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SfM photogrammetric techniques applied in the building archaeology works of the old cloister of the Monastery of San Francisco from the 16th century (Cazalla de la Sierra, Seville)

Manuel José León-Bonillo[1], Juan Carlos Mejías-García[2], Rubén Martínez-Álvarez[1], Antonio Miguel Pérez-Romero[1], Cristina León-Ortíz[3] and Carmen Marín-Buzón[1,*]

[1] Graphic Engineering Department, University of Seville, 41013 Seville, Spain; leonbo@us.es (M.J.L.-B.); rbnmaral@us.es (R.M.-Á.); tao@us.es (A.M.P.-R.); carmenmarin@us.es (C.M.-B.)

[2] Prehistory and Archaeology Department, University of Seville, 41004 Seville, Spain; jcmejias@us.es

[3] Faculty of Philology of University of Seville, 41004 Seville, Spain; crileoort@alum.us.es

*Correspondence: carmenmarin@us.es (C.M.-B.);

Abstract: The cloister from the old monastery of San Francisco (Cazalla de la Sierra, Seville) has been suffering a series of remodelling and transformations from its original construction, in the 16th century, to the current day. Thus, a study of building archaeology needed to be accomplished by using photogrammetric techniques by SfM (Structure from Motion) and laser scanning or TLS (Terrestrial Laser Scanning) that ensure a geometric exactitude and high resolution of the facings surveying. For that, over 500 images were taken for the 4 existing facings (about 78 lineal metres) from which a photogrammetric model was obtained of over 50 million polygons; as well as a cloud of over 40 million points from the laser scanning. It can be concluded that by using the techniques of SfM, the task of documenting, analysing and studying the facings of the historical buildings in order to establish its evolutional process, gains, not only in precision and exactitude, but also opens the possibility to go further by obtaining products that are capable in the labour of conservation, restoration and protection of the historical heritage, as well as the generation of 3D virtualizations, planned for the diffusion.

Keywords: building archaeology; photogrammetry; SfM; heritage; restoration

Citation: Lastname, F.; Lastname, F.; Lastname, F. Title. *Heritage* **2022**, *5*, Firstpage–Lastpage. https://doi.org/10.3390/xxxxx

Academic Editor: Firstname Lastname

Received: date
Accepted: date
Published: date

1. Introduction

The current Municipal Food Market of Cazalla de la Sierra (Seville) (Figure 1) is located in a building whose history begins at least from 1588, when the order of San Francisco, settled in Cazalla from 1493, in the old Monastery of San Jerónimo (current Hermitage of Carmen), decided to be relocated inside the walls of the city and build their new monastery in the block in which the monastery was located [1-3]. Although neither the exact date is clear nor the rhythm of edification of the new monastery, it would not be ludicrous to think that at least the main buildings would have already been built, especially the dependencies where the daily life would be developed and the cloister around in which the aforesaid activity will revolve around.

The exact space that the Market reuses from this monastery of San Francisco is its cloister (Figure 1), in which during the 10th century modifications and reforms of the original building have been realized so as to adapt it to its new use. But this cloister displays the footprint of other reforms and adaptations that it had had for previous uses that have taken place throughout its almost 450 years of history.

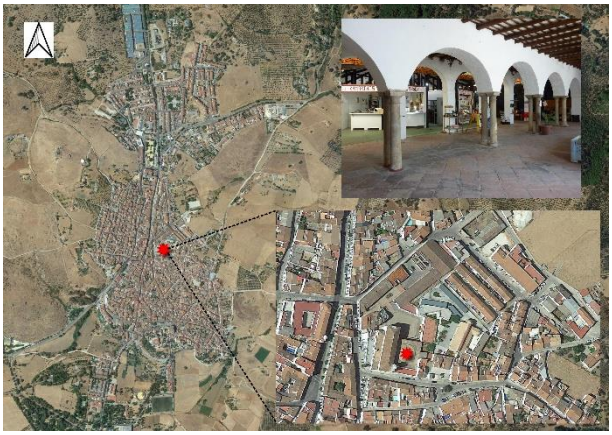

Figure 1. Location of the Food Market of Cazalla de la Sierra and indoor sight, where the cloister of the monastery of San Francisco is located.

With this background and as part of the works of retrieving of the cloister's original remains, an archaeological intervention was taking place so as to eliminate the current use as a market and all the elements added to the original building. For this task, the Ministry of Culture of Junta de Andalucía urged that a building archaeology study had to be carried out by the photogrammetric surveying of the different panels that the inside perimeter of the Municipal Food Market was compounded of, so as to elucidate what was preserved in the old Cloister of the Monastery of San Francisco and in what state were these possible remains.

The works were carried out by combining the photogrammetry techniques SfM (Structure for Motion) [4] and the laser scanning TLS (Terrestrial Laser Scanning) [5] with the purpose of generating a three-dimensional model (3D) of high resolution and geometric precision, from which it was possible to obtain scaled and georeferenced surveying from the 4 facings that the cloister was compound by. With these surveyings, the wall face analysis and the study of its components [6], would be carried out, as well as the cartographic and planimetric outputs needed for documenting and justifying the explanatory proposal and the subsequent labours of restoration, conservation and elimination of the outside additions outside of the original building.

Broadly speaking, it can be determined up to 7 different phases, an aspect that will be more fully developed when we go into the description and explanation of the facings it is composed by, each of which has left their respective footprints, some more visible than others, and some of them especially damaging in terms of what they have meant in terms of alteration concerning their initial appearance and irretrievable loss of those parts.

The phases referred to are the following:

1. Original building – Construction of the original cloister: circa 1588;
2. First reform of the cloister – first remodelling encouraged by the construction of San Diego's Church attached to its flank W: from 1623 to 1716 (ending year);
3. Final reform of the cloister – second remodelling because of the addition of a porticoed gallery with arcades: during the 17th century (in this phase a sub-phase can be identified, probably from the 18th century with light reforms);
4. Reforms during the Spanish confiscation period – third remodelling due to the fact of the Spanish confiscations and the implementation of a schnapps factory in its environment: from 1835 and during the rest of the 19th century.
5. First transformation for the Market's adequacy – reforms for the implantation of the municipal market: circa 1940;
6. Second transformation for the Market's adequacy – reforms for a new adequacy for the usage as a market: approximately in the last decade of the 20th century;

7. Current work – works on improving that were being carried out in the facings as of the date of the fieldwork for this study, July 2019.

