

The Construction of the Saint Felix Church Tower in Girona, during the Fourteenth Century: Workers, Materials and Equipment

Miquel Àngel Chamorro Trenado

Escola Politècnica Superior of the Universitat de Girona, Spain

ABSTRACT: I will analyze the construction of the Saint Felix church tower in Girona during the fourteenth century. Specifically, this study will focus on the workers, the materials and the auxiliary means used. To this end, I have consulted the building records of the church, an indispensable documentary source of the building's history. After an introduction describing the chronology of the construction work of the church, I analyze the data we have regarding the anonymous, and sometimes named, builders who worked there: their origin, working hours, the family relationships, wages and so on. In this section, I will highlight the importance of the work of women during construction which, at the time, was highly unusual, be it in Girona, Catalonia, Spain or indeed, anywhere else in Europe. With regard to materials, I shall focus on the most important data provided by the building records, such as quality, price, origin, transportation, etc. Finally, I will describe the characteristics, cost, ownership and function of the equipment used in construction.

INTRODUCTION

Before talking about the tower, we will give a brief chronology of the whole construction of the church of Saint Felix at Girona. The current place of worship took advantage of the pre-existing Romanesque structures; over the centuries there had been a graveyard (fourth century), then a *martyrium*, a Visigothic basilica with three naves (seventh century) and, finally, a Romanesque church (Canal et al. 2000). The old Romanesque church was partially destroyed in the year 1285 during the siege waged by the French King, Philip the Hardy (Philippe III). At the beginning of the fourteenth century, the church was rebuilt upon the remains. According to the Chapter book from 1309, construction work on the church began since, although the loans obtained for the work were in fact for the tomb of Saint Narcissus, this work was not carried out until the end of the first third of the fourteenth century. In the years 1315 and 1321 work was done on the apse (Marquès 2001, p.131).

From 1348 until 1391, the surviving building records (especially those concerning costs), provide comprehensive information on the construction timeline. Firstly we should mention the construction of the Vendrell chapel or of the Holy Sepulchre in 1349. It was built quite quickly for two reasons: because it was relatively small and because there was greater stability in Girona and Catalonia after the terrible plague known as the Black Death. The second major phase carried out was the Gothic cloister - there had been a Romanesque one - which was built between May 1357 and June 1361. This was demolished in 1374 due to the danger foreseen to both the church and the city by the imminent entry of troops from the Frankish kingdoms. In 1368, construction began on the Gothic tower, designed by Pere de Coma, which was finally completed at the end of the sixteenth century.

During all the phases of construction, the church of Saint Felix had to be fortified on many occasions (Guilleré 1993, p.170), a factor which slowed down its construction. The church was not completed, to the extent that survives today, until the end of the fifteenth century, and the façade was not added until the early seventeenth century. Finally, in the eighteenth century, the baroque chapel dedicated to St Narcissus was built.

LABOUR

Introduction

It is difficult to ascertain from the building records the duration of the working day of the paid workers that were contracted to build the tower, although they do show the daily and weekly absences of workers. Despite the lack of data provided by the documents consulted, we can use as a reference Domenge's hypothesis on the working hours at the Cathedral of Mallorca, which were around 12 hours a day, taking full advantage of natural light (Domenge 1997, p.237).

The records also show the annual festivities celebrated by all the workers. There are the moveable Feast Days of Palm Sunday, Good Friday, Easter Sunday and Corpus Christi, and the fixed feast days: St. John's on June 24, Saint James' on July 25, the Assumption on August 15, The Birth of St. Mary on September 8, All Saints' Day on November 1, etc. (ADG. Works. 1365 to 1391 (costs)).

Absences at work were caused by weather or for reasons of *force majeure*, such as illness or death. Sometimes, the time the worker was absent was specified (ADG. Works. 1365 to 1370 (costs) f.XVIIIv).

The number of workers per week working on the tower was highly variable and depended on the work being done. The maximum number of workers together at one time coincided with the execution of the foundations and during work on fortifications.

Sometimes the building records specify the work to be carried out by each of the craftsmen. Thus we can identify the costs corresponding to the week of the 17th to 22nd of July, 1368, in which stone masons worked the stone, while labourers and women were responsible for the task of clearing the debris. Also noted is the part of the building being worked on (ADG. Works. 1365 to 1391 (costs) ff. XX and XXVI).

