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A Mannerist polyhedral wood ceiling in Castroverde de Campos (Zamora, Spain)

Un artesonado poliédrico manierista en Castroverde de Campos (Zamora, España)

M. C. Fernández-Cabo (*), A. González Uriel (**), M. de Miguel Sánchez (***)

ABSTRACT

This paper analyses an outstanding case in the field of historic Spanish carpentry. Built in the sixteenth century, the five-panel wood coffered ceiling in the church of Santa María del Río in Castroverde de Campos (Zamora, Spain) shows a Renaissance layout with polygonal coffers. It combines Hispano–Islamic technological heritage with some innovative features, including singular disposition of timber, duplicity of structures and unorthodox carpentry joints. Furthermore, convex coffers are introduced among traditional concave ones giving it a marked Mannerist appearance. The likely double role of the author as designer and contractor explains the relevance of prefabricated elements in the construction process of the ceiling, since this effort for modulation and systematization rationalizes procedures and reduces labour costs.

Keywords: Castroverde de Campos, Spanish carpentry, historic carpentry, wooden ceiling, coffered ceiling, timber frame, framework.

RESUMEN

Este artículo analiza un caso excepcional en la carpintería de armar en España. Se trata del artesonado de cinco paños de la iglesia de Santa María del Río, en Castroverde de Campos (Zamora). Construido en el s. XVI, con una trama de artesones poligonales en su intradós, combina el diseño renacentista con la tradición técnica hispano-musulmana de estructuras de madera, y presenta aportaciones novedosas como la inusual disposición de escuadrías, la duplicidad de estructuras y las poco ortodoxas uniones carpinteras utilizadas. Además, la introducción de artesones convexos junto a los convencionales artesones cóncavos le confiere un marcado aspecto manierista y resuelve ingeniosamente el encuentro entre paños. La muy posible coincidencia de diseñador y constructor en la misma persona explicaría un proceso de construcción con módulos prefabricados, con el consiguiente ahorro de costes y riesgos laborales.

***Palabras clave:** Castroverde de Campos, carpintería española, carpintería histórica, techos de madera, artesonados, estructuras de madera.*

(*) Construction and Architectural Technology Department. School of Architecture, Universidad Politécnica de Madrid (Spain)
(**) Graphic Ideation Department. School of Architecture, Universidad Politécnica de Madrid (Spain)
(***) Architectural Department. School of Architecture, Universidad de Alcalá, Madrid (Spain)
Persona de contacto/*Corresponding author*: manuel.miguel@uah.es (M. de Miguel Sánchez)
ORCID: https://orcid.org/0000-0002-3393-2774 (M.C. Fernández-Cabo); https://orcid.org/0000-0001-8511-6720 (A. González Uriel); http://orcid.org/0000-0002-1803-2428 (M. de Miguel Sánchez)

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1. HISTORICAL FRAMEWORK

The rich tradition of wooden carpentry ceilings in the Iberian Peninsula would be strongly influenced by the forms which came from Italy upon the arrival of the Renaissance in the sixteenth century. Many examples of this built heritage are still standing in the region of Tierra de Campos (1). Wooden ceilings covered parish churches at important towns of the time such as Castroverde, as well as small village temples, most of them made of brick walls. The nearby cities of Zamora and Toro were important focuses of carpentry during the 15th and 16th centuries, as were Benavente and Villalpando.

There are medieval foundational references of the church of Santa María del Río in Castroverde. Its tower, south front and lower part of the walls were built in the thirteenth century (2). The single nave is fragmented by two diaphragm arches. These arches were finished by 1537, as is written on a sign inscribed in the stone pulpit railing (3). Over the ceiling of the first section, currently covered by a timbrel vault from the seventeenth century, there remains a stripe of a former polychrome medieval ceiling, with plasterwork and Gothic characters, which suggests that it should have been built between the thirteenth and fourteenth centuries. An octagonal wooden ceiling of unknown origin, leaning on side beams, can be seen at the west section of the nave. The central section is covered by the coffered ceiling, the subject of this paper. It presents a Renaissance style layout with a clear Mannerist character, according to the impression of showing different depths among its concave and convex coffers, called *artesones* in Spanish (Figure 1).

In 1991 the architect Miguel Carlos Fernández-Cabo, one of the authors of this article, led the restoration of the roof of the Church (Figure 2). He had then the opportunity to study the coffered ceiling in depth (4). No reliable data regarding its dating is yet known. However, the system of construction, geometric layout and ornamentation correspond to a work developed in the mid or late sixteenth century. Recent research (5) points to Alonso de Porquera (-c.1593), master carpenter and neighbour of Castroverde, as its possible designer, based on similarities with the choir ceiling at the local church of Santa María del Altozano in Bolaños de Campos (Valladolid), the contract for which he signed in 1572. That would date the work between 1570-1590.

2. TYPOLOGICAL AND STRUCTURAL SYSTEMS

The main structure of the coffered ceiling is arranged in the longitudinal direction of the nave, leaning on the diaphragm arches instead of the side walls of the church. In this way the structural span is reduced from 13.91 m to 8.93 m. Horizontal tie beams braced at the corners form an octagonal belt that contains the thrust of the structure, so no reinforcement of the diaphragm arches or the side walls of the building is needed.

The structural scheme of the gantries consists of polygonal arches. Its precedent originates from the tradition of rafters and collar beams (6), which constitutes a first approach to the arch forming three-panel ceilings and had been widely used during the High Middle Ages (7). In order to come closer to the perfection of the arch, the number of bars of the gantry increased from three to five, and then from five to seven, consequently producing five and seven-panel ceilings.

There is a rich built heritage of wooden ceilings in Spain (8), but five and seven panelled were not very common, as they were mainly used in costly works. One of the best known five-

Figure 1. Inner view of the coffered ceiling in the Church of Santa María del Río at Castroverde de Campos, Zamora, Spain, in its current state. All photographs and drawings by the authors.