2. Materials and Methods

2.1 Materials

The current Municipal Food Market is located in a building whose history begins at least from 1588, when the order of San Francisco, settled in Cazalla in 1493, in the old Monastery of San Jerónimo (the current Hermitage of Carmen), decided to be relocated inside the walls of the city and build their new monastery in the block in which the monastery was located [1-3].

We say at least from 1588 since that is the date in which the relocation from the old monastery of San Jerónimo to the new one of San Francisco is produced, thus it would be logical to think that at least the main buildings were already built, especially the dependencies where the daily life would be developed and the cloister in which the aforesaid activity will revolve around.

The relocation to the town centre was due to the ruin situation and to the distancing from the parishioners, that ask for the approximation of the monastery as it was quite far from the population nucleus.

The new monastery was located beside some wineries in which tithes were recollected and from that moment it began a slow, but intense, urban transformation of the buildings on which the monastery was settled, as well as its immediate surrounding, reaching to occupy the 15% from the total population area from that time.

The cloister, with a clear quadrangular layout, is currently formed by three facings of between 24 and 26.5 metres and a fourth, of which about 3 metres remain on each flank, where a double arcade was built to make this wall completely diaphanous, and where columns and capitals that were reused from earlier periods can be seen.

The concrete space of the Market from this monastery of San Francisco is the cloister, which presents some modifications and reforms so as to adapt it to its new usage, although it displays the footprint of previous reforms and adaptations for other usages that have taken place during its 405 years of history.

2.2 Methods

2.2.1 Coordinate System Implantation

Two pieces of equipment GNSS (GS18 and GS16) have been used, in order to place in the outdoor area of the market square a series of geo-referenced coordinate points, in the UTM projection, in zone 30 and ETRS89 datum [7], established by the IGN (National Geographic Institute) and official for the Iberian Peninsula. These points have been marked with nails that will remain in place for future interventions (Figure 2), and thus be able to work in the same coordinate system.

These absolute coordinate points will be useful so as to be able to geo-reference every point that will be taken inside the site.

Using a Leica's total station TCR705 [8], a free stationing has been carried out taking as reference the previously measured points with the GNSS, in particular those two which were visible from the inside of the site, located at the pavement from which the entrance to the market square is accessible (Figure 2). These points and the rest of the measured points in the work have been taken by employing a mini prism (Leica's GMP111-0), except those points that have been located on the surface of the walls to be measured, that because of being on top of a vertical plane, they were signposted by adhesive paper targets,

in this case, the TCR1705 is used in "red laser" measurement mode modifying the measurement parameters in the equipment (Figure 2).

Figure 2. GNSS stationing, placing and measurement of permanent points inside and outside the cloister.

The geodetic topographic work would be completed, by obtaining the following data:

- Points measured to generate the GNSS positioning network: 5 points, all outdoors;
- Points measured with the TCR705 inside the enclosure on the ground: 11 in total measured on mini prism;
- Points measured with the TCR705 on targets placed on the wall: 19 points, which will be used for adjustment in photogrammetry [9]
- Points measured with the TCR705 on scanner targets, GZT21 on a tripod pole: 7 points taken. [10].

It is necessary to adjust the point coordinates that have been obtained during the measurement by the GNSS. For that, supporting data from the Andalusian Positioning Network (its abbreviation in Spanish of RAP) that belongs to the Statistic and Cartography Institute of Andalusia (from its abbreviation in Spanish of IECA), obtaining a sub-centimetric precision [11].

These data have been loaded together with the GNSS data into the Leica Geo Office programme to calculate the coordinates of the base point where the GS16 was placed and to obtain these coordinates with great precision.

With all these points, different ASCII files were generated that were necessary so as to make adjustments to both the photogrammetric process and the process generated by TLS. A drawing file in DWG format was obtained with Civil 3D to check that all the obtained points were correctly located and to continue with the following processes.

2.2.2 Laser Scanner Method

With the laser scanner, 13 positions were done in order to cover up the whole site. In one of them, the scanner registered three GZT21 targets, [12] that were measured previously by using the total station, in the coordinate system established for the whole surveying. 7 positions of targets were carried out to encompass the three walls that the work was composed of. Due to the high precision of the scanner (a Leica's P20), only two targets would have been needed to be measured from each scanner position, but in order to obtain better results, three targets were measured [13].

The total number of obtained points in the whole process has been 40,461,333 points, generating with all of them a dense cloud of points in 3D with RGB colours [14] (Figure 3).

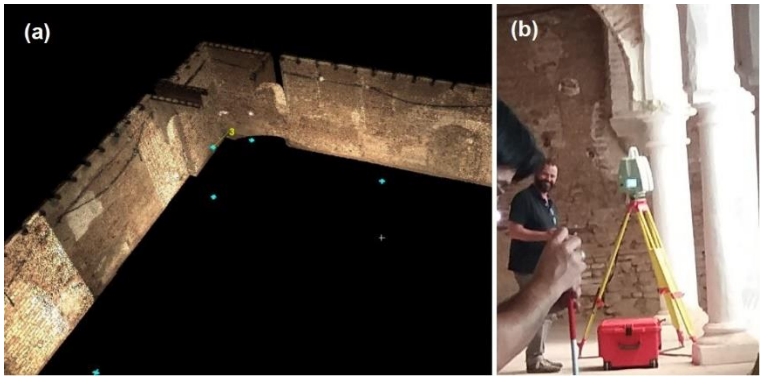

Figure 3. Dense cloud of points in 3D with RGB colours and Scanner P20 - Leica

2.2.3 Photogrammetric method

This method has been carried out in two phases: images acquisition and a subsequent processing of them [15].

In order to cover the first phase, and due to the location conditions -indoor areas with low natural light, it was necessary (to guarantee the luminosity conditions in the pictures acquisition) the usage of an artificial light equipment consisting of four neutral light luminaires that were distributed and moved as the interior atrium progressed. The images were taken every 2-3 metres (depending on the detail requirements of the area) with a coverage of 5-6 images at three heights.

Once the images acquisition was over, the second phase consisted of the processing of the images employing the Metashape programme so as to generate a three-dimensional model (Figure 4) and, subsequently, obtaining a set of four orthophotos. These orthophotos are the ones that have been taken as a base for the realisation of the wall face study from the archaeological point of view.