Workers' wages varied according to the work being carried out (specialisation). We can also see how wages vary over time. Sometimes payment was made in kind (wine, water or food), received by workers doing strenuous or dangerous work (ADG. Works. 1374 to 1384 (costs) f. 43).

At certain times, we find family clans at work, often with no indication of which family members are working there, since the entry simply reads *pro suo familia*. If reference is made to the family member, it is as wife, son, brother or niece (ADG. Works. 1365 to 1391 (costs) f. XXVIIIv).

Workers who were dependant on others, such as apprentices, were not directly paid a wage, since it was their master who received payment. The *macip* (apprentice) was paid a wage similar to that of the labourers and we do not know for certain if they received the whole amount or whether part of it was kept by their master as a fee for their upkeep.

Sometimes the building records refer, indirectly, to the age of the worker. The terminology used includes *manor de dies* (minor) or *iuveni* (juvenile), *filio* (son) or *filia* (daughter) and in some cases it is even recorded that small children were working (ADG. Works. 1355 to 1365 (costs) f.XVIr and ADG Works. 1374 to 1384 (costs) f.69v).

Many of the workers involved in the construction of the tower in the fourteenth century are from the city of Girona or the surrounding area, although their origin is often not specified (ADG. Works. 1365 to 1391 (revenue), f. XXVv). Also mentioned are workers who belong to other regions or cities like *Rumia* de Rossellon, a porter who has come from Provence, Joan (John) from *Mallorca* or Maria from *Aragon* (ADG. Works. 1374 to 1384 (costs) f.42).

Works director

The Master of Works charged with building the tower was Pere de Coma, who was master-in-chief of both the Cathedral of Girona and the Church of Saint Felix (ADG. Works. 1365 to 1391 (revenue), f.XXXV). At the time he was hired to do the tower, he was working on a bridge over the River Ter (Guilleré 1993, p.229). In 1385, he would work on the latrines of the Episcopal palace in Girona.

The first record we have of this master builder is when he crosses the river, with a certain Dalmau Corona, to make a design sketch for the tower (ADG. Works. 1365 to 1391 (costs) f.XV). This must have been made before July 3, 1368, since this was when work started on the project. The records also show that the hostel of Francesc Corona and Berenguer Hospital was demolished. The first stone was laid on the 11th of August, 1368 (ADG. Works. 1365 to 1391 (costs) f. XXIIIv).

The original sketch is held in the archives of the Diocese of Girona and is the oldest example of an architect's drawings in Girona and possibly in the whole of Catalonia. Drawn on octagonal-shaped paper, 16 x 16 cm, we find the sketch on the upper side, with the outer walls defined by the edges of the paper, the interiors are marked with ink and the place where the tower meets the walls of the church can be seen. On the walls that form the tower, we find the word *alambor* (embankment) which indicates that the tower walls were to be built on a slope, as was the case when the project was begun. On the reverse of the sketch, the measurements for the tower (an irregular octagon) are written down.

On the 5th of September, 1368, the master builder and the religious chapter signed the agreement for the new tower. Pere de Coma was required to avoid unnecessary costs, to not leave the site unless it was to work on the major bridge, in which case he had to spend at least one hour at the site of the tower and have a substitute to replace him. His payment was agreed at 4 sous a day (somewhat like pounds, shillings and pence: 1 *lira* = 20 sous, 1 sou = 12 *diners*), with an annual pension of 140 sous per year (ADG. Work, 1365 to 1391 (costs) f.XVv).

Pere de Coma absences from the site were quite frequent. In addition to his absences due to his work on the bridge, he was also absent during the week of September 27, 1368, when he moved to Castelló. His absences

became more frequent when on December 21, 1368, he replaced the master builder Francesc de Plana as master of the Cathedral of Girona. While Coma was away, the man in charge was a carpenter called Botet. He was the best-paid worker (ADG. Works. 1365 to 1391 (costs) f.XXXIII).

Pere de Coma had an apprentice named Guillem, who was paid 2 sous. This apprentice was also absent at certain times in order to work on the bridge project. In 1369, a certain Bernat became the master's apprentice while Guillem [Mieres], became a labourer (ADG. Works. 1365 to 1391 (costs) ff.XXIV and XXXVII).

After a long absence, beginning July 26, 1379, we again find de Coma working at the site, continuously, with his apprentice, Pere Riera, in the construction of the chapel beneath the tower. This apprentice was paid at a rate of 30 *diners* a day, whereas the previous apprentice, Guillem Mieres, received 36 *diners* a day. This seems to imply that within the category of trainees, some were more qualified than others (ADG. Works. 1374 to 1384 (costs) f.35v).