Figure 2. Exterior view of the ceiling during the 1991 restoration works directed by architect M.C. Fernández-Cabo and carried out by builder J. Alonso, REARASA Company.

panel ceilings in the country is that of the Golden Chapel of Tordesillas, which was the throne room of King Henry IV of Castile (1425-1474).

The joint system usually employed in this type of structures for the assembly of the gantry bars is the *garganta y quijera* model, a kind of T-bridle joint (Figure 3). The collar joist has a notch at the end that embraces the rafter on which the section has been reduced. This type of joint was characteristic of Spanish wooden ceilings, both Christian and Muslim. Its use can be dated before the eleventh century and continued being used extensively until almost the eighteenth century.

The Hispano-Islamic constructive solution for five-panel ceilings consisted of adding struts to the rafters, which involved a second lower level of fastening over the wall, where the struts lean. It was recorded in the treatise called *Carpintería de lo Blanco* by Diego López de Arenas (9). He also showed a type of section based on traditional T-bridle joints or *garganta y quijera*.

The ceiling subject of this research has a polygonal section to accommodate five panels, but interestingly, it only needs one single support level at the top of the wall, since the struts are inserted at the side knots of the gantries instead of at their lower end (Figure 3).

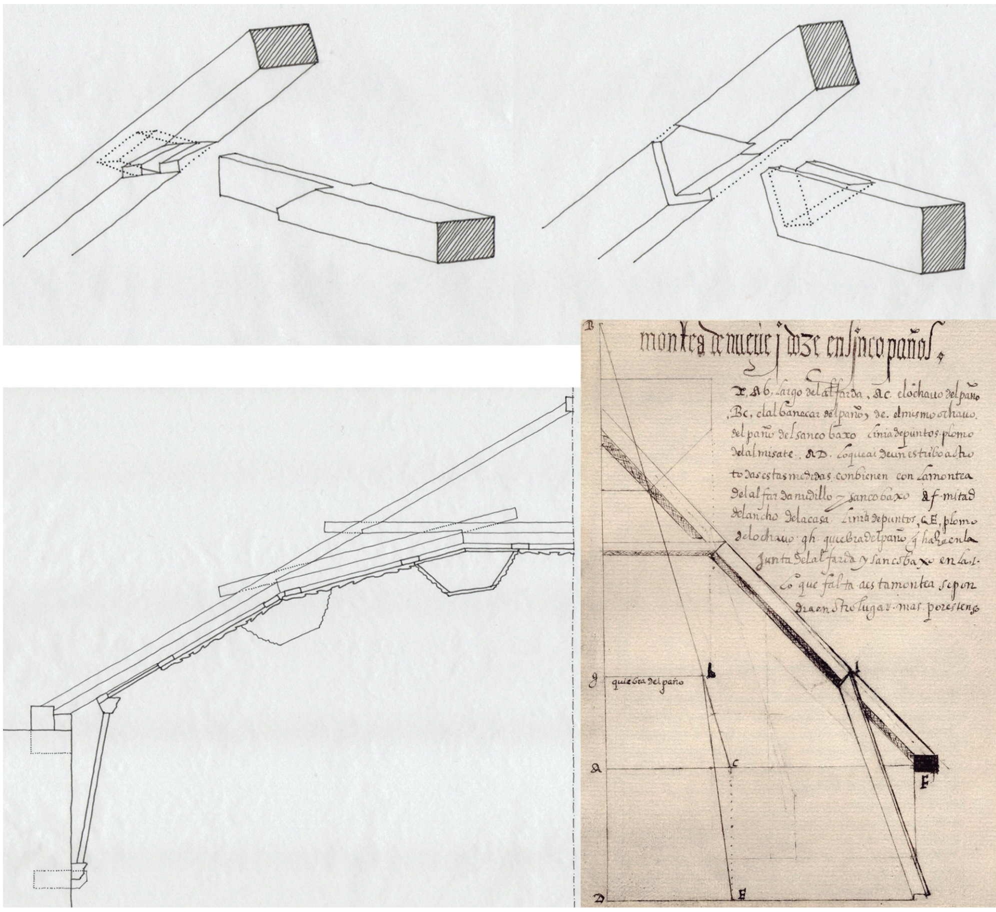

Figure 3. Mortise and tenon joint detail in Castroverde de Campos, with through tenons. Five-panel ceiling structure section in Castroverde, with one single support level at the top of the wall, and additional frieze borne by corbels at a lower level. Right: T-bridle or *garganta y quijera* joint detail. Five-panel ceiling section in the López de Arenas manuscript, showing two support levels.

Although the roof has a polygonal structure with five sides, it appears to have seven. This is due to the addition of a frieze that looks like part of the whole, and in this way the ceiling has the appearance of a seven-panel wooden vault. However, the frieze plays a secondary role, both by structure and composition. It is a decorative panel fastened to a beam that leans over corbels, inserted in putlog holes at a lower level.

3. INTRADOS LAYOUT

3.1. Cross section

The cross section scheme for a five-panel ceiling in the previously-mentioned work by López de Arenas recorded the common practice. Probably most of its drawings and texts were reproducing documents from earlier treatises, which was the usual custom until the eighteenth century. The treatise by López de Arenas was published at a historical moment when the Hispano–Islamic style of ceiling was starting to be abandoned. The Renaissance influence had already spread throughout Spain and even as far as Hispanic America. However, although the Renaissance was imposed at the level of design, at the strictly technological level the same practices and systems remained.

It is remarkable that no carpentry treatise on the Renaissance style appeared in the same period. This is probably because the geometrical and constructive principles used in the carpentry of the new ceilings were the same as the Hispano–Islamic style (3). It is also possible that among carpenters the medieval guild methods of transmission of knowledge (teacher-apprentice) were still maintained.

