CLOSE-RANGE PHOTOGRAMMETRY PRACTICE: GRAPHIC DOCUMENTATION OF THE INTERIOR OF THE WALLS OF AVILA (SPAIN)

L. Aliberti* [1] and P. Iglesias Picazo [2]
[1] ESNE. University School of Design, Innovation and Technology. Camilo José Cela University, Madrid - licinia.aliberti@gmail.com
[2] Universidad Politécnica de Madrid - pedroiglesiasarquitecto@gmail.com

Commission II, WG II/8

KEY WORDS: Architectural Heritage, Photogrammetry, Architectural Survey, Avila, Fortified Construction.

ABSTRACT:

This work presents the results of the photogrammetric survey of the inner side of the walls of Avila. The graphical restitution realized is part of the studies for the Master Plan of the walls of Avila promoted by the Cultural Heritage Institute (IPCE), under the Spanish Ministry of Education, Culture and Sport in 2017. The monument has been extensively drawn throughout history, but there isn't a complete and detailed planimetric documentation of its whole extent. The huge dimensions of the walls and the different conditions of the visible sectors of the interior side were difficult conditions to overcome. The versatility and great accuracy of photogrammetric method allowed the reconstruction of the interior of the walls in a short time and with accurate results. Moreover the possibility of integrating the results with previous surveys made it possible to present a complete and coherent documentation of the walls. This is an important point and in the research a continuity is sought between restitutions carried out with tools and at different times. In addition, a series of considerations are advanced about the transformation of traditional methods of representation of architectural heritage.

1. INTRODUCTION

1.1 Subject and context of the study

This paper describes a practice of photogrammetric restitution applied to architectural heritage. Documenting the current state of conservation of historical construction with new technical approach is a necessary requirement for relevant buildings even if they have been studied and represented by many authors and institutions. The intervention and modification of the building during time and the specific aims of new studies require an updated survey.

The present work of graphical restitution is part of the studies for the Master Plan of the walls of Avila promoted by the Cultural Heritage Institute (IPCE), under the Spanish Ministry of Education, Culture and Sport and directed by the architect Pedro Iglesias Picazo in 2017. This practice fits with the current trend towards a new process of enhancing of the fortified construction of Spanish historical towns (Aliberti and Iglesias, 2018).

The Walls of Avila are one of the most outstanding examples of medieval urban fortification, whose exceptional value, state of conservation and high symbolic content have been decisive for its declaration as a World Heritage Site.

Modern historiography considers that the walls have a late Roman origin and that they were later reused and repaired successively during the Visigothic period and perhaps during the Islamic occupation, until, in the 11th century, the current Christian walls began to be built over its ruins (Gutiérrez Robledo, 2005: 120), largely using reused material (Cátedra & Tapia, 2007).

According to chronicles, at the end of the 11th century, after the capture of Toledo in 1085, Count Raimundo de Borgoña received from his father-in-law, Alfonso VI, the instructions to repopulate these lands north of the Central System. The Count commissioned the construction of the walls to the italian Casandro Colonio and the french Florin, mentioned from the time of Ariz (González de la Granja, 2010). But it would not be until late in the twelfth century when the bulk of the construction work would actually be carried out as we know it today (Gutiérrez Robledo, 2009; Barrios, 2003).

Figure 1. Avila. North canvas of the walls. Interior side. Photo: Eugene Lefèvre- pontaiis. h. 1930. Col Ministry of Culture. France. European Archive. (NUMP) LP011394.

The walls of Avila have been extensively drawn throughout history due to their relevance as architectural heritage. In recent times two surveys of the exterior have been carried out by the University of Avila and the Municipality. These works don't include the interior side of the walls. The aim of this work was to generate a graphical documentation of the entire interior of the walls that could complete the existing survey. The extended dimensions of the walls and the different conditions of the visible sectors of the interior of the walls were difficult

* Corresponding author

conditions to overcome. The versatility and great accuracy of photogrammetric method allowed the reconstruction of the interior of the walls in a short time and with accurate results.
Part of the research was focused on finding a workflow in order to connect the new survey of the interior of the walls with the existing restitutions of the exteriors side and with the general plan of Avila.
Thorough this work we also aim to make some considerations about the role of the new rising techniques in the transformation of the traditional methods of graphic documentation of architectural heritage.

