DIGITAL SURVEY FOR CULTURAL HERITAGE SAFEGUARD: SAINT JOHN TOWER IN ENNA

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Abstract:
Cultural heritage is an important richness for future generations both as historical memory of the past, which tells the roots of our culture, and from a strictly economic point of view.
As a matter of fact, cultural heritage -natural and built- is a source of attraction of investment on the territory that, investing on economy of culture, produces a virtuous circle able to generate an economic-monetary benefit on the territory itself.
That being stated, it is an ethical obligation for all of us scholars, guardian of the past, to hand down to future generations this heritage undamaged and, above all, preserving its identity.
It is necessary, before any preservation and conservation work, to trace backwards the history of the cultural asset by means of survey. As a matter of facts survey is a knowledge tool which allows to investigate thoroughly both the project idea and the material execution, the shape and the dimension, the being and the essence of the work.
Nowadays, thanks to survey innovative technologies, such as laser scanning, it is possible to obtain acquisition data models that record and document cultural assets' dimensional, material and decay features. 3D Models that, in addition to constitute a data base of information, are a documentary heritage on which it is possible carry out different investigations.
This study deals with the research conducted on the medieval Saint John tower in Enna, which was the tower of façade of the homonymous church built in the 13th c. In the survey phase we used digital advanced instruments so that the accuracy of the measure should allow exhaustive hypothesis on architectural handiwork: a critical survey of the current situation and of the changes due to restoration works.
As a matter of facts, the materic and dimensional information extracted from the numeric model – point cloud – have been essential to understand the features which connote the handiwork. The accuracy of scans detail made readable masonry texture, materials decay and instability, being a valid aid for carrying out punctual thorough investigations.
Moreover, it has been possible to conduct a critic survey, verifying in retrospect both the geometry of the vaulted porch of the ground floor and the geometrical compatibility of the proposed and realized solution for roofing vault due to restoration works made by arch. Valenti in 1921.
Indeed the comparison among the surveyed data, the iconographic sources (Walter Leopold surveys) and the geometric studies carried out revealed the inappropriate work of reconstruction of the roofing vault. The results of this study testify once again the relevant and essential role performed by survey as instrument of knowledge investigation aimed to an accurate and exhaustive documentation of cultural heritage and to a conscious restoration work respectful of the essence of architecture.

1. INTRODUCTION

Over the last few years technological progress has enhanced methods for the acquisition, analysis, use and spread of information related to cultural heritage, which represents an important resource for generations after generations both as historical memory of the past as well as from a purely economic point of view. In fact, it attracts investments in the territory which, by affecting the economy of culture, trigger a virtuous process capable of bringing economic and financial benefits to the territory itself.

It is, thus, necessary to protect such heritage by means of actions aimed at the safeguard of the identity of each single heritage through a process of knowledge developed from critical analysis: by tracing back the history of each single heritage, by closely examining the idea of the project and the material quality of the work, its form and dimension, that is, the existence and the essence of the work.

For this purpose, support provided by today's computer technology during the phase of the acquisition of data gives excellent results in terms of both time and precision. An example of this technology is represented by the 3D laser scanner with which it is possible to sample millions of points of the object and, thus, obtain a faithful copy capable of providing a real-time three-dimensional representation of the heritage surveyed.

The result is a digital model which documents the dimensional, material and deterioration characteristics of the heritage itself, thus representing a documental resource to be examined.

This work, which is part of a wider study of Enna's medieval towers, has examined the bell tower originally set on the no longer existing church of Saint John (figure 1). Laid upon the main façade, according to the typological scheme of the *clocher porche* of the religious fortified architecture of northern France, the tower probably dates back to Norman times.

Figure 1: The bell tower of Saint John in the urban context

The detailed survey carried out through the 3D laser scanner made the a posteriori critical examination of both the geometry of the vault on the ground floor and that of the vault for the roofing possible. In particular, the metrical data acquired from the documents of the renovation works (1921) and from the photographic and iconographic documentation produced by the German scholar Walter Leopold (1901).

The analysis carried out has revealed some inconsistencies related to the reconstruction of the vault for the roofing of the tower, which have distorted the original identity of the tower itself.