From the drawings and explanations provided by López de Arenas, it seems that he does not preset the width of the panels or their interior angles, nor their slopes (10). However, he displays the support of the rafters and the struts on their respective beams as coincident on a vertical plane (both bases are aligned on the vertical). From a theoretical point of view this layout does not make sense, because when the wall was built anticipating the installation of this type of ceilings, its top would be narrowed to keep the two support beams over the wall at two different levels. The solution of Lopez de Arenas implies making putlog holes in the wall and leaning a horizontal beam supported in corbels.

The case of Castroverde, however, does not correspond to this scheme, since there is only one support level. The diagonal bars, fixed to rafters and collar beams, are smaller than the struts illustrated by Lopez de Arenas. As these diagonals are assembled at the level of the knots, only the rafters lean directly on the tie beam. The wall, built long before the construction of the ceiling, maintains all its thickness up to its highest level.

3.2. Geometric tiling

The rhombus pattern of the coffers is identically repeated throughout the roof, with the exception of the adjustment band which will be discussed later. The module of the geometric pattern is a pair of symmetrical rhombuses. This module runs horizontally on the first whole of panels along the entire perimeter of the structure. The symmetry of the same pair of rhombuses is also used to cover the intermediate panels. In Figure 4 the width of this module is indicated with m. Based on the measurements made on site, it's about 7 Castilian feet (195 cm).

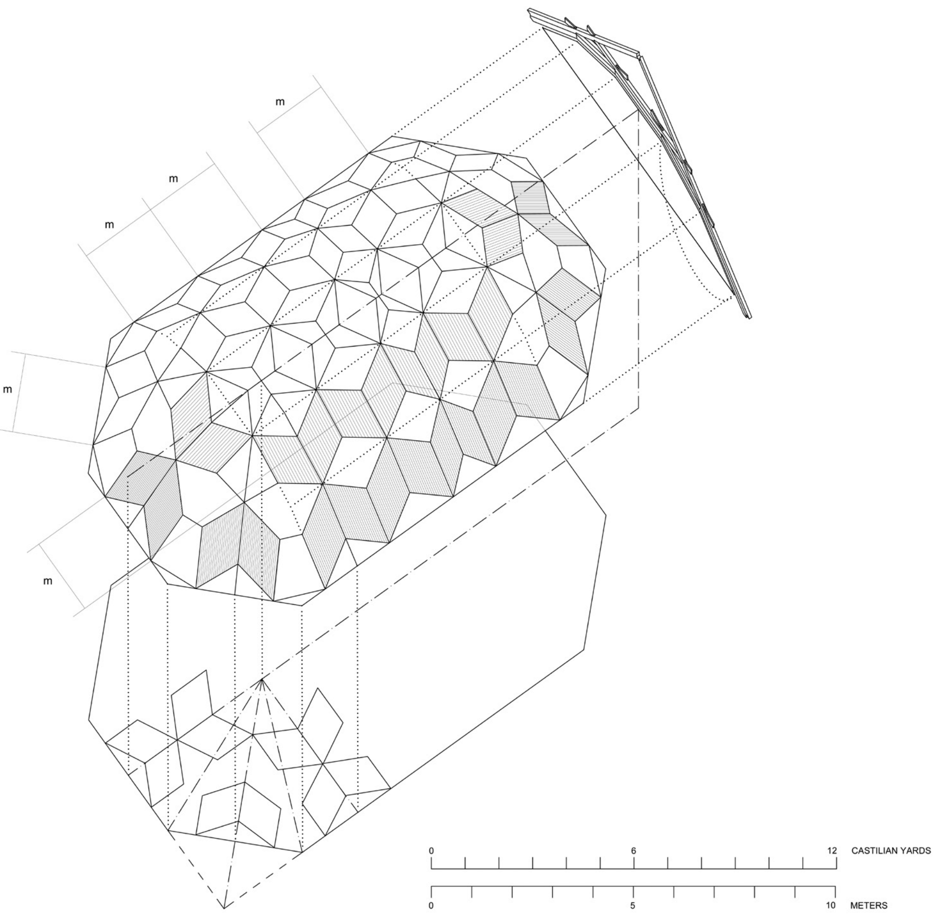

Figure 4. Geometric pattern hypothesis for Castroverde de Campos coffered ceiling: view of the folded surface showing cross section and axial symmetries.

Each one of these symmetrical rhombuses is the base of a concave coffer (Figure 5). Their angles are 60º and 120º, so they would make a regular hexagon in conjunction with a third. However, this third rhombus, cross to the others, plays the role of a hinge between different panels of the ceiling, so it is not exactly a planar polygon. It would be the base of a convex coffer.

The underlying pattern is thus a hexagon honeycomb tessellation, present in some Roman mosaics, though not exactly among the models of Serlio. Rhombuses are also on the pendentives, differently combined with hexagons and triangles in three of them. The fourth shows a four-point star and rhombuses design that has been related to Serlio's description of the ring vault decoration in Bacchus Temple –actually Saint Constance Mausoleum (5). Rhombuses are also combined with four-point stars at the top plane of the ceiling.

3.3. Rafter pitch

The dimensions of the slopes of the rafters taken on site, in their current state, oscillate between 30º and 34º. Whatever the rafter pitch used in the work, the structure had to adapt to the proportions of a pre-existing perimeter, a rectangle of almost 14 x 9 m, in current units. Inside the pitch range mentioned, it is not possible to fit the geometrical pattern of the roof in that rectangle using a whole number of modules in the longitudinal direction. To solve that, one of the four bands in which this direction is divided is not a whole module wide (7 Castilian feet) but significantly slimmer (4.5 feet, measured 120 to 130 cm in its current state). This irregular adjustment band lets the regular couple of rhombuses look exactly repeated in the rest of the bands as on the front and corner panels (Figure 6).

4. CONSTRUCTION AND STRUCTURE

4.1. Constructive system of the ceiling

As mentioned previously, the constructive typology of the ceiling subject of this research is a rarity in its time, since the dominant model was the Hispano–Islamic system, and the structures of five and seven panels were solved with struts supported on additional levels. Furthermore, the joints in the gantries, those used to articulate rafters and collar beams, are not the traditional *garganta and quijera*, but the mortise-and-tenon joints. This gantry has five bars and all of them have the same rectangular section. Bonded to the main gantry by its underside there is a wooden arch made with the same timber (Figure 7).