The stone masons

Stone masonry was a key occupation in medieval building. There were two types: those working in the quarry, which quarried and hewed the stone blocks, and those who worked cutting and placing the finer pieces. We can see this division of labour in the wages they received (ADG. Works. 1365 to 1391 (revenue) f.XXXIIIv).

The first master stone masons who worked on the tower - in July 1368 - were: Bartomeu Roca, Pere Roura, Miquel Vendrell, Pere Ramon, Guillem Albayan, Guillem Bofill, Nicolau Sans, Marc Albayan, Parçes and Berenguer Caulera. They were paid 3 sous a day. At the end of February, 1369, Pere de Torra worked on the oblique side of the tower (ADG. Works. 1365 to 1391 (costs) f.XVIIv and XXXVIv).

The wages of the master stone masons varied substantially when work on the tower was resumed in October 1375, rising to 3 sous and 8 *diners* for work in the quarry, an increase of 22% (ADG. Works. 1374 - 1384 (costs) f.14).

From May, 1377, working on the tower were Francesc Cassà, Guillem Barrera and Antoni Escuder. Their degree of professional qualification, while working on the chapel vault of the tower, can be seen in their wages: Francesc Cassà received 42 *diners* a day, while Guillem Barrera and Antoni Escuder got 40 *diners* (ADG. Works. 1374 to 1384 (costs) f.23v).

Bassa and Barrera would be responsible for building the spiral staircase of the tower in June 1380. They were paid 375 sous and 4 *diners* to cut 4 different types of stone for the stairs, which was completed on September 27, 1382 (ADG. Work. 1374 to 1384 (costs) f.46).

Pere Ramon, master stonemason, is documented for the first time on May 23, 1383 accompanied by his apprentice. We know he was a master stonemason because he was paid 4 sous a day, while other stonemasons received only 3 sous and 6 *diners*. Pere Ramon built the chapel of the tower - begun on May 4, 1377 and finished on January 13, 1384 - and sculpted the keystone, following the sketch by the painter Guillem Borrassa I. His apprentice must have been quite advanced, since he performed tasks similar to those of his protector (ADG. Works. 1374 to 1384 (costs) f.84v and 90v).

Stonemasons continued to work at the site, more or less the same ones as from the previous ten years, in the work on the paved finishing of the first floor, on the walls and on the vault that covers the second floor of the tower (1384 - 1388). Finally, they carried out the paving and finished off this second floor with an external parapet (ADG. Works. 1365 to 1391 (costs) f.XXXVIII-LIIv).

The labourers

The labourers were the people that carried out the most variable tasks (Domenge 1997, p.231). In the building records, their work is not specified at all, and only the place where they were working is mentioned. One of the tasks they carried out, along with removing rubble, was slaking the lime (ADG. Works. 1365 to 1391 (costs) ff.XX and XXVI). The variety of tasks also included helping the carpenters put up the scaffolding (ADG. Works. 1374 to 1384 (costs) f.3v) or working as porters, carrying materials and equipment to and from the site (ADG. Works. 1365 - 1391 (costs) f.XXXVv).

A labourer is sometimes referred to by name or by an alias, such as Pere Casademont (listed as Pere Basses), documented in 1365 before work on the actual building of the tower had begun. This man must have been a fairly high-ranking labourer, because he had an assistant. His son would also eventually work on the building, which reinforces the assertion made in the introduction to this chapter, on the presence of family clans in medieval construction.

From the beginning of construction, wage differences among the labourers can be found. A man named March was paid 2 sous and 6 *diners* a day, P. Basses and a man called Miron were paid 2 sous and 4 *diners* while another large group of labourers - 11 of them in all - were paid only 2 sous. These differences continue as work on the tower advanced, with another group of labourers being paid 1 sou and 8 *diners*. The wages of the labourers also fluctuate over time, as evidenced by the fact that in the week of August 19, 1368, the wages of Pere Basses increased by 2 *diners* a day, to 2 sous and 6 *diners* (ADG. Works. 1365 to 1391 (costs) ff.XVII, XXV and XXVI).

Another of the labourers' tasks was to store materials and tools. Less commonly, and only when necessary, the labourers had to repair the road to the quarry, so that the carts could move back and forth without difficulty (ADG. Works. 1374 to 1384 (costs) ff. 7 and 46).

