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Design and construction of timber roof structures, built over different structural systems. Cases studies at the Valencia Community

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Timber construction was not considered, up to now, a remarkable aspect of the Valencia historical construction. Nevertheless, magnificent examples of coffered ceilings and timber roof structures make reconsider its importance.

Unlike what happens in other regions of the Spanish geography, judging by the existing bibliography on this subject, in Valencia there are a few buildings that count with timber roof structures able to be seen from the interior of the rooms that those protect. The only examples are those timber roof structures constructed on diaphragmatic arches, counting with polychrome coffered ceilings, in the majority of cases.

Other timber structures that are seen from below, are mostly rafter trusses. Therefore, most of the studied cases belong to hidden timber trusses, by means of brick vaults or also by false plaster vaults.

The main differences between timber roof structures able to be seen from below, and those hidden from the sight, are based on its finishing, and on the greater freedom that the carpenters had to create the different roof trusses in each building. Solutions that in any case demanded to the carpenters to know with detail the building that was being constructed, as far as its constructive characteristics and their structural system.

These aspects we will be developed in this paper, applying these criteria to the studied cases.

Determination of the roof structure type

In order to choose the type of roof structure, we have to previously define the range of possibilities that the carpenter had, to adopt one or another design.

We have adopted the classification of the roof structures according to the disposition of elements denominated of 1st order, that is to say, those that are arranged in the first place on the wall structure. Thus we have that these elements can be purlins, rafters or scissors brace trusses. We identified one more group, the mixed trusses, formed by wooden and brick elements.

Purlin trusses consist of a pair of timber beams supported over the walls of different height, thus allowing to form the slope of the roof. These trusses were mentioned before, as those built over diaphragmatic arches. Torres Balbás, who studied this building type, described these structures like, of fast construction, without the complexity and slowness that required the vaulted forms.[1] Also its use was advantageous since it allowed that the timber elements could be thinner, as the distance between its supports were reduced.[2]

Rafter trusses consist of the formation of a central support of two-faced elements that are higher than the outer ends, in order to form slopes. They lean in the central point forming the ridgepole ensuring stability within its plane each one of the trusses. The rafters produce thrusts in the walls on which they support. The walls must resist these thrusts, constructing walls of greater thickness, building abutments to prevent the lateral motion, or introducing tie-beams to the system. In these trusses, the tie beams do not correspond with the rafters, existing a fundamental element of transmission of the lateral thrust, that are

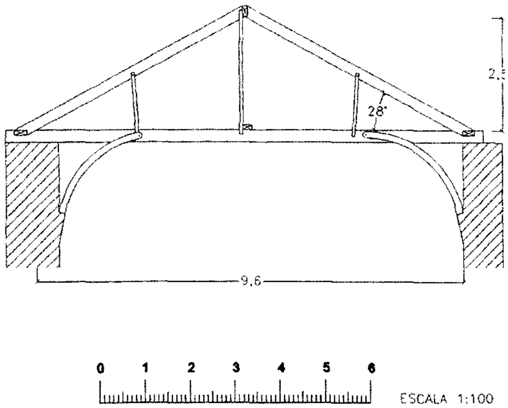

Figure 1

the wall-plates. On these elements they support the rafters, forming birdsmouth joints.

Rafters and tie beams that may incorporate also a king post and braces form the scissors brace trusses. This elementary triangle that was denominated as «scissors» by the Spanish authors of the c. XVII,[3] was already known by the Romans as describes Vitruvio in its Book IV, Chapter II.[4] He even relates that he has covered a basilica with that system, of 17,80 m width. Also we have archaeological knowledge that Romans knew the scarf-joint, as well as other types of joints and carvings, from the archaeological studies conducted in Pompeya and Herculano.[5]

These roof trusses have the thrusts balanced allowing a constructive solution in its supporting walls very different from the rafter trusses. In this case the support is made over the plates, while in the rafter trusses this element becomes necessary to form the support of the rafters, and to fix the tie beams simultaneously.

The different translations done during XVII and XVIII centuries of Alberti[6] and Palladio[7] treaties, caused that the scissors brace trusses became one of the most frequently structural systems adopted to support roof coverings. Also inspired the construction of timber trusses for great buildings as in the Sheldonian Theatre of Oxford, by Wren in 1663, similar to which proposes Palladio for the Theater Olympic of Vicenza. Proposals that also includes Benito Bails in his treaty[8] illustrating several of those type of trusses, like the one of the church of San Andrea of the Valley in Rome, and the one of the Great Theater of San Carlo in Naples.

