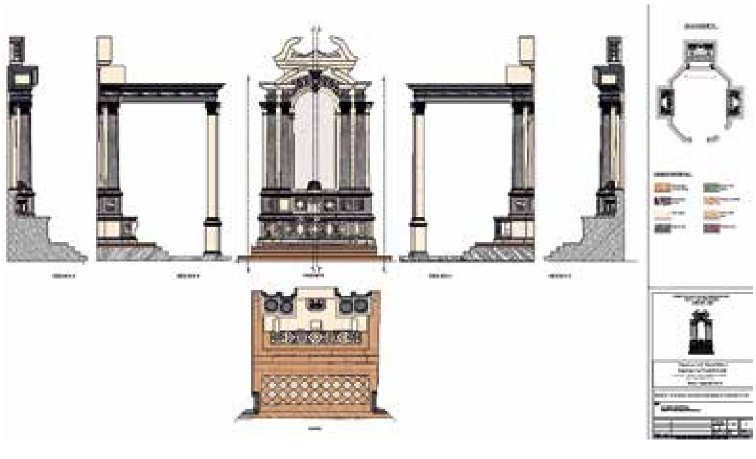

04

Water colors painting to visualize the final result for restoration and coloring of a 18th century façade of S Benedetto Po Monastery

work performed during construction. However, even in this case, as a designer you must perform good and reliable evaluations of the costs and bill of quantities. It is therefore more a kind of contract that of a real way of documentation.

BILL OF QUANTITIES (LIST OF MEASURES OR FLAT RATE)

Based on the considerations above, the bill of quantities must be attended with great attention to graphic documentation but still remains as susceptible to uncertainty and various interpretations on the consistency of the degradation. The computation of restoration works must be drawn up by technicians with proven experience in the field to avoid excessively underestimation of the work and at the same time to evaluate a reasonable and realistic total amount.

RENDERS

In case of plaster façades it is recommended to visualize the final result of the restoration and of the final coloring with some computer renders (figure 5) or, even better because more realistic, with water color paintings. This phase will allow to make decision about different coloring of architectural elements and possible lighting results depending of the chosen light systems.

TERMS OF REFERENCE

Last important document, part of the restoration project, is the Terms of Reference report (TOR) where the designer deeply describes the restoration procedures, the technical requirements and the technical sheets of all restoration products that are prescribed during the works, their required performance and expected results.

Lorenzo Piccinini

EXPERIMENTAL DIAGNOSTIC NON-DESTRUCTIVE ANALYSIS

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The assessment of the state of degradation of devotional image of the Blessed Virgin of the Castle

HISTORICAL BACKGROUND OF SANCTUARY, THE PAINTING AND ITS MATERIAL HISTORY

The object of study is a votive fresco in the Sanctuary of Fiorano Modenese near Modena (figure 1). The image of B.V. of the Castle (figure 2) is, in all, what today seems: a vertical pane where Mary occupies the right half, holding her Child, the latter in an approximately central position and the left side shows a kneeling warrior. The original Madonna is a type of mural painting, perfectly canonical in the fourteenth century, some academics are inclined to date the fresco work in the middle of the '300, date postponed to the end of the century when probably the work was commissioned to an accomplished artist by the Este House. The artifact has been the subject of a last restructuring documented in 1985, which has not removed any added element over the years. The image of Mary would be a portion of the wall of the ancient castle that once stood in place of the current sanctuary, and miraculously escaped from a fire set by the Spaniards in 1558.

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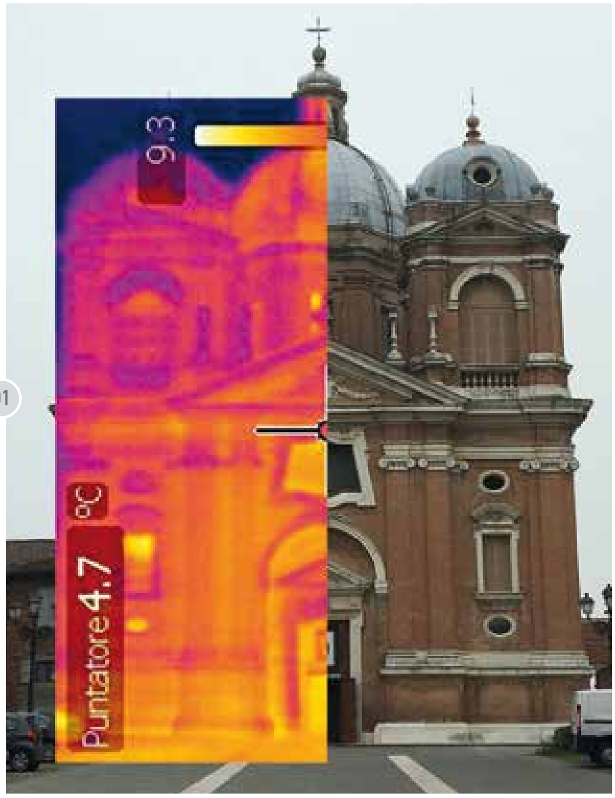

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THE SURVEY TARGETS

In the first place was carried a general Thermographic survey of the environments (figures 3-4), for an overall estimate of the conservation situation of structural and non-structural elements present inside. Second analysis was performed directly on the painting (figure 5) using non-invasive instruments, aimed at identifying the detached plaster, bulges, cracks and the presence of moisture and infiltration with the aim of identifying the most needy restoration areas of the element according to protect their conservation. The results obtained from this experimental investigation are recorded and processed to be delivered to the restorer, who will - if necessary - conduct further chemical / laboratory checks on pigments and plan material restoration. With the same purpose it was also conducted a ultrasonic survey on the stone Cross dated to 1276 a.C.

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THE INSTRUMENTS USED

Infrared thermal imaging camera, thermohygrometer, sonic and ultrasonic probes and unit.

THE GENERAL RESULTS OF THE SURVEY

Subsequently a thermographic/thermohygrometer analysis on general environment for defining the general climatic conditions of the Sanctuary, (figure 6) the infrared technology has been applied on the fresco of B.V. the Castle (figure 7). Passive Thermographic refunds have detected, as shown by infrared images, areas with surface degradation (humidity, plaster peeling). Subsequently, with the aim of determining with more precision the source and severity of such difettologie encountered in it was applied the active Thermography (by resorting to the use of artificial sources of heat) and related image processing through specific analysis software. Such control was then further expanded and enriched with sonic and ultrasonic investigation (figure 8) by comparing the reading frequencies that give back a tomographic mapping. The last step has been implemented the thermo-hygrometric survey to detect the presence of water and moisture in the fresco. Relativity to the stone Cross, the application of direct ultrasonic survey reveal internal inhomogeneity of sandstone: a minimal degradation that testifies excellent storage condition considering his date of accomplishment (figure 9).

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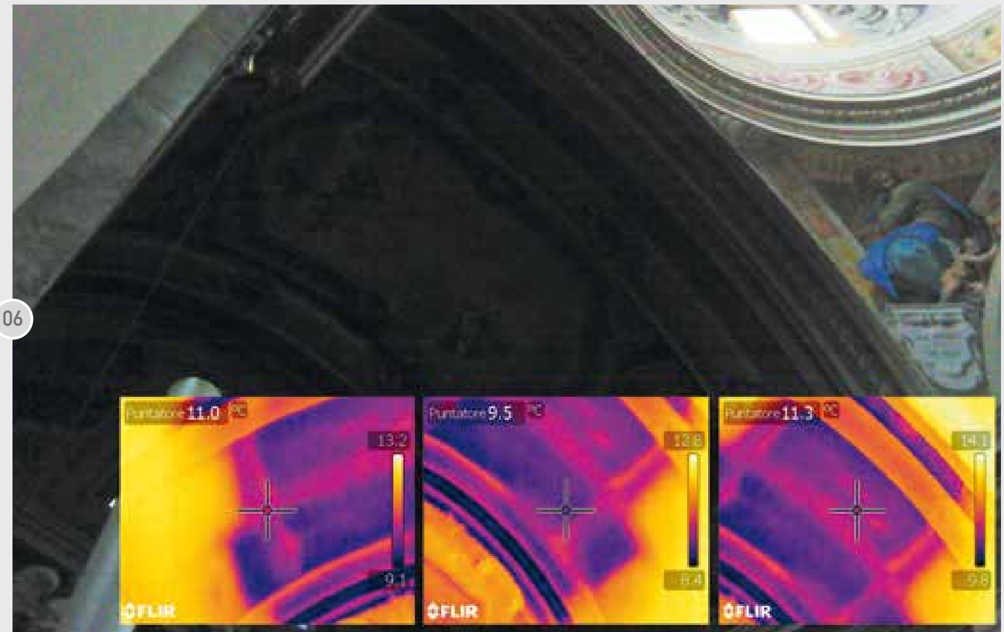

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Fig 8-9.
Such control was then further expanded and enriched with sonic and ultrasonic investigation.

08

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Fig 10.
Relativity to the stone Cross, the application of direct ultrasonic survey reveal internal inhomogeneity of sandstone: a minimal degradation that testifies excellent storage condition considering his date of accomplishment

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Vittorio Bresciani

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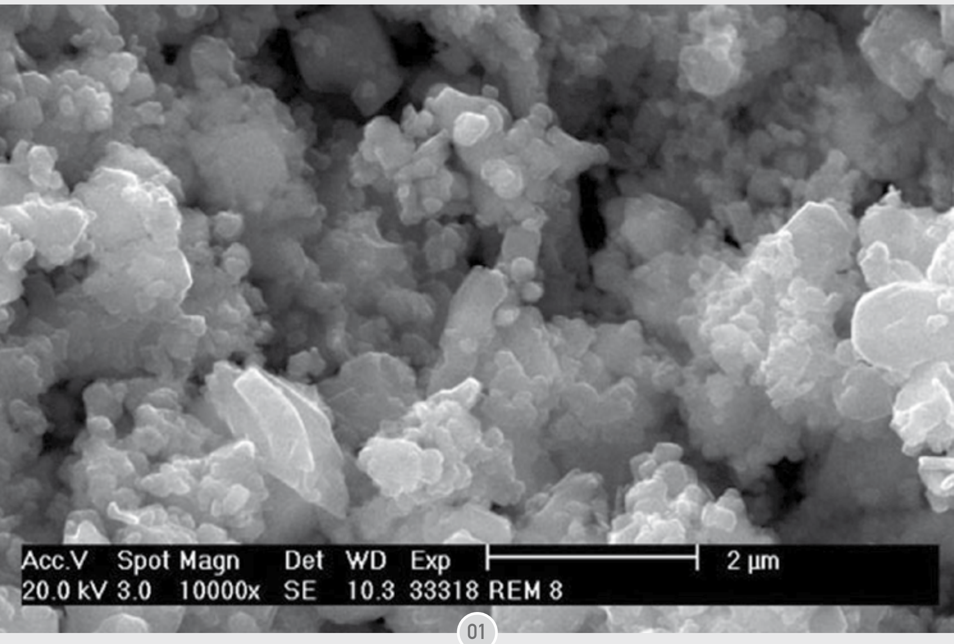
NANOLIME, NANOSILICA, BACTERIA. NEW TECHNOLOGIES FOR THE RESTORATION OF DECORATED SURFACES

The new technologies in the field of Restoration and Conservation of Cultural Heritage offer new tools for Restorers to resolve situations until now can not be addressed with traditional methods.
Of primary importance are the products based on nanotechnology, such as nanolime and nanosilica, allowing the consolidation of surfaces.
The nanolime, hydrated lime particles suspended in alcohol of medium size in order of only 150 nm, allow to lime (product of natural origin) to penetrate and to reconsolidate both natural and artificial stones (plasters). (figures 1-3)
With them it is also possible to produce grouting mortar to seal micro-cracks. (figures 4-5)
The nanosilici, silicon dioxide particles in aqueous dispersion of microscopic size of less than 100 nm, penetrate into the surfaces painted creating new aggregation.
They are especially used for the decorated surfaces with a superficial disintegration. (figure 6)
Also biology offers new tools to facilitate the work of restorers in the important cleaning phases.
For cleaning of the black crusts sulphate origin, frequently very hard to remove (figure 7), are now being used sulphate-reducing bacteria, present in nature and harmless to humans, able to destroy the incrustations, preserving the integrity of the artwork of which they have overlapped.



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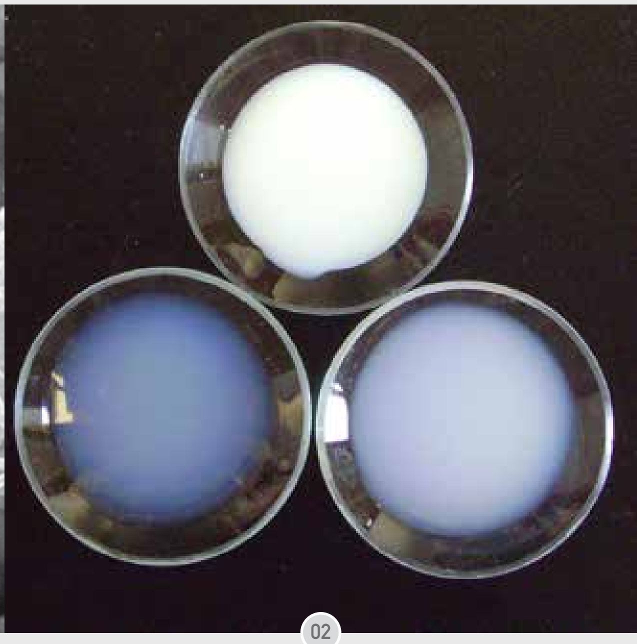

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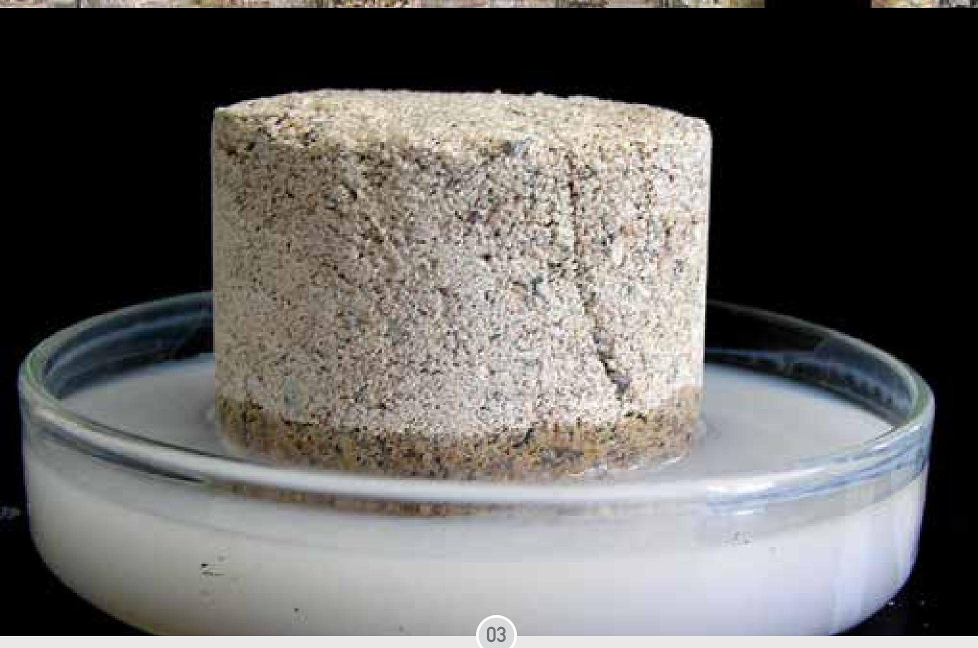

Fig 1. Calcium carbonate formed in porous mortar.