1.2 Available background graphic documentations

The research of the background studies focuses on recent surveys carried out using modern methods of restitution as they provide useful data for the work. The possibility to study this digital material allows to establish a direct reference for our work. The institutions involved in the work have cooperated actively to describe the surveys realized.
The most extended and accurate recent survey of the walls of Avila was realized in 2010 using a laser scan method by the research group TIDOP, which belongs to the Department of Cartographic and Terrain Engineering of the University of Salamanca.
The TIDOP group under the direction of Diego González Aguilera carried out a complete laser survey of the exterior of the walls. They developed a virtual navigator for the use of researchers and general public in order to visualize the great extent of the whole point cloud. They also generated a series of high-quality orthophotos from the northern and eastern sectors and the entire western sector. These orthophotos were produced only if required from the municipality of Avila for specific technique needs, so that they don’t represent the continuity of the walls. The TIDOP group made a complete elevation of the four sides of the walls with a low quality due to the huge dimensions of the monument. These elevations are orthogonal views of the point cloud conserving the chromatic values of the real model, but clearly they don't keep the same definition and detail level of the orthophotos.
In 2008 another survey of part of the walls was developed using photogrammetry by the company Metria, which is currently closed down. The company Metria generated a series of medium-quality orthophotos of fifteen of the twenty-seven cubes and their corresponding canvases from the southern sector. The orthophotos don’t represent the complete South elevation, so that the only side entirely documented is the Western side until today.
We keep an extensive documentation of the numerous modifications and restorations of the walls of Avila during time. Many of these interventions required a graphical documentation of some specific sectors of the construction. Some sectors of the walls have been represented with a higher level of details in order to document the area of the interventions. Some of these survey are detailed and complete. In other sectors of the walls which have been restored the graphic documentation isn’t so complete but it contains some more data on the specific area.
As a result of this study of the existing graphic documentation of the walls of Avila we can state that there isn't a complete documentation of the monument specially concerning the interior of the walls.

2. RESEARCH

2.1 General conditions

The photogrammetric restitution of the interior side of the walls of Avila was part of the research realized in order to elaborate the Master Plan of the walls during 2017. The general work was organized in three related phases, beginning from the knowledge, then the analysis and finally the technical proposal of action strategies.
The first phase aimed to obtain specific information on the walls in each field or area of knowledge carried out by different specialty teams. In this phase the architectural survey was an important element. We had to obtain a graphical restitution of the walls in short time as other teams needed this information to develop their specific studies. The current definition of architectural survey combines the complete study of a building including different items like the constructive, estructural, historical y formal characteristics. The description of tools and techniques used to perform the reconstruction is a required condition in every architectural survey (Almagro Gorbea, 2004). These combined analyses are necessary for a complete understanding of the building and they have to integrate with each other in order to advance the knowledge of architecture. In this process of integrating data the graphic representation is a common basis for all studies and its integrity and rigour in execution are of fundamental importance.

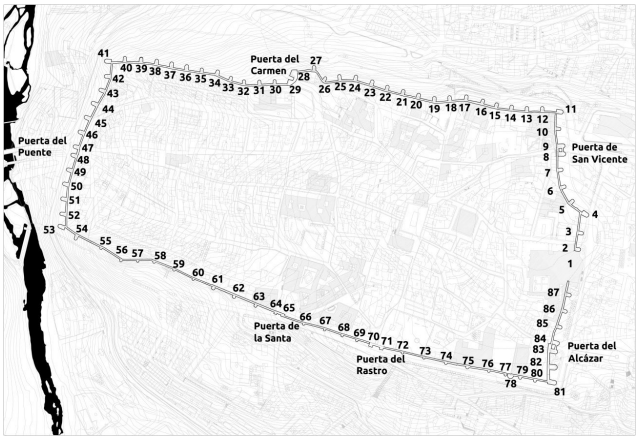

Figure 2. General plan of the walls of Avila. Numbering system of towers and sectors used for the research.

Figure 3. View from the terrace of cube 8 of sections 4-5-6-7-8 and cubes 4, 5, 6 and 7, in 2017.

2.2 Photogrammetric survey

The restitution of the interior of the walls was realized using the close-range photogrammetry, as a powerful technique that leads to new methods of architectural heritage documentation. The introduction of sophisticated automation mechanisms in the creation of point clouds from photogrammetric models allows the restitution of complex and extended objects through the use of standard tools.

A high definition reflex camera was used to acquire the photographic images necessary for the photogrammetric restitution. We used a Canon EOS 5D digital camera with a full frame CMOS sensor of 35,8 x 23,9 mm and 13,3 MP (12,8 MP in effective terms). This kind of frame allows to generate images of 24,65x36,98 cm with the high resolution of 300 dpi. The file format used for the restitution was JPG in high definition, which generates images of approximately 4 MB.

The data collection was carried out in different sessions using fixed lenses that were exchanged as required by local conditions. Some of the sectors had difficult lightning condition due to the presence of obstacles and the orientation of the walls. The lens used were Canon 50 mm (f 1/8) and Canon 24 mm (f 2/8).