Nevertheless, the triangle forms following the Roman model were not adapted to the accused slope used in the centre and north of Europe during the XIIth century. The first documentary references of these roofs we found in the medieval album of Villard de Honnecourt, perfectly detailed in his drawings.[9] Also we can see some of these medieval trusses of the French gothic style through the designs of Viollet-le-Duc.[10] These trusses can also be found in the historical English carpentry.[11]

There are also mixed structures that need of intermediate supports for the timber elements, to form the roof slopes. In these structures, not always special care was taken not to produce actions over the brick elements.

Figure 2

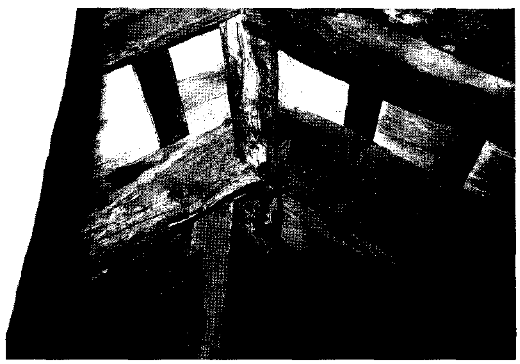

Figure 3

Figure 4

Therefore, there must be a direct relation between the structural form adopted for the timber truss and the configuration of the wall structure of the building.

The most stable form, the triangle trusses, when built over vaulted spaces, needs higher walls, in order to save the key of the vault. Rafter trusses need of some elements to avoid thrusts. Purlin trusses can only be laid over diaphragmatic walls, dividing the interior space in bays.

The way in which the roof trusses are built is inherent to the material, as it happens with most of the building materials used in construction. Timber elements used in construction entirely depend on its cross section and its length. When dimensions of length needed exceeds the one that can give us the available piece, the carpenter has to resort to the unions and joints. In the same way it happens when the carpenter has to put in relation several timber elements or parts of a structure, to build a truss.

The different joints are not conditioned by the different types of trusses described, but by the different efforts that the wooden elements have to transmit. In all the cases, the fact of making a joint supposes to make a cut in the pieces that are united, being created a weak point, which the carpenters have to diminish.

Availability of the material and use of timber construction at the Valencian Community

Timber used in historical building construction in this area have been varying, depending on the wood that was available in each place. The criteria of operation of the forests were not always based on economy, but in very diverse reasons. In fact, Europe was covered with forests, and has been men who made a way within them to obtain territories to cultivate or grass for the cattle that allowed its establishment.

The first types of timber construction were built with trunks, requiring a great ammount of wood.[12] They were constructed with softwoods that can give straight elements and of great length, aspects both of extreme importance in building construction. Hardwoods not always give straight elements, although for that reason was not less appreciated. It was mainly used disposed vertically, either forming elements of uniform section, or distancing the wood elements as posts. The intermediate spaces filled up

Figure 5

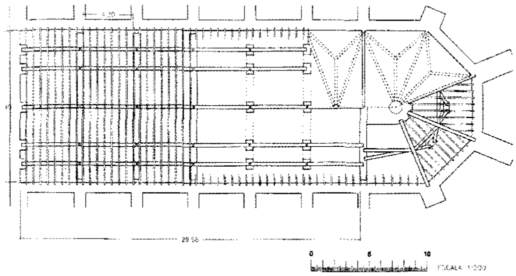

Figure 6

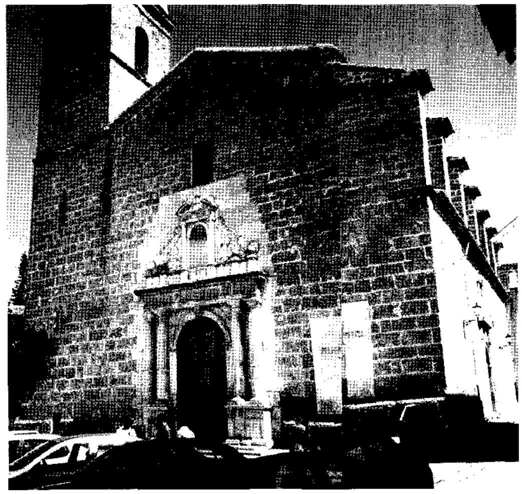

Figure 8

with other materials like clay or bricks, or also by means of wooden planks. Since this system allowed saving the material, it was the one that ended up prevailing.