Fig 2. Nanoline at different concentration.

Fig 3. Nanoline absorption test.

Fig 4. Microinjection.

Fig 5. Microinjection grout calcium carbonate fillers and nanoline.

Fig 6. Pictorial cycle of the Chapel of the Queen Teodolinda, Cathedral of Monza, Italy. Restored by Anna Lucchini.

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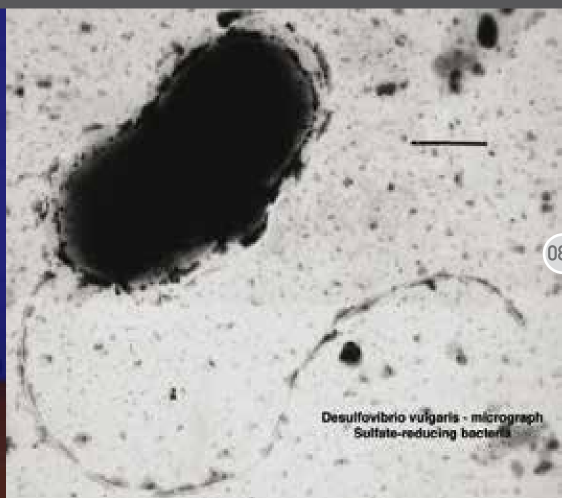
08a


Micro4Art-solfati
componente "C"
Micro4Art-solfati
componente "D"


Desulfovibrio vulgaris - micrograph
Sulfate-reducing bacteria

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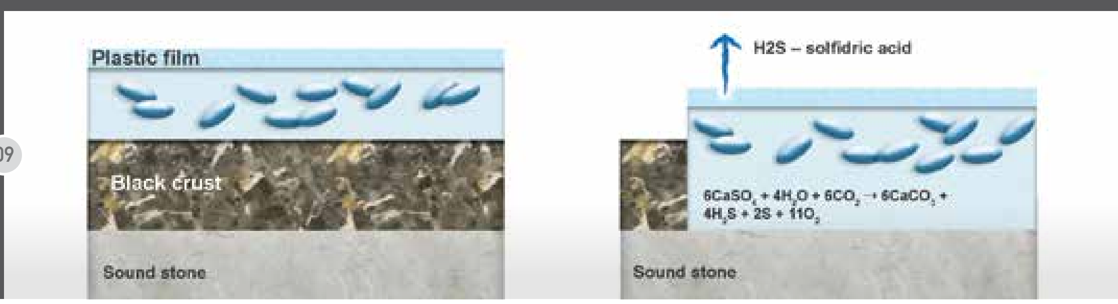
Plastic film
Black crust
Sound stone
H2S – solfidric acid
6CaSO4 + 4H2O + 6CO2 → 6CaCO3 + 4H2S + 2S + 11O2
Sound stone

For exemple, Micro4Art–sulfates is an innovative cleaning technology employing the sulfate-reducing bacteria (SRB) (figure 8a,b).
MECHANISM OF ACTION_Desulfovibrio vulgaris, thanks to its metabolism (figure 9), is able to dissociate gypsum into Ca^{2+} and SO_4^{2+} ions, and the SO_4^{2+} ions are then reduced by the bacteria, whereas the Ca2+ ions react with carbon dioxide to form new calcite[4] according the following reaction. $6CaSO_4 + 4H_2O + 6CO_2$ Ý $6CaCO_3 + 4H_2S + 2S + 11O_2$

In order to solve such specific sector problems it is necessary to have transversal competencies that enable the interaction of both the experimental scientific world, the one which produces and makes available to the market the variety of products for the resolution of various problems, with the sector that works on the construction sites for the preservation of the cultural heritage.

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10b

Fig 7. Test of bio-cleaning with bacteria by Restorer's Anna Lucchini.

Fig 8a. Desulfovibrio vulgaris.

Fig 8b. Packaging of commercial product.

Fig 9. Mechanism of action

Fig 10a,b. Biorestorative Microbes.
a) Before treatment
b) After Micro4Art-sulfates treatment

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RESTORATION MADE IN ITALY

THE COLONNADE OF ST. PETER'S SQUARE

The square in front of St. Peter's Basilica in Rome is known worldwide as a symbol of Christianity, as well as a baroque masterpiece due to the artistic genius of Gian Lorenzo Bernini who built it between 1656 and 1667. The restoration of the square, symbol of excellence of Christianity can be considered one of the most important opportunities to build on experience established by the Navarra brothers in decades of prestigious activity. It has concerned principally two materials: stone (travertino marble) with who balustrades, statues, coats of arms, the colonnade and the twin fountains are realized, and plasters.In view of the delicacy of the project, due not only to the uniqueness and artistic quality of the monument in question, but also to the fact that Saint Peter's Square in an integral part of one of the world's busiest places of worship, the restoration project was flanked by an historical-architectural study which commenced with an enquiry into Bernini's original building site and examined all the events and projects to which the square has been party, as well as an historical-artistic study of the statues of Bernini's colonnade.

Hand detail before restoration damages

Statue before restoration

Statue before cleaning

Statue detail before restoration

Statue after restoration

THE VILLA REALE OF MONZA

Hillside estate founded by the Habsburgs by architect Piermarini in the second half of 1700. The restoration involved the central body of the Villa, in internal and external. The materials that decorate the rooms of the Villa are: stuccoes, plaster, tapestry, wooden floors and furnishings, mural paintings and paintings on canvas. The ideas was to carry out a restoration that was as sensitive as possible to the past, that would convey what the palace would have been like at the end of the 19th century. The project of restoration of the last floor called Belvedere, has been done by Architect Michele De Lucchi who has put forward a flexible, modular plan for the area so that it can host events, conferences and workshop, but can also be used for temporary exhibitions and as a museum.

Ceiling before restoration

Ceiling after restoration

Stuccoes and frescoes during cleaning

Stuccoes and frescoes after restoration detail

vault Rocchetta 's couryards before and after restoration

plaster's consolidation detail

THE SFORZESCO CASTLE IN MILAN

The beginning of the construcion of the building as a defensive stronghold, dated around 1365 by Galeazzo II Visconti. During the following three centuries, there was other destruction and reconstruction. Following the unification of Italy and the purchase of the monument by the City of Milan, the building changes his historical function as fortress in museum.

The restoration work has centered on major areas of the inner courtyards retaining the texture of elements, saving and enhancing the historical memory and the artistic value of the architectural complex. The Sforza Castle is full of different materials: ornate plasterwork, masonry brick curtains, frescoes and decorative terracotta elements belonging to the different construction periods of the architectural complex. The most great discovery was made by the came to light of the 19th century frescoes on the vaults of the Rocchetta's courtyard recovered the grey plaster applied in the fifties of 20th century.

Roberto Meschini
Matteo Fabbri

PALMYRA

From virtual reconstruction to physical copy through the digital anastylosis

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The philological reconstruction of a work that has been destroyed by natural events or war is a complex operation. Although we live in a word where images (which for the most part are now digital) and three-dimensional models (from satellite maps) depict every place on the planet, monuments often lack documentation that is thorough enough to allow for their faithful reconstruction down to the last detail; this is especially true for at-risk areas, even those that are UNESCO World Heritage Sites. For example, there are over two million online images of the Coliseum in Rome, taken from every angle, in addition to drawings

01

and relief models from every era, and no less than 10 three-dimensional architectural models created by universities, foundations, or private individuals. Palmyra, which has been a World Heritage Site since 1980, has been known since the 19th century, when archaeological digs also took place, and documentation of it is thus rather obsolete. In particular, there are only a few relief drawings of the Temple of Bel, published in the books “The ruins of Palmyra, otherwise Tedmor, in the desert” by Robert Wood (1753) and “Le temple de Bêl à Palmyre” by Henri Seyrig, Robert Amy and Ernest Will (1975). These are the only two reference works featuring drawings and engravings that describe the temple in detail; in addition there are the historic photographs taken between 1867 and 1876 by the French photographer Félix Bonfils. The digital reconstruction of the ceiling on the northern Thalamos was based on these sources, which document the state of the monument upon its discovery, and on the photographs taken by G. Degeorge in 1999, the only high-resolution photos of the site. (figures 1-2)

The outside of the east wall of Bel’s Temple, Palmyra, 2009 (courtesy I. Baraldi)

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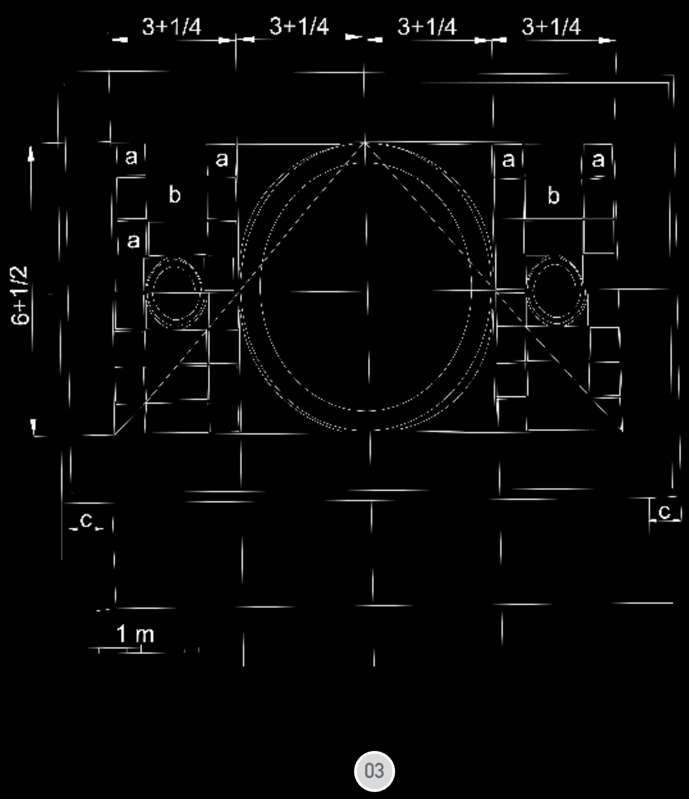
The inside of Bel’s Temple, looking towards the North Thalamos, 2009 (courtesy I. Baraldi)



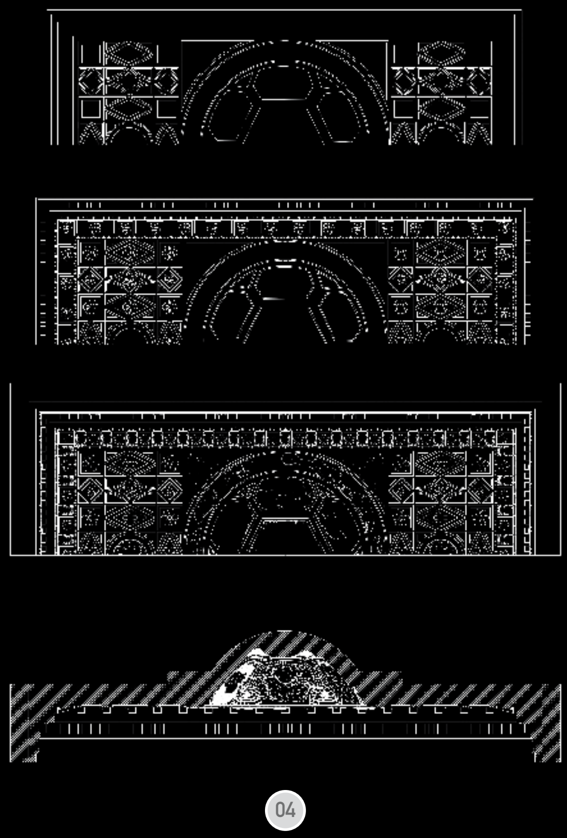


Fig 3. 2D CAD drawing showing the scheme of the composition and the relations between the decorative elements of the ceiling of the North Thalamos. The CAD drawing has been obtained using the historical drawings from the volume "Le temple de Bêl à Palmyre" Henri Seyrig; Robert Amy; Ernest Will (1975).

Fig 4. 2D CAD drawing of the main shapes of the decoration, obtained through vectorization and compensation of the drawings from the volume "Le Temple de Bêl à Palmyre"; Henri Seyrig, Robert Amy, Ernest Will (1975).

It took two technicians over a month to reconstruct the digital model. They had to carry out a careful iconographic analysis of the material they received from the archaeologists, make it philologically coherent, then put it together with enough detail to build the life-size replica. The relevant part of the ceiling of the northern Thalamos - which is 4 meters wide, 1.5 meters deep, and with a maximum height of 1.6 meters – is decorated by a rich array of sculptures, including numerous Greco-Roman capitals, kyma lesbio, acanthus leaves, human sculptures and sculptures of mythological animals, some headless, within a broader Greco-Roman architectural structure with decorated architraves.

CREATION OF THE ARCHITRAVES

The methodology used to carry out the project called for a sequence of procedures (analysis – modelling – construction) to ensure that the replica would be built properly.
The first step is an architectural analysis of the monument itself, through a historical and artistic analysis of its decorative and architectural elements, so as to identify their main characteristics and the style in which they were built. (figure 3)
This is followed by an iconographic analysis of all available images – photographs and historical drawings and engravings – to create a database of the elements necessary to achieve as lifelike as possible a virtual replica. This entails re-modelling the parts that are visible in photographs, and using available data and analyses to re-create the parts that are not.
This follows a methodology that has been successfully tested over the years in similar digital and physical reconstruction projects. First of all, paper material is digitized, then the images are vectorised by turning them from raster graphics to two-dimensional vector CADs.

