2023 IMEKO TC-4 International Conference on
Metrology for Archaeology and Cultural Heritage
Rome, Italy, October 19-21, 2023

Integrated survey techniques for historical architectures: first results for Santa Maria della Croce in Casaranello, South of Italy

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***Abstract* – Historic buildings are complex structures because of both materials and construction techniques that have occurred between the different eras, as well as from the historical point of view (periods of abandonment, changes of use, changes on the original plant, etc...). All events leave marks on the building that form layers legible with different techniques and appropriate analytical procedures. In recent decades, stratigraphic analysis of both positive and negative units has been performed through non-invasive and non-destructive techniques.**

Here the authors propose a "combined" analysis of different techniques in order to obtain a complete knowledge of the architectural structure of the building under investigation. The case study chosen is the church called S. Maria della Croce whose architectural vicissitudes are and have been the subject of study for the relevant historical interest of the monument. The investigation techniques identified to analyze the stratigraphic units of the building are 3D scanning, infrared thermography, and ground penetrating radar (GPR) techniques. These investigations aim to understand what was the original function of the building.

In this paper preliminary information of the research activity is reported, related to the thermographic investigation carried out on the front facade of the church object of investigation, through which the authors want to highlight possible traces of occlusions, openings, removal of materials that can clarify the original use of the monument.

I. INTRODUCTION

In the history of studies relating to the church of S. Maria della Croce "Casaranello" one of the most controversial aspects certainly remains that relating to the original layout of the building. A complex story that begins in the early years of the last century with the investigations of A. Haseloff, [1]; the German scholar then hypothesized an original Greek cross layout. This hypothesis was later taken up by A. Prandi [2].

Later, in the seventies of the last century, F. D'Andria, [3], and C. Bucci Morichi, [4], proposed an original Latin cross plan for Casaranello, but this hypothesis did not find fertile ground and was soon abandoned.

Thus we come to the study of Spinosa, [5], whose work had the merit of analyzing, from an architectural point of view, the entire complex of Casaranello. A century after Haseloff's first observations, Spinosa hypothesized an original basilica-type layout for Casaranello, thus subverting the entire reading of the late antique building.

Recently an essay by A. De Marco, [6] calls into play the original Greek cross layout through new surveys and the analysis, based on the visible, of the stratigraphic relationships between the walls of Casaranello.

The current architectural survey methodologies involve the integrated use of advanced procedures and instruments; these have been used in the present research thanks to 3D laser scanners and digital photogrammetry. [7], [8].

This technique of investigation allows the extraction of the necessary data to obtain the exact morphology of the artifact in the points considered significant and then visualize them three-dimensionally. The query of point clouds, suitably calibrated and parameterized, allows, in fact, to display even that information not easily detectable with the naked eye, or with traditional instruments, and to highlight elements of particular criticality [9]. In the same way, you can proceed with the direct reading of the building, the building morphology, the elements and the

materials of which it is made up, the working techniques [10], [11], and the phenomena of degradation and instability. Construction anomalies, wall discontinuities, additions, subtractions, or modifications become clearly legible in this way and are therefore functional to the effective understanding of the real conditions of the building in its complexity, highlighting the signs stratified over time [12], [13]. Going down the scale and working for example on individual rooms of a building, the three-dimensional survey can help to highlight not only the issues related to structural behaviour but also everything related to "environmental" issues present on adjacent or opposite sides of the same masonry [14]. Through contextual mapping and possible simultaneous visualization of data (mapping of rising, descending, or condensate humidity, microclimatic monitoring of temperature and relative humidity, return of information from thermographic surveys, etc.) a joint reading of the occurring phenomena could be obtained not only on the internal and external surface of masonry but also of those that affect it in its thickness and that relate it to the context of which it is part so that cause-and-effect relationships can be seen [15], [16].

Recent scientific works use the combination of data from multiple survey techniques, for example, thermographic and geometric reconstruction, for the accurate 3D documentation of architectural heritage [17], [18] useful for historical-artistic understanding. In this regard, for example, infrared thermography (IRT), a non-contact, non-invasive, and non-destructive imaging technique, allows today both qualitative and quantitative assessments of temperature to be undertaken. IR cameras, indeed, detect infrared radiation emitted by materials and create a thermal image depicting the surface temperature distribution. This thermal distribution is influenced by some physical conditions and material properties such as relative humidity, atmospheric temperature, reflected apparent temperature, and material emissivity.

