

The Gothic Ribbed Vault in Rodrigo Gil de Hontañón

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In vaults of Roman and Italian style, of which groins are without ribs, the vaulting surface is the leading feature, and the disposition of it the only object to be attended to. But in Gothic ribbed vaults, on the contrary, the ribs are the principal feature, and the vaults subordinate.

R. Willis: On the construction of the vaults of the Middle Ages. 1842

This presentation aims at illustrating the comment made by R. Willis when reviewing the work of one of the most important Spanish architects of all times: Rodrigo Gil de Hontañón. We intend, too, to show how in the sixteenth century, a period in which the Spanish Gothic was at its summit simultaneously with Renaissance, the Gothic vault was able to develop a great number of vaulted surfaces.

After the spectacular designs of its ribbed works, one finds some stone shells compared with which the classic French vault in crossed ribs becomes too primitive. Gothic style has evolved, and, not only in its multiplied ribs but also in its capacity to design and build new vaulted surfaces: the creation and construction of these surfaces is only possible through the geometrical control of its ribs; it relies in the capacity to create a spatial net on which to lay the vault surface.

Nobody believes nowadays in having to resort to the rib as structural element, but it proves to be indispensable to control the folds of the different lays which build up the vault surface. Beyond that appreciation, we could affirm that what is absolutely mandatory is to know precisely its axis, the line it describes. With this line the centrings on which to lay temporarily the vault's panels will be built; the stone or brick rib may no longer exist since they are irrelevant from the structural or constructive point of view.

Nevertheless, from the aesthetic point of view, the Gothic vault will be nothing without the ribs. Already in Romanesque style appears a creative impulse which consists in underlining with ribbed work the fold lines of the vaults and results in an endless multiplication of the ribs and, in late Gothic, in vaults as spectacular as the ones we will review now: Our analysis is not aesthetic or formal, but, on the contrary, it shows that behind that stunning decorative work there are some extraordinarily intelligent vaulted surfaces that follow the principle: to attain the greatest formal complexity with the greatest simplicity and standardisation.

LEVELLED RIDGE RIB VAULT

Cathedral of Salamanca - Vault on the central aisle

Here we deal with one of the most important vaults in Spanish Gothic. From a span of almost 13 metres length, the central boss reaches 8.00 metres high from the impost plan and is 35 metres high from the floor plan. It is built with 9 metres wide rectangular compartments. In the proportions rule recommended by Rodrigo Gil himself each compartment is a rectangle *sesquialtero*, that is with a 5/4 proportion (picture in **fig. 1**)

Each compartment is covered by a vault with a stellar system of ribs. The drawing of its ribbed work is formed with the two transverse arches, double tiercerons in the main axis direction and simple tiercerons in the minor axis. As you can see (**fig. 1A**), the main tiercerons' bosses are placed in the very middle of the semi axis; the rest of the ribbed work fits perfectly in an 8x4 pattern and the remaining bosses, 2 and 3, are obtained by alignments from boss 1. The subsidiary ribs form four conopial lobes which in the longitudinal axis end up in the boss of the first pair of tiercerons. The circular rib next to the boss enhances the central design of the vault making it somehow classic.

In **fig. 1B** the drawing of the arches has been carried out. First and in order to set a framework of reference, in elevation, a semicircular arch has been drawn with the same span as the diagonal rib. Subsequently, in the drawing, the real height of the central boss has been set: 8.00 metres; we realize that the keystone is 35 centimetres higher than the semicircular arch we had set as reference.

Then we have proceeded to perform the drawing of the arches. First, we verify that the diagonal arch is a semicircle; taking into account the height of the boss, the springing of this arch should be 35 centimetres above the impost plan. The diagonal arch might be not semicircular, but a slightly pointed arch. As it is so difficult to ascertain precisely this aspect, we have considered the first option as the most probable, that is to say, the ogival arch is a segment of a circumference raised 35 centimetres upon the impost level. Besides, this option is totally justified from a construction point of view: let us just recall the thickness of the wooden boards that enabled to build the vaults. The arch itself would spring from above this board.

Further on, with real life measures, the two axes' elevations have been drawn, showing the ridge ribs or liernes. We verify that, in the former arches, the ridge line is slightly downwards, about 50 centimetres, while the pitch of the ridge rib towards the transverse arches is less steep. These curves allow us to situate the heights of the tiercerons' bosses, so we can proceed to draw these arches. As we can imagine, ridge lines as the ones represented here will generate an extremely levelled vault.

