Geometric and Formal Characterization of the Church of Santa María de Tobed

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Abstract. In the mid-fourteenth century, in the context of the "War of the Two Pedros" and under the promotion of the Order of the Holy Sepulchre of Jerusalem, work began on the temple of Santa María de Tobed, declared a World Heritage Site by UNESCO in 2001. A prototype for a fortress church, thus named because of its defensive appearance, and which is a genuine Aragonese Mudejar architecture creation. The purpose of this work is the formal and geometric characterization of this masonry, for which a survey has been carried out that combines the terrestrial scanner with the exterior photogrammetry, with close-range aerial captures complemented by terrestrial ones. It has also been decided to analyse the layout of one of the main vaults, since it is presented as an articulating and generating element of Gothic design.

Keywords: Mudejar · Mediterranean gothic · Fortress church · Laser scanner · Photogrammetry

1 Introduction

In 1358, a series of confrontations began between Pedro I the Cruel, from Castile, and Pedro IV the Ceremonious, from Aragon, caused by territorial and dynastic conflicts. This war, called the War of the Two Pedros, is part of the Hundred Year War (1337–1453), in which England fought against France and which ended with the death of the Castilian monarch in 1369.

This warfare between Castile and Aragon had a special impact on the border area, where the cities of Calatayud and Tarazona were located. In this context, there is the consolidation and fusion of a new typology typical of the Aragonese Mudejar, the fortress church[1] (Borras 2006). Its structure is characterised by a rectangular floor plan composed of a single nave and side chapels between buttress towers and a straight chevet with three chapels that formalise the presbytery. Above this and the side chapels, on the first floor, there is a gallery to the outside and a sentry post accessed from the aforementioned towers, which together with a compact configuration gives them a defensive appearance, from which they acquire their name (Borras 2006).

[1] The denomination used by Borras (2006) to refer to the typology is "iglesia-fortaleza", which has been translated as "fortress church".

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Mudejar is an artistic manifestation that arises from the survival of Hispano-Muslim art in Christian Spain whose basic materials are brick and plaster. In fact, the importance of brick is such that it was commonly used as a true module in the proportions of Mudejar architecture (Lacarra 1981), although other authors, such as José Mª Estables, say that this fact would not condition the general measurements of the work, pointing out that: "The length of the brick that was regulated and controlled does not influence the measurements of the churches because the bricks are not placed next to each other, instead they are usually placed at an imprecise measure of 'one finger' and the separation is filled with lime mortar" (Establés 1984). Although what is certain is that the term "rejola" (fired mud used as bricks) was used in works contracts as the basic measurement unit for heights and widths (Lacarra 1984) and also that the total dimensions depend on the thickness of the joints, which were filled with plaster. The first examples appear in Aragon in the middle of the 13th century and its zenith occurred between the middle of the 14th century and the end of the 15th century. It was a living, permeable art, which naturally assimilated and adapted the different styles, and which is why a large part of these works are also considered Mediterranean Gothic, pursuant to various recent research investigations (Agustín, Vallespín and Santonja 2018), undoubtedly due to the intense relations among the different territories that made up the Crown of Aragon.

In this context, the same year that the conflict between Castile and Aragon began, construction began on Santa María de Tobed (Borras 1985), a fortress church designed in the Mudejar Gothic style. The interest in these constructions is highlighted by the López Landa study in 1923, in the journal Arquitectura, at the request of Leopoldo Torres Balbas, its director, who had already made reference to them a year previously in the aforementioned journal (Landa 1923). The Tobed church is considered an archetype of this typology. Its artistic value was recognised a few years later when it was declared a historical-artistic monument by Decree of the Ministry of Public Instruction and Fine Arts, 3 June 1931, published in the Gaceta on 4 June 1931. In 1950, José Galay considered it one of the most characteristic works of the Mudejar style (Galay 2002).

In 2001, UNESCO recognised the uniqueness of the Aragon Mudejar style, declaring six buildings in the province of Zaragoza that represent it as World Heritage. These are added to the four previously declared in 1986 in the Teruel Mudejar complex; the Santa Maria de Tobed Church is one of them.

Despite the relevance of this construction, there are few versions of plans published to study it: the first is a sketch of the ground plan made by López Landa [1923], and the most popular and recent is the renowned work of Gonzalo Borrás in 1985, which contains a general floor plan, a gallery plan, tower plans and the south elevation. This is a survey by Ramiro Moya and Francisco Pons Soroya before the building that was attached to its eastern facade was demolished (Borras 1985). It is worth mentioning here the sectioned axonometry published by José Mª Estables in 1984 (Establés 1984) in which, seen from the inside, one of the side panels of the masonry is represented in order to explain the entrance arches that are part of its ordered structural system. Although it is true that there are more recent surveys, carried out when it was restored, these remain unpublished, so it is considered appropriate to update this documentation. Thus, the purpose of this work is to carry out the digital reconstruction of the building, by combining the ground scanner with the photogrammetry of the exterior, for the formal and geometric characterization

of the masonry, also through obtaining the main planimetry, since the plan would be the resource that the master builder would have (Borras 1984) for the conceptualisation and formalisation of the masonry design. It has also been decided to analyse the layout of one of the main vaults, since it is presented as an articulating and generating element of Gothic design (Violet 2000).