When the operations of forests were made in an uncontrolled way, the constructors of cathedrals worried about it, because the distances they had to make to obtain adequate timber for that purpose employed a greater time.[13] Soon local resources were exhausted, and it was needed to bring timber from other sites getting to better prices. In fact, the wood coming from abroad was becoming a reality in the centre and the south of Europe, being mainly softwoods the wood employed for structural use.

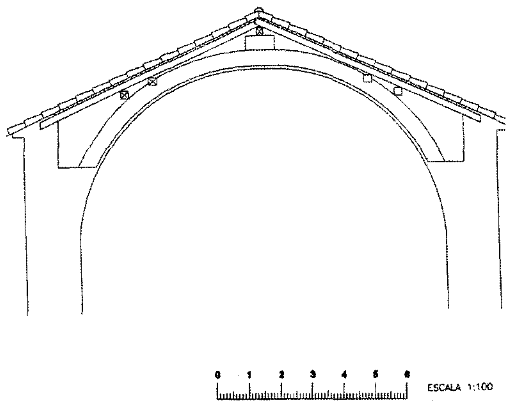

Figure 7

The great demand of wood for coal at the end of XVIIth century and for the construction of huge vessels, considerably reduced the reserves of forests. This affected to all Europe in general, and in a more serious way to those countries of great tradition of navigators and conquerors who needed great number of vessels.

The wood used for building construction in Spain has been basically obtained in the area where the building was built, coming from surrounding forests, arriving at the cities through rivers, or by sea through some next port.

The wood species used more in Valencia have been *pinus sylvestris* and *pinus halepensis* also called «pine from the river». This arrived at the city through the Turia River, *in rais* coming from the forests of the provinces of Teruel and Cuenca.[14] Sanchis Guarner[15] says that the wood used by the medieval carpenters, in XIV and XV centuries, coming from territories of the interior, had originated a powerful naval construction and an important industry of furniture.

The Xúquer River was used for wood transport in cities like Xàtiva and Gandía. In Alberique was the «*Vado de Barragà*», distant about 12 km to the city of Xàtiva, from where the wood arrived to be used in building construction.

It was from the XIXth century when «mobila « was imported from the United States with certain volume.

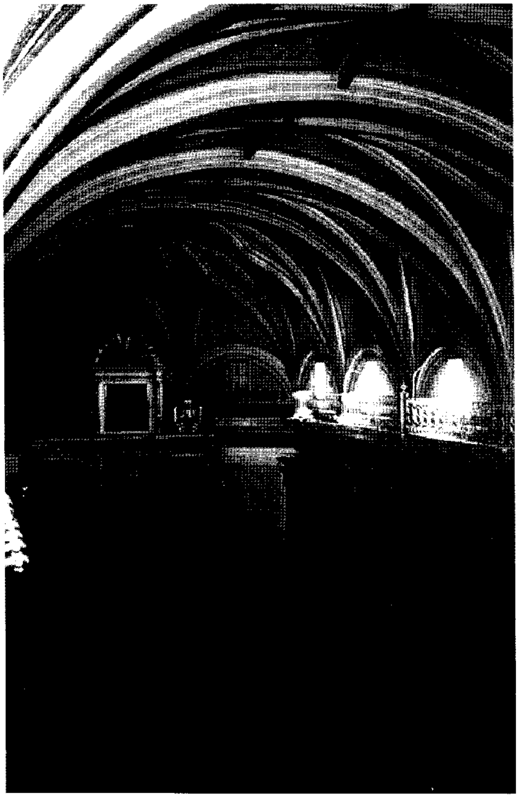

Figure 9

By this name there are identified five species coming from the south of the United States, from the port of Mobile,[16] in the Bay of the same name and next to the city of New Orleans. Between 1815 and 1861 this port reached his maximum splendour, with its exports of cotton and wood, fundamentally.

THE DESIGNERS

Trusses were built through specific rules based on the geometry, reaching their greater development towards the end of XVth century. All the treaties of architecture of XVII and XVIII centuries actually include knowledge of Arithmetic and Geometry like fundamental components of the architecture.