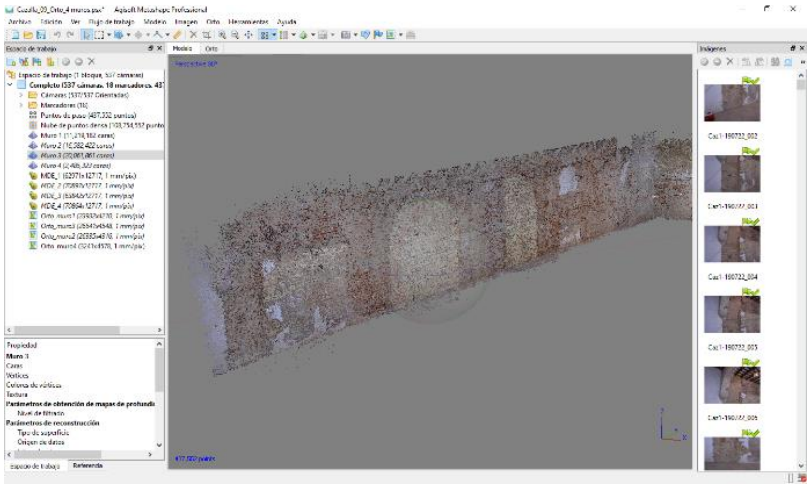

Figure 4. Processing of pictures in Metashape

For the correct execution and dimensioning of the model, the same targets, that have been established in the walls, were used, measured both by scanning and by total station, although they were ultimately removed thus that each area could be photographed to obtain the real texture of these parts of the walls without the appearance of elements foreign to the object of study.

In the first phase, 537 pictures were acquired.

During the second phase, different tests were done, obtaining the optimum result with a "dense cloud of points" of 108 million points [16] (Figure 5.a).

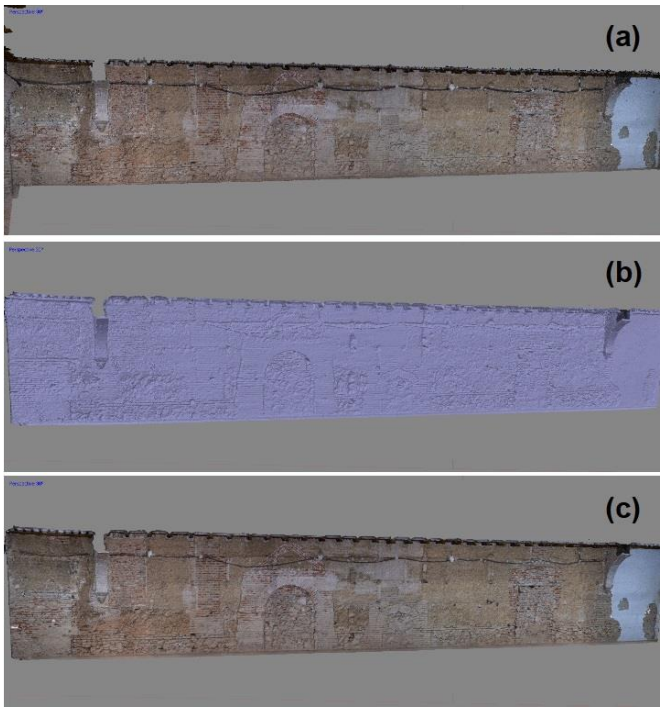

Figure 5. Wall 2 (cloister's N panel): (a) Dense cloud of points; (b) Solid mesh; (c) Texturized mesh

2.2.4 TLS Results and Photogrammetry

Conducting a comparison of the obtained results with the different methods [17-18], the following can be observed:

- With the TLS technique more than 40,000,000 points have been obtained. All of them are part of a dense cloud of points in 3D and with RGB (Red Green Blue) (figure 3.a). The cloud of points is the result of the union of several scanning taken from different positions and that are integrated into a single geometry thanks to the field measurement of the HDS targets that were previously surveyed with the total station. After making the register process, employing Leica's CYCLONE programme and integrating the partial clouds of points, a joint cloud is obtained, scaled and precisely georeferenced.
- With the photogrammetry technique, a dense cloud of points of more than 108,000,000 points was obtained, and a 3D mesh of more than 21,000,000 polygons (Figure 5.b-c).

2.3 Wall Face Analysis

In the archaeological analysis and comprehension of the buildings, the principles of stratigraphy as defined by E.C. Harris [19], later improved and completed by A. Carandini [20] regarding the buildings studies, are a key when establishing topologic relations of the facings and its parts, as well as the establishment of a method of a systematised data collection.

Based on approaches by Harris and Carandini, from the 1990s onwards, a whole series of works and methodological proposals emerged, headed by the *Archeologia dell'architettura*, term that was coined by T. Mannoni [21], that collected the accumulated experience in Italy during the previous decade [22-26], and which was followed by many others developed all over Europe: the *Archéologie du bâtio* or *Archéologie des élévations* in France [27-29], the *Bauforschung* in Germany [30-31], or the *Ar-chaeology of Buildings* or *Building Archaeology* in Great Britain [32-34].

Spain currently has one of the best exponents of archaeology of the architecture in the System of Archaeological Analysis of Historical Buildings developed by M.A. Tabales [35-38] and launched in several real estates of Seville, among them, the Reales Alcázares [39], to which we can add the work of L. Caballero Zoreda, one of the precursors of building rehabilitation studies [40-41], or that of the Conservation Service of the Barcelona's Deputation [42-46].

The analysis carried out on the facings of the cloister of San Francisco has attempted to combine three fundamental principles for this type of work on emerging archaeological structures:

- the concept of transformation of the structure, i.e., of the changes, added and modifications that at an archaeological level had occurred, which model variations in the uses;
- the concept of archaeological sequence occurred over itself, understanding this as the evolution that the structure displays through the documented stratigraphic sequence, defined by each of the identifiable elements in the building structure and its spatio-temporal arrangement, from its construction until the present time or until its definitive amortisation.;
- and the concept of a historical process, that goes further from its physical nature and that requires its environment, both level of the edification and the historical moment in which each structure, or its parts, are framed.

A systematic strategy has been carried out by the application of a series of consecutive and interrelated procedures, because the development and the partial result of one help in the execution of the following one, which is described below:

2.3.1 Building Components Definition

This process has been about the observation of the surveying generated in the photogrammetric procedure so as to identify and map all and each of the components that had a function or that represented similar characteristics. As an example: facings, hollows and their consecutive closures, pathed by reforms, etc.