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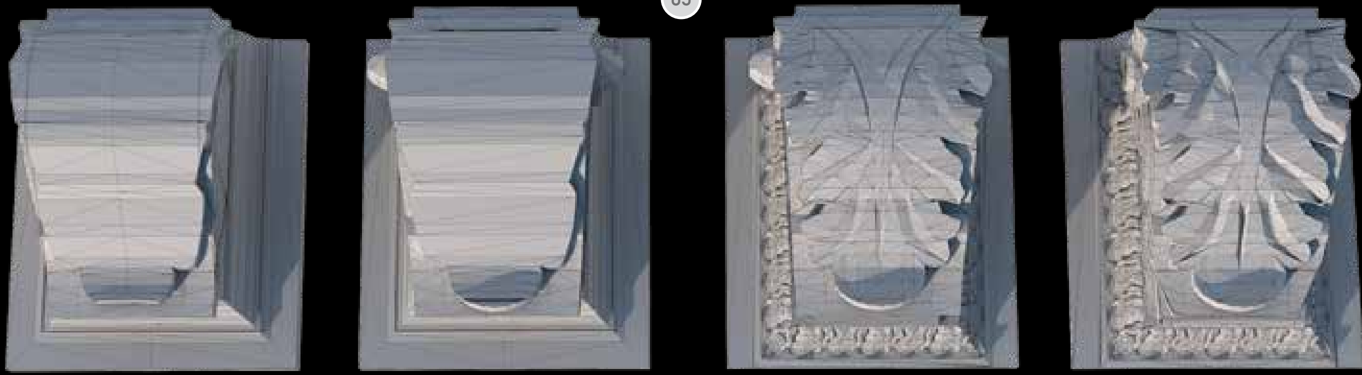

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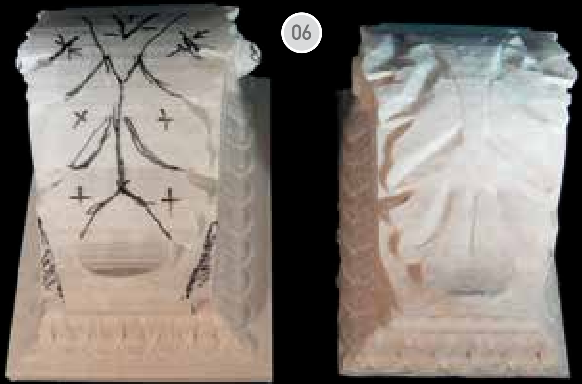

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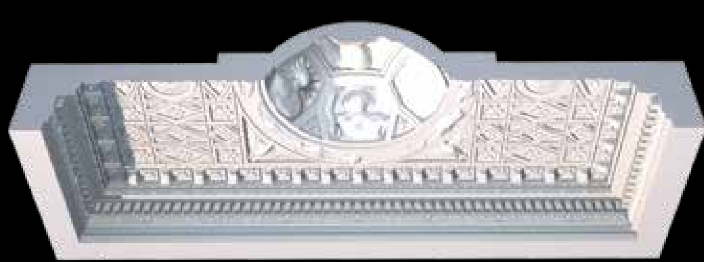

Fig 5. Sequence of 3D models of one of the capitals of the ceiling of the North Thalamos. The sequence shows the modelling methodology applied to the entire ceiling: starting from a proportioned volumetric model, the level of detail has been increased through the interpretation of the provided drawings and photographs.

Fig 6. Printing test of the capitals of the ceiling of the North Thalamos. Through printing a trial version of the models is possible to physically check the various decorative components and control the aspects that could be not evident in the virtual model.

Fig 7. Image of the portion of the ceiling of the North Thalamos, chosen to create the copy, rendered through a 3D modelling software. All the decorative components have been modelling like a newly-finished sculptures in order to better understand dimensional relations and decorative correspondences.

The data are then cross-checked, and a two-dimensional file is created that takes into account all deformation and possible interpretations of the drawings and photographs. This makes it possible to obtain coherent maps, cross-sections, and perspective drawings that can be used to draft the 3D model. (figure 4)

Starting from file CAD 2D, which comprise mainly lines, curves, and two-dimensional polygons, another software is used to draft the model, with the lines, curves and polygons being modified by specific modelling functions to create a three-dimensional model. In order to maintain original proportions, a specific order is followed from the architecture to decorative details, and the model is fine-tuned for subsequent modifications, beginning with the overall architecture and ending with the tiniest details. (figure 5) In the case of the Temple of Bel we also made 3D prints of the decorative elements at the various modelling stages, from the first rough draft to the finished piece, in order to compare the various components and understand them better. Subsequently, the changes to be adopted in the final model are marked on the 3D prints themselves. This makes it possible to follow the evolution of the process step by step, including by constantly revising the draft versions with the help of the archaeologists. (figure 6)

Such an approach is necessary because the final product is a life-size 3D model – not a render image, but a tangible object. Additionally, the impossibility to compare the model directly with the original, which has been destroyed, required a new approach to modelling that was as objective as possible despite the initial constraints.

The virtual model looks like a newly-finished sculpture, as it shows no signs or wear or damage, whether natural or man-made. The only exception concerns the figures that decorate the dome, which were severely damaged, and would have made for an unrealistic reconstruction. This choice was made to ensure that the replica would match the original, including the correct architectural and decorative ratios. The replica was then aged manually by a technician who analysed the photographs and the wear patterns of the stones used to build the temple. By removing some of the materials and adding tints (some parts are blackened by soot and ash), he gave the replica its appearance in 2015, before it was destroyed in August. As we firmly believe in the importance of a 3D database for a monument of such great value, we made a 3D scan of the finished model after the end of all operations and final revision by experts. This meant that all of the project's work - research, digital reconstruction, and manual reconstruction - came together in a single model to be preserved for future research and other works. (figure 7)

CREATION OF THE PHYSICAL COPY

Starting with the virtual model – complete down to its decorations – a life-size physical replica was created. As this replica is quite large, the model had to be broken down into about 250 sub-section to be assembled. Additionally, since the replica needs to be transported and installed in the exhibition venue, it was made using lightweight materials (polyester and polyurethane) coated with a water-and wear-resistant resin.
In order to optimize the process, we decided to apply a number of different digital construction techniques, which exploited the model's data through CNC machines to craft the various components.

HOT WIRE CUTTING MACHINES

The general architectural model was made using a hot wire cutting machine that automatically shapes the parts exported from the CAD drawings: starting with a large block of polyester, extruded polystyrene, or similar material, the various elements were cut using a system of pulleys and other mechanisms that allow a hot metal wire to run through the

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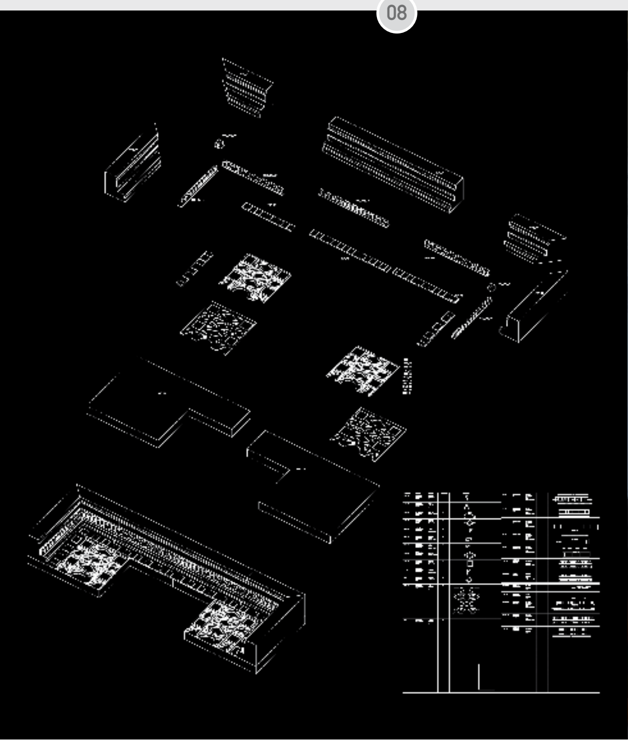

Fig 8. Exploded axonometric projection of the components of the bearing structure of the portion of the ceiling of the North Thalamos, which has been realized shaping a block of polyester using a CNC hot wire-cutting machine.

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Fig 9. Image of the 6-axis anthropomorphic robotic arm used to mill the dome of the ceiling, which is decorated with many sculptures. This machine has an high degree of precision and the automatic change of the cutters, combined with the six degrees of freedom of the arm, allows to mill particularly complex elements.

material. This system was used to create 140 different elements, with the smallest having sides of 10 cm, and the largest 1.4 meters. (figure 8)

ROBOTIC ARM FOR MILLING

The part of the dome decorated with many sculptures was made of 5 parts that were milled using a robotic arm with six degrees of freedom. Starting with the digital model and using the processing software, the machine is programmed and the milling cutters work the way a sculpture would. (figure 9)
The robotic arm makes a first rough cut from the block of polyester, then by automatically changing the cutters, it carves it in more detail. (figure 10)

3D PRINTING SYSTEM

The monument is decorated with a series of repetitive (figure 11), modular sculptures as follows: 11 modular decorations divided into 23 capitals, 25 cinquefoils and 30 six-lobed rosettes of various sizes; 12 modules of acanthus friezes with bull's heads topped with a three-lobed kyma lesbio decoration and one frieze comprising 32 modules of acanthus decorations under a ribbon of biconvex whorls with oval pearls; these biconvex whorls are also present in a ribbon separating the capitals from the flat decorations. Due to the high number of serial elements to be reproduced, and in order to optimize production times, we decided to use rapid prototyping techniques to create the ceiling decorations separately, then apply them to the base. Having obtained the modules from the overall model, we applied two different 3D printing techniques. Complex, decoration-rich elements were made using a professional chalk-powder 3D printer, which can deliver a high degree of precision (0.01 mm for each layer)[1], while simpler elements were made with a thermoplastic FDM printer whose degree of precision is sufficient for simple geometric shapes (0.06 mm for each layer). (figure 12) Once the modular components were printed in 3D, we used a silicone mould to make all necessary copies, which are faithful down to the last detail but made of a lighter material. (figure 13)

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Fig 10. An intermediate phase of the milling. The robotic arm, following a previously programmed paths, makes a first rough cut from the block of polyester, then, by automatically changing the cutters, it carves the tiniest details.

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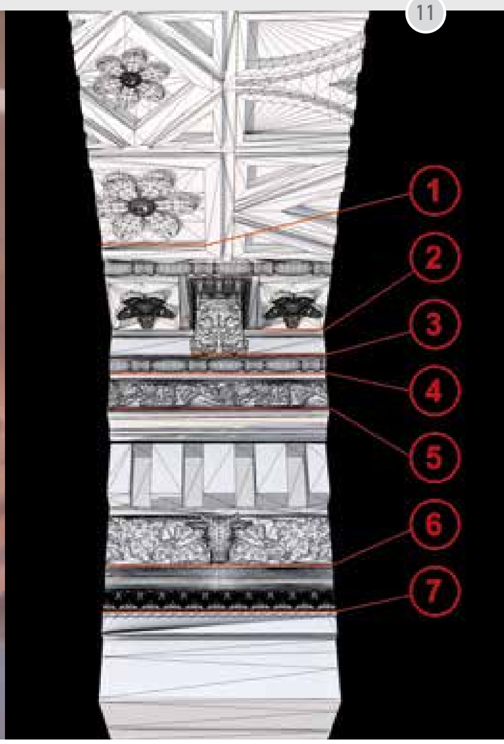

Fig 11. Image of a portion of the model of the ceiling of the North Thalamos rendered using a 3D modelling software. It shows all the principal decorative elements:
1) Six-lobed rosettes;
2) Five-lobed rosettes;
3) Acanthus leaves capital;
4) biconvex whorls with oval pearls;
5) Acanthus friezes;
6) Acanthus friezes with bull's heads;
7) three-lobed kyma lesbio.

12

Fig 12. Image of the capital printed in 3D using gypsum powder. 3D printing can deliver a high degree of precision reproducing the digital model of complex decoration with many details.

ASSEMBLY AND FINISH

Having verified that all the components were present and having completed the dry assembly of the model, we used certified epoxy resins to add all of the parts that were printed and milled using CNC. We thus obtained a complete copy of the ceiling, whose morphology matches that of the temple's ceiling before natural and human-generated wear. In order to make our replica match the appearance of the original right before it was destroyed, we added wear and tear both manually and mechanically to the decorations and some of the architectural parts, using the images we were provided as a model, and in constant contact with the experts from our scientific committee.

Once this phase was finished, we consolidated the decorative elements using a thin layer of synthetic chalk enhanced with oxides and sandstone powder (much like the original) to make the entire replica monolithic and give it a uniform tone. The back and sides were strengthened with a layer of fiberglass. (figure 14)

The final tint of each component was picked from a series of samples by the scientific committee in order to best match the effects of wear from time, wind, temperature changes, and human activities, such as the destruction of parts of the ceiling and soot from bivouacs inside the temple. (figure 15)

After balancing the colours of each component and completing all the various tints using suitable liquid and powdered acrylic and oxide-based pigments, the entire replica was coated with a transparent opaque acrylic protective layer. (figure 16)

Fig 13. The silicone mould of the elements with the bull's heads, obtained by the model printed in gypsum powder. In the selected portion of the ceiling ten bull's head are present with different kind of wear, thus a mould of the newly-finished element has been done and each bull's head has been aged manually on the base of the provided photographs.

Fig 14. The real size copy of the part of ceiling of the North Thalamos, including all its components. It shows the first uniform tone obtained using a thin layer of synthetic chalk enhanced with oxides and sandstone powder similar to the original.

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Fig 15. Samplings of different kinds of colour finishes, made in real size on a meaningful detail of the model. On the samplings different finishes has been tested to reproduce the effects of time, wind, temperature changes and human activities and then submitted to the scientific committee.

Fig 16. Beginning of the final phase of the realization of the life-like model.

Fig 17. The real-size copy of the portion of the ceiling of the North Thalamos set at the exhibition.

Fig 18. Detail of the dome of the ceiling.

The project highlighted the problems associated with safeguarding the memory of historic sites when they are struck by tragic events. The implementation of data collection and archiving projects, including through new technologies, would make it easier to study and share this issues, for both restoration and promotion of historic sites. More specifically, such an approach would limit the subjective interpretation of scholars in cases of replicas and reproduction – which bias is inevitable when consulting photographs and historical data – and ensure certified precision.

The replica described here is the outcome of a major collaborative effort between professionals from various sectors. It would have been impossible without the desire to raise awareness on these issues, and saw the involvement of the project promoters, its scientific committee, and the entire staff of TryeCo 2.0 srl, Alex P.O.P, and Andrea Fantini Studio. Along with us these companies actively contributed to the project's success.

(1) *3D printers make three-dimensional objects through the overlap of two-dimensional layers, the thickness of which determines the precision of the final model.*

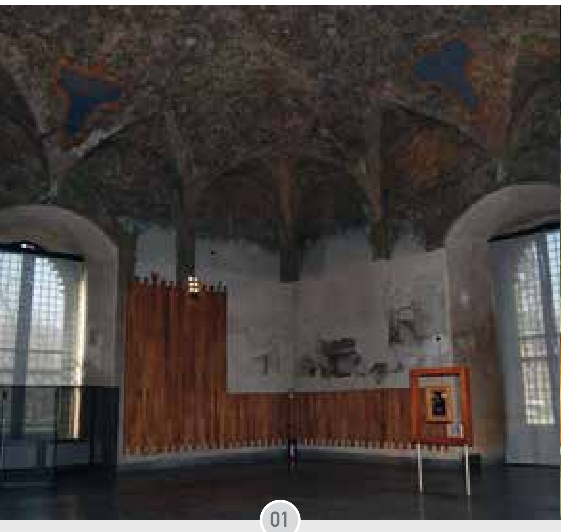

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Fig. 1 Milan, Sforza Castle, Sala delle Asse, Leonardo da Vinci, 1498. The north corner before the last restoration, 2008

Fig 2. Milan, Sforza Castle, Sala delle Asse, Leonardo da Vinci, 1498. The south corner before the last restoration, 2008

Fig. 3. Milan, Sforza Castle, Sala delle Asse, Leonardo da Vinci, 1498. The north east wall, 2014, Copyright Milanese Municipality (all rights reserved) Photo by M. Ranzani

Fig 4. Milan, Sforza Castle, Sala delle Asse, Leonardo da Vinci, 1498. Test for the repainting removal, 2015, Copyright Milanese Municipality (all rights reserved) Photo by M. Ranzani

Fig 5. Milan, Sforza Castle, Sala delle Asse, Leonardo da Vinci, 1498. The Luca Beltrami's furniture and Ernesto Rusca's repainting, 1909-1929. Photo by Anderson

Fig 6. Milan, Sforza Castle, Sala delle Asse, Leonardo da Vinci, 1498. Total view of the vault, 2013, Copyright Milanese Municipality (all rights reserved). Photo by M. Ranzani

RESTORATION BETWEEN TRADITION AND INNOVATION

The case study of the unknown Leonardo da Vinci's mural paintings of the Sala delle Asse in the Sforza Castle in Milan

In 1498 Leonardo da Vinci was still living in Milan painting the Sala delle Asse decoration in the Sforza Castle. (figures 1 and 2)

He couldn't finish his work due to the arrival in Italy of the French troops in 1499; provoking Duke Ludovico Sforza and Leonardo da Vinci's escape from Milan.

