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Castiglioni Chapel in Pavia: a methodological approach for documentation and virtualisation techniques

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***Abstract* – In the reuse project of an environment, in order to define the set of residual services provided by the building organization as a whole, both spatial and material analyses of the current state need to be paired with a survey of both environmental and technological systems. In the case study of the Castiglioni Chapel, it is also essential to associate the various diagnostic outputs with the survey, in order to plan specific interventions for the site management project. The presented survey methodology targets the analysis of the alterations and evident cracks in the intrados of the vault. AR/VR systems allow to enhance the representation of the proposed reuse of the Chapel. All the aforementioned are aimed at devising a function that makes the space as a place of knowledge and digital use of the Chapel.**

I. INTRODUCTION

The project of *Cappella Castiglioni* (Castiglioni Chapel) presented in this paper is part of a broader path, characterized by diversified analyses, which include both the documentation phase and the technological investigation of architectural elements. Inside the project, still under development, the entire documentation process is covered for the planning of interventions, starting from the geometric and material survey up to the diagnostic and characterization stage of degradation for the definition of a possible future intervention of conservation. The surveys have seen the use of TLS digital laser scanner (Terrestrial Laser Scanner), ground photogrammetry for the interior and UAV systems for roofs and external fronts.

The vector drawing of the detailed architectural elements serves as a basis for the planning of diagnostic activities. In addition to the instrumentation for surveying, the use of 360 ° photo and video cameras allows expansion of virtual platforms, enrichment of the navigable models that are being developed with an enablement for AR/VR systems.

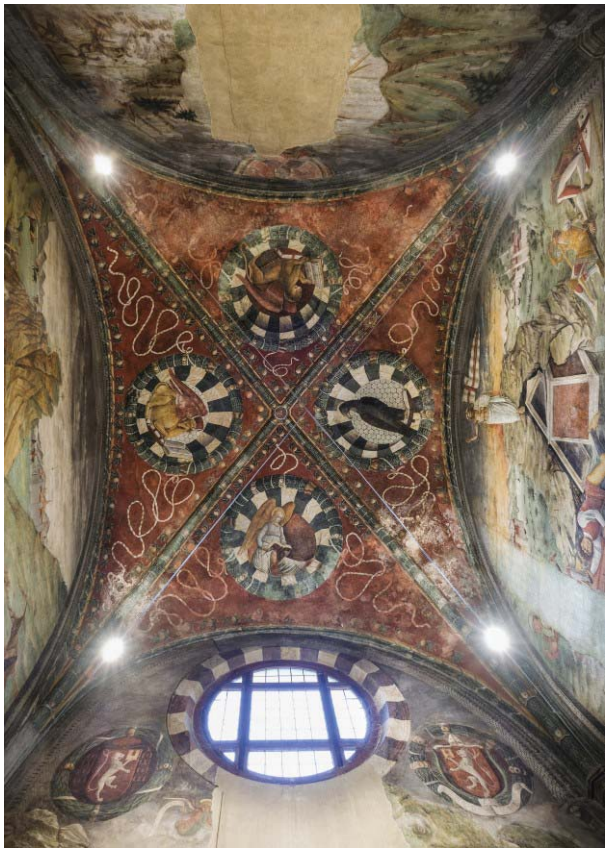

Fig. 1 Intrados of the vault of the Castiglioni Chapel and evident deterioration of the wall frescoes.

II. BRIEF HISTORY AND STATE OF FACT

The building that today incorporates *Collegio Castiglioni* (Castiglioni College) was donated to the brothers of the same name in 1419 by Pope Martino V. The current palace was born from the union of two residential structures, originally separated from each other, of which today no trace remains.

Fig. 2 Setting of the College in the city of Pavia.

The Palace Chapel has a square-plan structure, covered by a vault painted with architectural trompe l'oeil. When the chapel was repurposed as home of the custodian of the Brugnatelli house, the frescoes were seriously compromised (interventions such as the installation of stoves led to damage to the decorative apparatus). The first surveys to document the factual status of the building date back to 1948, together with a series of analyses conducted by Professor Carlo Aschieri, inspector of the Superintendency [1].

A. The paintings in the Chapel

Cappella Castiglioni was founded together with the College dedicated to Saint Augustine in 1429 but, from known documentation, it appears that the Oratory was already active in 1437 [2]. The frescoes are commonly considered [3] as an important testimony of Bramante's influence in Lombardy. The vault of the chapel is painted with trompe l'oeil, including structural elements such as ribs, shelves and decorative elements, pillars with polychrome marble and ending with Corinthian capitals that support a shelf collecting the ribs of the vault and floral festoons [4]. The vault has a red background and is characterized by plant elements, with pomegranates, other fruits, and green-leaved elements. In the vault there are four oculi that integrate the symbols of the Evangelists. The oculi are represented to look like holes in the vault; two of them have as background the pictorial representation of the leaded glass, comprising the preciousness of the materials with the insertion of colored marble paintings [5].