In carpentry and architecture treaties the layout of roof trusses are defined. Repeatedly it appears in the

Figure 10

bibliography this detailed description about how to draw up trusses by means of triangles.[17] The Anglo-Saxons fundamentally use the squares for the design and layout of trusses, although in the Japanese carpentry there is also a tool that directly gives the dimensions of the elements to construct and form a truss. These systems are still used at the present time. Determination of the width and height were used to define the timber elements, based on proportions, thus defining all the elements that constitute the corresponding trusses and its joints. Once defined the slope, all steps followed to build the trusses were similar, in all methods.

Carpenters to show the clients the idea they will develop in the future building frequently used models. Fray Andrés de San Miguel says that in case of doubt « . . . *and in works that they have difficulty*

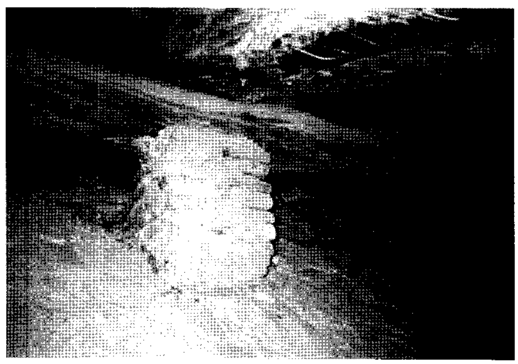

Figure 11

Figure 12

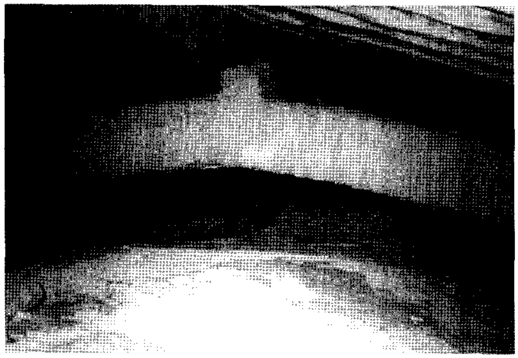

Figure 13

is accustomed to the most understood to make model than it is the same work in small, where they correct the defects and they are hazen better than in the work . . . ».[18]

The «*tracistas*» were master carpenters, master bricklayers or master masons. They were formed in geometry so that they were able to represent his idea, in drawings or models. They not only had to be formed in geometry, but, in addition, they had to know about the last architectonic forms and tendencies. They were who determined the slopes of the trusses, as well as the type of truss more suitable for each construction. The masers masons or master bricklayers, denominated «*pedrapiquer* « and «*obrer of villa* « respectively, they could be the «*master of the work*» when they directed it, and not necessary be its designer. By the way, a carpenter could be «tracista» or designer of altarpieces and roofs, and even of the complete building.[19]

Case studies

The case studies that are included in this article have been selected in such a way that they offer a variety of different solutions in relation to the wall structure We can try to to infer on those, who were the possible authors of their layout.

The selected cases talk about the different types of trusses before mentioned. Thus we have a rafter truss, like the one over the dormitories at Santa Clara Monastery, in Xàtiva, a purlin truss of the roof at the church in Albaida, and a scissor brace truss, the one over the Golden room, at the Palace of the Duc, in Gandía.

The roof structure of the dormitories at the convent for nuns of Santa Clara,[20] Xàtiva

The convent is in the street of Montcada at Xàtiva, next to the square of the Trinidad. Here another convent was located, the one of the Trinidad, that gave the name site, although this one no longer exists.

Fray Alberto Pina, Carmelite architect who resided and worked in Xàtiva in centuries XVII and XVIII, being director of the Colegiata of that city, wrote a «Description of the measures and magnificence in which it is constructed the real Monastery of very illustrious Nuns of Santa Clara in the city of San Felipe», that allows to know its configuration in those dates. It says that the monastery has four facades, one to the Montcada street (main facade), to the one of the Leon, and the convent of the Trinitarians monks.

Each side measured 343 Valencian handspans, by 74 of elevation. From the pointed arch access with battlements, we can reach the patio of entrance of the nuns, house keeper, door of the church, parlour, the dormitories of the nuns and the stairs to access to the door of the superior cloister. This piece is of starred vault and has 80 handspans.