Leonardo (probably with some helpers) painted a fake arbor on the vault of the room, made by a series of intertwined branches and golden ropes. He probably finished the mural painting of the vault but the decoration on the walls therefore remained at the stage of preparatory drawing (figure 3).

Foreign troops controlled the Milanese Dukedom until XVIII century and the Sforza Castle was used as barracks by the invading armies until it was taken over by the Italian troops. For years the Corte Ducale was used as a stables for horses and all the paintings were covered by layers of whitewash. Then, in 1893 the property of the building was passed on to the Milanese municipality and the architect Luca Beltrami started an important restoration of the Castle. The layers of whitewash were removed and traces of Leonardo's forgotten vault painting were discovered.

Removing layers of whitewash caused serious damage (figure 4) to the original mural painting; so architect Luca Beltrami decided that it had to be repainted over by the painter Ernesto Rusca who concluded this work in 1902 (figures 5 and 6). Between 1955 and 1956 there was a new intervention but Leonardo's picture remained under Rusca's repainting (figure 7).

In 2006, due to the state of degradation, a new restoration and study project was set up to analyse the conservation condition of the paintings; it was clearly necessary to begin an urgent restoration intervention. The Milanese municipality[1] brought in the Ministry of Cul-

(1) *Project team: dott. Claudio Salsi, dott.ssa Francesca Tasso, dott. Luca Tosi*


04


05


06

**Milan, Sforza Castle, Sala delle Asse, Leonardo da Vinci, 1498.
A part of the Ernesto Rusca's repainting,
2016, Copyright Milanese Municipality (all rights reserved).
Photo by M. Ranzani**

**Milano, Sforza Castle, Sala delle Asse, Leonardo da Vinci, 1498.
Leonardo's picture traces discovered under Rusca's repainting,
2016, Copyright Milanese Municipality
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07

Fig 7. Milano, Sforza Castle, Sala delle Asse, Leonardo da Vinci, 1498. The so-called monochrom on the east wall, 2013, Copyright Milanese Municipality (all rights reserved). Photo by M. Ranzani

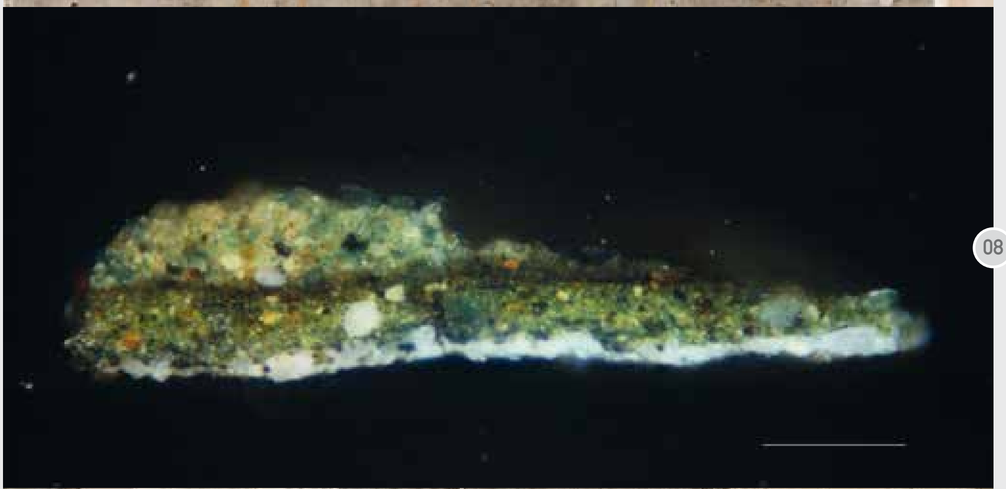
08

Fig 8. Section of a fragment of the pictorial film, optical microscope examination for checkig results of laser cleaning, 2016. Photo by ICVBC – CNR


09

Fig 9. Milano, Sforza Castle, Sala delle Asse, Leonardo da Vinci, 1498. Traces of preparatory drawings found under the layers of whitewash, 2016, Copyright Milanese Municipality (all rights reserved). Photo by M. Ranzani

tural Heritage and Activities and Tourism to start the new intervention with three goals: to understand and remove the causes of deterioration (figure 8); to find traces of Leonardo's vault painting (figures 9 and 10); to remove the layers of whitewash to allow the vision of the Leonardo's preparatory drawings on the wall (figure 11).
Opificio delle Pietre Dure di Firenze[(2)], doing the study work, and the writer of this documentation, the director of the restoration activity; are bringing to light important results regarding the methodology of restoration. As with the other mural painting of Leonardo da Vinci, The Cenacolo (the Last Supper), this is also a very difficult case due to the pictorial techniques used by the great master and also for the particular history of the hall.

(2) *Project team: Dott. Marco Ciatti, dott.ssa Cecilia Frosinini, restauratori: Fabrizio Bandini, Alberto Felici, Maria Rosa Lanfranchi, Paola Ilaria Mariotti*

Fabrizio Settanni

IBIX SPECIAL CLEANING

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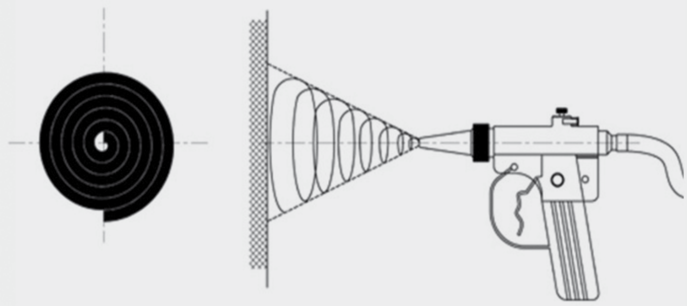
FONDI CAL AQUILEIA RESTORATION

The Roman city of Aquileia was founded in 181 BC by a handful of legionaries on the march to defend the borders of the empire from the barbarian invasions. Thanks to its strategic position, the military post soon turned into a thriving city, an essential intersection for the trade routes of Rome.

Some evident signs of its ancient greatness remain up to these days: the archaeological findings clearly show a past full of richness, the foundations of buildings design the plan of the ancient city. And among the walls, there are still intact mosaics characterised by an extraordinary beauty.

These huge archaeological areas, however, are not exempt from suffering the ravages of time. The delicate materials, which have survived more than two thousand years of history, are affected by natural elements, water, wind and biological infestations.

The company Arecon Restauri has been commissioned to carry out the special conservation cleaning of the area known as ‘Fondi Cal’, a large space in which the original floors of Roman dwellings are still preserved among the ancient foundations and low walls.



The company has decided to use IBIX air-blasters for cleaning the delicate stones of the low walls. The method is based on the controlled, low-pressure projection of extra-fine inert material that is able to remove biological infestations and smog, while also protecting the noble patina of stones.

For greater gentleness, restorers have decided to employ the HELIX helical vortex technology, an original patent. The tool is able to apply a rotary movement to the inert material coming out of the air-blaster gun. In this way, the jet does not reach the treated surface perpendicularly, but rather always in a tangent direction; the rotating movement also contributes to the removal of harmful coatings (patinas). Thus, the intervention becomes softer but, at the same time, more effective. On this type of applications, the use of the HELIX technology guarantees a 30% increase in effectiveness as well as considerable savings in terms of the material used.

Whereas as regards the cleaning of the precious mosaic tiles, a different procedure had to be followed. The first operation carried out consisted in a biocidal treatment, which was necessary in order to dry mould, fungi and other biological infestations that would otherwise appear again short after the cleaning treatment.

After this first phase, the floor tiles that were not firmly attached were removed. This was done in order to prevent the treatment from damaging the small tiles or from removing them, causing their loss.

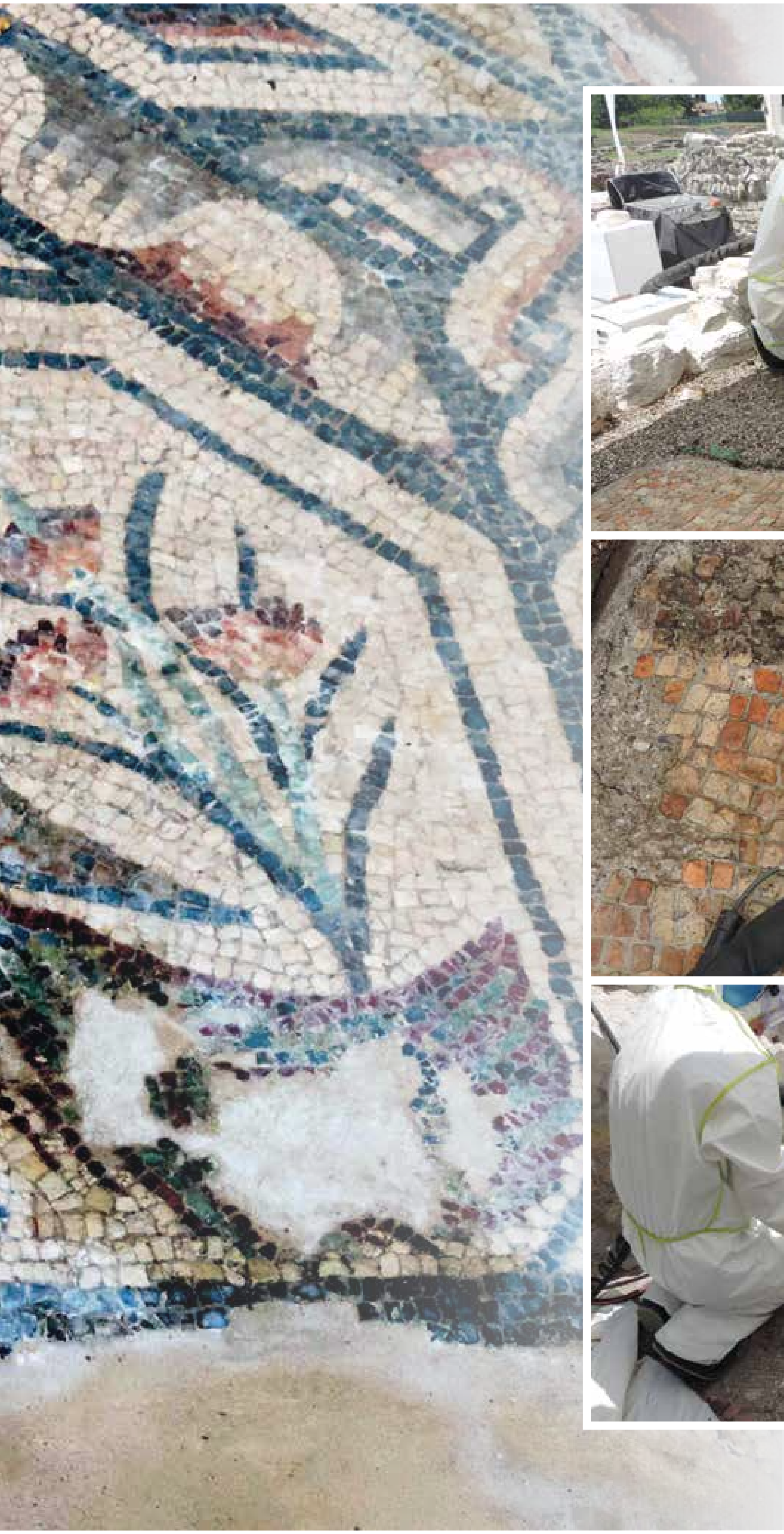
Then, it was decided to apply the cryogenic technique, i.e. the projection of Co2, dry ice, on the surfaces to be cleaned. For this operation, the IB-ICE equipment, also supplied by IBIX, was used. Unlike traditional cryogenic cleaning, which is mainly used in the industrial sector, IBIX has developed a low pressure (3 bar) intervention parameter that has made cryogenic cleaning much more delicate and economical than the standard interventions. As a

matter of fact an IB 2000 compressor supplied by IBIX was employed. Such compressor is able to supply 2000 litres of air per minute (this power is extremely lower than the one regularly used for interventions with cryogenic technology). Thanks to these adaptations, a generally aggressive technique has been turned into a suitable procedure for a delicate restoration intervention.

A characteristic of the cryogenic method, which made this technique particularly suitable for the restoration of the findings in Aquileia, is that it does not leave any residues during the cleaning operation. This was one of the main problems to be faced in the 'Fondi Cal' intervention; in fact, any technique that would generate even the slightest waste would have compromised the delicate mosaics, which are precisely made up by typical interstices between the small tiles from which it would have been impossible to remove cleaning residues afterwards.

Another feature that has made the IBIX system particularly suitable for the work in the archaeological site lies in the fact that all the technologies used have been transported to the area with a commercial van of average dimensions. In addition, all the machines are wheeled, light and easy to carry around and transport, thus ideal to work in the difficult spaces of archaeological sites and excavations.

Special thanks to the Friuli Venezia Giulia Landscape and Cultural Heritage Regional Head Office for granting the images. The restoration of the archaeological site "Fondi Cal" was organized and funded by the Aquileia Foundation. The works were performed by the company "Arecon – Arte Restauro Conservazione"



Maria Elena Moschella
Mariano Cristellotti

DIAGNOSTIC AS A TOOL FOR RESTORATION AND CONSERVATION OF WALL PAINTINGS, SCULPTURES AND DECORATIVE APPARATUS: APPLICATIONS

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Diagnostic, in particular non-invasive methods, is fundamental for researches concerning the conservation and restoration of cultural heritage, and for studies on building materials and related production techniques. Furthermore, it represents an essential tool to investigate alterations, weathering phenomena and their causes allowing also the monitoring of the effectiveness of restoration methods.

The work of art is an abstract idea of the artist that is shaped with different materials. The characterization of artistic materials is essential in order to optimize the restoration project and to safeguard the material itself through time. A lack of analytical data on materials and on decay products can lead to improper restoration choices.

Restoration phases can be grouped in four categories: cleaning, consolidation, integration and protection. This partition is generalized, because every work of art, as a patient of a doctor, needs of an ad hoc treatment. The cleaning is the most critical phase: everything that is removed is lost; it's impossible to turn back or put right the damage created in this operation. A lot of cleaning methods exist: physical and mechanical, chemical and physical/chemical, and biological. Each one of these methods can be applied in many ways, from the choice of the best abrasive to the creation of the appropriate chemical solutions for removing stain or an altered layer, to the choice of enzymes or other biological agents.