The main gantries lean on the wall on a double tie beam so that it can comfortably support both the rafter and the under-rafter. The rafter lower end is birdsmouth cut to accommodate the arris of the bigger beam and the under-rafter end is plumb and level cut to fit upon the smaller beam. The under-rafter arch, made by simple miter cuts, will be used to support the transversal short bars, tenon members between mortise members. These in turn support the wooden boxes of the coffered ceiling. In this way the main gantries avoid the joints that weaken the section of the timber. Primary and secondary structures are working together and at the same time they have their functions clearly defined (Figure 7).

The bars of the structural gantries are joined by long tenons that go through the section of rafters and collar beams. This joining method leads the carpenter (designer) to invert the position of the timber, turning the longer dimension of the bar to the horizontal position and the thicker to the vertical, contrary to an intuitive understanding of the structure that should produce better efficiency of the inertia, by placing the section in a vertical position. If not, the bar that holds the hole would be too weak, since the gap is 1/3 the width of the bar (Figure 8). The cross section of the main gantry bars measured on site, in their current state, are 14.5 to 16.5 cm wide, and 9.5 to 9.8 cm high. A rectangular section 15.4 cm x 9.5 cm has been used in the model.

Once the rigidity of the main gantry is guaranteed, the carpenter adds a polygonal arch on its underside, using this under-arch as a support to place the short purlins and to assemble them in the workshop. This eases the prefabrication of the ceiling and minimizes, as will be discussed below, the operational time of the carpenters on the structure.

From the point of view of the ornamental-geometrical layout, this ceiling may be understood as a Renaissance work with Roman influence. Given the ornamental pattern of the coffered ceiling, it is likely that the author had a good knowledge of Italian architecture and carpentry. At that time, very well-known Spanish architects, for example Juan Bautista

Figure 5. Unmounted rhombus-based concave coffer during restoration works, 1991.

Figure 6. Above, front and top views of the structural system with concave and convex coffers. Below, right and bottom ortographic projections of the ceiling in its actual state, prepared by means of laser scanning and automated photogrammetry. The regularity of the coffered ceiling, compared with the deformations in the walls, frieze and pendentives, seems to confirm the rigidity of the coffered set and the validity of the analysis.

de Toledo, author of the Royal Monastery of San Lorenzo de El Escorial (1515-1567) travelled to Italy, as did other Europeans such as Inigo Jones (1573-1652) in order to improve their training and knowledge of the new Italian architecture (especially Palladio) inspired by the world of Ancient Rome. Probably his knowledge of Italian ceilings and those of other countries had a bearing on the decision to abandon the traditional Spanish T-bridle joint (*garganta y quijera)*, replacing it with the mortise and tenon system, even though the way this joint is used here was not common practice in Italy either. In fact, it is likely that this new model of gantry with through tenons joints was an innovation of the author. On the other hand, there was no continuity in Spanish carpentry for this new technique, as it remained using the traditional Spanish system.

Mortise and tenon joints have been present in carpentry works since ancient times. They were used in ancient Egypt and then in Greek and Roman works, also being common in the manufacturing of doors and windows as well as furniture, until the present day. In construction carpentry they were used in framework walls to solve the joints between vertical

Figure 7. Details of the original structure in its state during the 1991 restoration works. Above: rafter pitches with higher ends birdsmouth cut to accommodate a lost ridge beam. Collar beams and under-rafters can also be observed. Below: Short side of the rectangle from the top plane or *almizate*. The picture shows the short struts between under-rafters forming 4 point stars on the top plane. On the descending panel, a rhombus based coffer can be seen upon the struts between under-rafters. The rafters upon these, perpendicular to the main ones, are cut a little above the joint.

and horizontal pieces of timber. Therefore, this system has long been utilized and is well-studied. What is innovative in Castroverde is its combination with the rafter-joist joint. The traditional model was characterized by a *garganta y quijera* joint which, in the shape of a fork, allows certain flexibility, and the performance of the wooden gantry is similar to that of an arch. The solution analyzed here implements the use of struts forming triangles in the knots, making them stable without needing to insert nails, and which are held together only by their own geometry.

To verify the performance of the main gantry, a 1/5 scale physical model was made. In this way the hypothesis of assembly of bars, connection angles, necessary clearances and stability have been checked (Figure 8). The system keeps timber together and their triangulation produces more resistant knots and fewer horizontal thrusts than those of the traditional model. It is important to highlight that the gantry is also stable when it is hung and not only on the ground. This fact leads us to think that these innovative joints could have been implemented in order to secure the stability of the structure when it was hoisted up to roof level.

4.2. The duplicity of the gantry and the construction process: towards prefabrication

In Spanish Pre-Renaissance professional practice of carpentry of ceilings at the time of Castroverde, it was common for the carpenter to also be the designer, master builder and contractor, bearing the financial responsibility for the ceiling (9). Cases of ceilings designed by architects or painters who would not intervene in their execution and contracting would become increasingly frequent since the Renaissance period. Nevertheless, the features and context of the present work show a greater likelihood of the first option. This is a key circumstance in order to formulate a hypothesis concerning