According to that document, each cloister measured 208 handspans of length (about 47.32 meters) and 18 handspans of wide (4.095 m), and 28 handspans height (6.37 m). The cross vaults were

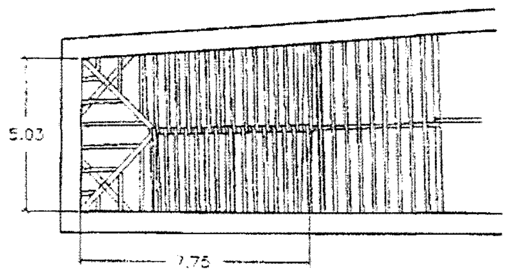

Figure 14

decorated with bosses. The dormitory of the community measured 116 handspans (26.39 m), of 40 of width (9.10 m) and 38 of height to its vault (8.65 m).

The superior cloister, to which was acceded by the door of the Virgin, did not have vaults, and agreed with those of the ground floor in its dimensions. The high closing was not gothic but renaissance, like the superior choir and chapter house. The church, of 110 handspans of length (25 m) by 38 of wide (8.65 m), had lateral chapels. It was reformed in XVII century, for the construction of the high and low choir, and renovation of finishing of the walls.

Damages caused by the 1748 earthquake

The city of Xàtiva underwent the 1748 earthquake, having its epicentre in that city. In a report on the damages caused by the 1748 earthquake we can read that « . . . some ruins in the cloister are recognised, particularly the one that noon light receives, leaning about three fingers, and the floor of the superior cloister, with some cracks, are seen going inwards the walls of the cells; that the pieces of the infirmary, the rooms, kitchen, common place, tower and noviciate, have leaning their walls and partitions; that in the choirs high and low where the large corbel that maintains one of the main beams was broken, a corner of them was opened and by the thirds of the arches it was breaking all the nave of the church, sacristy and parlour, opening vaults, arches and walls. And finally, the corner of the wall of the angle of the closing that is next to the door of the Leon, that before earthquakes already had a crack opened from above to down, has increased up to four fingers by the violence of the earthquake. But that, the referred ruins, admit safe repairs, like it has been made already in the wall that divides the dormitory of the common place, that it has been rebuilt from the foundation of the main wall; in the kitchen of the infirmary, that has been completely repaired, giving support to the tower, rooms noviciate, and common infirmary; in the walls of the church, that have been closed and joined with the greater firmness; in the bell tower, that already is strengthened its stairs and ends; in the chapter house where the arches with a pillar of five handspans have been filled up until receiving a third of the arch that it loads to the corner of the tower; and another one underneath the floor of the refectory of the infirmary, lying down the corresponding chains so that everything is left all the rest well joined and then that is recognised badly joined, can, with facility, to be applied the repairs corresponding to way that strengthens its security . . . ». Next, the report values the expenses of the repair in about 3,000 or 4,000 pesos.

It acted of witness for that report, the Carmelite architect Pina, who years before, in 1744 had made a report on the state of the «modern vaults and its tile roof» It said that after inspecting the vaults he appreciated that « . . . the roof structure that it loads on the pointed arches, without the requirements that the art requires, reason why must disarm all the tile roof demolishing the old arches and all the load of ashlars, jointing the new tile roof in scissor trusses or purlin trusses, tightened the four walls . . . ».

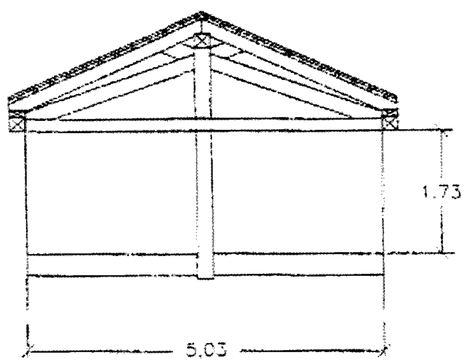

Figure 15

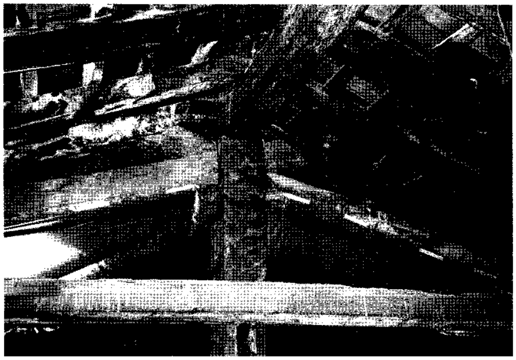

Figure 16

The timber trusses are on the church and the dormitories. We do not know if the dormitories are the original ones of the convent, described by the architect Pina, or if they were constructed after his intervention in it. He, given the state that presented after the earthquake, which we have described, also reformed the church. Both trusses we think that have been constructed by Fray Alberto Pina.