Many studies on the emissivity of structural materials have been conducted [19], [20] and have shown increasing interest in infrared thermography methodologies. IRT has been successfully used for the damage assessment of historic structures [21], [22] and for monitoring the degradation of ancient wall paintings, [23], monitoring the conservation state of metallic discoveries, [24], evaluating the integrity state of archaeological discoveries, [25].

Moreover, in the context of masonry texture identification, of historical stratification, and of geometrical reconstruction, Ground Penetrating Radar (GPR) emerges recently as an effective survey method, due to its high-resolution and non-destructive approach [26]. The contribution aims to analyze a new strategy of analysis, combining different investigation techniques, in order to obtain a complete knowledge of the architectural structure and its physical properties.

The case study proposed here is the church called S. Maria Della Croce in Casaranello, South of Italy, chosen because the restoration reports and the architectural surveys performed so far do not dissolve some important issues that, if resolved, could be fundamental for a complete understanding of the architectural events that affected the church. In this contribution the authors, after having examined the different theories supporting the hypotheses on the original function (mausoleum, Christian Basilica...) of the building proposed on the basis of historical investigations-architectural, report the first results obtained from thermographic surveys.

II. CASE STUDY

The church of Santa Maria Della Croce, known as the Casaranello Church, is one of the oldest monuments in Puglia, known for its interesting mosaic decorations and wall paintings inside. Early Christian mosaics, [27], dated to the 5th century, decorate the vault of the east arm and the dome of the cruciform choir, as shown in Fig. 1.

But, the correct definition of the original architecture of the complex of Santa Maria della Croce is not a secondary aspect, compared for example to the mosaics present in the church, far from it.

In fact, the deepest meaning of the monument lies precisely in its initial architectural form. Hence the need to further investigate the building through a multidisciplinary approach through the use of technologically advanced, effective, and non-invasive instruments such as the thermal imaging camera rather than the laser scanner.

In particular, the investigations still in progress with a thermal imaging camera were directed to the main facade of the building, since in the observations and surveys of D'Andria it would seem that in the current prospectus of the church some previous structures are hidden.

Fig. 1. Inside of the church of Santa Maria della Croce, Photos: Marco Santi Amantini.

In the hall of the Church, there are three naves with a barrel roof, communicating with each other by means of three large low arches resting on pillars with a square base that ends on two half pillars that insist on the counter and the choir.

The entrance portal, the subject of the proposed investigation (fig. 2), is inserted in a portion of masonry that develops to reach the double arch of discharge; on this section of masonry is also inserted the rose window.

Fig. 2. Main facade of the church. Photos: Marco Santi Amantini

This masonry section is different from the one that completes the remaining part of the facade. As described by Spinosa, [5], which analyzes the entire architectural structure of the church, the wall band between the portal and the double arch is made of medium-sized limestone ashlars perfectly shaped and of constant size. The remaining part of the facade, instead, is made with large tuff ashlars of various sizes, placed in a regular manner up to the point where there are traces of two entrances now buffered (Fig. 3).

Fig. 3. Architectural relief of the main facade of the Church [5].

Figure 4 shows the plan of the Casaranello church with highlights of the archaeological structures brought to light during the restoration works of the seventies of the last century

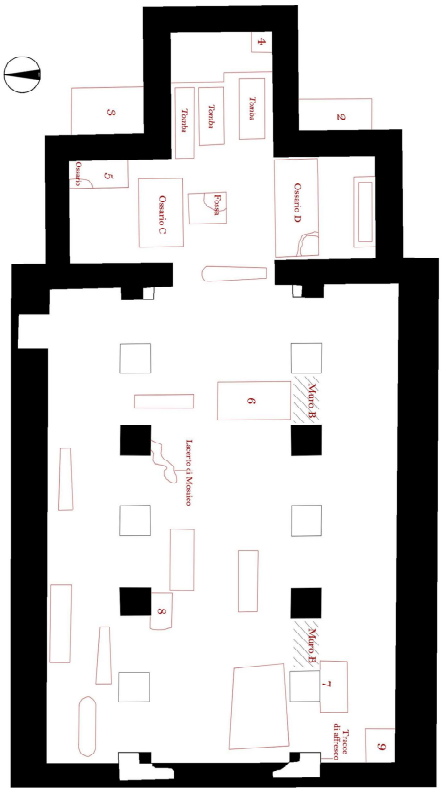

Fig. 4. Plant of the Church [6].