We worked in different sectors of the walls with independent models as the extent of the monument is very huge. Moreover the interior of the walls is fragmented by the presence of several attached buildings that break the sections of the wall and lead to realize separated models.

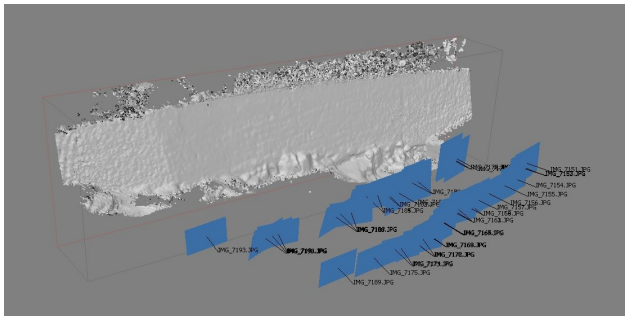

Figure 4. View of the dense point cloud of one sectors of the interior of the walls and images orientation.

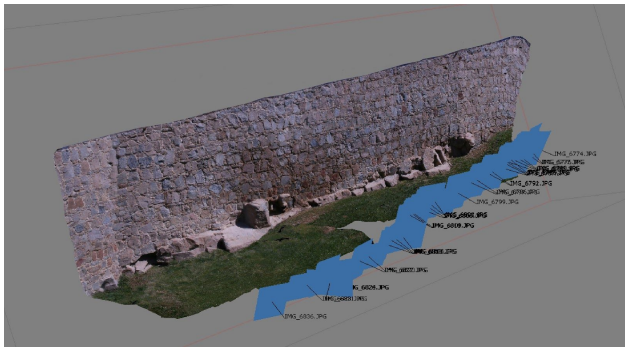

Figure 5. View of the textured model of one sectors of the interior of the walls and images orientation.

Figure 6. Orthophoto of sector 28-29.

The sectors have different sizes, orientation and characteristics. We assigned to each tower an identification number that is represented in the general plan of the walls, starting from the cathedral and turning in counterclockwise direction (Fig. 2). There are 87 towers in total and the sectors are identified as the part of the walls between two towers. In the interior of the walls not all of the sectors are visible or accessible, but they are already a very relevant number of elements for an architectural survey.

The Agisoft Photoscan program was used to realize the photogrammetric restitution, to obtain the three-dimensional models and to extract orthophotos. AutoCAD vector drawing program was used for the graphic restitution and the general presentation of the work.

The compiled photographic material has been sorted in series of photographs for each section of the wall and for each tower. Throughout the work an evident difficulty has been detected in the restitution of the interior of the walls as in some of the sectors the difficult accessibility didn’t allow a correct data collection. The fragmentation of the interior sectors accessible was a difficult condition as the aim was to produce a whole restitution. In order to obtain a complete and uniform documentation, the model was scaled and oriented using as reference data the point cloud of the exterior of the walls realized by the research group TIDOP and the general plan of the town.

The alignment of photographs was realized using a high accuracy and the generic pairs selection. The construction of the dense point cloud and of the mesh surface were processed at medium quality (Fig. 4 and Fig. 5). Because of the great extent of the monument we tried to reduce the weight of the archives and thus to speed up the work. The current graphical restitution programs are very advanced and standard computers normally available may not achieve the highest possible definition level supported by the software. However, we assured that the settings used provide models with enough accuracy for the graphic representation of the monument.

The result was a series of oriented models which were used to extract orthophotos and to adjust the floor plan of the walls in some areas. The quality of the images leads to a high definition of the surface of the walls with detailed information of material and of the cutting of the stones (Fig. 6 and Fig. 8).

2.3 Graphic representation

The graphical documentation of the walls presented in the Master Plan includes both orthophotos and drawings, like plans and sections at different scales. This way to represent buildings by mixing information can be particularly useful for studies of architectural heritage. On one hand the use of measured and editable drawings is still a necessary tool for analyzing the architecture; on the other hand the great amount of information present in the orthophoto of the building offers very useful and detailed data for the study of the state of conservation and

cutting of construction material. Moreover in this case study we had to face to the great extent of the building and the reduced time available to complete the work so that the orthophotos came to take the place of drawn elevations.