The contours of the principal components were accurately mapped and the secondary components were simplified. Moreover, the interior of the units (masonry, fills, walling) was limited to a more schematic mapping, which was only carried out in detail when they presented particular characteristics of interest.

2.3.2 Assignation of Materials to the Components

Once all the components are delimited, these elements were classified into a typology of masonry material. For example: masonry, rammed earth, stone, brick, etc. This classification helped in the determination of different moments for components that at first glance appeared to be similar.

2.3.3 Establishment of usage and components' function

Based on the acquired experience until this point, regarding the delimitation of components and material of their composition, we proceeded to establish the different uses

and functions that each of them had to have in their historical moment to which they were ascribed, taking into account the whole building and its general articulation as well.

2.3.4 Ascription to the phases of the archaeological sequence observed

Depending on the topological relationships of the different components, on the similarity or equality, in some cases, on the factory materials and its physical and formal characteristics, we established the archaeological sequence that would allow order them in a temporal and sequential logic. For this, we relied on the Harris matrix generated for each facing in particular and all of them in general.

2.3.5 Determination of phases and historical contexts

In a process of accumulated knowledge throughout the different phases of the procedure that were developed before, and having as a result of the temporal logic of the archaeological sequence established in the previous step, the correct adscription of each component with a phase and historical context is derived.

Some gaps have remained in this part of the study, which cannot be resolved with just a wall face analysis of the building, but it will be necessary to deepen its study with a series of archaeological soundings in the sub-floor.

For the determination of the historical contexts, it was necessary to go beyond the limit of the concrete space of the cloister, so as to attempt to understand the totality of the monastery and to be able to accurately match the final proposals of the evolution of the building in general and the cloister in particular.

3. Results

The analysed facings (Figure 6) have been numbered for its correct identification, going clockwise starting from the most W point.

Figure 6. Localization and numeration of the studied walls panels

The results that we will display are going to be referred to each phase that was documented after the wall face analysis, without going into describing and commenting on each individual facing separately. So as to have more information and details about the

results of each particular facing, we referred to the supplementary documentation that joins this article in which the results are developed in detail.

The photogrammetric method has allowed us to obtain 4 ortho-photos generated from an X-Z or Y-Z view, both front view and back view, as appropriate for the spatial location of each facing (figure 7). Thus, the final photogrammetric product that we have to perform our analysis is the surveys of the 4 facings studied.

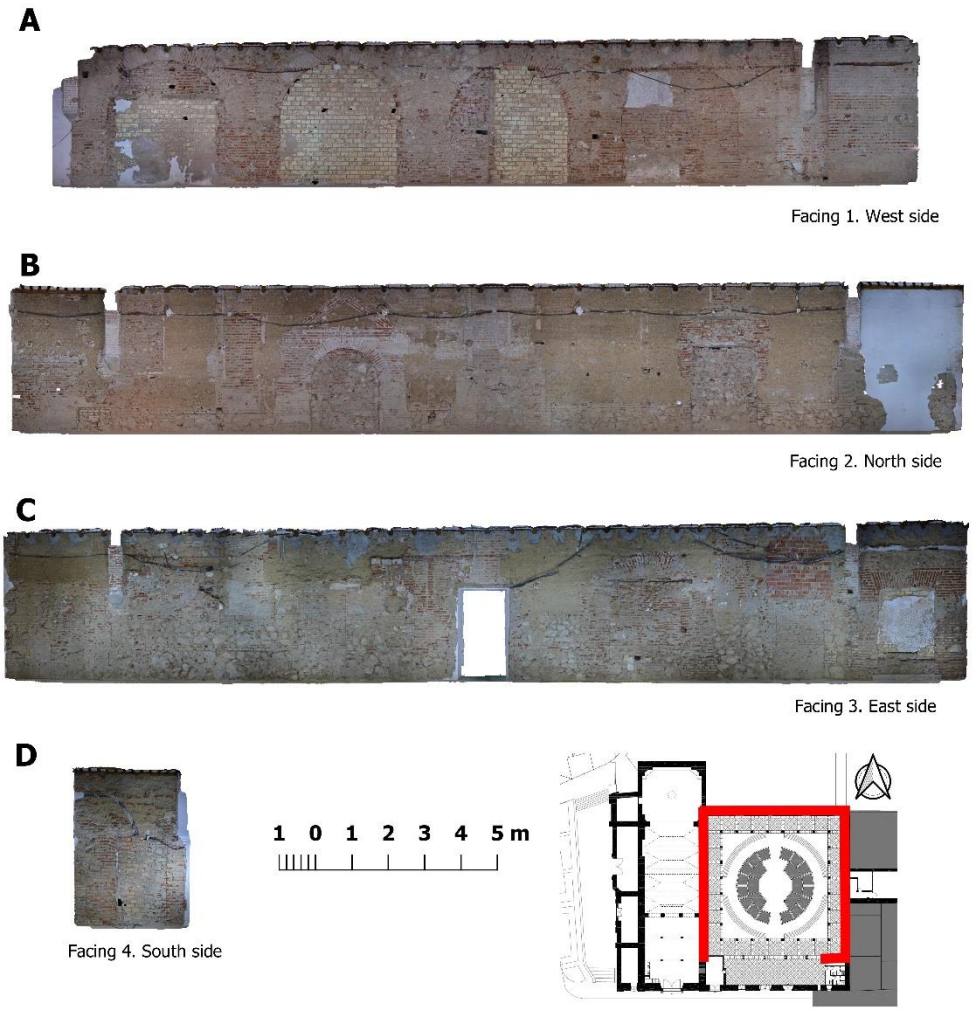

Figure 7. Facing´s ortho-photos

The obtained surveys by photogrammetry have paved the way for delimitation of the building components being able to map them in a high precision since the surveys resolved 1 mm (figure 8).