Among the singularities of this plan, two portions of the pillar incorporated in the current facade stand out. These elements were interpreted by D'Andria as the traces of the ancient facade of Casaranello, which linked to "Wall B" constituted the central nave of the building.

Few and confused are the data available to define the relationship between the architectural structure, the mosaics, and the wall decorations on the pillars (the graffiti show some dates that suggest the 11th century). Many questions remain about the dating of the original plant and the subsequent architectural additions.

III. THE PRELIMINARY THERMOGRAPHIC SURVEY

In order to investigate the possible structural changes in the church facade, thermographic surveys were carried out exploiting the differences in heat exchange between the building radiated by solar energy and the surrounding environment. The measurements were carried out within a sufficient period of time at sunset when the heat exchange is most significant.

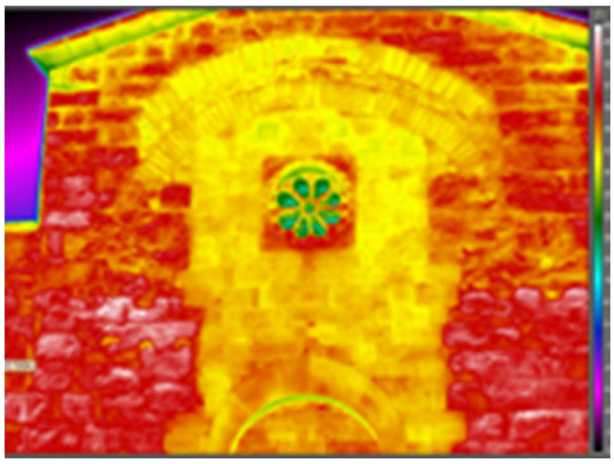

Fig. 5. Thermographic image of the church façade.

During that period of time, some areas of the facade were investigated. In particular, the investigations concerned the side areas of the main entrance.

The recorded sequences have highlighted some details: looking at the facade, on the right side of the entrance portal, is clearly visible a small door now occluded, already evident from the architectural relief, visible in the thermographic image shown in Fig. 6. The area at the left side of the entrance (Fig. 7) highlights a hidden structure, not visible either from inside the church or from outside, and which could represent those structural elements highlighted in [3].

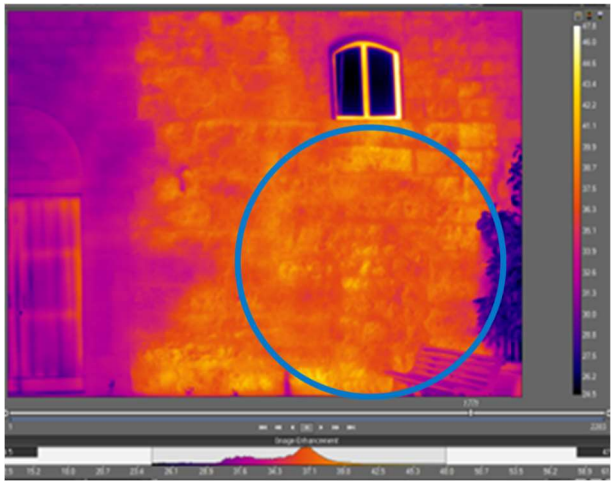

Fig. 6. Detail of an original portal disclosure at the right side of the church main facade.

In the thermographic image of Fig. 6, a possible structural difference is visible, not visible indeed to the naked eye, and once again highlighted by the differential heat exchange.

Fig. 7. Hidden structure at the left side of the church main entrance

IV. CONCLUSION

Some preliminary tests have been carried out by means of the thermographic technique on Santa Maria della Croce Church in Casaranello, located at the tip of the Italian heel. The aim of the present study is to assess a new integrated strategy of investigation, made by different but complementary techniques (3D scanning, infrared thermography, and ground penetrating radar) apt to reveal the original architectural structure of historical buildings. At this stage, the results of the tests refer to the Church's main facade, where the thermographic inspections have highlighted interesting hidden structural details.

The next step will be to use the cited surveying techniques in order to reconstruct the entire wall texture of the Church and carry out its historical stratigraphic identification.

ACKNOWLEDGEMENT

The Authors express deep thanks to Archeo APS ETS Association for their constant support, and to Casarano all citizens for their kind hospitality.

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