Mondovì - CN. Chiesa della Missione. Wall decorative stucco, 17th century

Mondovì - CN.
San Donato Cathedral.
Decorative apparatus,
19th century

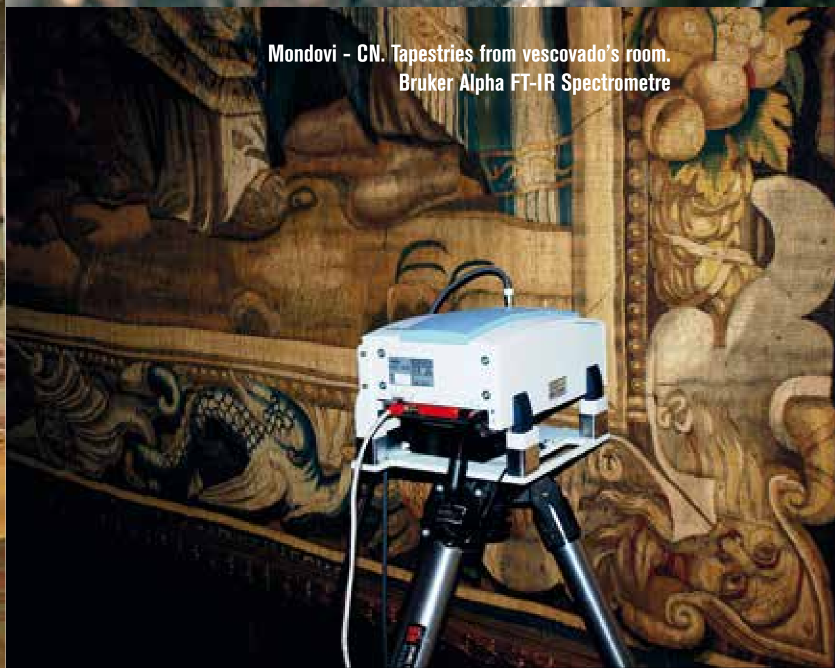
The importance of the knowledge of the substrata is evident, as well as their chemical/physical characteristics, because basing on these features, it is possible to select the best cleaning methods, respecting the opera itself and the other layers. The same guidelines are valid for the selection of consolidation, integration and protection methods. Furthermore, another important factor is the operator protection: detrimental chemical solvents are often used. Today it is possible to utilize alternative materials respecting the health of the operator and of the safeguard of the natural environment.

The long-timed experience allowed our team to ideate an operative protocol that takes into account diagnostic tools applied to restoration techniques. For this reason, the team benefits of the support of a conservation scientist who selects ad hoc materials and methods for every case study.

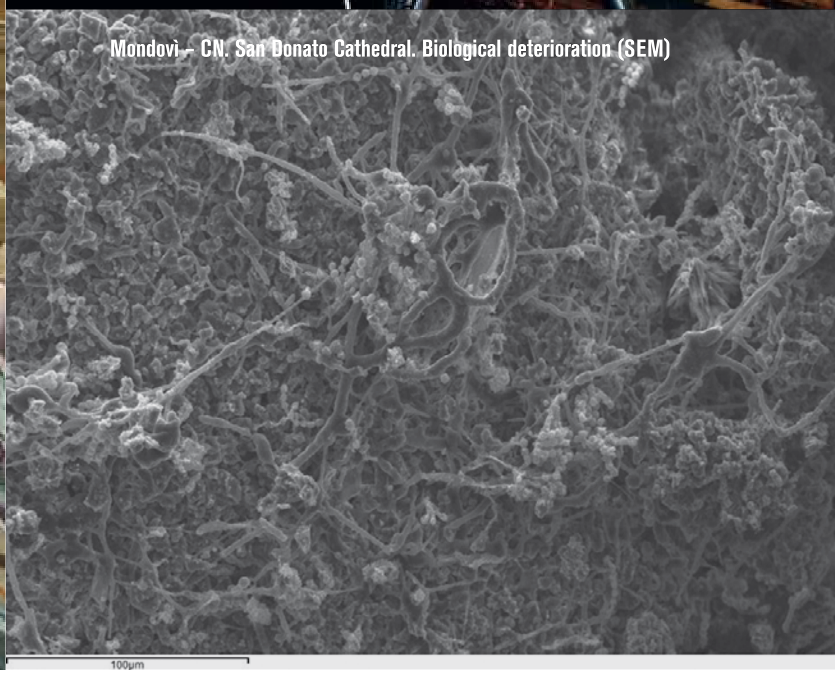
By a technical point of view, conservation science is a complex discipline because artistic techniques are not "standardized". In fact, artistic materials can have different properties and behaviors, these affect the nature of degradation products and the weathering causes. Conservation scientists, restorers, art historians and other professionals have to cooperate to achieve the best results during and after the restoration intervention. Besides, our team collaborates with the Earth Sciences Department of the University of Turin, which offers its scientific support.

Mondovì - CN. Chiesa della Missione.
Andrea Pozzo, vault wall paintings,
17th century

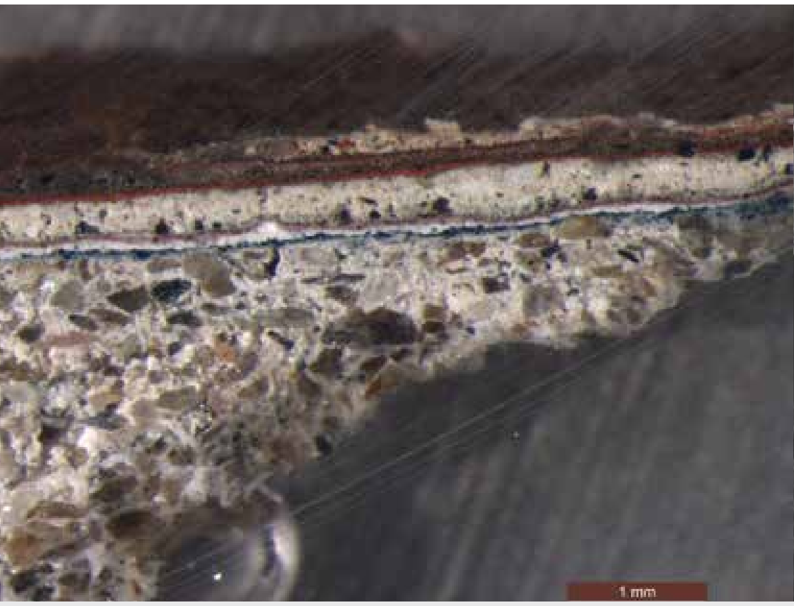
Mondovì - CN. San Donato Cathedral. Efflorescence



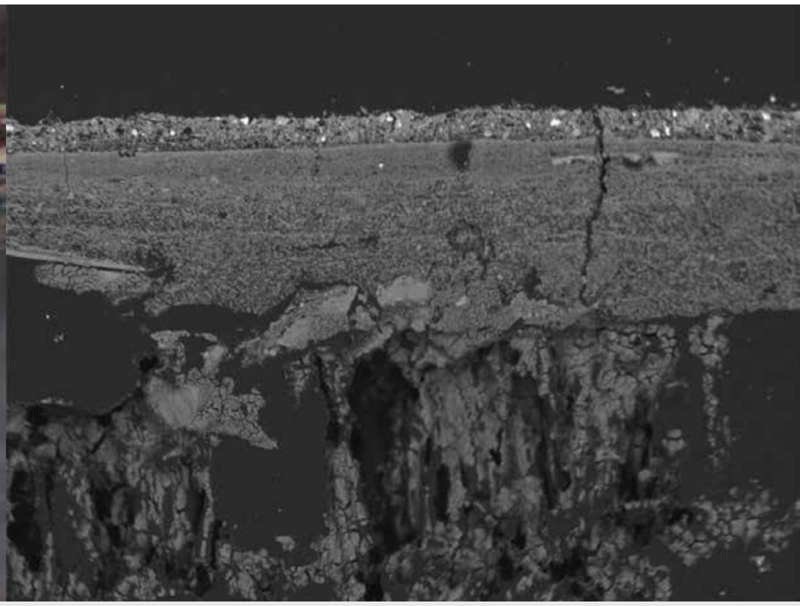
Mondovì - CN. Tapestries from vescovado's room.
Bruker Alpha FT-IR Spectrometre



Mondovì - CN. San Donato Cathedral. Biological deterioration (SEM)



Saluzzo - CN. Chiesa di Santa Maria della Stella.
Stratigraphic section (O.M.)



Saluzzo - CN. Chiesa di Santa Maria della Stella.
Stratigraphic section (SEM-BSK)

Analytical techniques must be chosen according to the properties of different materials and to the kind of data required. The first step of an ideal operative protocol is the observation of the surfaces that require the intervention; this can be done by naked eye, optical microscopy (also using portable devices) and digital cameras. Imaging in raking visible light or also using infrared and ultraviolet light sources, can display otherwise unnoticed details. This kind of observation gives preliminary information on materials, artistic techniques, alterations, weathering causes and monitoring data on the operative steps controlling the effectiveness of cleaning and consolidation.
After, if necessary, the sampling spot is chosen and a small fragment of material is collected. Whenever possible, non-destructive techniques have to be preferred in order to avoid the alteration of the work of art. In some cases, sampling is necessary and the choice of the spot has to be the more representative as possible. Sampling operation must always be supervised by a conservation scientist who is able to identify the correct sampling site and the opportune sampling methodology. Samples can be collected in different ways (solid or liquid) according to analytical necessities. Whether a stratigraphic section is needed, the collected sample is embedded in resin, cut perpendicularly to its surface; the resulting section shows the sequence of pictorial and preparative layers.
Analytical techniques can be subdivided in the following categories:

- **MORPHOLOGICAL.** The sample can be observed by means of optical microscopy (O.M.) or scanning electron microscopy (SEM) that allows to obtain high magnifications.

- **MOLECULAR.** Infrared and microRaman spectroscopies give data on functional groups, hence on the kind of molecules composing the material. These techniques can also be applied with in situ portable devices that do not require sampling. Our team owns a portable FT-IR spectrometers (Bruker Alpha). Molecular spectroscopies are particularly useful in the identification of organic materials used in painting (pigments, binders and varnishes).

_ **ELEMENTAL.** Investigating materials with elemental spectroscopies permits to identify which elements are present in a determinate analytical spot. These techniques are useful in particular for the identification of inorganic materials. Furthermore, trace elements analysis can give information on the provenance of certain materials. Examples of elemental techniques are SEM-EDS (energy dispersive spectroscopy), XRF (X-ray fluorescence), ICP-OES/MS (inductively coupled plasma – optical emission spectroscopy/mass spectroscopy).

_ **CRYSTALLOGRAPHIC.** These techniques are used to obtain information on the crystalline phases present in a sample, helping in the discrimination of polymorphs and those phases not identifiable though elemental techniques.

_ **CHROMATOGRAPHIC.** Particularly suitable for complex organic materials, for example gas-chromatography allows to easily distinguish oil and resins.
_ **DATING and PROVENANCE**. Dating of samples can be in certain cases be accomplished by means of 14C and termoluminescence. Isotopic analyses for stable isotopes can give provenance information.

In conclusion, analytical techniques can give complementary data and information. An optimized operative protocol allows to use a limited amount of sample and to obtain good results demonstrating how the integration of analytical data with operative procedures is fundamental for an enhanced restoration intervention.

**Ivrea – TO.
Twin bell towers of
the cathedral
12th century**

Laura Bartoli
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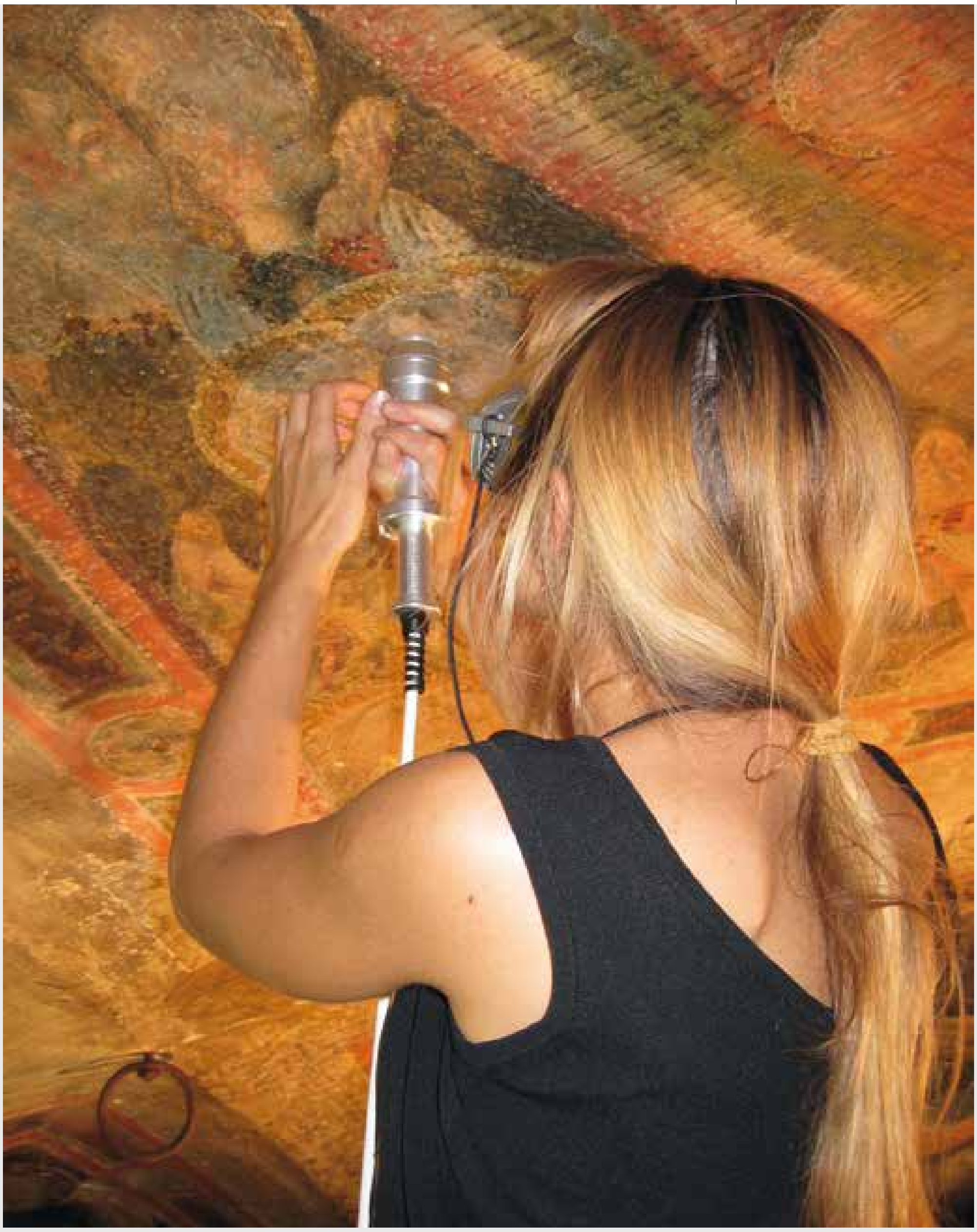
MOST ADVANCED TECHNIQUES FOR THE PRESERVATION OF DECORATED SURFACES

Laser cleaning gained in the last years a prominent position among the cleaning techniques for the conservation of Cultural Heritage. The use of laser for the restoration of artworks started in the 70s but the technique actually began its rise at the end of the 90s when scientific studies validated the efficacy of the use of a laser beam to clean masterpieces. The emission parameters of the lasers have been also optimized in order to guarantee a safe and efficient cleaning of different substrates. Laser cleaning was initially applied only for the removal of black crusts from white marbles but, thanks to the technological innovation and to the background of scientific studies, its use has been extended to other materials such as metals, gilded bronzes, wood, ceramics and wall paintings. One of the first case studies in the use of laser cleaning on wall paintings is dated back to the beginning of 2000 and took place in Siena, Italy. The Old Sacristy and the Chapel of the Mantle are two painted halls within the complex of Santa Maria della Scala in Siena, one of the oldest European hospitals opened about 1000 years ago and functioning until 70 years ago. Santa Maria della Scala has been gradually turned into a museum. The walls and the

Laser cleaning on the wall paintings of Villa of the Mysteries in Pompeii

Frescoes cleaning in the Old Sacristy in the Santa Maria della Scala Complex, Siena



vaults of the Old Sacristy were painted by Lorenzo Vecchietta between 1446 and 1449 with scenes from the Old and New Testaments. The paintings were coated with layers of whitewashing applied in the past. Used as first-aid room, the Chapel of the Mantle shows three spans divided into groin vaults painted by Cristoforo di Bindoccio and Meo di Pero in 1370. Again, in the past the paintings had been almost completely whitewashed. Traditional chemical and manual techniques proved unsuccessful in the removal of the whitewash because it was strongly attached to the pigments underneath. For this reason, restorers thought about the groundbreaking use of lasers. Preliminary tests were carried out using two intermediate-pulse systems: used together or one by one, they resulted in the successful removal of the whitewashing, revealing the frescoes underneath.