2. SURVEY, ANALYSIS AND REPRESENTATION FOR THE KNOWLEDGE OF THE TOWER OF SAINT JOHN

The bell tower of Saint John is part of the original defensive system of the city of Enna [1]. It constituted the front-tower of the fortified church of Saint John, and, over the years, was first used as an arsenal (1866) and, then, as a town hall (1934). These latter transformations did not damage the bell tower which, in its mighty and austere wall structure, extends along three tiers marked by rectilinear frames upon which the openings of the upper floors lie, thus making more gentle its severe, massive structure (figure 2,3).

Figure 2, 3: The bell tower of Saint John from different views

The first tier is made up of a loggia covered with a high rib cross vault with a hanging keystone in the middle. On the battlement of today's town hall (once the main façade of the church) we can still see the traces of the original entrance of the church. The pointed arches with a multiple crown archivolt, which delimit the three fornices of the loggia, are surmounted by a stone string course ending in a corbel with a little bearded head at the height of the impost of the arch and are framed by thin little columns with bulb-shaped capitals with foliage and multi-style pedestals decorated with leaves turning downwards.

In the second tier, an elegant ogival three mullioned window with multiple archivolts which frame the elegant marble lace lunette in the *vescica piscis* shape (partially rebuilt during the renovation works) enriches the façade. The three mullioned window on the main façade is supported by thin little columns with a truncated cone base and with capitals which both have foliage decorations. The most external archivolt ends with two corbels with phytomorfic motifs.

The third and last tier consists of the bell chamber, with round arch lancet windows on each of the four sides, ending in an external stringcourse with corbels at its ends which represent little heads of bearded men. The top of the tower ends in a small hemispherical dome in the Arabic style as a result of the renovation works led by Mr Valenti, architect and Cultural Heritage conservator, who, besides the rebuilding of the roofing, also dealt with the restoration of both the porch on the ground floor of the tower, and part of the elegant three mullioned window on the second tier as well as the deteriorated crown molding.

For the survey of the turreted structure, the Leica Geosystem HDS 3000 3D laser scanner, belonging to the University of Catania 'Luigi Andreozzi' laboratory of architectural photogrammetry and survey, was used. The accuracy of the data/measure helped formulate more daring hypotheses on the architectural handiwork through a critical and analytical interpretation of the actual condition and possible modifications resulting from the renovation works [2].

In fact, information on dimension and material, deriving from the cloud of points, turned out to be essential for the understanding of the features which connote the handiwork. Moreover, the accuracy of the details of the scanning made the wall structure, the deterioration of the material and instability evident, thus representing a great aid to the carrying out of accurate tests to check conditions of conservation.

2.1 Data acquisition and processing

The work of data acquisition took into consideration the geometrical characteristics of the tower as well as the accessibility of the places along with the specific characteristics of the equipment being used. In particular, the coverage of the three façades of the tower was made by setting up two land stations which were conveniently positioned so as to get a good overlap margin for the following operations of recording of the scanning in one model (figure 4).