The convent it returned to be partially destroyed in the last war, having left very few original constructions: the church, the refectory and a dormitory constructed in century XVIII. Here we present the roof over the dormitories.

The roof truss over the dormitories

The aisle of the dormitories, according to the description of the architect Pina, measured 26.39 m long (116 handspans) by 9.10 m wide (40 handspans) and 38 of height of its vault. The width of the timber structure is 9.26 m, since it is built over the thickness of the wall, in one of its ends.

The structure is a rafter truss. Each two rafters there is a tie beam, that is assembled to the wall plate. This structure holds curved wooden elements to form a false plastered vault.

The dimension of the braces is of 12 × 26.5 cm, whereas the rafters measure 10.5 × 23 cm. A horizontal plank crosses the trusses along, uniting them at the level of the tie beams. This plank measures 0.11 × 0.21 cm. The separation of the rafters is of 0.69 m, whereas the one of the tie beams it is of 0.87 m.

Considering half of wide of the aisle in the 4,55 m and height of the ridge purlin located to 2.63 m, the angle formed by the rafters and tie beams is of 30°, being able to be drawn up with the triangle of 6.

The roof of the church at Albaida

Albaida is a population that is to few kilometres of Xàtiva. The church was constructed in 1621, in the centre of the villa. Next to the church one is the Palace of Marquise de Albaida, and the Abbey House, constructed in 1772 by the mentioned Marquise.

The church displays an interior with quadripartite vaults with tiercerons, and consists of five bays, plus the apse, that is of polygonal form, of five sides. The wide one of the nave is of 13.40 m, and its length of 40.80 m.

Figure 17

Due to the proximity with Xátiva, it is probable that the 1748 earthquake has affected the vaults, although the data has not been located to document this fact. In one of the little pillars that allow the disposition of the common purlin in the roof, there is a date, that of 1736, previous one to this earthquake, which allows to think that a total collapse of the structure did not take place.

The purlin truss of the church

The roof of the church is of two slopes, defining in the apse a polygonal form. The structure presents purlins as 1st order elements, being classified within this type of trusses.

The arches that divide the nave in bays, of 5 m of length (to axis), surpass the height of the brick vaults, allowing to support the common purlin on these. In the arches that separate the second and third bays, there are no such over-elevations, being necessary to supplement the height of these by means of small brick pillars.

The common purlins, therefore, rest on these small brick pillars built over the arches that divide in bays the nave. The ridge purlin, of great dimensions, (20 × 26 cm) is practically laid upon the keystones of the arches. The purlins, like the other elements that constitute the structure, are trunks decorticated with quite coarse squaring. These measure 25 × 24 cm and 23 × 27 cm. Over the purlins, there rafters, as elements of 2nd order, of variable section (of 10 × 19 cm, and 12 × 18 cm).

The roof of the apse is solved by means of a peculiar system that defines supports built over the vaults, although resting the small pillars on the nerves or stars or rosettes of the rib vaults, without affecting webs.

On that area were created two systems of supports, one displayed over the vaults, by means of small pillars on which they support common purlin. On these common purlin it arranges others that they are parallel to the sides of the polygon that defines the apse. On the first system of common purlin it locates the rafters that define the edges of the polygon. Smaller elements support them on the second system of common purlin.

In relation to its mechanical behaviour it is necessary to indicate that in this truss, the common purlins are deflecting because of the loads of the covering material, that gets by means of the elements from 2nd order to them. The common purlin, of 5 m of length, with sections of 24 × 25 cm, fulfil their resistant mission.

With respect to the solution given to the truss of the apse, the disposition of the architectonic elements in its design has considered, supporting elements of the roof where there were nerves of the inferior vault.