We should know that the arches designed are those which describe the contact lines between the surface of the vault and the *intradós* of the rib. By some appropriate geometrical constructions, have been drawn, successively, the transverse (arch 6), the former (arch 5) and the three tiercerons, (arches 2, 3 and 4).

We immediately verify that there are coincidences in the curvature of these arches, such as between the transverse, the tierceron of the minor axis 4 and the semi circumference of the ogival arch, all coincidental in the same arch. Besides, with a different curvature, the former and the tiercerons 2 and 3 are also coincidental. In short, we could say that the whole vault could be built with only two different arches; obviously, this type of coincidences is deliberate, since they can largely simplify the construction of the vault.

When the diagonal semi circumference is used, as it is the case when drawing the ribbed work (tiercerons, former and transverse arches), the result is unfailingly a levelled ridge rib vault. Those coincidences in the arches' curvatures are not fortuitous, but they aim at simplifying the number of different arches; therefore, we can conclude that the constructive criteria of rationality and simplification have essentially determined the former arches.

In **fig. 2** we can see a volume reconstruction of this type of vault, showing the horizontal feature of the ridge lines in the two main sections of the vault. You can see as well the bosses which, according to Gothic patterns' canon, follow a vertical axis.

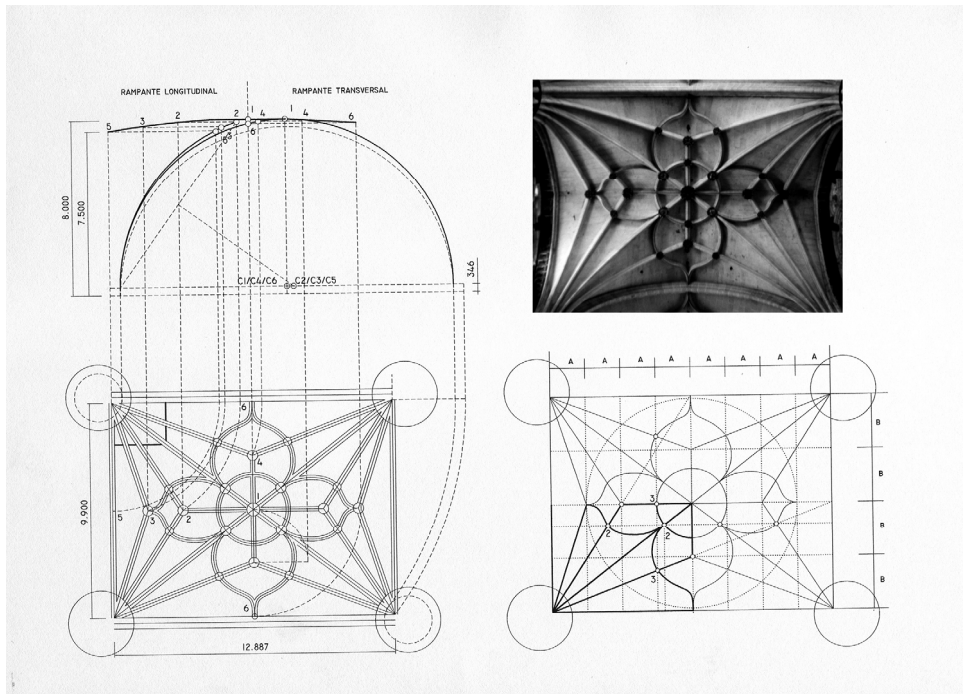


Figure 1. Salamanca cathedral, picture of the vaults which cover the central aisle; A, drawing showing the pattern to establish the design of the nervatures; B, Plan and elevation of geometrical method followed to obtain the curvatures of the ribs. Conclusion: only two different arches are needed to build the vault.