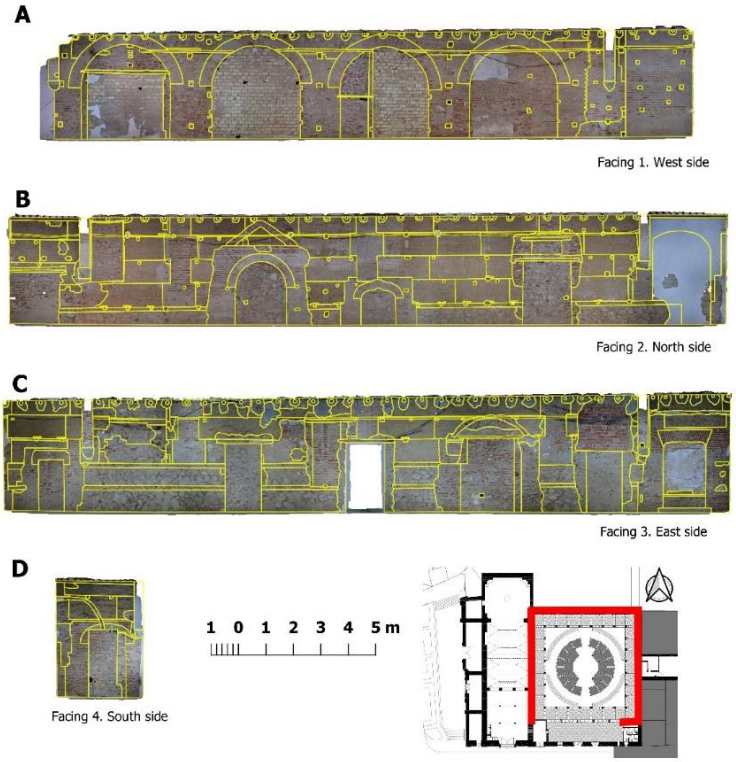

Figure 8. Documented building components

With that high resolution, the assignation of materials and the establishment of the usage and components fiction (figure 9) was relatively easy, which were carried out by the combination of the ortho-photos visualizations, visual inspection in situ, and the field data taken during the process of chipping the faces of the facings.

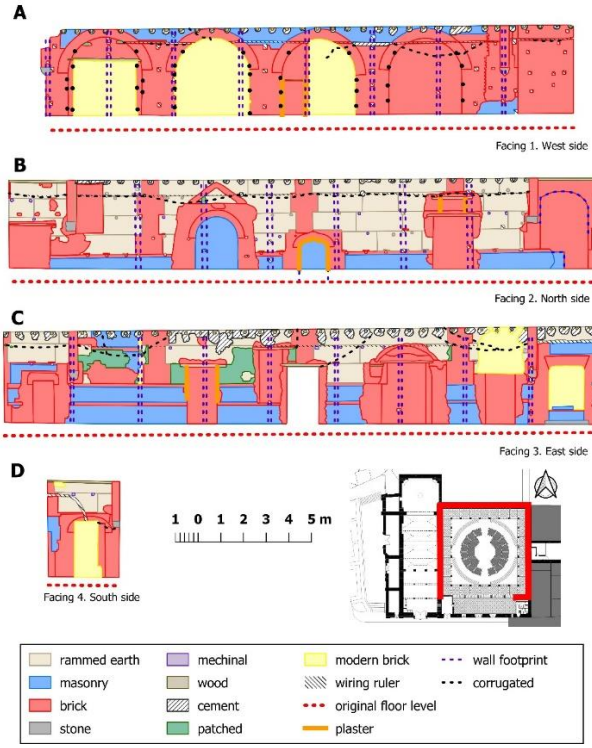

Figure 9. Construction materials and elements

Finally, the determination of the chronological phases, embodied by a colour system over the ortho-photos, allows us to observe the chrono-stratigraphic evolution of the facings (figure 10).

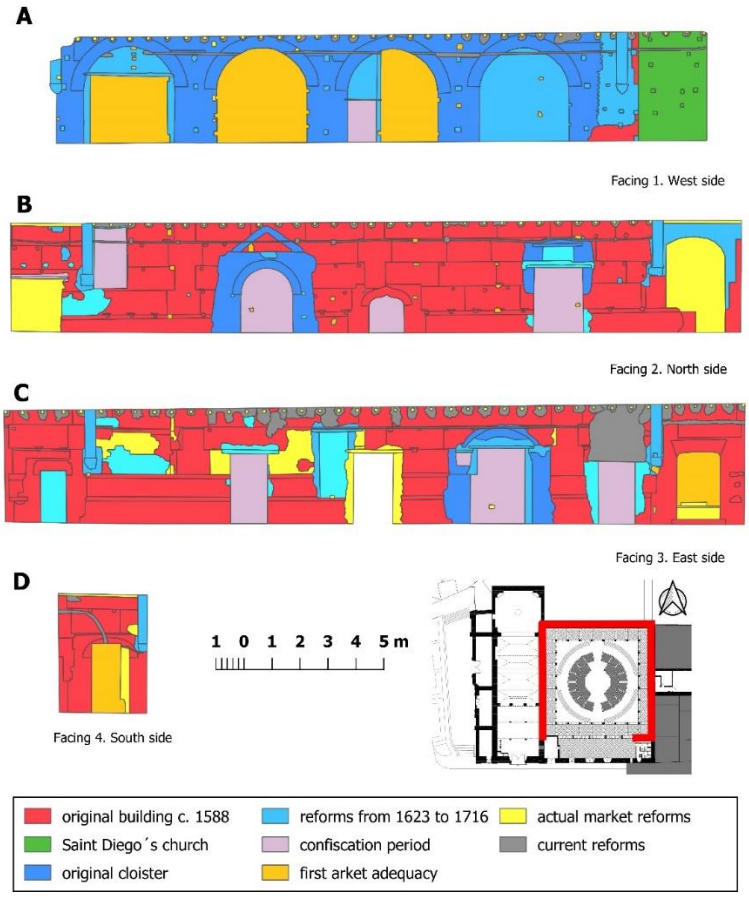

Figure 10. Chrono-stratigraphic phases

3.1 Original building – Construction of the original cloister: circa 1588

The original cloister presented a quite different physiognomy from what can be observed nowadays, which also differs from the one that took shape after the huge reforms carried out in the 17th century and some other minor reforms in the 18th century.

In general terms, its aspect was soberer and austere, which is in perfect consonance with the philosophy of the Franciscan Order for those moments.

The patio must not have had a porticoed gallery, as no evidence of such a presence has been preserved in the original preserved part of its facings. The scarcity of doors and gates would further emphasise the sobriety to which we are referring.

The production of the walls of the original cloister are made of two different parts: a plinth of masonry of stones of a medium size well-edged on the visible faces of the facings; and a remaining wall of improved rammed earth, separated from the lower plinth by a double brick wall, with well-differentiated boxes with fine lines of lime, and with brick chains at certain distances [47] (figure 11).