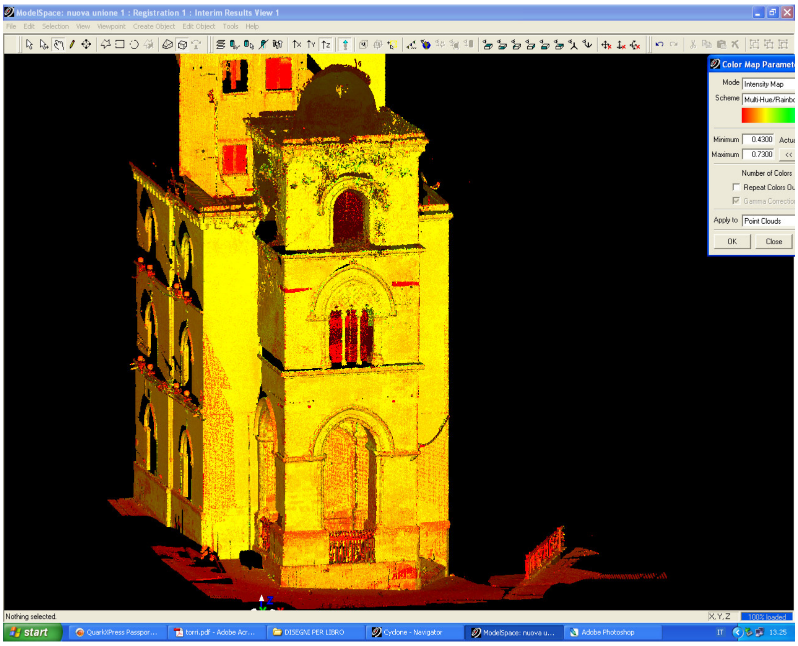

Figure 4: The overall model of the bell tower in a flat view

A further station was positioned inside the porch on the ground floor of the tower, which is now one meter higher than the road level, in order to acquire information necessary for the study of the geometry of the rib cross vault which covers it.

The state of conservation of the tower did not make access to the first tier possible, whereas it is possible to access the second tier of the bell chamber directly from the terrace adjoining the town hall. Two stations were planned: an outdoor station which guaranteed a sufficient overlap with the scanning made from downstairs; for the other station, the equipment was positioned on the base of the lancet window through which it is possible to access the room, in order to obtain information on both a large part of the inner space including the intrados of the dome for the roofing, and a small portion of the room underneath. In fact, because of the very bad condition of the floor, it was not possible to safely carry out the scanning of the loggia from the inside.

The scan step (which can range from 5 to 10 mm) perfectly combines in situ timing with research needs so that it is possible to obtain a detailed description of the geometrical, morphological, stylistic and building (structure of quoins) characteristics.

The following phase of recording of the clouds in one digital model was carried out through the collimation of homologous points, by linking together the scanning through areas of overlap.

The validation of the alignment, in the absence of a topographic support, was tested within the proprietary software (Cyclone and Cloudworks by Leika Geosystem) through the following steps: creation of a layer for each scanning, use of different colors, creation of slices based on a model with 1 cm slices according to the horizontal and vertical planes; detailed comparison of the results. The results of the test were more than positive, with an accuracy contained within the instrumental error.

From the overall model thus obtained (about 15 million points) were then removed the disturbing elements (vegetation, lighting devices, signs) which had generated shady areas with the consequent loss of information on the surfaces of the tower.

2.2 3D virtual model analysis

The tower's ground floor with its porch is covered with an overhead rib cross vault on a rectangular base. The condition of high deterioration of some elements, along with the existence of parts reconstructed during the renovation works, made the identification of the most significant profiles, which were necessary for the analysis of the geometrical genesis of the intrados surfaces, difficult.

The analysis was, therefore, conducted on the least altered groins and ribs, which can provide more authentic information on the geometry (figure 5,6).

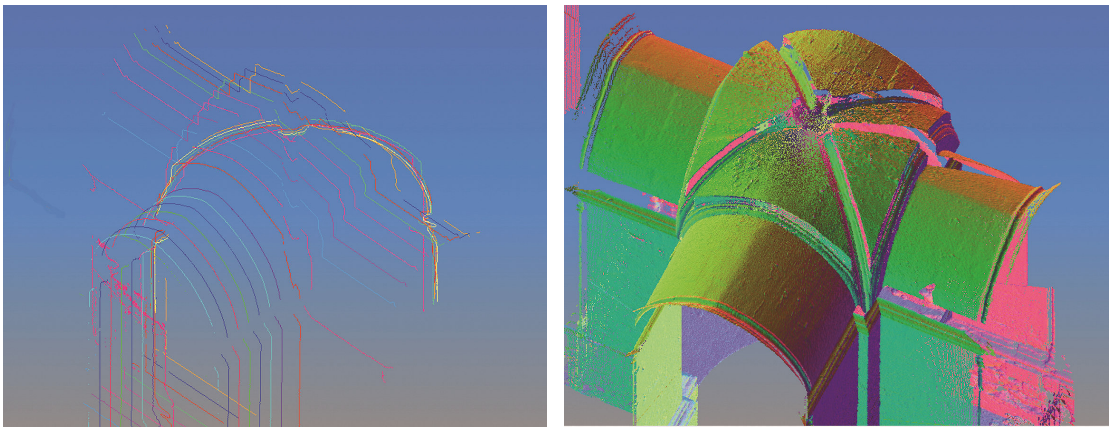

Figure 5,6: Analysis of the geometrical genesis of the rib cross vault covering the porch