2 Methodology and Results

For the correct analysis of the masonry layout, two basic factors have been established. The first has to do with the study of the different historical sources, which enable the constructive evolution of the monument to be reconstructed in a sufficiently reliable way. The study of the different interventions it has undergone, together with the reading and analysis of the building itself, enables evaluation of the originality of the layouts studied, thus avoiding falling into the study of false histories that could distort the results and, therefore, their rigour. The second factor involves the reliability and precision of the survey, as well as the graphical procedure for conducting the analyses. In this case, combining two complementary techniques, a terrestrial scan with which has been registered, with a total of 58 scan stations, the interior of the building, both on the ground floor and the galleries and choir, and the exterior from the ground level, with the photogrammetry of the exterior through ground and close-range aerial captures, since the photographs taken with a drone have provided data for the restoration of the roof area geometry.

Fig. 1. Complete point cloud of Santa María de Tobed (Prepared by the authors).

The point clouds resulting from these technologies have been combined thanks to the identification of common points, to which the same coordinates have been assigned in both models. As is logical, a minimum of three points is required, although it is advisable to use a greater number that are conveniently distributed to minimise the error in the assembly (Fig. 1). This model has been inserted into a computer-aided design (CAD)

software to delineate the layout of the floor plan (Fig. 2), sections and the geometry of the different arches of a vault of the nave, since the geometric definition of the vault was made through the trace of a linear element, the arch (Rabasa 2013). It has been decided to represent its geometry by delineating the floor plan projection and, in correspondence with it and lowered in true magnitude on the same plane, the intrados of the arches that define its geometry. This method enables the layouts to be read and compared quickly (Palacios 2009), which has been disclosed by various treatises from the 16th century. In order to obtain greater reliability of the geometry of the trace of the archs, the curvatures have been obtained for the represented section and their geometric coincidence with the other arches of the same nature has been verified, thus identifying some arches that differ from their equivalents, which may be due to deformations or adaptations derived from the construction process. It has been decided to use the metric system as the measurement unit so that the results can be comparable in cases where Medieval metrology was not the same.

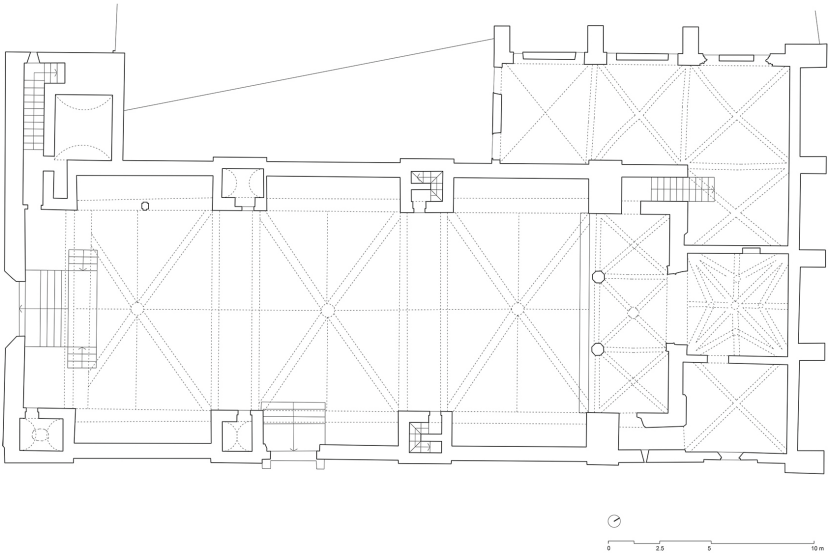

Fig. 2. Santa María de Tobed floor plan delineated from the point cloud (Prepared by the authors).

The works on the church began in 1356 (Borras 1985), under the patronage of the Order of the Holy Sepulchre of Calatayud and with the patronage of Pedro IV. According to a document from 1385, it is known that on this date the masonry had not yet been completed (Borras 2006), which was completed at the beginning of the 15th century with the patronage of Pope Benedict XII, whose weapons appear in the keystone to the vault of the last section (López 1923).