After this first successful result, laser cleaning has been widely applied for the cleaning of frescoes and wall paintings also in very particular and extreme environments such as catacombs. One beautiful case study regarding underground locations is the Catacomb of Domitilla, in Rome, in particular the "bakers' niche" which is located on the first floor of the catacombs. Its walls are mainly frescoed, often with dry overpainting. The microclimate inside the hypogean structures of the catacombs is usually quite stable, featuring high relative humidity between 96% and 100%, and temperatures around 14-17ºC all through the year. One of the most common decay problems concerns the precipitation and crystallization of calcium carbonate that covers the frescoes almost entirely. An instance of such decay is the typical dark film covering the vaults and the upper walls of the rooms that may range from thin films to very thick layers.

Santa Croce Church, Florence

During the last twenty years, the removal of incrustations has been carried out mostly manually, trying to remove the most of the concretion, at the same time protecting the original painting. Nevertheless, the results obtained with this method were unsatisfactory as they did not result in the complete cleaning of the surface. Therefore, after cleaning tests, two laser systems with optimized pulse duration have been used for the removal of the black film. The cleaning has been extremely satisfactory and brought back to light the beautiful colors of the original paintings. The laser has been able to safeguard all the different shades of colors, from red to ochre, from white to green.
A similar conservation problem was faced in the first century A.D. Roman complex of the Underground Basilica of St. Maria Maggiore in Rome. This is a beautiful and fascinating hypogean temple decorated with fine stuccos and a fresco, a three-nave hall destroyed and buried few decades after its completion. Here, too, the laser had to intervene for removing thick layers of mineralized carbonation that obscured and covered the precious depictions. Thanks to the experience gained in the first laser cleaning interventions on wall paintings the technique has been lately applied on many other important wall paintings such as in the Villa of the Mysteries in Pompeii, in the Main Chapel of the Santa Croce Basilica in Florence, in the Santa Tecla's Catacombs in Rome.
Armed with this experiences, this advanced cleaning technology for decorated surfaces has been applied successfully in other difficult interventions outside Italy such as on the murals of the temple of Mut in Jebel Barkal in Sudan, on the funerary paintings of the tombs of Xi`an and on the walls of the monastery of Quqa (Xinjiang) in China.

Cleaning trials on the stuccos of the hypogean Basilica of Porta Maggiore in Rome

Carlo Cacace
Director section microclimate models and data management IsCR

MICROCLIMATE ANALYSIS: DIAGNOSIS AND MONITORING

The environment-masonry system must be considered as a physical system, whose evolution can be controlled by understanding and measuring its parameters. Based on this assumption, a microclimate survey plays the special role of analysing the interaction between air and the materials, which helps control environmental aggression, on one hand, and understand how to minimize material deterioration, on the other hand.

This theoretical outline is useful to describe the majority of the phenomena that can be observed in a degradation process. When the functional interactions between the physical characteristics identified to describe the evolution of the system are known, these variables can be measured. The experimental data acquired with this procedure, in addition to characterizing the system, represent the basic knowledge to develop any environmental rehabilitation and, as a consequence, to control conservation conditions. Degradation happens when the state of conservation of the constitutive materials of a masonry changes. Generally speaking, degradation, in other words the state of conservation, depends on the energy balance between the two elements of the system. When a thermo-hygrometric unbalance is triggered between them, the system changes its state of conservation. In other words, a process is activated that will either improve or worsen the state of conservation of the material. Therefore, understanding the environmental conditions of a building, with regard to the chemical-physical relations of its constitutive materials, as well as to the state of aggregation and conservation of such materials, is an essential condition to control the process of deterioration. On the other hand, the so-called 'natural ageing', that is, the natural processes caused by the spontaneous interaction with the environment, must not be neglected. However, the way degradation develops and how fast it progresses not only depend on the amount of energy exchanged through the surfaces of the building, but also on the "initial conditions" and on the "boundary conditions" of the system, and namely on the way the latter can vary or be changed.

Spreading a protective coat on a dry finish or on a fresh one (different types of surfaces) during restoration can modify the boundary conditions and evolve into a different conservation pattern.

Installation of sensors to detect ambient temperature, the superficial temperature of masonry and relative humidity

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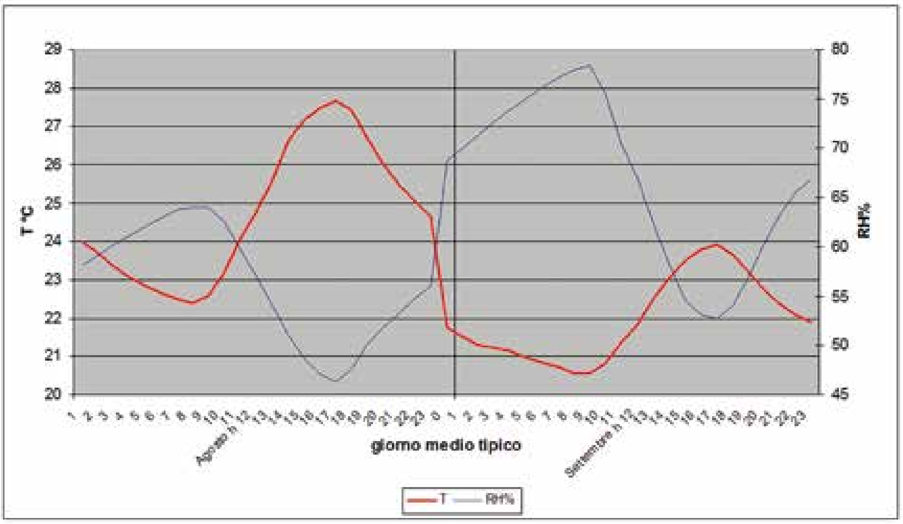
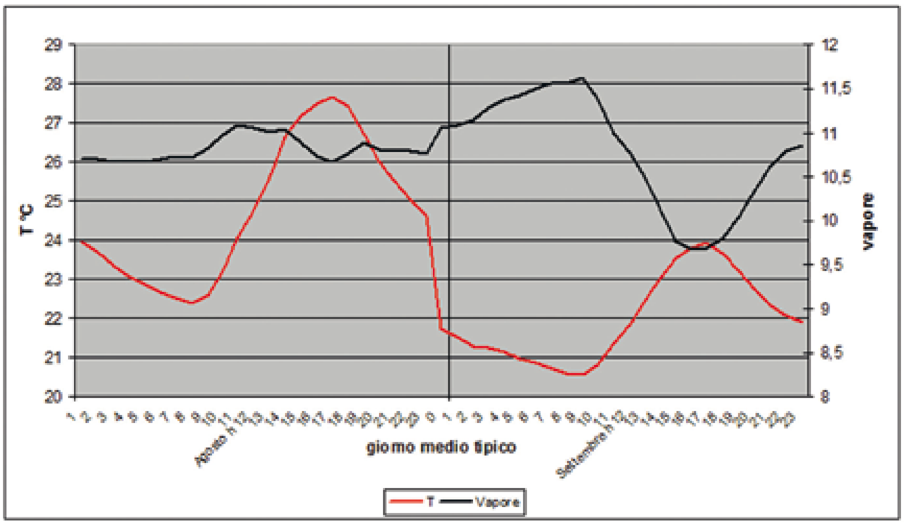


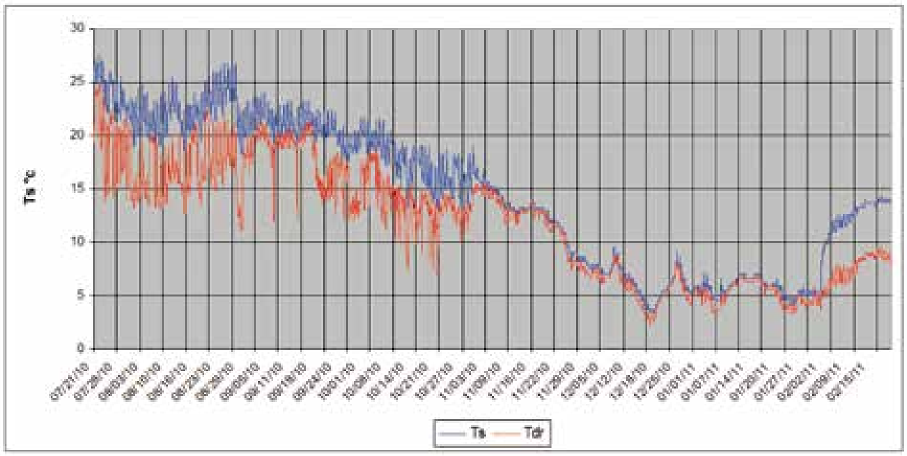
Comparison between temperature and relative humidity: as temperature rises, relative humidity decreases; as temperature falls, relative humidity increases.

03



Comparison between temperature and vapour: different patterns. In August, vapour remains constant, while in September the value corresponds to thermal variations

04



Comparison between the superficial temperature of masonry and the dew point, and monitoring of condensation. When the superficial temperature of masonry is lower or equal to the dew temperature, superficial condensation is observed

Also, clearly enough, masonry is not isolated with respect to the surrounding environment, but makes with it a physical system evolving with time. The evolution pattern depends on the type of energy involved (heat, mechanical, chemical, electro-chemical, etc.) and on the factors mentioned above. The 'environment-masonry' system can then be defined by the physical characteristics and by the mathematical relations that quantitatively describe the evolution in time and in space. Such evolution can be detected with the help of control units capable of recording the change over time of such physical parameters as air temperature, masonry temperature, relative humidity, air velocity, solar radiation, etc. Understanding the characteristics and the functional relations governing the transition from one state to another is essential to control and modify, following some selected indications, the pattern of degradation. However, one should always bear in mind that the physical characteristics have a different influence, depending on the nature and shape of the material.

Taking the model described above as a reference, the objective of a microclimate survey is to understand and identify the patterns governing the thermohygrometric balance of the environment-masonry system and to establish the conditions to slow down the process of deterioration of the material. The presence of water vapour in air and the hydrophilic characteristics of masonry are the main cause of deterioration generated by thermohygrometric exchange.

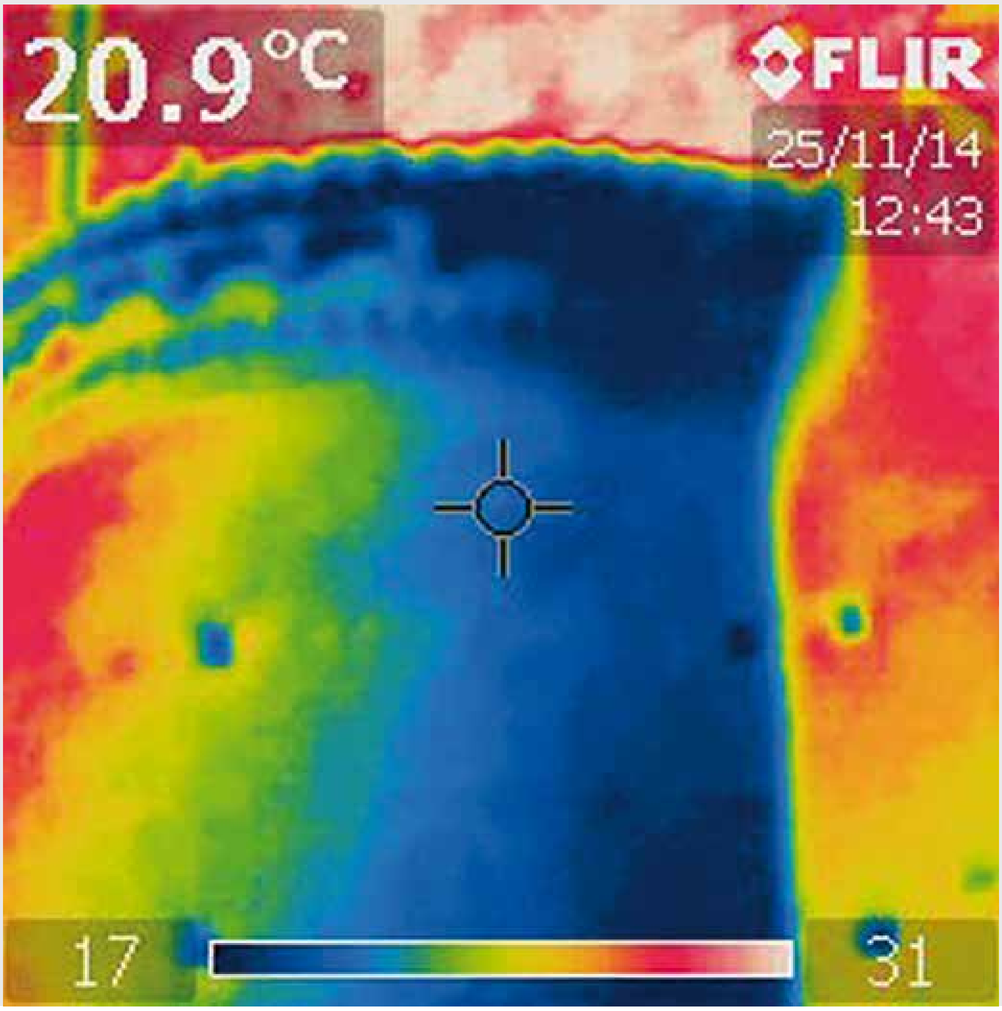
The most important parameters governing this type of interaction essentially depend on the physical state of water (vapour, liquid, solid). With mortar, they concern the nature of the binder and the mineral composition of the material, which, owed to high polarity, attracts water, also because of the porous microstructure of plaster generated by carbonation. For a thorough understanding of the ongoing and potential deterioration mechanisms, it is essential to learn about the porosity, hygroscopicity and wettability of a surface, because these parameters, when the thermohygronometric pattern remains equal, are capable of diversifying the behaviour of a system in the processes of absorption, adsorption, desorption, condensation, evaporation and sublimation. If we rule out the case of water infiltration or rising damp, owed to leaks from faulty piping or bad sealing of windows or roofing, the behaviour of any hydrophilic and porous material in a large enough environment that will not be influenced by any water absorption or desorption by the material itself is governed by the thermohygrometric pattern of air, and therefore of local climate.