Fig. 3 Documentation of frescos and acquisition of photographic data set.

B. Architectural interventions of the past

From the twentieth century the concerns of the institutions about the state of degradation of the Chapel begin, returning from its function as home of the custodian of *Casa Brugnatelli* (fig. 3). A floor was built inside the chapel in order to obtain two levels for the house and new walls to delimit different environments. The openings in the wall, new and buffered, and the presence of a chimney the construction of which has

resulted in serious losses in the decorative apparatus also remain evident. The intervention on the Chapel concerned the elimination of all internal partitions to restore the spatial conformation to the original one. The activities are also concentrated on the pictorial elements, treated with consolidation, fixing, removal of improper ancient restorations, cleaning and final plastering in neutral color of the fresco parts now totally lost. The walls most subject to degradation are those facing south and north; to avoid the total loss of the decorations, portions were torn in these two walls in 1966. These frescos are then replaced in their original position by arranging them on special frames, made to measure, to keep the plasters spaced from the masonry [1].

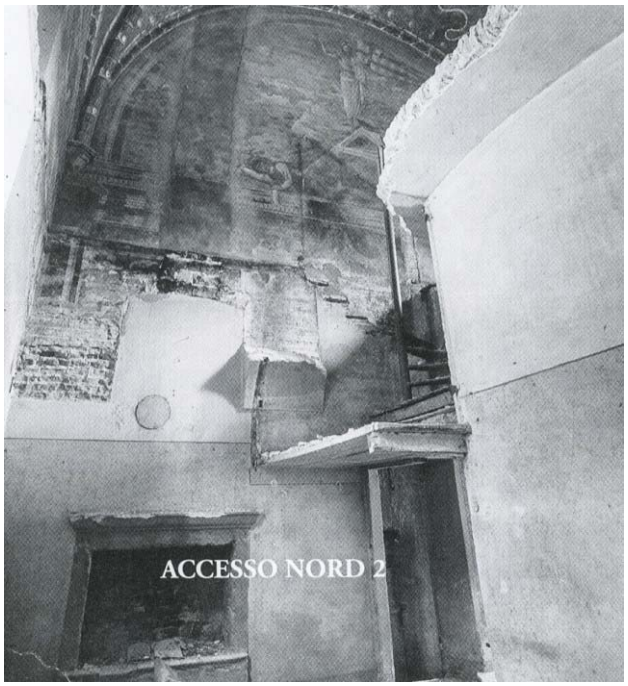

Fig. 4 Casa Brugnatelli/Brugnatelli Home: view of the chapel with the partitions still present, to adapt it to the home (Cfr. Vicini 2010).

III. METHODOLOGICAL APPROACH: SURVEY AND DOCUMENTATION METHODS

The relevant actions and documentation described here are aimed at defining the knowledge bases of representation necessary for the subsequent phases of technological and diagnostic analysis (invasive and non-invasive) for the integral mapping of the state of conservation [6]. One of the most damaged technological elements is the vault, which shows clear fractures and saline efflorescence due to water infiltration from the roof. The situation is made more complex by the inaccessibility of the vault's upper surface, the attic compartment not communicating with other portions of the building. The space of the attic itself is cramped, on the verge of crawlability. In order to understand the construction technique of the vault and observe directly if the lesions found on the intrados were passing through the extrados, it was necessary to create a temporary access compartment that allowed inspection by using a spider lift elevator platform.

Fig. 5 Spider lift elevator platform used to access the extrados of the chapel vault.

A. Laser scanner survey for technological analysis

The survey project therefore had as its primary objective the investigation of the structure of the vault. The aim was to define the construction technology with the intervention that it was the least invasive possible. For this reason, the opening in the roof has been reduced in size to the distance between the joists, in order to add only those necessary for the insertion of the laser instrument and for the passage of a person. The narrow passage in the roof allowed to proceed with the laser scanner survey, taking care to use a suitable tripod: in fact, in order to use the laser scanner inside the attic, it was necessary to use specific trestles and tripods given the reduced height and the need for inclination.