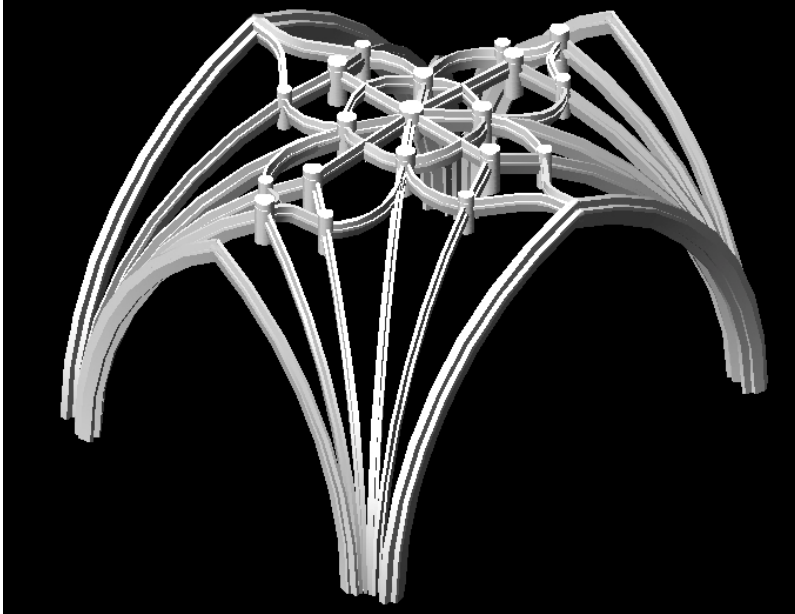


Figure 2. Three dimensional reconstruction of a vault in the central aisle of Salamanca cathedral in which one can notice the flat level of the ridge.

VAULT OF “*RAMPANTE REDONDO*”

Cathedral of Segovia - Vaults over the central aisle. Rodrigo Gil de Hontañón

The cathedral of Segovia is the last one of our Gothic cathedrals; the beginning of its building goes back to the second half of the sixteenth century. It coincides with that of the Real Monasterio del Escorial. The vaults over the central aisle, having a 13.74 metres of span and a 10.18 metres wide compartment, design some rectangular sections of *sesquitercia* proportion, that is to say a 3:4 rectangle. Needless to note here the enormous symbolic content of this proportion which, once and again, is present in architecture from the most ancient times (Picture in **fig. 3**).

The drawing of the tracery is a new version of the Castilian quatrefoil. Here, the two lobes situated on the main axis are conopial, while the other two are circular. In the centre there is a rhomb with broken sides whose vertices are placed on the four bosses of the tierceron ribs.

The tiercerons are placed on the bisection of the angle made up by the former and the transverse arches, and their bosses are on the axes. Boss 4, on the lower side, is the centre of the circumference of the transverse arch and the distance between these two bosses, when splitting up in four segments, allows us to locate bosses 5 and 6 with which the whole drawing is established (see **fig. 3A**). The mid point of the rhomb sides seems to be a consequence of the alignment of these bosses.

When, based on the basis of their actual measures, we reconstruct the elevation of the curve of its arches, one can appreciate Rodrigo Gil's intention to set criteria of rationality and standardisation (see **fig. 3B**). As in the vaults in Salamanca cathedral, the two tiercerons and the transverse arch are the same, while the two arches, former 4 and cross rib 5, constitute a different arch.

The diagonal arch 1 is, in fact, a precise semi circumference; the bosses of the two tiercerons, 2 and 3, are situated exactly on the curvature of this arch; therefore, they are portions of it. The other arch, with its centre C4, C5, allows us draw the former and the big transverse arch; when reconstructing it, we notice that its centre seems to be precisely at 1/10 of its span, next to the vertical axis; this might have been the criterion when choosing its curvature. It is an important arch which shapes the whole aisle; therefore, its form may have been carefully selected.

In a three-dimensional reconstruction of the vault (**fig. 4**), we can see more accurately the roundness of the vault designed by Rodrigo Gil, which, built in his maturity period, can be considered as a real prototype. In the detailed picture, one can appreciate the “twist” of its ribs and bosses, with its strictly vertical axes and, consequently, different, according to the position they occupy.