As a general rule, the variation of water content in masonry is linked to these patterns and tends to diminish as temperature rises, because the latter is associated to the decreasing trend of relative humidity, and vice versa. The material tends to release water into air when temperature rises and relative humidity decreases, and to absorb water in the opposite conditions (figures 1,2,3). In these cases, it is theoretically beneficial to annul vapour exchange through the surface and therefore reach stable microclimatic conditions.

To minimize thermohygrometric variations induced by the exchange and recirculation of internal and external air, it is convenient to enhance the insulation of masonry and roofing alike, the seal of doors and windows, and the insulating conditions of the whole environment. All these interventions will inhibit heat and water vapour exchanges and strike a stable balance between air and the constitutive materials. In some special conditions,

e.g. high relative humidity, it is difficult to identify and understand whether the causes for deterioration actually depend on the wetting of a surface owed to rising damp, or to condensation after the dew point is reached, (figure 4), or to adsorption, or to condensation caused by the presence of hygroscopic salts and/or chemicals used during cleaning, consolidation and protection works, or to deposits of particulate or gaseous pollutants.
However, degradation caused by wetting may also be owed to the presence of a thin water film of few microns that is likely to form on a surface under conditions other than saturation, which is hardly detected with direct observation.
The absorption of sulphur trioxide (SO3), for instance, varies depending on the material, also as a function of superficial microporosity, and on the values of relative humidity. The presence of chlorides generates a different pattern of absorption, which needs to be assessed each time. In these cases, the critical threshold can fall far below the conditions of air saturation. Another important parameter to be considered is the heat strain caused by daily solar radiation. The energy released by a heat source propagates in different ways, depending on the type of source and on the physical state of the materials where heat is propagated. Any time there is a difference in temperature (heat gradient) between two physical systems or even two elements of a system, thermal energy is transmitted by conduction, convection and/or radiation, depending on the medium intervening between the heat source and the receiving system. Heat energy can, however, be measured instrumentally by measuring temperature and observing the heat-induced phenomena (figure 5).

Thermographic imaging of solar radiation on masonry



View of the Charles Bridge during the restoration works.
On the background, Prague's Castel and Cathedral.

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THE CHARLES BRIDGE IN PRAGUE

An ancient and picturesque monument withstanding damages and floods

The Prague castle is the oldest standing bridge over the river Vltava in Prague and it is the second oldest preserved bridge in the Czech Republic. The Charles Bridge substituted the previous Judith bridge which was broken down during the spring thaw in 1342. The Charles Bridge construction was started, under the auspices of the Charles IV king of Bohemia and Holy Roman Emperor, by the foundation stone laying down in 1357. The construction of the bridge was finished in 1402.

The Charles bridge is 515.76 m long and 9.40 – 9.50 m wide. The height of the pavement is 13 m above the normal water level. It is created by 16 arches. Their span is 16.62 m – 23.38 m. Bridge pillars were not founded in the rock because it was too deep. Therefore the bridge was founded in the foundation pit on running stones which were supported by oak piles. The bridge is made of blocks from different types of sandstones which make the framework; most of the pillars are bricked. There are also three towers on the bridge.

Building investigation in 1966-1967 revealed that the bridge was endangered especially by small cracks which allowed ingress of rainwater with soluble salts used for the winter pavement maintenance.

It was decided that the bridge opening had to be blocked off by the framework of anchors. Probably since 2001 specialists and also the public authorities and Prague citizens have been discussing about subsequent repairs of the bridge. The previous capital repair had some problems: the waterproofing treatment under the pavement did not perform very well and did not prevent the rainwater ingress into the construction.

In 2004-2005 the last repair intervention schedule was set down. Finishing building investigation and gathering complete documentation had to be done in 2005 and 2006. In 2006 the first two pillars (the eighth and ninth from the Little Quarter side) were anchored to concrete sarcophaguses.

The Old Tower Bridge, entrance gate to the Charles Bridge from Prague old town

The Charles Bridge is made of blocks from different types of sandstones which make the framework and were carefully analysed. Damaged sandstone blocks were changed in the whole bridge cladding

The bridge masonry repair is considered to be the most difficult phase of the whole repair. Every stone block was investigated by experts who decided whether it was to preserve, clean or substitute.
The upper construction repair started in August 2007 and took approximately 3 years.
Two different aspects were solved in the first phase of the bridge pillars repair. The first one was the appropriate formula of the mortar to be used under water level (some pillars under water level), which would have met the requirements for the permanent contact with water and would feature higher abrasion resistance and sufficient strength.
A wall made of steel casing was built up around the pillars in order to increase their protection and resistance and MAPEGROUT T60 sulphateresistant shrinkage-compensated fibre-reinforced thixotropic mortar was used for the repairs. The second aspect was to find the substitution of the original historical mortar for walling and grouting of the sandstone masonry above water level (only with random flooding during spring thaw).
MAPE-ANTIQUE LC was used in this case, salt resistant, hydraulic binder based on lime and Eco-Pozzolan, cement-free, mixed with local aggregates in various grain sizes to reproduce the original mortar. MAPE-ANTIQUE I, super-fluid, salt-resistant, fillerized hydraulic binder, based on lime and Eco-Pozzolan was used for consolidating masonry by injection of some sections in the bridge pillars.

After careful analysis MAPE-ANTIQUE LC, cement-free, hydraulic binder based on lime and Eco-Pozzolan was used to repair the sandstone blocks

A detail view of the bridge after completion of the repairs

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RESTORATION OF "CASALE DI PIAZZA ARMERINA" ROMAN VILLA. SICILY

Casale Roman Villa is a late roman residential building, commonly called "villa", although it does not have the proper features of the countryside roman villa, but rather those ones of the urban imperial palace. The remains are placed about four kilometers from Piazza Armerina, a small village in the heart of Sicily. From1997 it is a UNESCO World Heritage Site. The Villa belonged to a representative of the roman senatorial aristocracy, probably a governor from Rome (Praefectus Urbi). Instead, according to some specialists, it was built and expanded on direct imperial patronage. Considering its beauty and the complexity of its plan, it is considered one of the most significant examples of representative dwelling,

Biological attack

Reinforced iron bars removal

compared to other contemporary ones of the Roman Western Empire. The high profile of his owner is celebrated, in a very eloquent manner, through an iconographic program, conditioned in its style by the north-african roman culture, that is displayed with a compositional richness in many rooms, both public and private ones.
The first museological arrangement was planned at the end of '50s by the architect Franco Minissi that, with the knowledge of that time, worked for protecting the Villa and its mosaics from the bad weather. He designed a cover, definitely modern and innovative at the time, using iron posts and trusses and plexiglass sheets covering the roof and closing the perimeter wall of the Villa. It was the age developing new materials, and plexiglass, flexible and versatile, was suitable on the purpose. Then arch. Minissi designed a cover recalling the third dimension, the volumes of the Villa. Even this was an innovative choice, along all the scenario of the contemporary coverings in the italian archaeological sites. Moreover He assembled the external wall using wooden sheets, closing the external perimeter, and invented the ingenious solution of the footbridges, installed on the internal crown walls. It was a very useful system for visiting the Villa, that allows walking the tour around the rooms and enjoying the view of mosaic from above.
Unfortunately the system did not work long, because the sun deteriorated plexiglass, and the water continued to enter from the inner portico, that was left open. So arch. Minissi, claimed several times to solve the problems complained, replaced the side walls plexiglass sheets with glass ones and with the previous ones he closed the large space of the portico. These changes, if from one side tried to solve the problem of rainwater, in another one transformed the Villa in a huge greenhouse, with in addition the presence of the velario, a plastic curtain, installed in the rooms to quench the shadows threw by the transparent cover on the floorings. Practically the false ceiling, closing the space under the roof, has created the conditions for a heat accumulator.
The survey on all the decays of the Villa, through several components, has allowed us to provide a comprehensive response to the alleged issues. The project springs, indeed, from all the information provided by the various technical specialists, chemists, physicists, biologists, technologists, that in an interdisciplinary way have contributed to solve the different decays.

Execution of the grids

Support's consolidation

Consolidation

THE RESTORATION INTERVENTION

The intervention aimed to recover the original idea of arch. Minissi, giving back life to the spirit of the project, replacing the materials, used originally for the covering, with others more suitable for conservation.

In detail the work was focused on the visiting walkways, the covers, the perception of light and shadow relationships within the Villa, the research of compatible materials for the construction of the roof and the restoration of the mosaic decorations and painted plaster.

THE MOSAIC SURFACES

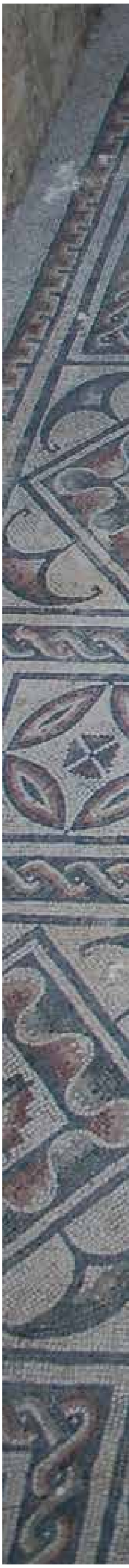
The conservative restoration of floor and wall decorations ensured a general conservation aimed to stop or considerably reduce the decay processes. The necessary operations, for performing the restoration, were supported by all laboratories' tests, useful for a correct intervention.

Concerning the mosaic carpets, the painted plasters and the statues, specific methods for the execution were settled, considering the peculiarities of each case and the different issues for 120 million tesserae, assembled in about 4000 square meters of mosaics and marbles. The cleaning and restoration of the mosaics were carried out by technicians and specialists coming from the local market, from rest of Italy and abroad. For years the restorers worked continuously in alternate shifts, developing innovative methods and techniques. It was a real health clinic for tesserae and floorings, populated by white overalls technicians and experts. First were removed old silt layers, mold, algae, bacteria, fungi and salts; cleaned the tesserae, damaged by aggressive products of earlier restorations (waxes, encrustations, resins); detached small mosaic portions to intervene on the reinforced iron bars of cement screeds, now rusty; leveled the gaps and infiltrated into the substrate consolidating products, as barium hydroxide that has been injected with needles inserted between the tesserae, using hundreds of drip bottles. It allowed the removal of some salts and the cohesion of the support.

The next step was the reconfiguration of the gaps, using the technique of carved tesserae for the geometric decorations, and the neutral base for the figures. It allowed recovering the legibility of most of the original mosaics.
In the Villa, for the first time, a precious reconstructive technique of the gaps was implemented, carried out in some details of small dimensions figures, using chromatic dispersion carved mortar, according to the primary colors on the edges, borrowing this technique from the pictorial reintegration of paintings and frescoes.

Cleaning phase

Reconstructive technique of the gaps – Chromatic dispersion



Reconstructive technique of geometric gaps

01 The cathedral of Our Lady of the Assumption is the most important Catholic church and the bishop's see in Cremona, Lombardy. It is a large Romanesque building, restyled in the Gothic, Renaissance and Baroque periods. Its interiors preserve remarkable artworks of sculpture and painting, including the tomb of Saints Marius and Martha and their sons Audifax and Abachum, a Christian family from Persia who suffered martyrdom in Rome, also known as "Sarcophagus of the Persian martyrs"

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ELECTROPHYSICAL DEHUMIDIFICATION OF MASONRY

Conclusion of the Study of the capacity of the method in the crypt of the Cathedral of Our Lady of the Assumption in Cremona, damaged by rising damp

It has successfully completed an independent study on the effectiveness of the Electrophysics dehumidification system of walls with Genié. The research was conducted at the crypt of Santa Maria Assunta of Cremona Cathedral, damaged by rising damp, where the humidity conditions of the masonry are now back to physiological values.
Damage to plaster, salt efflorescence, stains and mold in the masonry of underground and groundfloors are often the result of the so-called rising damp inside walls. The crypt of the Cathedral of Our Lady of the Assumption in Cremona was affected by extensive damage caused by rising damp. In February 2013, the bishop of Cremona decided to choose, among various methods available in the market, the most convenient solution to counter the problem in such a wide a complex; Genié, a solution based on the innovative electrophysical dehumidification technology using "multiple frequency impulses". A study conducted by Luigi Soroldoni (scientific advisor for cultural heritage and professor at "Aldo Galli" Academy in Como) and Umberto Casellato (former Associate Head of Research with IDPA – CNR) demonstrated that the problem was eventually solved. (figure 1)

HOW GENIÉ WORKS

Genié generates an electromagnetic field inside the masonry, which interacts with the water molecules and prevents them from rising. Unlike other similar methods, which use monofrequency, Genié generates a train of impulses at different frequencies allowing to obtain guaranteed results on all types of masonry, regardless of the shape of their capillary pores and of their composition. Genié is installed by fixing it with four standard screw dowels and connecting it to a standard socket.

1_ Because water molecules are bipolar, they are attracted by electric forces into microscopic canals, also known as capillary pores.
2_Each molecule of water found in the ground can therefore migrate upwards through the capillary pores of the foundations into the walls of a building.
3_During its rise, water dissolves and carries with it any salts met on the way, which in turn are one of the main causes of plaster degradation.
4_The rise stops along a "0 potential" line, where capillary adhesion and gravity get balanced.
5_Here, the water found in the walls evaporates, it is released in the environment and replaced by more water rising from the ground.
6_Genié generates impulses capable of disturbing the electric forces of adhesion inside the capillary pores of walls.

02

03

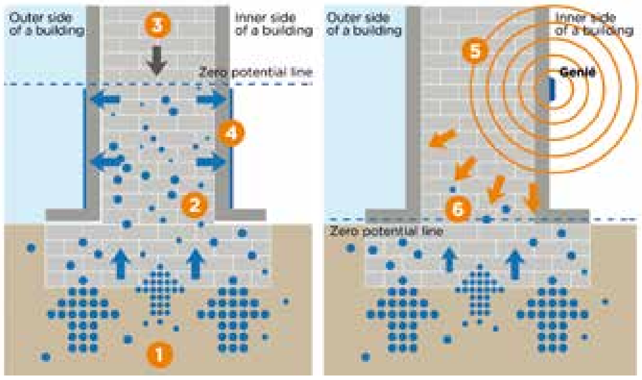

Fig 2. Genié is available in 10 models with a different range, and in two versions, Light and Pro. Genié is based on the innovative electrophysical dehumidification technology using "multiple frequency impulses".