In the 16th century, a reform was carried out to provide the church with a new main chapel and sacristy (Condor 2010), for which two sections of the arcaded gallery that had previously been attached to the eastern facade were used, and that continued with the one attached to the north facade.

The next major reform was in the 18th century, carried out for the placement of a Baroque organ purchased in 1737 (Condor 2010), which was located in the gap of the western chapel on the Gospel side, and a lower choir that occupied a large part of this third section making the entrance unusable, so a new one had to be opened on the south facade.

In the mid-eighties, the City Council Building, which was attached to the west facade, was demolished and a major restoration project was carried out in 1985 led by the architect Úrsula Heredia, which returned the temple to its original entrance and recovered the valuable decoration of this facade. The clock and the machine room attached to the tower were dismantled, reinforcing and lowering it, eliminating what was understood as an addition, as mentioned by José Galay (2002). The western gable facade is one of the most outstanding elements of the temple and also of the Aragonese Mudejar style (Fig. 3). The entrance, through an opening with a pointed arch, as well as the upper oculus are arranged in the axis of the nave. However, the composition of the facade is not symmetrical as one of the towers has larger plan dimensions, as will be described later. In addition, two openings are opened between the main door and the oculus, which are not arranged according to the axis of the nave, nor the facade as a whole, but their left jambs are aligned to the door ledge, in such a way that one is above the door and the other tangent to it. A bold composition that is completed with careful decoration formed by horizontal brick bands with different geometric motifs, such as interlocking mixtilinear arches, loops of six or mixtilinear loops, which are also used on the wall of the Seo Zaragoza parish church with which it has been formally linked (Borras 1985).

Fig. 3. Axonometric view of the photogrammetric model of Sta. María de Tobed (Prepared by the authors).

As previously mentioned, Santa María de Tobed has the canonical structure of a fortress church. Its nave is articulated by sections of a simple ribbed vault that alternate with pointed barrel vaults, which cover a span of about 9.7 m and rest on the buttress towers with a square floor plan and 2.55 to 2.6 m side, while the side chapels, also covered with pointed barrel vaults, are aligned with the ribbed vaults. These barrel vaults also discharge onto the buttress towers and act as support arches (Estables 1984) of the north and south walls, with a thickness of 70 to 72 cm, which is equivalent to two stretcher bricks from Zaragoza mould (Borras 1985), a pattern that is repeated on the second level, which arises from the impost line and which, in this case, act as formers for the ribbed vaults. This configures a highly efficient and robust structural system.

On the side chapels and the head, there is an exterior gallery as a sidewalk, which opens to the interior through large windows and to the exterior with pairs of openings in each section. This gallery is accessed from some of the buttress towers and the high choir that is arranged over the entrance enables passage all around.

The symmetry of the masonry is broken at the foot of the church, as it has a rectangular buttress tower on the Epistle side that is somewhat higher than the others (3.46 by 2.66 m), which acts bell tower, and which is not repeated on the Gospel side, in which there is a volume of lower height and greater dimension in floor plan than the rest of the towers. This volume contains a staircase around the perimeter, covered by a staggered corbel vault and, in the free space left by it, a series of rooms covered by a barrel vault that follow one another in height, so that they open into alternate sides on each level. This gives the main facade a width of 20 m compared to the 14.85 m that the masonry has at the height of the buttresses. The larger dimension of the building volume that the original masonry encloses is 33.2 m, to which the volume of the main chapel that occupies part of the arcaded gallery that was attached to the east side must be added.

The vault of the intermediate section of the nave has been chosen for analysis. This is a simple rib vault with moulded brick ribs with stencil, the side arches are not materialised with visible ribs, but through the edge resulting from the intersection between the web and the wall. From the analysis of its layout (Fig. 4) the following results have been obtained. The vault covers a span of 9.72 m and a bay of 7.17 m measured from the axis of the transverse arch, which represents a practically sesquitertia (4:3) ratio proportion, rectangle formed by joining two Pythagorean triangles on the diagonal, in other words, two “perfect” right triangles with catheti in proportion 3 and 4 and hypotenuse of 5, one of the most used for Gothic vaults in Spain (Palacios 2009). The transverse rampant has a wide curvature of 18.16 m radius, so it can appear to be flat, and a difference in elevation of 0.46 m at 4.41 m (straight slope 9.58%), while the longitudinal rampant, with a slightly smaller radius of 15.50 m, has a drop of 0.27 m and a straight slope of 11.04%. The ogive arches are pointed, with the centre very close to the impost line, which does coincide in the transverse rib, whose curvature closely resembles that of the ogives (difference of the 3.76% radius), while the side arch, with a somewhat more pronounced curvature, is banked with its centre 1.76 m from the impost line.