The Golden Gallery Roof. Palace of the Duc. Gandía

The «Golden Gallery», or «Obra Nueva», was built by D. Pascual of Borja in the last quarter of XVIIth century. There are five united halls to each other forming a gallery. These halls separate by means of

Figure 18

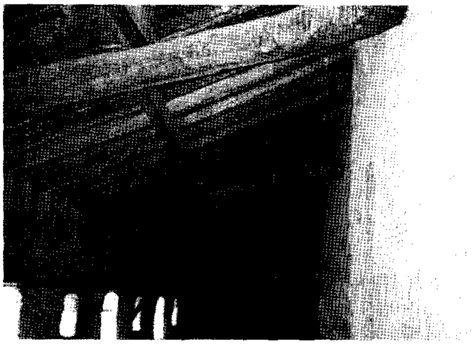

Figure 19

carved and golden polychrome wooden elements. It has 38 m of length, and it is at the western side of another room, the Green one.

The roof that we present in detail corresponds to the western extreme of the gallery, presenting a three sloped roof, in a length of 10 m. The rest of the Room has a roof structure made of rafters, to one slope, to the leaning to the patio of «Cañas».

This roof it is considered to be the original one of its construction, although some substitutions of their elements are appraised. The trusses are displayed at a height of about 2.40 m with respect to the coffered ceiling of the Golden Room.

It is braced scissors truss, formed by rafters crossed to support the ridge purlin, a tie beam that is assembled in wall plates, on which there stands the rafters. There is a great beam to a height of 80 cm on the ceiling of the Golden Room, that is related to the king post that it crosses all the height of the scissors, from the ridge purlin to form the support in this great beam. There are three of these scissors trusses, being the last one solved to procure the third slope of the roof.

The dimensions of the elements that constitute it are the following one: the pairs are of 14 × 21 cm, the brace of 17 × 21 cm, the inferior beam of 29 × 30 cm, and the kingpost of 22 × 26 cm. The rafters are assembled to each other with halved joint, and to the hip rafter; kingpost is assembled with half lap joint to the tie beam and the beam.

From the last two scissors start the hip rafters in the diagonals of the plan, to support the third slope, related together by means of struts. Over the hip rafters are disposed rafters, like small purlins.

The covering material has been recently treated against insect attack, and verified its watertightness.

The rest of the room displays a structure of rafters to solve the one slopped roof. Since the rafters have too much length, a support of beams disposed longitudinally to the room has been procured, resting over great beams that lays on the outer wall to the patio of Cañas and on the wall that separates this room to the next one.[21] These beams are distanced about 6 meters and they are not horizontal, presenting a small inclination, like the rafters, but with minor slope.

Conclusions

In all the studies cases carpenters and master builders knew how to complete the roof structures in the most accurate way in each building.

Carpenters had shared the knowledge of the office and applied them to these solutions. These masters extended it all around the world, obviously with the particularities that the different carpenters added to those.

The case studies of these buildings contributed to recover this knowledge, and can help to us to value them more accurately.

Notes

1. Torres Balbás, L., Naves de edificios anteriores al siglo XIII cubiertas con armaduras de madera sobre arcos transversales, *Archivo Español de Arte*, CSIC, Madrid, 1959, page 109 and s.s. y Torres Balbás, L., Naves de cubiertas con armadura de madera sobre arcos perpiaños a partir del siglo XIII, *Archivo Español de Arte*, CSIC, Madrid, 1960, page 19 and s.s.
2. Exist some very well conserved examples in the Valencian area. Recently the coffered ceiling of the church of Sant Pere at Xàtiva and the one of «la Sangre» at Lliria, both in the province of Valencia, and the one of Santa Maria in San Mateo, Castellón, have been repaired. A great number of buildings with this type of ceiling could be cited, like the churches of Santa Tecla and San Felix in Xàtiva, the church of «de la Sangre» in Onda, the chapel of the communion of the church of Godella, the church of the Cristo de La Paz, the church of El Salvador of Sagunto, the church of San Anton in Valencia, and the church of Santa Maria of Alzira. See Zaragozá Catalan, A., Naves de arcos diafragma y

techumbre de madera en la arquitectura civil valenciana, *Actas del I Congreso Nacional de la Construcción*, Ed. CEHOPU y ETSAM, Madrid, 1997. Page 551 and s.s. See also Zaragozà Catalán, A., *Arquitectura Gótica Valenciana*, Valencia, 2000.