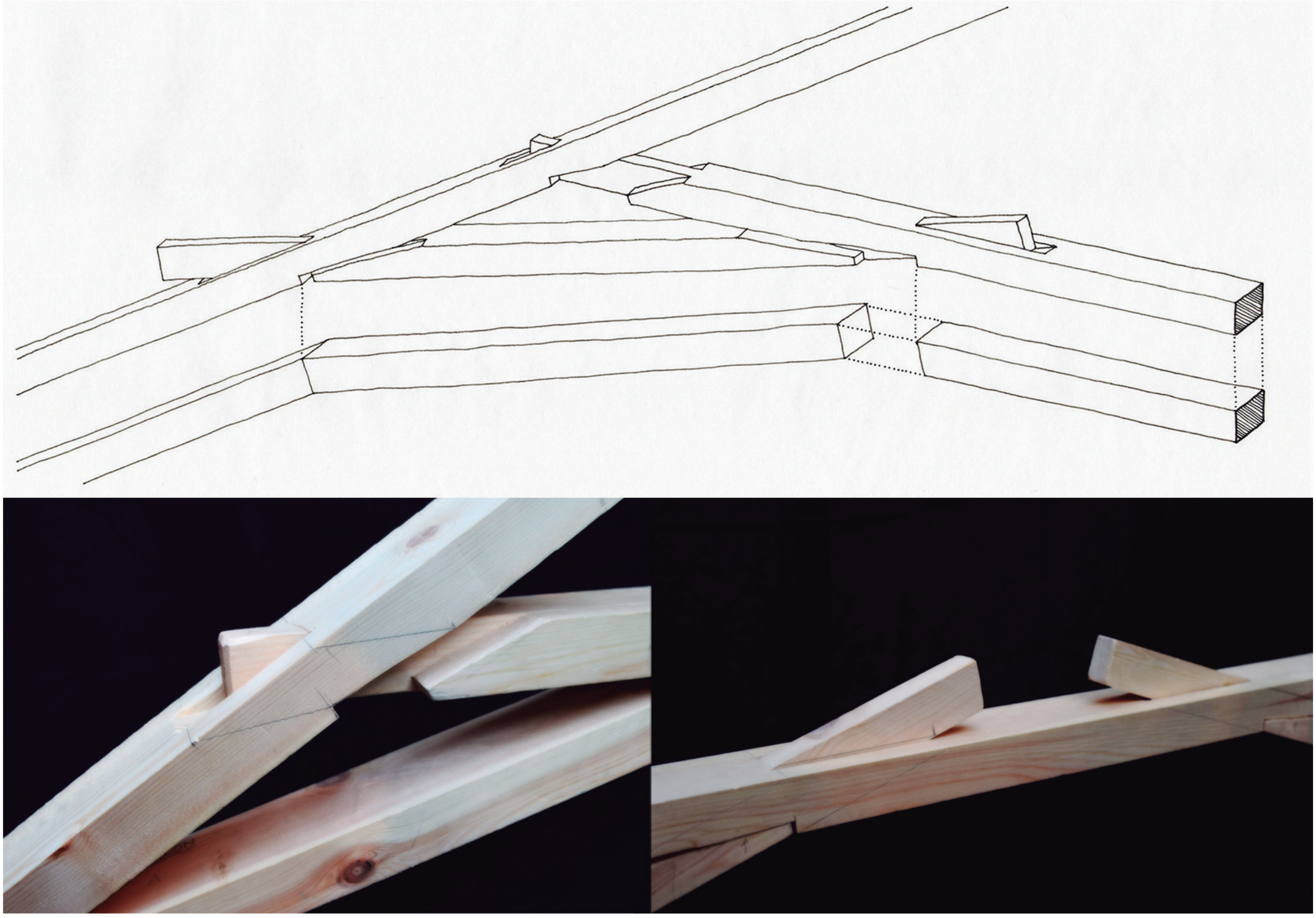

Figure 8. Above: Detail of the structural gantry joints. Mortise and through tenons in the main gantry, and miter joints in the under-arch. Below: Joints assembly detail tested on a 1/5 scale physical model. Photographs © Carpentry workshop of MUCTEH, University Master's Degree in Construction and Technology of Historical Buildings, Technical University of Madrid, 2017.

the design and construction of the ceiling, since the author was economically involved in its execution and it was expected that he would try to resolve the roof as inexpensively as possible. This definitely leads towards the simplification of the execution and commissioning processes. That is to say, towards prefabrication.

It was probably Enrique Nuere (11) who first pointed out the logic of prefabrication by panels in the carpentry of the Hispano–Islamic system, when attempting to explain the appearance of the *lima moamar*, a paired hip rafter in substitution of the *lima bordón*, a single hip rafter. This is an apparently inefficient design that consists of placing two timbers together to support a weight that could be borne by only one. The explanation lies in each panel being assembled in the workshop and then taken to its position, instead of putting every timber in place separately. It is known that a carpenter tried to spend as little time as possible on the structure, preparing most of the work either in the workshop or on site, at ground level, where he would set up his field workshop. Consequently, the author could reduce scaffolding costs and labour risks.

In the case of Castroverde, as with the *limas moamares*, the bars were duplicated as a constructive solution in order to ease the prefabrication of the panels. First, a triangular gantry with struts is assembled using the through tenon joints. Two of these triangles form the main structure where the rest of the module is going to be fixed. Attached to the lower face of the triangular gantry there is an under-arch. In this case, the joints between bars were simple miter cuts as if they were the voussoirs of a stone arch, and then they were nailed to the gantry. In fact, these hand-forged nails can be seen from the back of the ceiling and are bent at 90º after crossing the under-arch and the main gantry.

Once the gantry and under-arch have been integrated in a module, they are joined to another parallel unit by means of transversal bars. These short struts are joined by mortise and tenon(s) joints to the under-arch (Figure 9). The concave coffers are supported by this timber lattice, which were previously assembled, using miter joints and small nails. The characteristic decoration of the coffered ceiling is carved on the boards (2 fingers thick) that form these wooden boxes. Once the whole is secured it is taken to its final position.

Finally, the convex coffers are fixed after the rest of the structure is set in place. Its form fills the gaps between the concave coffers, hanging from a wooden tie bar and a bolt (Figure 10). The intersection of different planes produces warped polygons that the Master covers in this original way. The presence of convex coffers on a coffered ceiling is a singularity, as other examples of this are barely known. One is the previously mentioned choir of the parish church of Santa María del Altozano in Bolaños de Campos, designed in all likelihood by Alonso de Porquera, and this supports the authorship hypothesis presented above. In a band of that wooden choir, the main motif of which is concave hexagonal polygons, some triangles can be seen covered with convex coffers, similar to the rhombuses in Castroverde. The similarities between our convex rhombuses and those convex triangles are evident, although their outline is much less appealing than in Castroverde, highlighted by its dramatic Mannerist composition.