Figure 11. Original factory on facing 2

The facings 2 and 3 preserve a huge amount of this original factory, and in them, it can be easily observed the characteristics of it and the specificity that can be observed in facing 3, in which the plinth presents a higher height, and even reaches the ceiling of the wall in some parts. This variant obeys facts of structural nature of the panel of the wall.

No windows have been documented to allow light into the rooms that must have been arranged on the other side of the facings, and the doors were scarce and of a size more in keeping with the human scale than with any other module designed to show exuberance.

The layout of these doors seems to display a well-designed scheme to go unnoticed. Doors have been preserved at the distal ends of facings 3 and 4, and we believe that there must have been another one located at the N extreme of facing 1, currently hidden under a wall panel belonging to the later church of San Diego. In this way, facings 1, 3 and 4 located to the E, W and S respectively would have had a door at each of their distal ends, making the rest of the wall continuous and conveying the sensation of austerity that was sought for the whole complex.

This austerity was broken in facing 2, located at the N of the cloister. In it, just a door is documented, located in the exact centre of the wall and that has an ogee arch on the top. Despite this stylistic licence, the door presents a similar size to the rest of the documented doors (figure 12). The fact of locating just a door in this facing, centred concerning it and with a slight stylistic and formal difference concerning the others, leads us to believe that it would have been the access to the noblest area of the monastery at that time, perhaps a chapel or some other room of rank and importance in the life of the monastery.

Figure 12. Main door of the original cloister with an ogee arch on the top

Finally, we should point out that the floor level that is currently conserved, would make it impossible for what we have indicated as a door in facing 2 to be a door as such since its passage would be too low to allow passage through it adequately and comfortably. Later we will explain that the current level of the cloister floor is not the original one, and we will see how the one corresponding to this initial moment would be sufficiently lower to allow passage through the door without major inconvenience.

3.2 First reform of the cloister – first remodelling encouraged by the construction of San Diego's Church: early 17th century

Between 1623 and 1716, the edification of San Diego's Church took place, which is completely attached to the W flank of the cloister, causing the almost total transformation of this. We say almost total, because only a small residual sample of the original masonry can be seen at the N end of facing 1, which we have already mentioned in the previous section (figure 13).

Figure 13. Detail of the facing of the church, the original wall and the reforms of the Cloister

The austerity of the philosophy of the Franciscan Rules was complemented in this case with the idea of communication and opening to the people that pretended to be evangelized, and due to this fact, the physiognomy of facing 1 will reflex this aspect.

The new built church openly communicated with the cloister through a series of semi-circular arches, up to 4, whose middle pillars will connect with church's arches that will support the vault.

Regarding facings 2 and 3, that represented an austere aspect, mainly because of the absence of windows and doors, except the ones located in the extremes, will be transformed with the openings of some hollows added to the previous ones. This is going to be the most significant fact regarding changings in this phase.

The most noticeable change will be the one produced on facing 2, where another new door will be opened immediately beside the one existing in the previous phase. This new door is bigger than the previous one, presenting a triangular front at the top, of which only the traces of its fitting into the original masonry of the cloister wall remain (figure 14).

Figure 14. Detail of the front and the semicircular arch of the new open portal on facing 2

This fact only redounds to the idea we expressed earlier, that behind this facing must have been the noblest rooms of the monastery, so it makes sense to monumentalise the access to these rooms in some way.

In facing 3, in addition to the smaller windows and doors mentioned above, there is also a door of larger dimensions, similar in size to the monumentalised one in facing 2, but simpler in its execution and ornamentation.

3.3 Final reform of the cloister – second remodelling during the 17th century and the first third of the 18th century

The reforms that take place in this phase have a higher expression in the configuration of the cloister patio, which acquires its final aspect and that will transcend to the current days.

In general terms, the porticoed gallery was built and the corner of the arches must be fitted into the original walls. In some cases, this fitting is very evident and has left significant traces (figure 15), while in others it is softer and it is hardly noticeable.

Figure 15. Corbel in the shape of a human head from an arch in the porticoed gallery on facing 2

In some cases, the facing of the original building had to be almost completely replaced by a new facing of solid bricks in order to have the right consistency to fit the arch and its corresponding bracket.

Another significant aspect of his facing is the elevation of the pavement coordinate of the cloister, elevating it up to reach the usage level that is observed in the current days.

Thanks to georeferenced photographs of facing 2 and superimposing on it the mapping of the main components of the wall obtained from the ortho-photo generated by photogrammetric methods for this work, it can be established that the original pavement is approximately 0.60 m below the current one (figure 16).

Figure 16. North facing 2, with the elements of the south face, georeferenced and indicating the original floor level of the cloister

The rest of transformations of this phase correspond to the closure of almost all the hollows of the previous phase, as well as the openings of some news and the partial reform of several of the previous ones that were not closed.

To conclude, the visual connection that was established with the connected church by a series of four big arches closed with grids, disappear completely when three of them were closed and the fourth one is reduced in size.

3.4 Reforms during the Spanish Confiscation period: from 1835 and during the rest of the 19th century

The Spanish Confiscation of the cloister will mean a radical transformation, both in visual aspect and the uses it will have from that moment.

The cloister, and probably some other dependencies of the cloister, including San Diego's Church, will become places destined for the production of Miura's anisette that was installed in 1870 in what it used to be the monastery's vegetable garden.

This new adaptation of the cloister to the new use was to receive resulted in the closing of all the doors and openings in the walls, except for the one that existed at the NE extreme of facing 2, which must have served to connect with the rooms of the factory, built in that sector.

The industrial use of the monastery must also have entailed the demolition of the northernmost wing of the cloister, preserving only the facing separating the two areas.

3.5 Transformations for the Market's adequacy: circa 1940 and the last decade of the 20th century

The reforms in order to adequate the cloister to Local Market use will be produced in two different moments: circa 1940, when it was installed there; and in the last decade of the 20th century, when the physiognomy changes to the current one.

In the first reform, all the hollows that could have been left opened were closed and a new door is opened for a connection of the centre of facing 3 with the dependences of the W wing.

What is more, a series of brick quoins, loosely embedded in the original walls, are placed along the whole length of the cloister gallery, so that they share the cloister (figure 17), defining different quadrangular spaces used as stalls for the sale of goods traded in the market.

Figure 17. Imprint of the market walls, drawn on the wall of the cloister

The second reform supposed the elimination of stalls attached to the original walls of the cloister, which shared the porticoed gallery, leaving it diaphanous and placing the stalls in the centre of the patio.