The wages of the labourers increased when work on the tower was resumed, in 1375, from 2 *sous* and 6 *diners* (in 1368) to 2 *sous* and 8 *diners* (an increase of 6.6%). In contrast, between 1382 and 1385, there was a decrease of 30 or 33%, when they were paid only 2 *sous* a day (ADG. Works. 1365 - 1391 (costs) f.XXIV).

Women

I have deemed it appropriate to dedicate a section specifically to women because they took part in large numbers in the construction of the tower. In contrast, their presence was scarce in the construction of the cathedrals of Mallorca and Tortosa in the same century (Domenge 1997, p.234 and Almuní 1991, p.118). Women played an extremely important role when demolition and rubble removal had to be carried out. The wages they received were considerably lower than any labourer's. The husbands of the majority of them were working on the site, and some also took their children to work (ADG. Works, 1365 - 1391 (costs), f.XLIV).

Among the jobs carried out by women was the transport of materials, stone or mortar. Women were paid 1 *sou* a day when they cleared rubble from the house of Francesc Corona and Berenguer Hospital - July, 1368. This wage was maintained until the construction of the tower was completed. Some women were paid 10 *diners* and others, 12 (ADG. Works, 1365 - 1391 (costs), f.XVIII).

When work on the tower was begun - July, 1368 - there is evidence of a large number of women on site. The week of 15 July, 1368, there were 24 women (two were the daughters of a woman worker), working in the removal of rubble (ADG. Works, 1365 - 1391 (costs), f.XIX and XIXv).

When work on the tower was resumed in 1379, the number of women was significantly lower than in other periods. The second week of August, 1379, 4 women were working: Miquela Pasquala, Margarita Garnana, Banyeres and Santera (ADG. Works, 1374 - 1384 (costs), f.37v). From then on, there was only the odd woman, normally labourers' wives, until September 1382, when 5 women were accounted for again: Abrila, Compta, Francesca Rigau, Barutela and Bansells. The number of women stayed within constant numbers of 5 or 6 during this period.

The women working on the tower had other trades: bakers, bread makers, farm workers, etc. (ADG. Works, 1365 - 1391 (costs), f.XLIV).

Porters

The porters had one of the hardest jobs in medieval construction. Technical means at their disposal were limited and they had to make up for them with their own physical strength. They had an animal, an ass or a mule, sometimes a cart, and transporting was often carried out by the porter himself loading the material onto his back, or in pairs, with the help of a stretcher. Many of them were farm workers that had beasts of burden, and they were called *bastaixos*, carters and *bracers* (ADG. Works, 1374 - 1384 (costs), f.74v).

Porters were paid for trip made or load transported, in other words, at a fixed price. It is sometimes difficult to know the cost of transport, since the porter's wage, the cost of the material and the cost of the animal, whether his own or hired, were mixed up together.

Porters transported stone, lime, sand, wood and sometimes, even iron. Lime and sand were often transported together, but the cost of transporting one material or the other was always specified. Transporting lime doubled that of course sand; transport costs varied when fine sand was transported. Transporting the rest of the materials was carried out at the same price as lime. Included in transport costs would be the purchase of oats for the animal and also, at times, food and drink for the porters (ADG. Works, 1365 - 1391 (costs), f.XXXVIII).

In very busy building periods, more men and animals were hired for transporting jobs. At times the cart was not the farm worker's, but belonged to the site, and the one belonging to the Cathedral of Girona was also used (ADG. Works, 1365 - 1391 (revenue), f.XXIII).

Sometimes the porter was recorded as working with a type of assistant: *socio* (ADG. Works, 1365 - 1391 (costs), f.XXVII). At no time was the wage received by the porter or his assistant specified. Occasionally there is evidence that the Master of Works accompanied the porters in order to ensure that the transporting of material was carried out correctly (ADG. Works, 1365 - 1391 (costs), f.XXXVIII).

In September, 1368, Oller and Pere Basses, the son of Basses, the labourer, were in charge of transporting enormous stone blocks to the site that other porters or workers were unable to transport due to the weight. They were paid two *sous* each (ADG. Works, 1365 - 1391 (costs), f.XXXIII).

Carpenters

Reference was constantly made to the carpenter's trade in the construction of the tower. They were the ones who earned most, after the stone masons. They were in charge of building scaffolding and formworks - above all, centrings - and moulds, as well as repairing roofs.