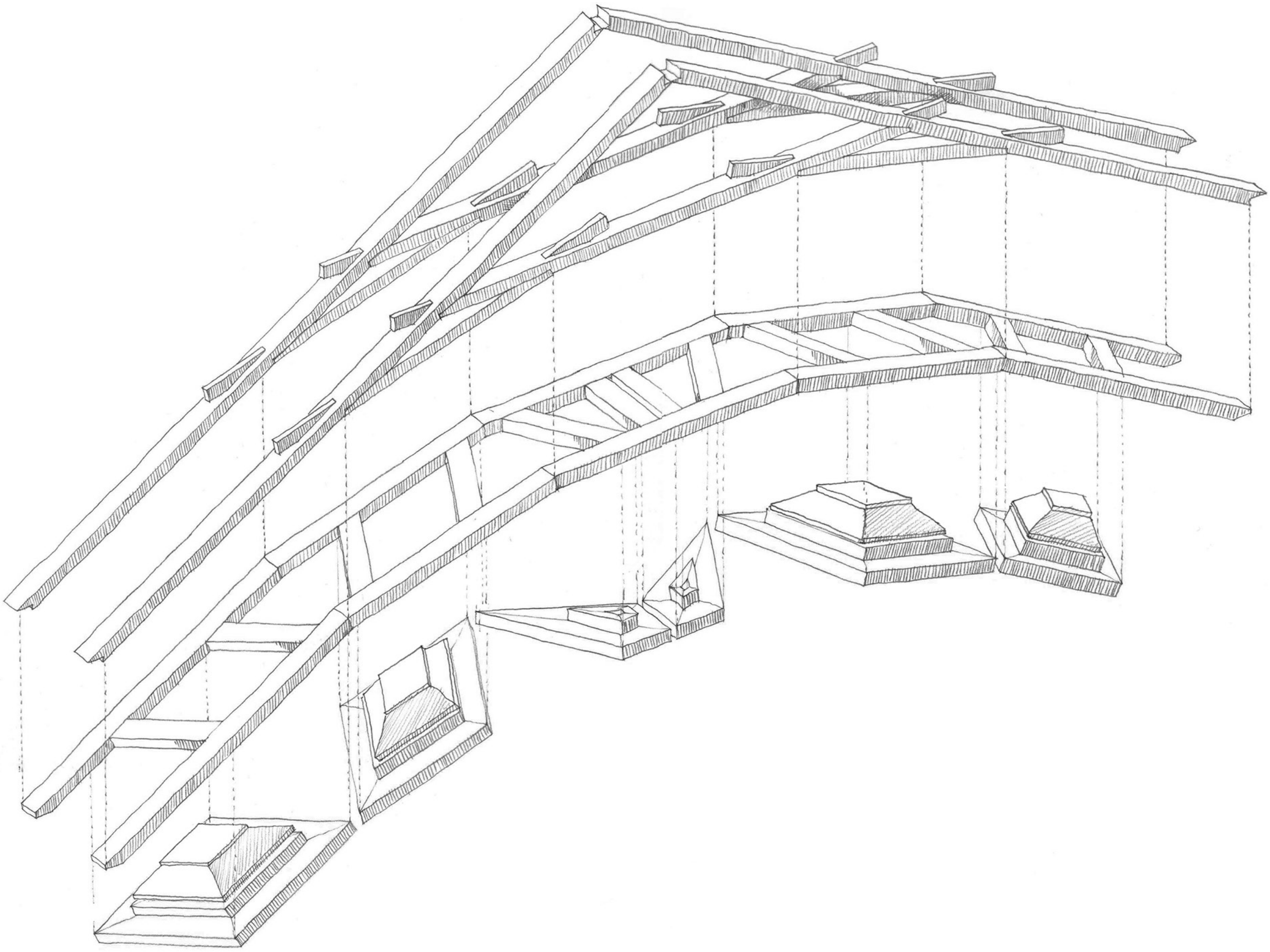

Figure 9. Prefabricated module hypothesis: main gantries + under-arches and short struts + rhombus based concave coffers.