3. Fray Laurencio de San Nicolás, *Arte y uso de la arquitectura*, Madrid, 1639 and 1664. Re-Edition Madrid 1989. Collection Juan de Herrera. It mentions the called scissor brace trusses talking about this type of structures.
4. In Book IV, Chapter II, we found a description of the form to construct the roofs: « . . . en todos los edificios se pone encima maderaje, a cuyas piezas solemos dar diferentes nombres, según son también sus usos diferentes. Maderos mayores, ó madres se llaman las jácenas o piezas que se sientan sobre las columnas,. Los de los altos quartones y tableros . . . » It continues saying that « . . . En la armadura del techo, si el espacio es muy grande, se ponen el madero del caballete en lo alto, llamando columen (de que tomaron nombre las columnas), los tirantes y los cabrios. Si el ancho es moderado, entra también el columen y los pares llamados cantérios, que vuelan fuera de la pared a formar el alero. Sobre dichos canterios, van las vigas o quartones llamados templos: y sobre éstos inmediatos a las tejas los listones llamados asseres, que también salen fuera de las paredes cuanto baste a protegerlas. Y en esta forma todas las cosas tienen su propio lugar, género y orden . . . ». Vitruvio, *Ten Books of Architecture*, translated by Jose Ortiz y Sanz, Madrid, 1787.
5. Adam, J. P., *Roman construction,* Ed. Los Oficios, Leon, 1996. Page 222 and s.s.
6. Alberti, L. B., *De re aedificatoria,* Florence 1485, translated by M. Alonso Gómez, 1582, Reedited by Ed. Albatros, 1977.
7. Palladio, A., *I Quattro Libri dell'Architettura*, Venice, 1570, Reedited by Ulrico Hoepli, Milano, 1968.
8. Bails, B., *De la arquitectura civil*, 1ª Edition 1783, Reedited Murcia 1983. Volume I, Critical Study, by Pedro Navascués Palacio.
9. Cuade*rno de Villard de Honnecourt*, Akal Editions, Madrid, 1991.
10. Bechmann, R., Los dibujos técnicos del Cuaderno de Villard de Honnecourt, *Cuaderno de . . .* , op. cit.
11. Viollet-le-Duc, *Dictionnaire Raisonné de l'Architecture*, Volume II, Paris, 1859.
12. Hewett, C., *English Hisotric Carpentry*, Ed Phillimore, Sussex, 1980, and «English Cathedral and Monastic Carpentry», 1985.
13. This building type has been used indifferently in the Scandinavian region, alpine zone and in North America. See Brunskill, R. W., *Timber building in England*, London, Ed. Víctor Gollancz, 1985, page 24.
14. Bechmann, R., *Les recines des cathedrales*, Ed. Payot, Paris, 1984. Page 93 and s.s.
15. There are references of the wood purchase coming from territories of the Marqués of Moya, in the Province of Cuenca, 1533, for the construction of the coffered ceiling of the Consulate of the Sea in the Market of Valencia. Aldana, S., *La Lonja de Valencia*, Valencia, page 55.
16. Sanchis Guarner, M., *La Ciutat de Valencia*, Main House of Valencia, Valencia, 1972. Third edition 1981, pages 175.
17. The port of Mobile depended in century XVI of the Spanish crown, and, in century XVII of the French. It was in 1780 when this port returned to depend on the Spaniards, until 1815.
18. See Nuere, E., *La carpintería de lazo. Lectura dibujada del manuscrito de Fray Andrés de San Miguel*, Colegio de Arquitectos de Málaga, Málaga, 1990; Mariátegui, E., *Breve compendio de la Carpintería de lo blanco y tratado de alarifes*, 1° Ed., 1867, Madrid, 1912.; Fray Laurencio de San Nicolás, *Arte y uso de la Arquitectura*, Capítulo XLVII, Trata de que fuerte se hayan de trazar las armaduras, y cuantas diferencias hay de ellas, Madrid, 1639 y 1664. Collection Juan de Herrera, Madrid 1989.
19. Nuere, E., *La carpintería de lazo*, op. cit., page 26.
20. In documents to contract the roof of the Sala Nova at the Palau of the Generalitat, end of XVIth century XVI, it was proposed to be given to «mestres architectors, pedrapiquers o altres qualsevol persones» Gómez Ferrer, M., *Arquitectura en la Valencia del siglo XVI. El Hospital General y sus Artífices*, Ed. Albatros, 1998. Page 176.
21. The wife of Admiral Roger de Lauria, Doña Saurina de Entenza, founded the monastic house of the nuns on 1325.
22. This room is the one named «Sala de los Carroces & Centelles y de los Estados de Cerdeña».

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