In addition, the carpenters had a lot of work during the periods when the tower had to be fortified. Most of the elements used in defence work were made with wood, as in this way, they were easily dismantled, and moreover, the material could be reused (ADG. Works, 1365 - 1391 (costs), f.XXXII).

As mentioned before, one of the main jobs of the carpenters was to make centrings, which are the formworks used in making arches and vaults. Centrings were used in the chapel and in the first level from 1381 to 1389 (ADG. Works, 1374 - 1384 (costs), f.70). Carpenters' wages were similar to those of the master stonemason, and were often paid for job done, including the materials.

The carpenters also did minor jobs, such as making and repairing the doors of the tower, or building banisters. At the end of April, 1381, Berenguer Serra was making the doors of the spiral staircase (ADG. Works, 1374 – 1384 (costs), f.69).

In one particular case, already mentioned in the section dedicated to the Masters of Works, Botet, a carpenter, is recorded carrying out the duties of Master of Works of the tower. This carpenter, the same as any master of works, had his apprentice who helped him (ADG. Works, 1365 – 1391 (costs), f.XXVv and XXXVIII).

Sometimes, the carpenters bevelled the wood in its place of origin, as happened with the wood destined for the winch – an elevating device – in 1387 (ADG. Works, 1365 – 1391 (costs), f.XXXVIII). described...

Blacksmiths

The blacksmiths, when working on the construction, did not work on site, but had their own workshop where they repaired the tools used on site, and made new ones. They also had to have tools ready so the stonemasons could work the stone. They also made nails for the scaffolding. The blacksmith was paid for job done, not for days worked.

The tools had to be constantly repaired, since they were extremely prone to being worn down and were often damaged. The blacksmith was responsible for reinforcing these tools with steel and iron, and for operations destined to hardening the iron in the tools, such as *bulir* (boil) and *loçir* (sharpen). When a tool was sharpened it was often necessary to add new iron, because of wear (ADG. Works, 1365 – 1391 (costs), f.XXVIv).

Expenses generated by this group of workers are extremely variable, since they depended a lot on the job and the amount of work to be done. They were recorded repairing one single tool, repairing several tools, making nails, etc.

Ironsmiths also had to boil the wedges used by the stonemasons to break the blocks of stone at the quarry. In many cases, wedges were made of oak wood, which had been soaked to make them dilate. Blacksmiths were also responsible for repairing the cart which transported material from the quarry to the site.

MATERIALS

Introduction

The most important material used in the construction of the tower was the stone. Medieval buildings were built with stone blocks held together with lime mortar. The stone was extracted from the quarry, where a first cutting of the blocks was made. These were then transported to the work site to be cut more precisely. The lime used to manufacture the mortar was slaked at the work site in large pools of water.

The second most important material was wood, not so much in the construction itself - except in scaffolding and formwork - but in the execution of temporary structures, such as the fortification of the tower. The wood was supplied by private individuals and transported overland to the site. Sometimes this timber would have to be stored in stacks at the work site before being used.

There is a wide variety of other materials found in the building records, mostly of minor importance in the construction of the tower, for example, nails, spikes or staves and ropes. Some of these materials are bought far from the city of Girona. Not all the materials used were new; the records mention materials recycled from the hospices.

The stone

The tower was built with Girona stone, which is a microcrystalline nummulitic limestone from the Middle Eocene period (Lutecian), grey in appearance and typified by the fossilised nummulites (*foraminifera*) ranging from 0.5 to 6 cm in diameter. It is a compact, coherent and relatively homogeneous stone, composed of calcite (83%), dolomite (2.5%), feldspar (9.5%) and quartz (5%). The important thing about this stone is its low open porosity, its low and relatively slow absorption capacity, a slow rate of drying, a high resistance to compression and a medium modulus of elasticity (Esbert, 1989).

The quarry where the stone was extracted may have been owned privately - perhaps by the stonemasons who worked on the tower - or belonged to the project. In the building records, we have found references at the quarry to Guillem Bofill and two men named Barrera and Bassa. The only quarry that can be situated physically - at the Pedret fountain - is the quarry owned by the Provosts of December of the bishopric of Girona (ADG. Works. 1374 to 1384 (costs) ff. 64 and 84v).

With regard to the stone, the records always specified the type of stone being transported, hewn, cut, polished, and so on, as well as where it was placed. We will cite some of these entries to show the great variety that existed.