Regarding the facings, it has supposed a new plaster that homogenises its appearance and which is the one that has survived to the present day.

4. Discussion

The results of the analysis of the facings described in the previous section (identification and mapping of the wall components, assignment of materials, classification of the typology of use and establishment of the chronostratigraphic sequence), allow us to establish and locate the documented phases and the different elements and transformations that took place in the cloister within its chrono-spatial context, that is, concerning the rest of the known buildings of the monastery and taking into account the historical process that justifies it.

The block in which the monastery is located currently is completely built, except for some little empty spaces in its insides.

Looking at an ortho-photo of previous years (although we have available ortho-photos from 1945, we have opted for a 1977's one [48] due to the resolution quality that it offers), it can be identified more clearly the different parts of the monastery that transcended up to its definitive destruction of the last room of the 20th century, as well as the ones that are still preserved (figure 18)

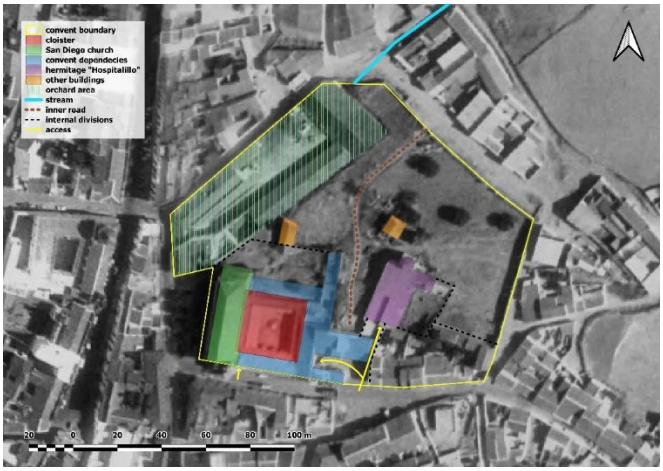

Figure 18. Identifiable elements of the San Francisco Monastery on the 1977 orthophoto

It can be identified the church, the cloister and part of the dependencies of the monastery, as well as the hermitage known as the "Hospitalillo" (diminutive name for Hospital). All of these elements still exist nowadays. It is only to be regretted the destruction of the N part of the monastery dependencies, and the transformation of the rest of them, including the church, for other uses.

The accesses to the complex would be mainly on the S flank of the plot: the one located further to the W to access the noble part of the convent; and the one located in the centre of this flank to access the Hospitalillo and possibly the convent's dependencies for supplying or similar tasks.

The Miura schnapps factory is currently located on the N flank, where the monastery's vegetable gardens were once located. Another unidentifiable element is a group of dependences to the S of the Hospitalillo, which we are not in a position to say whether all or any of them could belong to the monastery. It is most likely to be the result of the process of urbanisation of the block, already visible in the orthophoto of 1945.

The rest of the monastery space is free of buildings except for a couple of small buildings in the centre of the plot, none of which exist today, and a series of internal partitions with fences, as well as a path. All these elements can also be considered as fossilised remains of the monastery, which at the date of this ortho-photo would have had other functions, and which no longer exist today.

4.1 Evolution of the Cloister in the cloister's context

The original cloister (figure 19.a), as already described in the wall face analysis, developed the four sides of the square that formed it. The W and S flanks are hypothetical in most of their layout, as only a small part of them currently exists at their respective extremes. It is logical to suppose that their continuity is a viable proposal, bearing in mind that these parts exist, as can already be seen in facing 1, cut to build a new wall, that of the arcades of connection with the future San Diego's Church.