The main difficulty of this phase was that of positioning because the attic is a narrow space in which it is possible to move only lying on the ground. For this reason, the relief was only possible of a pitch of the roof and only of half the extrados of the vault, since to pass the ridge it would have been necessary to increase the opening in the roof. Despite the deposits and the limited space, the laser survey was conducted, the direct survey for some portions and the photographic campaign. In addition to this, the lifting platform was used to make some scans of the roof from the outside.

The use of the spider lift (elevator platform), necessary for accessibility, complicated the laser scanner survey due to the intrinsic mechanical vibrations of the elevation vehicle. This required careful error control in post-production to verify that the oscillations of the vehicle had not affected the results of the scansions.

However, the recording of both internal and external scans made it possible to read a fundamental fact: the thickness of the vault. This surveyed thickness, together with the observation of the bricks in the the uncovered extrados, allowed us to define the construction technology with which it was made.

Fig. 6 Images taken from the point cloud acquired with laser scanner Faro CAM2 150.

B. Photographic survey

The main problem encountered during the survey inside the Chapel was the type of natural light that complicated the photographic acquisition. The Chapel has in fact a single large circular window, and it was necessary to use associated artificial lighting and specific parameters of the cameras. To avoid having a too intense backlight effect, the photographic survey was carried out during times when there was no direct light from the window. However, to obtain a functional result for post-production processes for the creation of orthoimages, the photos were taken remotely with a special photo tripod.

The colorimetric acquisition of the laser scanner was instead conducted with the artificial lights turned on and with a vertical balance of color and light.

The point cloud thus captured all the colorimetric details of the pictorial decorations, which would not have been possible only with natural light, the only alteration of the data is in correspondence of the artificial lights.

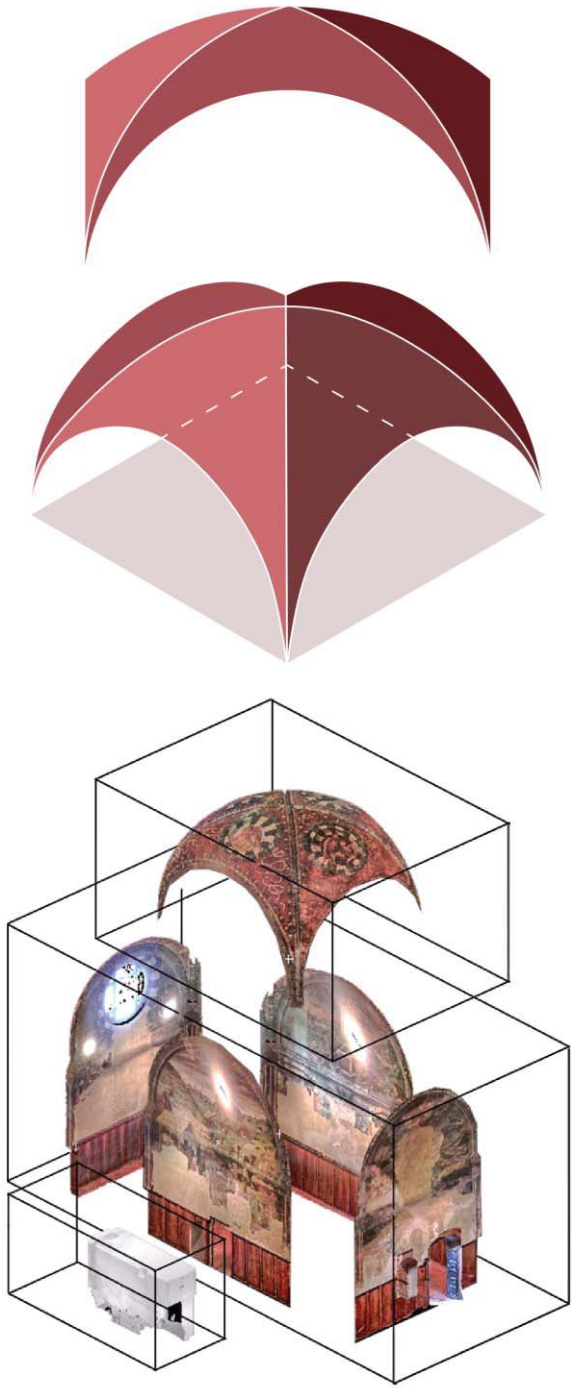

Fig. 7 The vault is a cross vault with double curvature and raised center (monte rialzato).