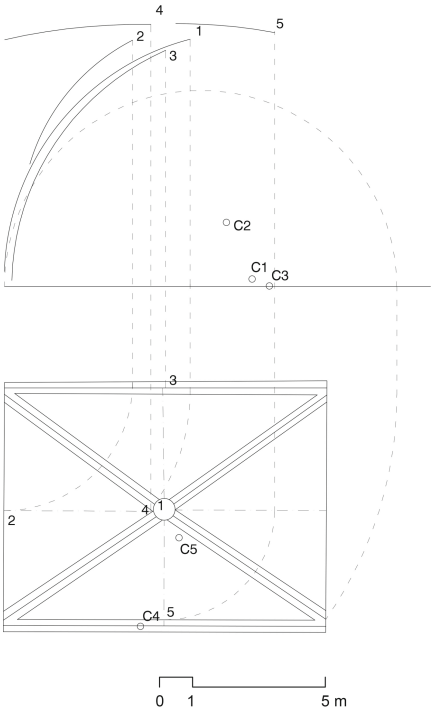

Fig. 4. Analysis of the vault layout (Prepared by the authors).

3 Conclusions

The survey method carried out by combining photogrammetry with laser scanning has enabled formal and geometric characterization of the building, which requires a subsequent graphic analysis of the model to study the building's layouts. Due to the importance of the ribbed vault for defining Gothic period architecture, its layout needs to be studied as a key step for the correct understanding of the geometry of the complex. As they are three-dimensional elements defined from linear components, the use of a system with the arches retracted in true magnitude enables a complete analysis. It has thus been observed that the curvature of the tranverse arch closely resembles that of the ogive ones, which may imply an intention to standardise. The use of a sesquitertia floor plan has been detected, one of the most used for Gothic vaults in Spain.

The results of the research also affect the uniqueness and value of the Mudejar style and, more specifically in this case, the fortress church typology.

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References

Agustín Hernández, L., Vallespín Muniesa, A., Santonja Jiménez, R.: El alma del gótico mediterráneo. La Corona de Aragón. L'anima del gotico mediterraneo. La Corona d'Aragona. Gobierno de Aragón, Zaragoza (2018)

Borrás Gualis, G.M.: Los materiales, las técnicas artísticas y el sistema de trabajo. Como criterios para la definición del arte mudéjar. In: Actas del III Simposio Internacional de Mudejarismo, pp. 317–325. Instituto de Estudios Turolenses, Teruel (1984)

Borrás Gualis, G.M.: Arte mudéjar aragonés. Tomo II. Caja de Ahorros y Monte de Piedad de Zaragoza, Aragón y Rioja and Colegio Oficial de Arquitectos Técnicos y Aparejadores de Zaragoza, Zaragoza (1985)

Borrás Gualis, G.M.: Estructuras Mudéjares aragonesas. In: Lacarra Ducay, M.C. (coord.) Arte mudéjar en Aragón, León, Castilla, Extremadura y Andalucía, pp. 297–313. Institución Fernando El Católico (C.S.I.C.) Excma. Diputación de Zaragoza, Zaragoza (2006)

Condor Abanto, L.: La iglesia de Santa María de Tobed. Patrimonio de la Humanidad. Colección Cuadernos de Aragón, nº45. Institución Fernando el Católico, Zaragoza (2010)

Estables Elduque, J.M.: La reinterpretación cíclica y la trasposición de piedra a ladrillo de una estructura de origen oriental integrada: el quincunx. El ejemplo de las iglesias-fortaleza de la provincia de Zaragoza. In: Actas del III Simposio Internacional de Mudejarismo, pp. 415–323. Instituto de Estudios Turolenses, Teruel (1984)

Galiay Sarañana, J.: Arte mudéjar aragonés. Reproducción facsímil de la edición de 1950. Institución Fernando el Católico, Zaragoza (2004)

Lacarra, J.M.: Introducción al estudio de los mudéjares aragoneses. In: Actas del I Simposio Internacional de Mudejarismo. Teruel, 1975, pp. 17–28. Instituto de Estudios Turolenses, Teruel (1981)

López Landa, J.M.: Iglesias góticomudéjares del arcedianado de Calatayud. Arquitectura **49**, 125–135 (1923)

Rabasa, E.: Estereotomía: teoría y práctica, justificación y alarde. Informes de la construcción **65**(2), 5–20 (2013)

Palacios Gonzalo, J.C.: La cantería medieval: la construcción de la bóveda gótica española. Munilla-Leria, Madrid (2009)

Viollet-le-Duc, E.: La construcción medieval. In: Rabasa Díaz, E., Huerta Fernández, S. (eds.) Instituto Juan de Herrera/ CEHOPU/ CEDEX, Madrid, 2nd edn. (2000)