In October, 1368, the records mention the embankment stone (*alambor*), which is the type of stone placed at the sloped base of the tower. In this case, the wall is set at an angle of over 90 degrees with respect to the soil. One of the faces of the stone, the exterior one, could not be cut like the others because it did not form a right angle (ADG. Works. 1365 to 1391 (costs) f.XXXIIIv).

Also mentioned are the curved stones used to construct the ogival arches and, at the beginning of 1381, the stones that made up the *formerets*, or ribs of the vault (ADG. Work, 1374 – 1384 (costs) f.84v).

Peres de fil (thread stones) were relatively small blocks, less than 25 kg, which made up lines (threads) of stone along the walls. In June, 1380, they were priced at 3 sous per *cana* (ADG. Works. 1374 to 1384 (costs) f.46).

Along with these "thread stones", there was the occasional mention (in 1380, for example), of *peres de caragoll* (snail stones) destined for the spiral staircase. They were also known as *bombarda* stones (ADG. Works. 1365 to 1391 (revenue) f.LIIIV). These stones were more expensive than the thread stones (costing 4 sous per *cana*), as they had to have a rounded shape. Along with these pieces, and in the same location, the records refer to the large single blocks that made the steps of the spiral staircase. In mid-May, 1381, these stones cost 10 sous each (ADG. Works. 1374 to 1384 (costs) f.60).

Finally, the last example we wish to cite is the *vousoir* stones cited as *volsas previs* and *volsas magnis*, and sometimes as *volsorus*. These were wedge-shaped stones used to form the curved part of the arch (*architraves*) of the doorway; they were also, therefore, curve-shaped stones (ADG. Works. 1374 to 1384 (costs) f.60v). The terminology for working the stone includes *escalabomades* (hewn) or *boscades* (rough cut), where only the initial approximate shape of the block was hewn, while the *brocades* (fine cut with picks) had been worked on more carefully (ADG. Works. 1365 to 1391 (revenue) f.XXXV and LVIV44).

Wood

Wood was essential for making the auxiliary equipment needed for construction. All the scaffolding, the formwork, the centrings supporting the arches and vaults under construction and moulds were made of wood, as well as parts of the machinery and tools.

Many kinds of wood were used: fir, *poulegas*, oak, chestnut, walnut, olive tree, or white poplar, alder, holm oak, and so on. The most valuable wood was oak, for its great strength, which was bought per unit - the rest were bought by the dozen. The price of oak varied depending on width of the pieces, but it is impossible to establish a unit price because width was not specified in the records. Only two references are recorded, in 1382, but these refer to length (ADG. Works. 1374 to 1384 (costs) f.67v and 68)

We found one case - in 1387 - in which it was specified that a beam with perfectly planed sides was to be used, although references to the finished version of the wood are rare (ADG. Works. 1365 to 1391 (revenue) f.XXXVII). Usually, the material that arrived was non-planed, sawn pieces of wood (ADG. Works. 1374 to 1384 (costs) f.35v).

Sometimes there was no need to buy wood because it was obtained by other means, for example, in October 1368, when wood from buildings purchased by the Chapter was re-used. Among the individuals who sold wood, there is mentioned one Pere Mascarell from the village of Campllong. It is mentioned in some cases that the wood was bought unprocessed (ADG. Works. 1365 to 1391 (revenue) ff.XXXIIIv, XXXV, XXXVIv and LIIIv).

Agglomerates: mortar, lime and sand

Lime was measured in *quarteres*. Lime and sand were transported together. The lime is the most widely used material, after stone. Lime was much more expensive than sand. At the end of 1379, lime cost 10 *diners* per *quatera* (ADG. Work. 1374 to 1384 (costs) f.41v), while sand, at the beginning of 1381, cost 1 *diner* per *somada*. The cost of transporting lime was twice that of the sand.

The lime, once it arrived, was slaked in a pool at the worksite. There are some references to how the lime was mixed to produce the mortar (ADG. Works. 1365 to 1391 (revenue) f.XXIIIv). The lime was usually bought from one of two lime producers (*calciners*), Bernat Julià and Llorens, although sometimes it was produced in the cathedral kiln and then transported to the tower. In addition to the Cathedral kiln, and those of Julià and Llorens, another lime kiln belonging to the project itself is mentioned (ADG. Works. 1374 to 1384 (costs) ff.5, 38, 48 and 67v), along with another called *el forn del Carme* - Carme's kiln (ADG. Works. 1365 to 1391 (revenue) f.LVIv).