The sections with vertical planes parallel to the front of the groins highlight the course of the directrices of the vault which are, in both directions, pointed arches. Instead, the profile sections carried out by planes passing through the ribs and the diagonal arches result in a curve comparable with an elliptical arch. Finally, the generatrixes are rectilinear with a slanted course but they are not parallel in relation to each other: it is, therefore, evident that the analyzed groins are of a cylindroidic geometry [3, 4].

Finally, the geometrical irregularities found in the ribs, which do not coincide with the diagonals of the rectangle at the base, are probably due to an incorrect re-assembling during the renovation works.

The geometrical analysis of the last tier of the tower concentrated, above all, on the examination of the geometry of the intrados of the roofing so as to dispel any doubts about two contrasting positions: the position of Walter Leopold who, in 1910, claimed that ‘the tower ended in a conical steeple made of quoins, only in part conserved, which lies on corbels grossly walled in the corners of the upper floor’ [5], as opposed to what Valenti stated in 1921: ‘the bell tower was covered with a dome of which one part exists’[6]. This latter assumption justifies the renovation action carried out by Valenti who built a small dome made of opus signinum copying the Norman cube of Palermo rather than a cone shaped steeple, a solution evident in some bell towers of the surrounding territory (for example, the bell tower of the cathedral of Nicosia).

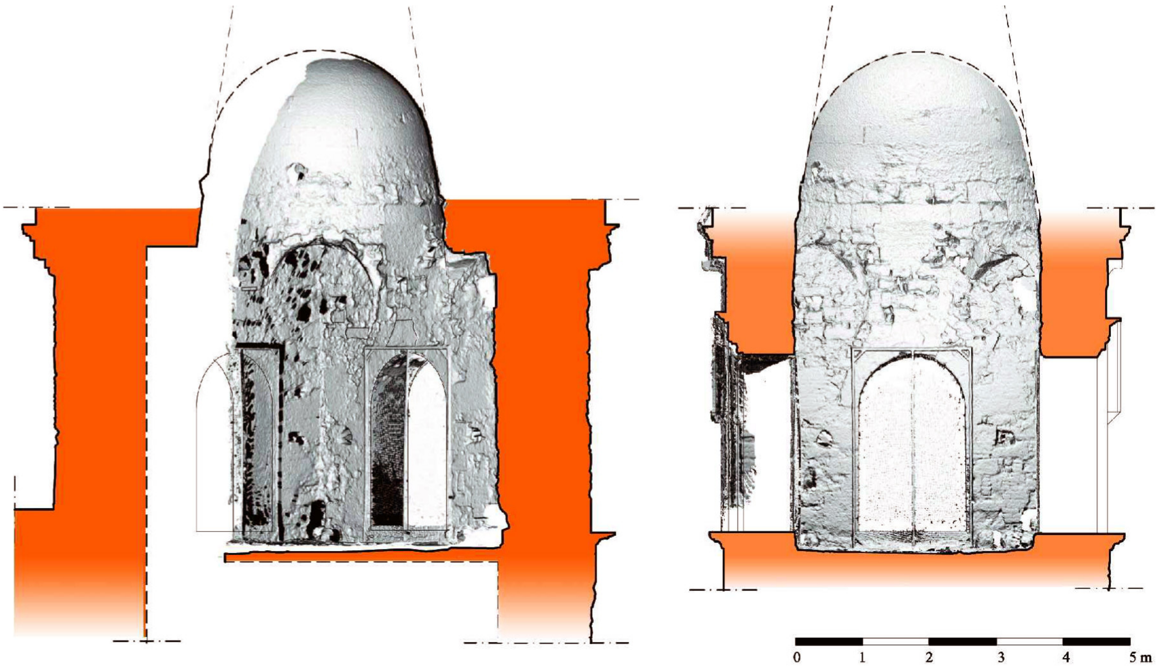

Figure 7,8: The two sections of the bell chamber (diagonal and transversal) reveal the right geometry of the roofing: a conical steeple with a circular base

Despite the partiality of the acquired data due to operational difficulties which occurred in situ, the cross section and that passing by the diagonal of the square at the base give information more than sufficient to carry out the necessary tests.