Fig 3. Genié's effects on rising damp.

Fig 4. The 5 areas of the crypt that were tested for humidity.

Fig 5. The picture shows one of 4 Genié devices mounted on the wall of the crypt of the Cathedral of Cremona.

With a constant and targeted work, the installation brings the "0 potential" line down, by pushing water back into the ground. This helps stop mold and avert all risk of masonry degradation.
After the walls are rehabilitated, they can be brought back to their original state, with no further risks of plaster damage, salt efflorescence, stains, mold, etc.
Genié is totally safe and can be used in any living environment, even with children, old people or sick people. In fact, Genié generates an electromagnetic field inside the masonry, which does not interfere with human beings or with any electric or electronic appliances of sorts, including medical and sanitary apparels. (figures 2-3)

METHOD OF STUDY OF THE EFFICIENCY OF THE DEHUMIDIFICATION METHOD

Sampling was performed through measurements of the humidity (free water) content with the thermo-gravimetric method, by calculating the weight balance after water was eliminated by forced evaporation. Two samples of 3-5 g were collected in each examined

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area, by using a core-drill (18-20 mm wide), of which one at a depth of 0-10 mm and one at a depth of 50-150 mm, at floor level and at about 1.5 m above the floor, respectively. The samples were weighed with precision scales (sensitivity of 1 mg), stored in special glass containers and then put in a heater under controlled temperature (105º C) until they reached a constant weight.

The balance between the initial weight and the post-drying weight expressed as a rate of the dry material represents the value of humidity found in the sample.

To allow any future measurements after the dehumidification process or any further assessments, the wall was plugged with some specially conceived small cotto bricks, whose water absorption capacity is similar to the old bricks, so that they may be removed with no need for further core-drilling.

HUMIDITY MEASUREMENTS AND CONCLUSION

In February 2013, before dehumidification works, the wall showed visible damage from rising damp, and namely portions of plaster lifting and peeling off, and powdering of the painted layers, which are all the result of water movements and, above all, of the exchanges with the inner environment during evaporation and condensation.

After 12 months of operation of Genié devices (1 device + 1 satellite installed on the south and on the north wall, respectively), moisture in the walls fell heavily, by as much as 70% in some cases; after 16 months, the dehumidification process brought the rate of humidity of masonry down to a range between 2% and 4% (physiological rate in masonry). Some humidity (10-16%) was still found in two out of 12 spots on the north wall.

After 16 months, the rates have stabilized at values of physiological humidity, except in the area A due to the sensitivity to interstitial condensation and the salt.

Although the effectiveness of Genie was already defined, in May 2016 was made one last measurement that showed the return of normal humidity values even in the most problematic area. To conclude, after the installation of Genié devices, the conditions inside the crypt improved sizably in general terms.

Fig 6. The vast crypt, carved during the Romanesque era but restyled in 1606, includes one nave and two aisles and preserves the tomb of Saints Marcellinus and Peter, dating from 1506.

Fig 7. Overview of humidity rates over time.

07

		02 Feb 13	04 Sep 13	31 Jan 14	18 Jun 14	06 May 16
	North wall, to the left of the headstone	**% damp**	**% damp**	**% damp**	**% damp**	**% damp**
A1A	20 cm from the floor	11,2	7,7	2,9	8,1	3,7
A1B	20 cm from the floor	15,9	9,8	16,1	12,5	3,9
A2A	150 cm from the floor	5,2	1,7	1,5	6,8	3,4
A2B	150 cm from the floor	4,3	3,2	1,7	8,9	2,7
	North wall, to the right of the headstone					
B1A	20 cm from the floor	4,1	3,5	1,7	5,3	2,5
B1B	20 cm from the floor	10,5	6,4	10,4	4,5	4,2
B2A	150 cm from the floor	4,4	3,3	1,2	2,1	2,5
B2B	150 cm from the floor	0,8	4,9	3,5	3,2	1,0
	North wall, to the left of the second altar					
C1A	20 cm from the floor	4,5	4,8	2,0	2,0	2,6
C1B	20 cm from the floor	9,2	10,5	2,8	5,8	3,5
C2A	150 cm from the floor	3,4	4,5	1,1	1,0	2,7
C2B	150 cm from the floor	14,3	6,5	4,3	4,3	3,9
	South wall, to the left of the second altar					
D1A	20 cm from the floor	6,0	2,2	2,5	3,0	1,6
D1B	20 cm from the floor	9,0	3,3	3,5	3,3	3,0
D2A	150 cm from the floor	6,7	8,4	1,3	1,9	1,4
D2B	150 cm from the floor	8,2	1,8	6,4	3,3	1,2
	South wall, to the right of the first altar					
E1A	20 cm from the floor	3,7	1,6	1,8	2,4	2,1
E1B	20 cm from the floor	5,3	2,9	2,7	2,6	0,6
E2A	150 cm from the floor	4,1	1,5	0,9	1,4	1,9
E2B	150 cm from the floor	8,3	6,7	4,7	3,8	2,2

Flyer of presentation of the exhibition "Palazzo Te at the Mirror", scientific coordination by Politecnico di Milano

Alessandro Bianchi

HERITAGE ENHANCEMENT AND COMMUNICATION: FOLLOW-UP OF THE EXHIBITION PALAZZO TE AT THE MIRROR

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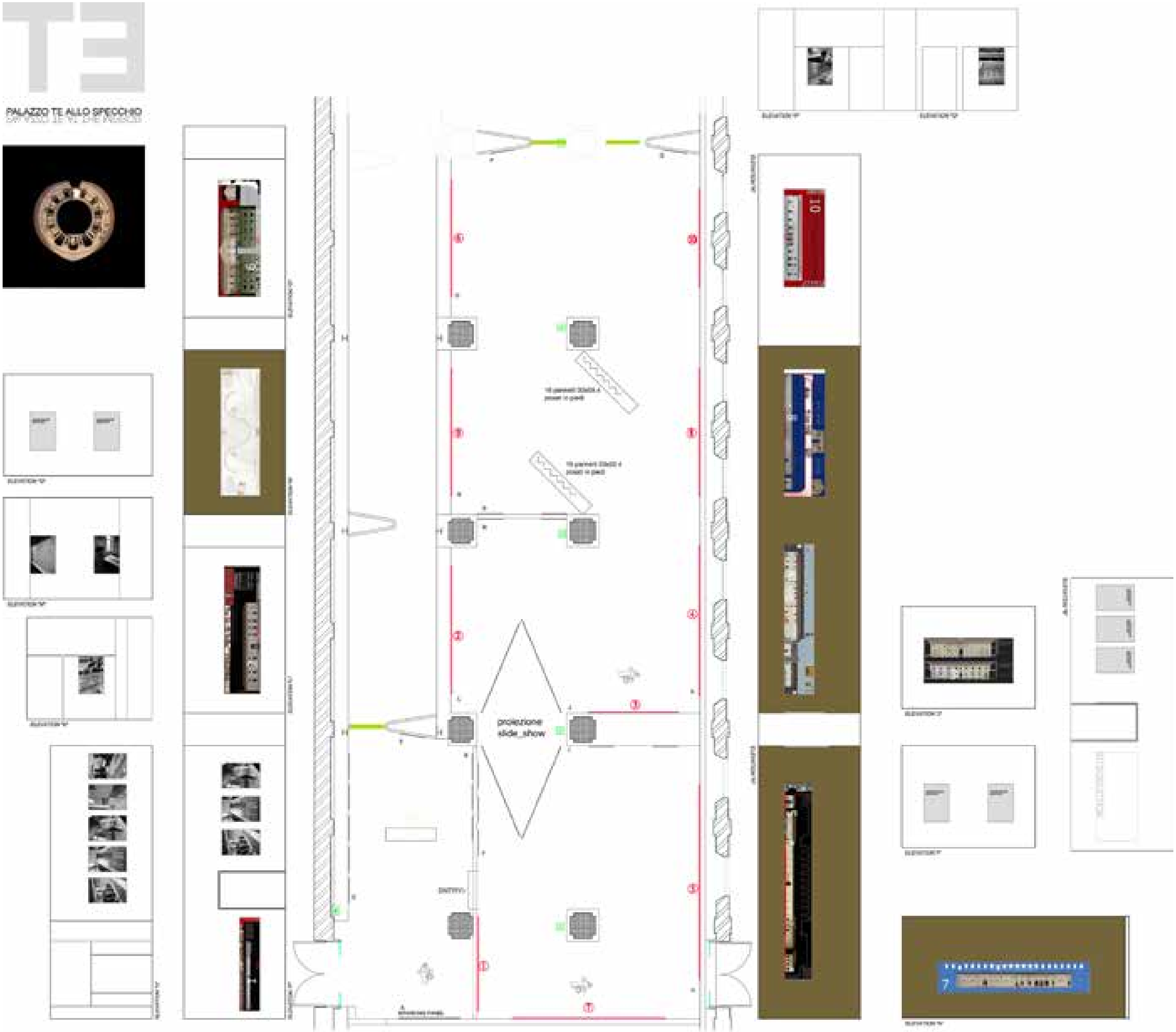
Oscar Wilde in "The Picture of Dorian Gray" denounced the double face of beauty: eternal youth at the price of corruption of the soul. Nowadays, the risk befalling architectural heritage is the same: preservation of the monument at the price of its marketing. Which perspectives may arise from such a remark? Problems connected to the 70's methodologies of preservation appear now as out-of-date due to the cogency of a much relevant problem: the unavailability of the finances needed to carry out even the most ordinary maintenance



Preparation of the exhibition "Palazzo Te in the Mirror" (edited by Abad Architects Milan)

procedures. The critical urgency is shifting from a cultural to an economical dimension and the present times are not favourable ones. It is necessary, therefore, to make the management of the monument a previous step to its preservation, also for the reason that we understand that nowadays the economic management stands to preservation as oxygen to human life. As people in charge, as being cultural operators before being economic ones, we cannot afford to be deprived of the co-ordination of the process, in order to ensure preservation to be regarded as a primary issue for architecture. How to carry this out? The purpose of the present communication idea is to create a doorway towards the future for architectural design linked to photography, to the digital world and to the survey for architectural heritage. Exhibition and events aim to open a door on the future of the architectural design and preservation, where organisation could be a driver for the marketing of the worldwide historical architecture, becoming the main engine of fundraising for the enhancement and

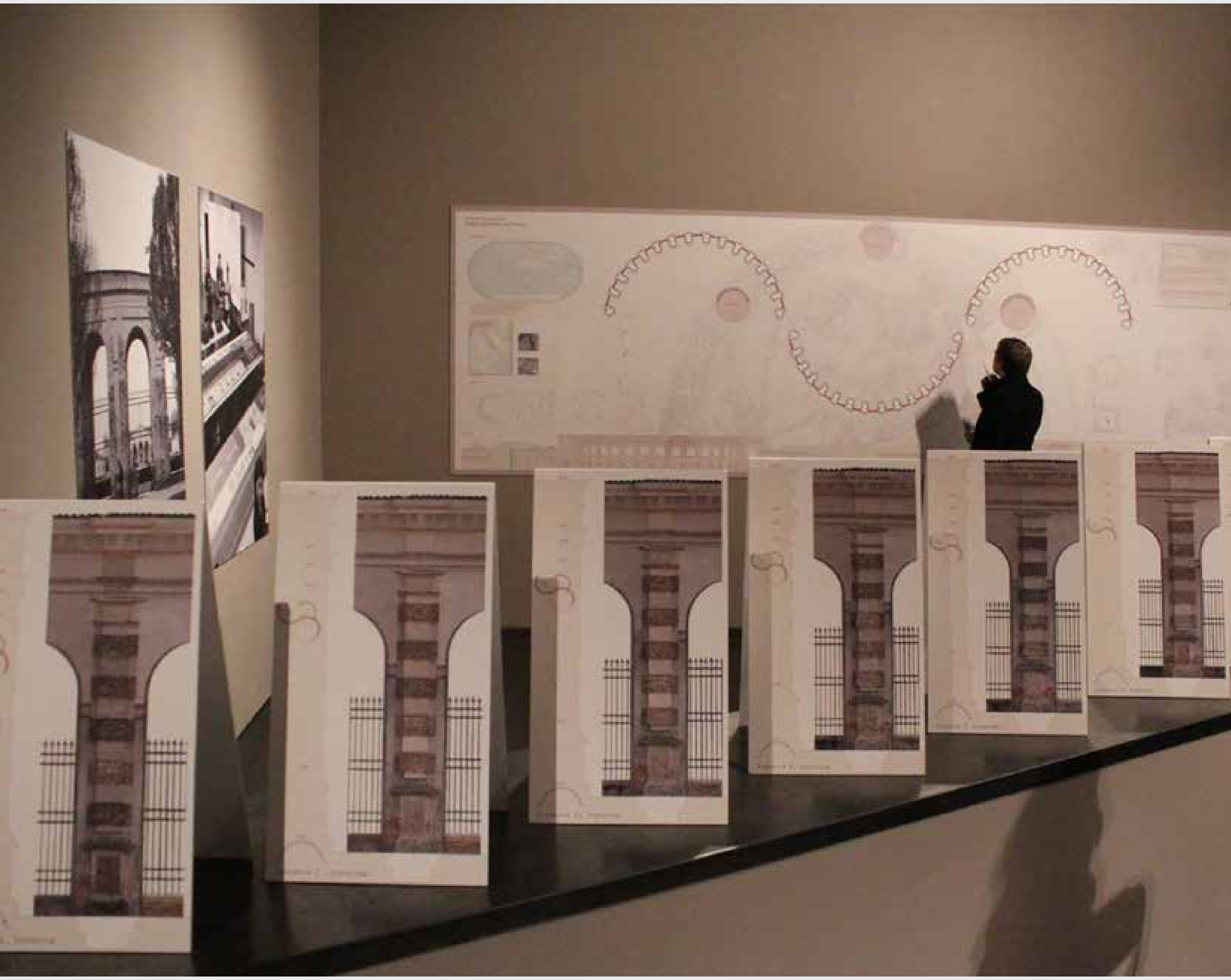
restoration of the heritage.
E.N. Rogers writes: “Conservare e costruire sono momenti di un medesimo atto di coscienza, poiché l’uno e l’altro sono sottoposti a un medesimo metodo: conservare non ha senso se non è inteso come attualizzazione del passato e costruire non ha senso se non è inteso come continuazione del processo storico: si tratta di chiarire in noi il senso della storia. Conservare e costruire sono atti creativi”.
Additions, renovations and maintenance of 500 years of history have produced the image of Palazzo Te today, and the presented survey wants to be the open photo to the judgment of posterity, who tomorrow will judge our present actions, beyond preconceptions that dulling our crystal ball.

Visitors at the opening of the exhibition at the Fruttiere Hall of Palazzo Te




Speakers at the opening of the exhibition.
From left: M. Zigoi, A. Bianchi, A. Crespi, N. Sodano and E. Aiello

Speakers at the conference and authorities.
From left: A. Bruno, S. Crotti, F. Benelli, M. Rakatansky, I. Pagliari, M. Tonelli



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