When the lime was mixed with quarry refuse and other materials, in order to fill in the sides of the *vousoirs* in the vault (1388), the records mention the word *crespy*. This *crespy* is mixed by roof-tile (ADG. Works. 1365 to 1391 (revenue) f.XXXVIIIv).

Sand for the mortar was of two types: large grain and fine grain. Mortar made with fine grain sand was better quality. It is not known if all the sand came from the nearby River Onyar (ADG. Works. 1374 to 1384 (costs) f.51 and ADG. Work. 1365 to 1391 (revenue) f.XXXIII).

The word *morter* (mortar), in fact, rarely appears in the records; the synonym *argamassa* was used instead. The word *morter* does not appear until July, 1369 (ADG. Works. 1365 to 1391 (costs) f.XL).

AUXILIARY MEANS

Introduction

The auxiliary means include the tools, the machines, the formwork and the scaffolding that make it possible to complete the work. The building records provide us with a good deal of information about the formwork, the scaffolding and the tools used in the construction of the church tower. The information on the lifting devices is scarce, since it only regards maintenance, but it is important enough to give us an idea of the *machines* used. The interest in medieval techniques has led many scholars to analyze the auxiliary means used in the construction at that time. Among the sources used for this study we can highlight the *Quadern* of Villard de Honnecourt and, most importantly, the miniatures where these machines are depicted. Among the secondary sources we could highlight the very interesting studies pursued by A. Graciani (1991).

In the majority of cases tool repair is mentioned, not tool purchasing, since the tools, especially those made of iron, were expensive and very variable in price (ADG. Works, 1365 – 1391 (costs), ff.XXX, XXXIIIv and XLVv). All the formwork and scaffolding were made from wood joined together by cords or nails. The type of wood most used for this purpose was fir. The moulds and the templates to make stone parts were also made of wood.

Tools

We will group the tools into different categories: tools meant to transport materials by hand, tools used by the stone masons, tools meant to handle lime and tools to perform a variety of other tasks.

The group of tools meant for material transport includes two-handled baskets, made from woven esparto (ADG. Works, 1365 – 1391 (costs), f.XVII), the *covens d.aloch* (type of shrub) and the *senayes*, wide-mouthed baskets of esparto as tall as they were wide (ADG. Works, 1365 – 1391 (costs), f.IIIv). Also belonging to this group is the oak *civeria* (stretcher), a tool made entirely of wood with four handles (for two workers), used to transport small-sized material (ADG. Works, 1374 – 1384 (costs), f.50).

The tools designed to transport liquids to prepare materials or to quench the thirst of the workers should also be mentioned. Used for the transportation of liquids – and for the lime – was a *semal*, a half barrel-like container reinforced with metal hoops, because if not it would likely break apart. To supply water for the workers buckets, cruets and cups were used (ADG. Works, 1374 – 1384 (costs), ff.33, 49v and 88v).

The second large group of tools includes those of the stone masons. Within this group we can distinguish those used in the quarry and those used at the worksite, although some were used in both places. Among the tools meant for working in the quarry we have included the wedges of iron or wood, essential for cutting blocks of stone. In addition to the wedges, at the quarry there were sharpening stones to sharpen the stone tools. The price of the sharpening stones varied from 2 to 5 sous, certainly according to the type and the size (ADG. Works, 1374 – 1384 (costs), ff.32 and 35). Other tools used exclusively in the quarry are the *piquerola* and the stone-cutting hoe, which was used to break the stone when the precise shape was not too important (ADG. Works, 1365 – 1391 (costs), f.XIXv).

The club was a tool that could have various shapes; it could be made of iron or of wood and it was used both in the quarry and at the worksite. Many references to repairs made to clubs can be found, and there is a record of one having been bought (ADG. Works, 1374 – 1384 (costs), f.34). A tool associated with the club was the hammer. Other tools used by the stone masons are picks, bush hammers and choppers. The bush hammers must have been used constantly, since many of them are recorded as being bought or repaired (ADG. Works, 1365 – 1391 (costs), f.XXXIVv).

Among the tools used less often by the stone masons we can find squares and rulers (ADG. Works, 1365 – 1391 (costs), f.XXXVI) and the *perxa*: a wooden pole used to take measurements. This last tool is referred to later as a ruler (ADG. Works, 1365 – 1391 (costs), f.XLIIIv).