From the geometrical analysis of the profiles obtained, it is evident that the small dome built by Valenti in 1921 lies on a truncated cone shaped tambour. This leads one to think that in reality the original roofing of the tower was not a dome, but a conical steeple with a circular base, thus confirming Leopold's hypothesis (figure 7,8).

Finally, the passage from the square at the base of the bell chamber to the circular impost of the dome finds a solution through angular joints made up of a corbel shaped through subsequent projections and supported by groins whose diagonal arches are elliptical, the generatrixes in the keystone are rectilinear with a horizontal course and the arcs of the impost are quarters of an ellipsis.

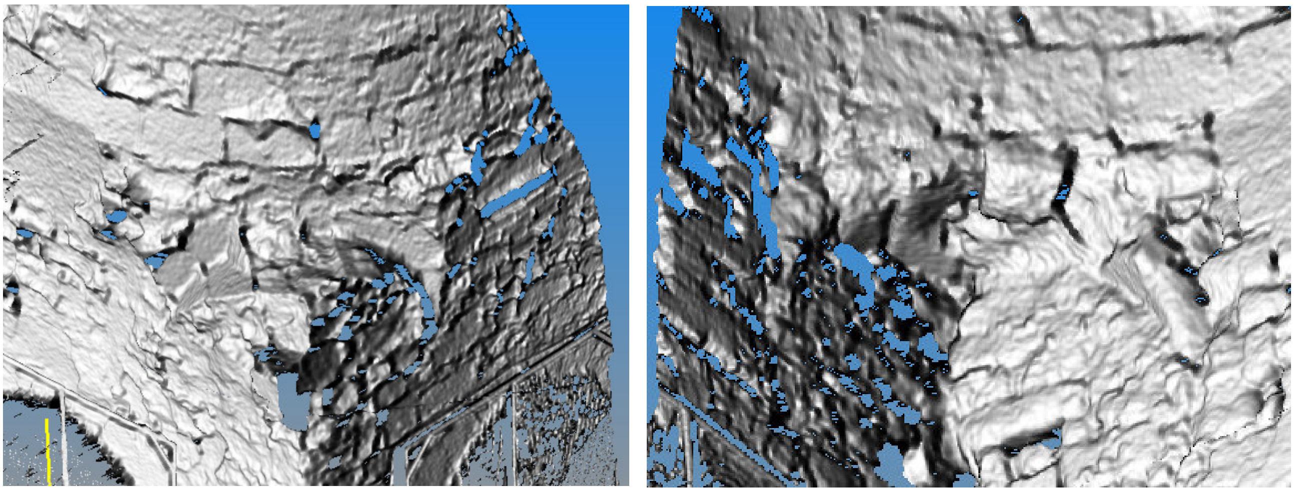

Figure 9,10: Views of the meshed model of the angular joints.

2.3 3D textured model

Once the geometrical study of the genesis of the surveyed vaulted surfaces was completed, the construction of the triangulated surfaces model and the following texturing of the mesh surface were tackled.

The Gexcel Reconstructor software employed for the operations allowed us to set up and vary, within the model itself and in a critical manner, the parameters underlying the dimensions of the triangular meshes, so as to mediate between the need to obtain a 'simplified' surface and the necessity not to lose the detail of the material quality of the single lava quoins.

As for flat surfaces, an 'intelligent' reduction of the triangular meshes was carried out though maintaining the definition of the material quality of the stone, the irregularities, and the roughness, so as to make the file lighter [7].

On the other hand, the plastic moldings and the sculptural elements of the architectural details required the creation of a thick triangular mesh capable of describing the complexity of the surface.

With the application of photographic texture on the obtained surfaces, a model is created which, by combining the geometrical and dimensional data with the material data, faithfully describes the basic elements of the architecture, and offers, in just one system of representation, all the possible visual combinations.