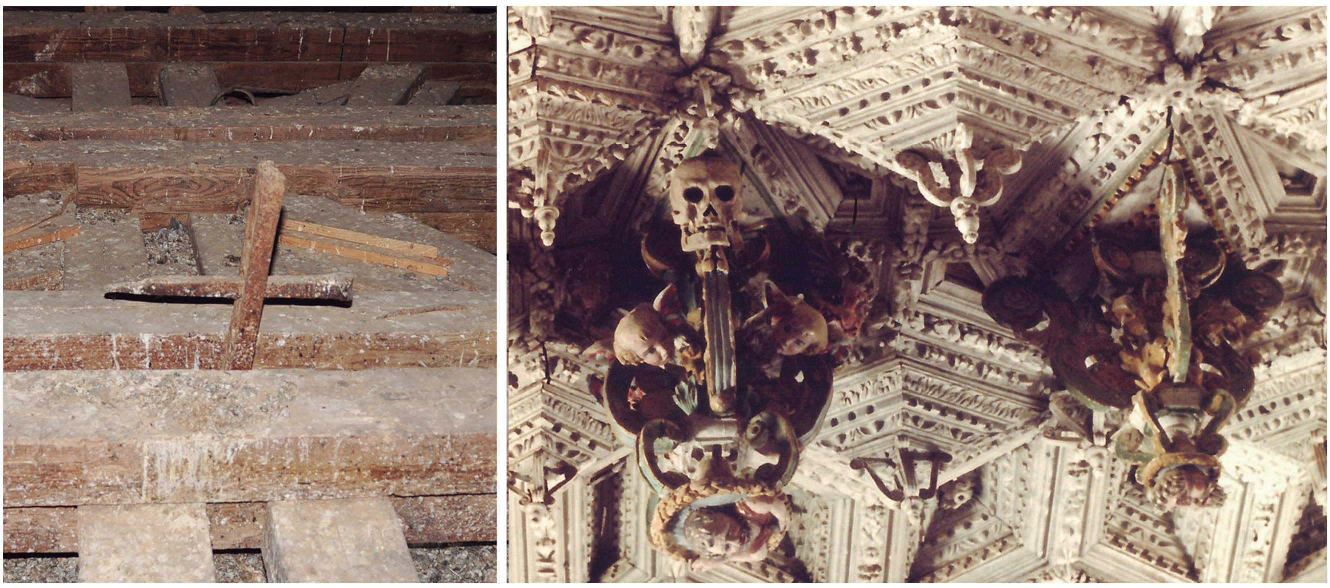

Figure 10. Left: View of the wooden bars used to hang the convex coffers and pendants. Right: Fleurons, carvings and three large pendants hanging from the top horizontal plane.

5. HYPOTHESIS OF EXECUTION AND INSTALLATION OF THE CEILING

The manufacturing and assembly hypothesis introduced in this section is ruled by two premises: on the one hand, the laborious geometry of the work and, on the other, the need to simplify processes and reduce costs. It is most likely that the designer and contractor was the same person (possibly the master named before, Alonso de Porquera) and for this reason the planning of the installation processes had to influence the design of the structure from the very beginning.

As has already been said, carpenters of the time would work in a workshop or on site at ground level, rather than on the structure, although this was not always possible. Working in the workshop offered the optimal conditions for the carpenter to make the structure with maximum precision and at minimum cost. Nevertheless, transportation costs were also a major burden. For this reason, it was usual to work in the field, setting up an itinerary workshop, usually sheltered by part of the building already constructed. The master carpenter Alonso de Porquera lived in Castroverde at the time, so if he were the author of the ceiling, both possibilities, i.e. preparing the pieces at his own workshop and then assembling them on site, would be valid.

The ceiling is built on the inner edge of the rectangle formed by the walls. Its base is a wooden polygon with the shape of an irregular octagon, given that the corners have diagonal braces at 45º which reinforce the set. Those timbers are needed to form the perimeter tie-beam, prepared for supporting the thrusts of the gantries (Figure 11).

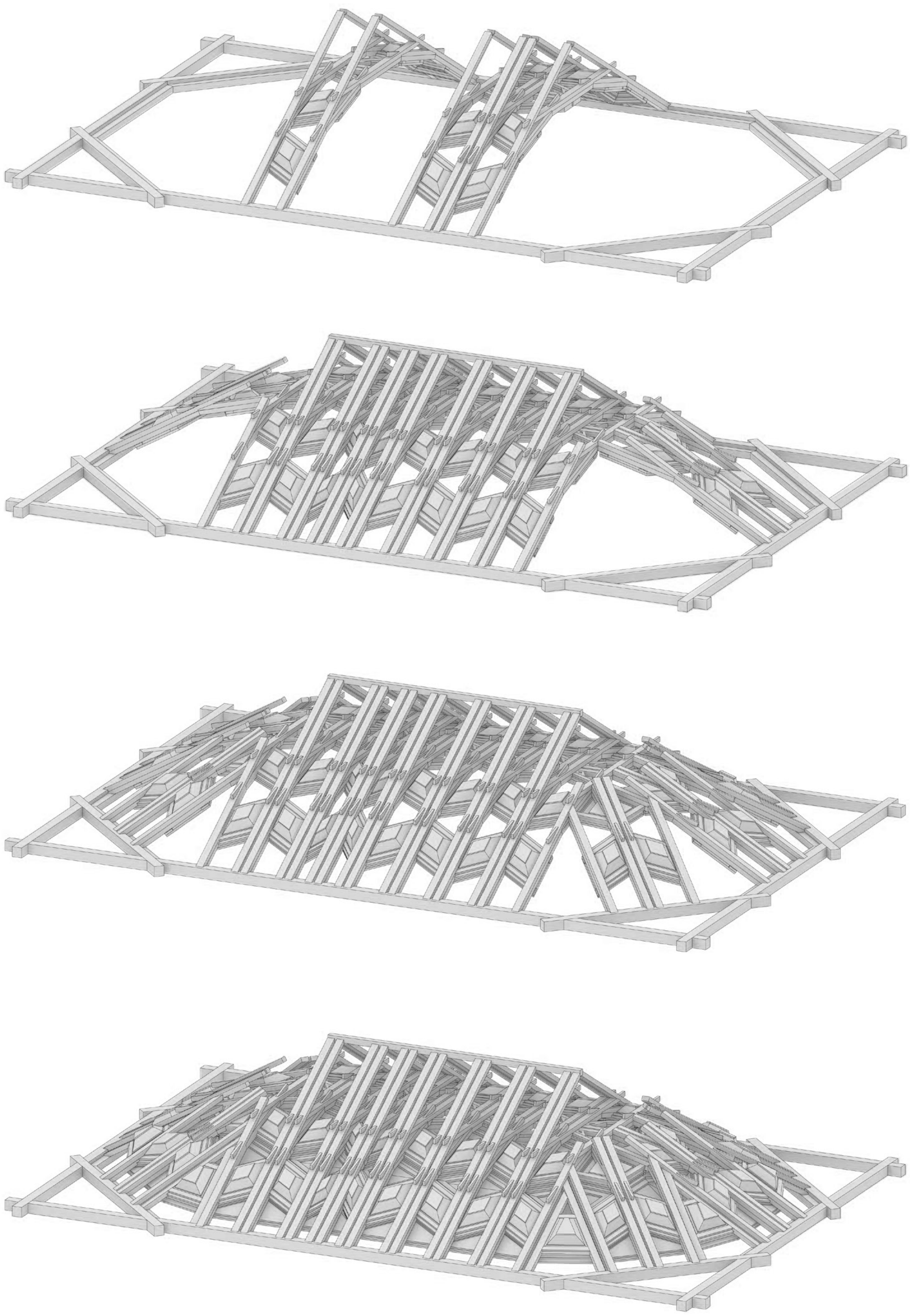

Figure 11. Assembly hypothesis for the whole structure.