Among the tools used to handle the lime we can find sieves (also used to sift sand), *espaedoras* for the lime that must be slaked and troughs to make mortar (ADG. Works, 1365 – 1391 (costs), f.XVIIv and LVv). An *espaedora* was a recipient to slake the lime in small quantities.

Sometimes the workers themselves improvised to make tools to perform specific tasks. On 7 October 1383 a wooden box was made to carry stones to the top of the vault of the chapel of the church tower (ADG. Works, 1374 – 1384 (costs), f.88v).

The cost of the tools varies greatly. Sometimes there is variation because the recipients are of different capacities; thus, for example, the baskets cost between 3.50 *diners* and 8 *diners* each, and the wooden spade cost 8 *diners* in 1374 and 6 *diners* in 1379 (ADG. Works, 1374 – 1384 (costs), f.36v and 85v).

Machines

One of the machines used in the construction of the church tower is the windlass. Here we must proceed carefully, since windlass sometimes refers to the mechanism used to ring the bells. The windlass was a device used especially to lift and haul materials (ADG. Works, 1374 – 1384 (costs), f.1v).

At the end of June 1379 we find a series of expenses for the construction of a hoist, a device to raise heavy weights, which was of a wooden structure made from two supporting beams and an elevating device (a pulley and ropes made from esparto). The expenses refer to the purchase of the wood and the nails necessary to build the hoist. Later the purchase of fir wood to make the bars of the hoist windlass is mentioned. The hoist was transported from the quarry to the worksite at the end of 1380. This was certainly exceptional, because the hoists were needed both at the quarry and at the worksite and, therefore, there must have been several of them (ADG. Works, 1374 – 1384 (costs), ff.33v, 34 and 48).

Mentioned among the large machines used in the construction of the tower is the winch. This was a vertical drum windlass used to lift heavy weights. It was disassembled on 10 March 1384 (ADG. Works, 1374 – 1384 (costs), f.91v) and was reassembled at the worksite on 14 April 1388. The winch would be disassembled in April 1389, when the work on the second level of the church tower was completed (ADG. Works, 1365 – 1391 (costs), ff.XXXVv, XXXXI, XXXXIV and LIIv). Like the other machines, the winch needed to be maintained to guarantee proper functioning and safety at the worksite. One of the tasks performed regularly to keep it in good working order was to spread animal fat all over it. It was very important to keep the winch, as well the other lifting devices, perfectly lubricated to attain good performance (ADG. Works, 1365 – 1391 (costs), ff.XXXIIv and XXXXVIII).

Scaffolding

The expense records specify the places where the scaffolds were to be assembled. In April 1381 one was assembled to continue building the walls of the church tower (ADG. Works, 1374 – 1384 (costs), f.68v). In the building records the scaffolding appears as *bastiments* or *bastimenta* and on rare occasions as scaffolding (ADG. Works, 1374 – 1384 (costs), f.3).

Each level of the scaffolding was built as if it were a dwelling, since it was made of wooden beams and slats (*tagel*) upon which a wooden platform was placed (ADG. Works, 1374 – 1384 (costs), f.39v).

The various elements that made up the scaffolding were sometimes joined together with nails, not cords, because they were very tall and stability and worker security were improved in that way. The stability was also improved by anchoring the different parts of the scaffolding (ADG. Works, 1374 – 1384 (costs), f.3).

Although not exactly a scaffold, we must mention the wooden bridge between the church tower and the church (1382). It was a horizontal platform that made it easier to work at heights (ADG. Works, 1374 – 1384 (costs), f.80v).

Formwork

In the building records the formwork that appears most frequently is centrings, which were used for the stone arches and vaults. The words *encindries* and *bastiments* are used to describe work on the vaults. The first would be the centrings while the *bastiments* would be their vertical element of support; they were made of wood and the various elements were joined together with nails (*clauels* of different size) and pieces of iron. We find explicit references to the place where this scaffolding was assembled, such as 1381 when the frames – the ribs – of the chapel under the church tower are made (ADG. Works, 1374 – 1384 (costs), f.48v i 51v).

In addition to the centrings, the stanchions or uprights, which would be like *bastiments*, are also scaffolds. The building records include the word *jamás*. They are nothing more than wooden supports placed at the extrados of the wall to support the centrings. A synonym also appears: pine props (ADG. Works, 1365 – 1391 (costs), f.XXIIIv).

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