Indeed, the fact that it was possible to project the textured model onto conveniently selected reference systems, thus obtaining metrically precise orthophotos, represented a successful means of integration of material and construction data in the still essential two-dimensional survey representations in the traditional Monge style (plans, façades, and sections).

Figure 11: Textured model of the ogival three mullioned window

3. CONCLUSIONS

The results of these studies are once again evidence of the crucial and essential role of the Survey, as a means of research for a detailed and successful documentation of cultural heritage in order to operate through conscious actions which do not pervert the essence of the architecture.

Furthermore, the use of digital technology, for its huge potential, represents by now an essential passage for those who work in the field of the documentation and representation of cultural heritage.

Indeed, the remarkable amount of acquired information, stored in the digital model, provides an alternative approach to traditional research methods, which aim at penetrating the complexity of the architectural, archaeological, or environmental/naturalistic element by encompassing all the values and the perceptual as well material qualities which characterize it.

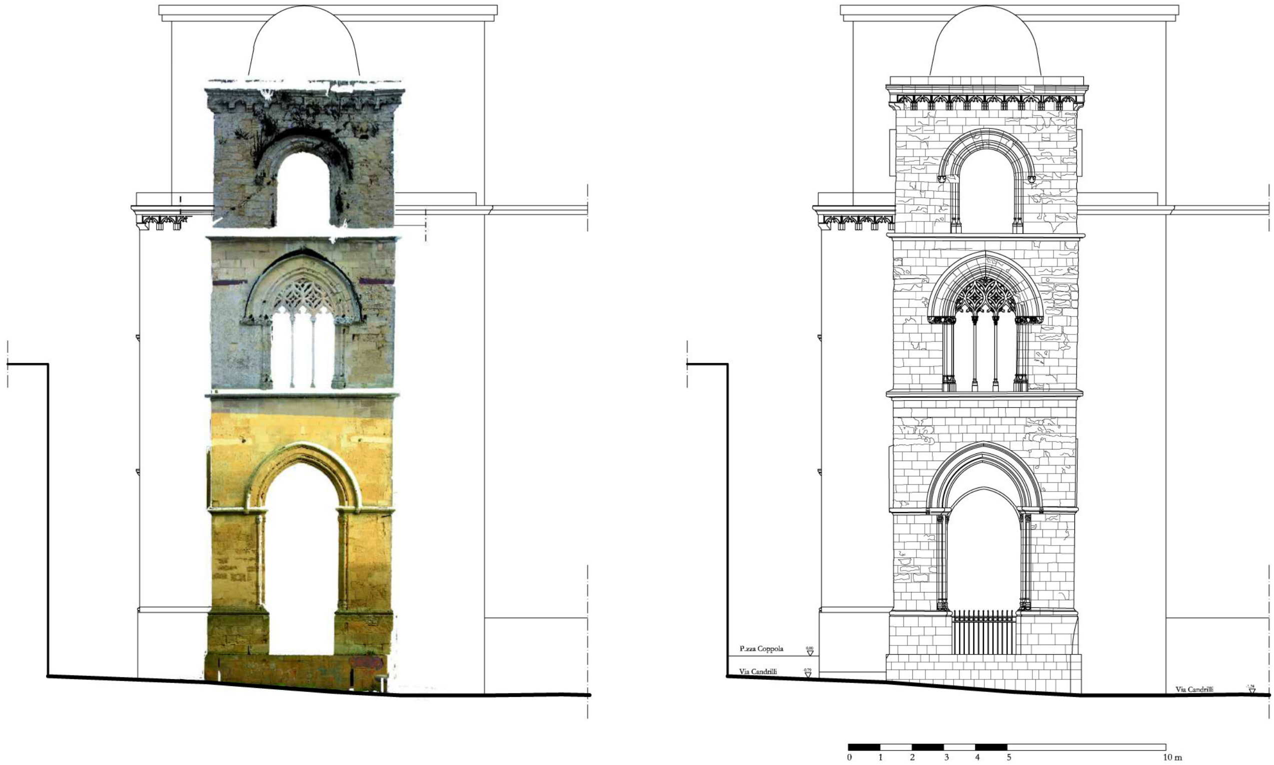

Figure 12: Orthophoto and graphical representation of southern façade.

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