The ceiling is a self-supporting structure integrated by a large number of pieces, which contribute to the stability of the whole. The joints between these pieces are variously ranged and difficult to execute. The study of these joints allows us to deduce the way in which the assembly was made. The working position and the order of installation of each timber follows a certain logic. For example, a nailed joint needs a firm support against which to strike, while a mortise and tenon joint requires space for a displacement on its axis. On the other hand, the possibility of assembling the whole system in its final position is not feasible, since it would involve an excessive scaffolding system, the loss of precision and greater labour risks. Economic and technical reasons lead us to consider the prefabrication of a module of the structure, assembled completely at ground level, which was both rigid and light enough to be raised in one piece to its final position.

According to these conditions and the theory written previously as regards duplicating the gantries, there is a basic unit of the structure compounded by two main gantries, formed by rafters, joists and struts, with the mortise and tenon joints already described, reinforced by under-arches of the same width and nailed to its lower face. Between the arches of two parallel gantries there are several short bars that support the concave coffers in the form of rhombuses. These double assemblies are a work in series, prefabricated in a workshop. The resulting unit meets the conditions of rigidity and lightness required.

Once placed in its definitive position and fixed to one another, the eight transverse modules of the ceiling make the whole structure already stable. Then the two semi-gantries of the front panels can be added, rotated 90º from the first. Later, the four corners have to be closed at 45º. Finally, with a trapezium shape at 22.5º, concave coffers are also placed in the perimeter and supported by a secondary structure. Above these, at the junctions between the intermediate coffers, the four warped quadrilaterals that fill the gaps between rhombuses are covered with pairs of concave coffers of triangular base. By this method the structure is completely stable and prepared to receive the convex coffers.

The convex coffers are the rhombuses that complete the hexagonal geometry of the intrados and are fixed to the ceiling after the module is placed in its final position, as they close the gaps between modules. They are pyramidal hanging boxes, for which a wooden bar is used. The bar passes through the gap between duplicated gantries and is locked to the main frame through a bolt. These convex coffers must solve complex intersections between the edges of the concave planks, which form warped quadrilaterals. There are also eight pentagonal hanging pyramids on the irregular spaces due to the rotation of the modules, for which the corresponding convex coffers are also constructed on site, once the support lines and angles have been measured in situ.

In order to support the perimeter frieze that finishes the coffered ceiling, putlog holes have to be made in the walls, in which wooden corbels have been introduced. On these pieces lay the horizontal beam and the little pillars that organize the frieze boards. Four pendentives are placed at the corners below the frieze. They show concave and convex coffers on different combinations of rhombuses, triangles and hexagons based on a hexagonal geometry again.

The last phase of the process is the installation of carved lids, garlands and busts. These elements were fixed to the structure from beneath. To do this, it was necessary to have a light scaffolding available, which could be moved throughout the plant, according to the planning of the work.

Corresponding to the data taken for the analysis of the structure, the prefabricated module has an estimated weight of between 400 and 500 kg, while the coffers and minor pieces range from 10 to 50 kg. Therefore, the construction should mainly require two auxiliary means of raising: a system of pulleys, possibly hung from wooden beams, to hoist the prefabricated modules, and also movable scaffolding that would allow the operator to work on the underside of the ceiling, handling the convex coffers and the decorative elements.

6. CONCLUSIONS

During the sixteenth century a combination of the formal influence of the Italian Renaissance and the constructive tradition of the Hispano–Islamic wooden ceiling can be seen in Spain. The work which is the subject of this study, in addition to being a fine example of this mixing, presents important technical innovations in its constructive system and its geometric configuration. Such is the case of the mortise and tenon joints of the main gantries and the triangulation of the knots, which gives greater rigidity to the gantry and allows a prefabricated module to be lifted safely. Also, there is the special combination of rhombuses and trapezoids in polyhedral intersections of very difficult setting and execution and the use of convex coffers.

The shaping of the ceiling conveys dynamism through the incoming and outgoing of the coffers, and the many angles and polygons, showing a complexity beyond the classical forms, in an absolutely Mannerist language. However, behind the aspect of a contrived texture there is an innovative polyhedral pattern. It is an ordered and rigorous mosaic that develops in three dimensions. The set constitutes an organism composed of separate elements, which ease their repair or replacement, and which collaborate and resist in solidarity. The joints, in addition, are flexible enough to allow the relative movements of their parts, mainly displacements due to changes in temperature or humidity, without losing resistance.

From what has been stated above, it can be deduced that the construction process required an important rationalization of the work. Making most of the structure in the workshop was an essential condition to achieve optimum precision. Likewise, the best assembly order and prefabrication of elements at ground level and their subsequent placement in their final position were needed for this work to be successful.

Additionally to the already mentioned unusual use of mortise and tenon joints on gantry knots or the peculiar projection of the mosaic over the polyhedron of the roof, the presence of doubled gantries, unnecessary for resistance purposes, is remarkable. This leads us to analyze them as a decision of the assembly process. That implies an integrated module that was probably built at ground level and later placed on the roof. The repetition of that unitary block is, without doubt, the reason that justifies the appearance of such duplicated structures.

The likely hypothesis regarding the identity of the author of the project and also of the work, master carpenter Alonso de Porquera, is based on formal features of contemporary works located nearby, although the coffered ceiling of Castroverde is his greatest design in importance and originality. This work has been compared with structures built in other parts of Spain and although these wooden ceilings form a coherent artistic set, the relevance of its innovative contributions makes it a unique case, a *rara avis*, within the context of Spanish Renaissance coffered ceilings.

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