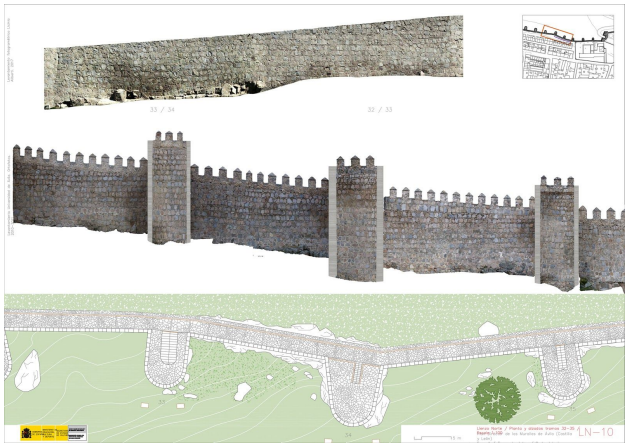

Figure 7. Example of one of the plans: floor plan, orthophoto of the exterior side (University of Avila) and orthophoto of the interior side.

Because of their level of fidelity to the built forms the orthophotos are currently used in many studies of architectural heritage and in some cases comes to replace the traditional plans drawn. The use of new technologies leads to a transformation of the way to represent architecture. The linking the new results of technological survey with the traditional systems of representation of the architecture is a complex work (San José Alonso 2018). In fact, representation by means of continuous elements is still an important tool in the analysis of historical constructions and cannot be replaced by elaborate graphics derived from photogrammetric surveys or by laser scan. In addition, each building or monument constructed requires a specific approach and a series of graphic works useful to represent its own characteristics. The direct study and knowledge of a building is an indispensable condition in order to develop detailed analyses and to complete coherently the documentation necessary for its description as the architectural survey process requires (Docci and Maestri., 2010).
The main difficulty of this work was to unify in a single document the results of different surveys composed with different graphic elements and criteria. Finally this varied material has been brought together in a single document consisting of different plans (Fig. 7). Each plan included the inner and exterior elevation of all towers and sectors of the walls in combination with the floor drawing of each area. Some of the orthophotos didn’t cover all the zone and they were completed by drawing or by frontal views of the point cloud. Since the views of the model did not offer sufficient definition, we decided to visualise them with a slight level of transparency in order to indicate their difference in relation to the other graphic elements of the plan.
The walls were represented in a scale of 1:100. Since the document covered the entire length of the walls divided into zones this scale of definition has been considered appropriate.
The possibility to use as a reference a previous survey that was carried on with laser scan is an example of the great potentialities offered by technologic method of restitution. We can register the different documentation of the same building during time using similar techniques and integrating datas. The challenge is to establish new workflows in order to be able to exploit these possibilities to the maximum while maintaining the rigor of the method.

3. CONCLUSIONS

The representation of a monument with so huge extent is a challenge for architectural survey. One of the result of the work is the complete documentation of all visitable sectors of the interior of the walls of Avila.
In addition, we must highlight the fact that the work explore new ways of representing architectural heritage by mixing the results of different surveys and by using orthophotos as primary elements for the representation of architectural heritage. On the other hand, as the work shows, the representation by drawn plans is still a necessary tool for the whole understanding of the monument. The architectural survey as an integrated study of the building is implemented by mixing the traditional methods of representation with graphic document derived from current techniques of architectural survey.

ACKNOWLEDGEMENTS

We want to kindly thank the help and the availability of the University of Avila, especially Prof. Diego González Aguilera for providing us with very relevant material and for sharing useful informations. We also acknowledge Avila Municipality for their great collaboration during the research and the IPCE for promoting this work.

REFERENCES

Almagro Gorbea, A., 2004. *Levantamiento arquitectónico*. Granada: Universidad de Granada.

Aliberti, L. and Iglesias Picazo, P., 2018. New Survey Methods for Graphic Documentation of Architectural Heritage: The Remains of the Walls of Santo Domingo de La Calzada in La Rioja (Spain). In: *Architectural Draughtsmanship. From Analog to Digital Narratives,* pp. 1567-1557.

Barrios García, Á., 2003. Realidad e imágenes de la muralla Abulense. In: VV.AA., *La muralla de Avila*. Madrid, pp. 11-56.

Cátedra Tomás, M., Tapia Sánchez, S. and Sanchidrián Gallego, J. Mª., 2007. *Para entender las murallas de Avila. Una mirada desde la historia y la antropología*. Valladolid.

Docci, M., and Maestri, D., 2010. *Manuale di rilevamento architettonico e urbano*. Bari: Laterza.

Gutiérrez Robledo, J. L., 2005. Las Murallas de Ávila. In: *Congreso internacional Ciudades Amuralladas*. Pamplona 24-26 de noviembre 2005. Pamplona, pp.117-150.

González de la Granja, Mª E., 2010. Construcción y evolución temporal de la muralla de Avila. Últimas aportaciones historiográficas. In: *Norba: revista de arte*, 30, pp. 9-24.

San José Alonso, J.I., 2018. Levantamiento, tecnología y documentación de la arquitectura. In: *EGA. Revista de Expresión Gráfica Arquitectónica*, vol. 23, n. 34, pp. 240-251.