In addition to the photographic survey of the interior, a drone survey was also conducted to survey the roofs. This survey was conducted by structuring the acquisition for post-production with the SfM structure from motion technique in order to obtain a three-dimensional digitization of the building. From this technique it was possible to obtain a point cloud. This was combined with

the one conducted from the ground with laser scanner to complete the gaps in both and have a complete finished product. The final product was merged thanks to the common points present in both point clouds, and made it possible to obtain a cloud of points from which to investigate both the external characteristics of the roofs and the detail of the extrados of the vault.

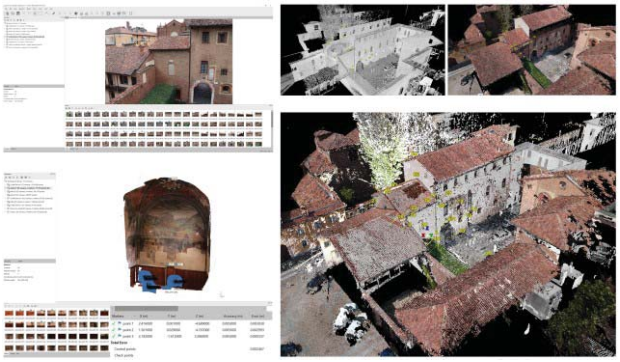

Fig. 8 The integrated laser scanner and UAV survey made it possible to fully acquire the internal and external surfaces of the Chapel.

C. *Documentation for the intervention on existing building heritage*

The documentation project and technological investigations that are in the planning stage have as their purpose not only the definition of research methods, but also a new functionalization of an environment now in disuse. The theme of the reuse of ecclesiastical buildings is in fact an important topic for the city of Pavia, which has numerous representative cases within it [7]. The ecclesiastical heritage of Pavia was reused in 55% of cases with functions related to the University, and the building in which the Castiglioni Chapel is located follows this majority line despite the fact that the chapel itself does not yet have a defined functional reality.

Castiglioni Chapel is a perfect historical asset on which to establish a research process that allows the comparison of different methodologies for the documentation and the management project of the built heritage. Its small size, decorative richness, stratifications of the centuries and technological complexities make it an ideal case study for comparing different analyses and action methods. [8] The carrying out of the diagnostic investigations is functional to the material and petrographic characterization of the factory elements, to the determination of the degradations in addition to the monitoring of some instability phenomena. The set of knowledge that will be acquired in this phase will be functional to determine possible conservation strategies.

The result of these investigations will be an integrated set of geometric, technological, and material knowledge aimed at targeted interventions for the recovery and planned management of the property.

Fig. 9 Sections and orthoimages of external fronts. The stratifications of elements and modification are evident observing the openings in the walls.

IV. CONCLUSIONS AND FUTURE DEVELOPMENTS

The research project developed in the Castiglioni Chapel case study, here described for the documentation and survey phases, lays the foundations for further research focused on the enhancement of the asset itself. The intent of conserving an architectural artefact of such artistic relevance should not be understood as the arrival point of the research, but as part of the process of museum display and protection and enhancement of the cultural heritage [9]. It is on the basis of these assumptions that, in parallel with the diagnostic

investigations, it is important to start evaluations regarding the development of the process of knowledge of the cultural value of the property in the urban context of the city of Pavia.

Fig. 10 Sections of the Chapel.

It is essential to define the processes of remote use of the asset by addressing the different types of users. With the use of Augmented Reality and Virtual Reality technologies it will be possible to create an informative digital site through a three-dimensional representation of the architectural artefact [10]. This object will allow to show morphologically reliable information, not only as a synthesis of the collected data, but also including historical and artistic information. The story of the architectural asset will not be limited to fruition in situ but will allow remote access by facilitating its spreading.

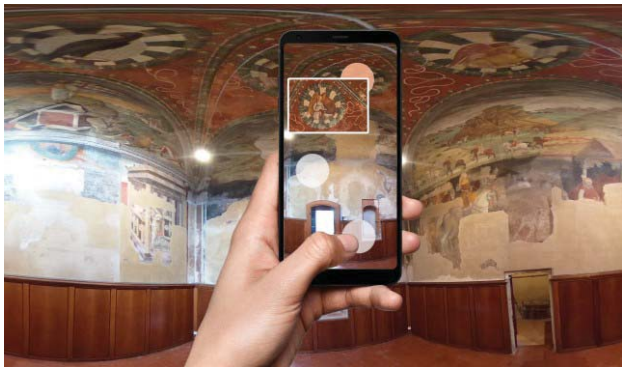

Fig. 11 AR and VR tools allow you to define new uses of architecture, ensuring better accessibility to the property and increasing the possible actions remotely, both in the tourism and diagnostics and investigation fields.

V. ACKNOWLEDGEMENT

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