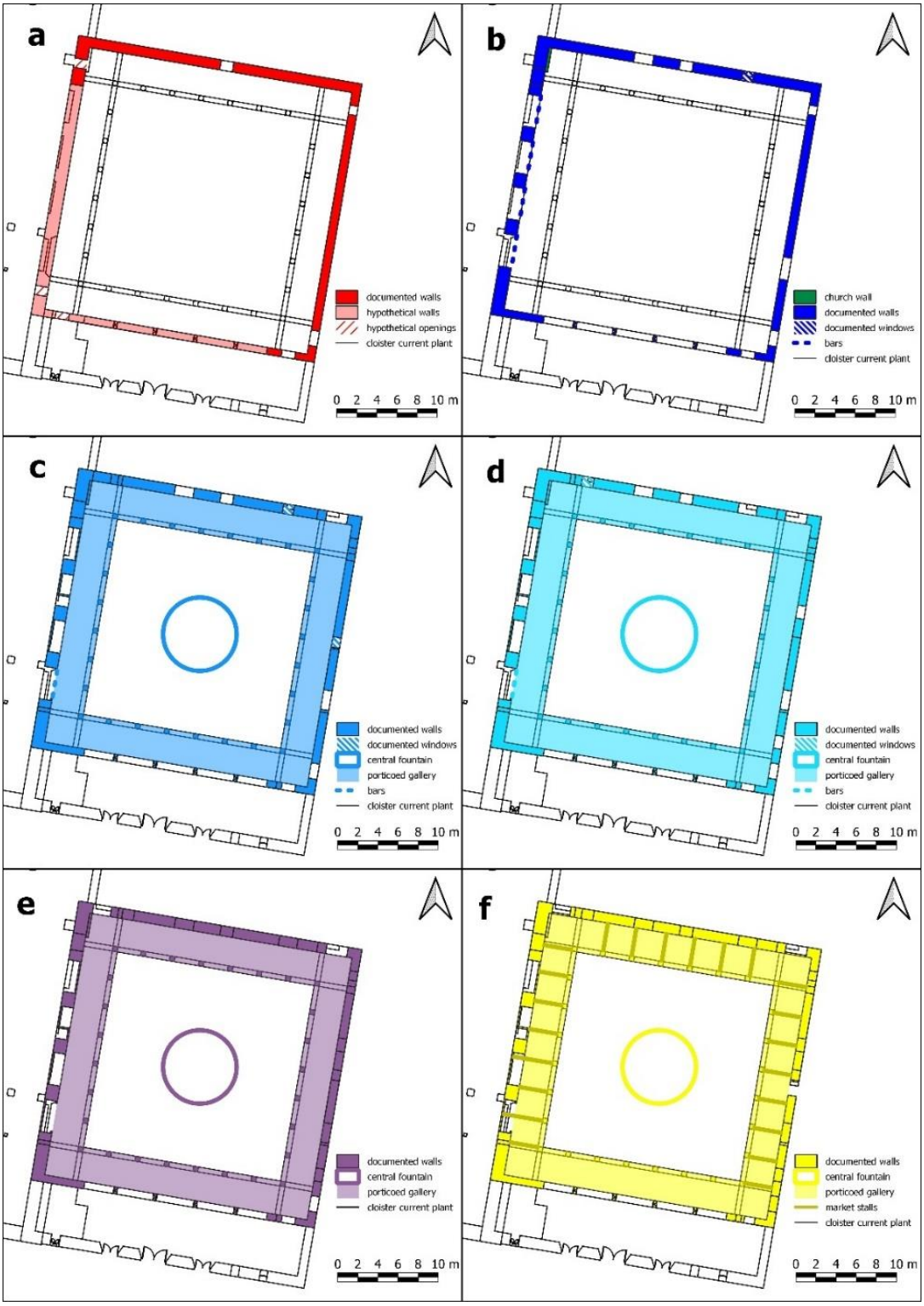

Figure 19. Evolution of the Cloister: (a) Original building: circa 1588; (b) First reform of the cloister encouraged by the construction of San Diego's Church attached to its flank W: from 1623 to 1716 (ending year); (c) Remodelling because of the addition of a porticoed gallery with arcades: during 17th century; (d) Light reforms from the 18th century; (e) Remodelling due to the fact of the Spanish confiscations and the implementation of a schnapps factory in its environment: from 1835 and during the rest of the 19th century; (f) Transformation for the Market's adequacy: circa 1940

When San Diego's Church was being built, attached to the W flank of the cloister, this suffers an important transformation (figure 19.b). On this side, a new facing was built between both spaces that consisted of four big arches that paved the way for the intervisibility between them, but which are closed by grids to prevent direct communication

There are also two new doors, one on the N and the other on the E flank, of large dimensions, which must have given the cloister a more monumental appearance. There is also a small window on the N side of the cloister.

Another big reform was the demolition of most of the S wall to create 5 large arcades supported by pairs of columns, which should have further enhanced the monumental aspect mentioned above.

It was in the mid-17th century that the big reforms mentioned above must have taken place, affecting not only the cloister but the monastery in general. It was at this time that the "Hospitalillo" was built, which is how the hermitage built to the E of the main convent buildings was known. This building had its access from outside the monastery, isolated from the monastery, through which the users of this facility could reach it without interfering with the monastic life.

Regarding the cloister, there were two types of reforms and transformations that gave it its current appearance (figure 19.c).

On the one hand, several hollows of the previous phases were closed, as well as some new ones were opened. Moreover, all the arcades that visually communicated with the church were also closed, except for two of them: the first from the S, whose width was reduced and which was fitted with a new grid; and the third from the S, which reduced its space to a small door that facilitated physical communication.

The great transformation took place inside the cloister. A porticoed gallery was built with seven semi-circular arches on each side. The fountain that existed until recently in the centre of the cloister patio must also have been built at this time.

During the remaining life of the cloister, the reforms are reduced to the opening or closure of some hollows (figure 19.d).

With the arrival of the Spanish Confiscation, the cloister will suffer some changes that advocate, especially, in the aspect of its facings: almost all the hollows are closed, including all the arches that connected with the church; and a new hollow is opened on the N wall (figure 19.e).

The greatest changes of the 19th century are produced in the rest of the dependencies and cloister's space. In 1870, the factory of Miura schnapps is installed where the vegetable gardens were before, in the N zone of the plot of the monastery. This implantation led not only to this transformation of the N space, but it also supposed the demolition of all the attached buildings of the cloister on its N flank, leaving its facing exempt.

Likely, the existent dependencies of the E flank were segregated to the cloister, from that the closure of all the hollows of this sector, which would open new accesses from the indoors.

The last great reform of the cloister was produced so as to adequate it as Food Market circa 1940 (figure 19.f).

All the remaining hollows are closed completely and just one new is opened in the middle of the E facing so as to give access to the dependencies of the new market located on the other side. As commented above, the stands are arranged under the porticoed gallery, building brick quoins from each column of the gallery to the corresponding wall of the cloister at its perpendicular. This way, 23 stands are available.

Years later, the definitive reforms of the Market were carried out in order to eliminate the stands under the porticoed gallery, the facings of the cloister were flushed, by the closure of the hollows that remained in the W facing, and the stands were arranged around the central fountain, which was eliminated.

This way, an attempt was made to somehow recover the space and appearance of the porticoed gallery in exchange for completely changing the concept of the cloister by installing a roofing system to protect the entire open space in the patio from the weather.

5. Conclusions

In this research work, the advantages of using contemporary geomatic techniques in the traditional tasks of archaeology and heritage recovery are corroborated.

Which we emphasize the use of topographical instruments such as GNSS and total stations, in order to correctly georeference the project, as well as using or facing similar techniques to obtain point clouds with laser scanners and photogrammetric techniques.

In this sort of studies, it is clearly reflected the visual and geometric advantage that SfM has against TLS since, despite being a slower process because of the quantity of inverted time in the aligning processes of images and the generation of a dense cloud of points and after that the mesh and texture, the final result allows to have a faithful representation of the real aspect of the facings, with a lower cost on materials and equipment than in TLS.

Author Contributions: Conceptualization, J.C.M-G and M.J.L-B. ; methodology, A.P.-R.; M.J.L.B.; R.M-A.; J.C.M-G and C.M.-B. ; software, R.M-A. and A.P.-R.; validation, M.J.L-B; C.M.-B. and J.C.M-G; formal analysis, C.M.-B. and M.J.L-B.; data curation, M.J.L-B.; J.C.M-G.; R.M-A.; A.M.P.-R. and C.M.-B.; writing—original draft preparation, M.J.L-B; J.C.M-G; C.L-O and C.M.-B.; writing—review and editing, M.J.L.B.; J.C.M-G.; C.L-O and C.M.-B.; supervision, C.M.-B.; project administration R.M-A. and A.P.-R.; funding acquisition, C.M.-B. and J.C.M-G. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Cazalla de la Sierra Council and the University of Seville.

Data Availability Statement: Data retrieved from the Scopus database.

Acknowledgements: The authors thank the University of Seville for their support.

Conflicts of Interest: The authors declare no conflict of interest.

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