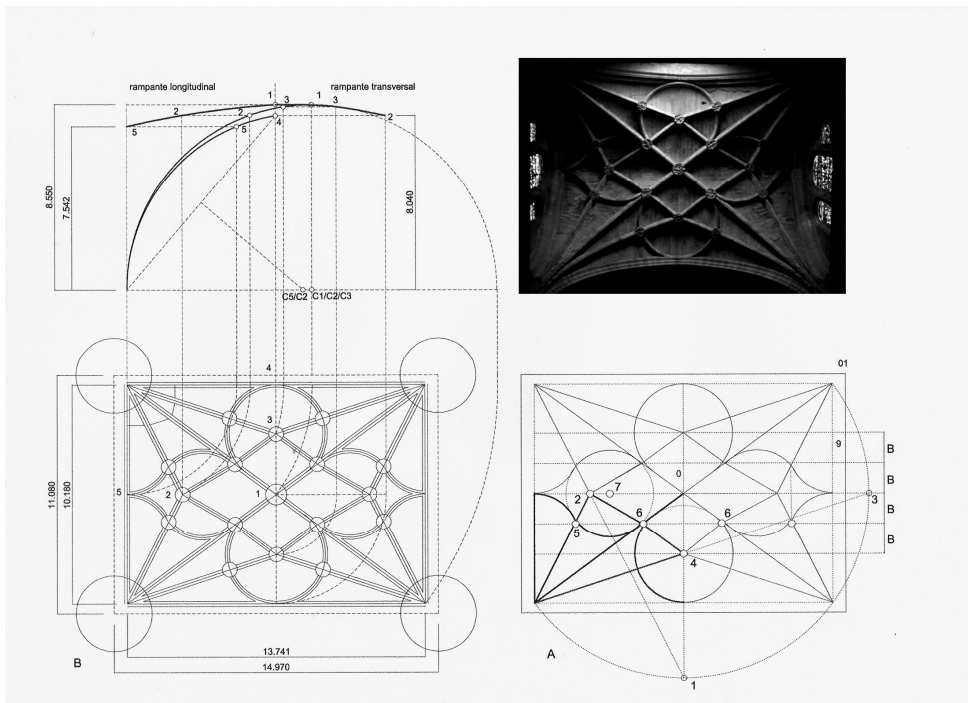


Figure 3. Segovia cathedral, picture of the vaults which cover the central aisle; A, drawing showing the pattern to establish the design of the nervatures; B, Plan and elevation of geometrical method followed to obtain the curvatures of the ribs. Conclusion: with only two different arches the vault can be erected.

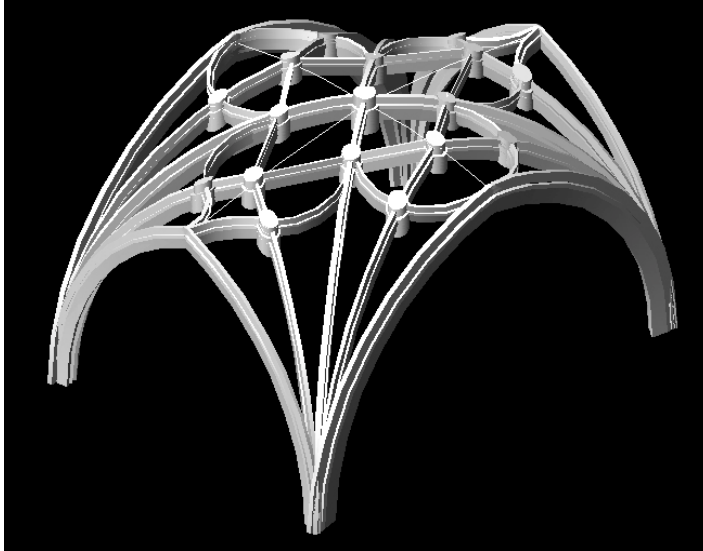


Figure 4. Three dimensional reconstruction of a vault in the central aisle of Segovia cathedral in which we can notice the curvature of the ridge line.

THE SPHERICAL VAULT (“*EN LA BUELTA DE LA DIAGONAL*”)

Rodrigo Gil is the designer of one of the drawings that, without exaggeration, can be defined as one of the most important in Europe (**fig. 5**). It represents the only case in which the construction of a ribbed work vault is explained in detail; it is the only witness from the 16th century which tells us the difficulties entailed by the building of this type of vaults. It is needless to go here through the various details the author himself analyses; let us just say that the most important part of the drawing is the elevation of the great semicircular diagonal arch.

Nevertheless, this big arch is not only the drawing of the diagonal arch, as it has traditionally been thought. The lower right half of the arch represents, in fact, the diagonal arch up to its keystone; in this portion, we see how the central boss and a secondary one are inserted, while, in the upper left part, the arch represented is the ridge line or *lierne*. In order to draw this curve, previously, in plan, the horizontal projection of this line has been turned, and then, an elevation has been done. The ridge line used by Rodrigo Gil turns out to be an extension of the diagonal semi circumference, so the *lierne*, and, thus, the whole vault is built “*en la buelta de la diagonal*”, using Rodrigo Gil’s own words, that is to say, with the same curve of the diagonal: the half-centred arch.

But, if both the diagonal and the ridge curvature are semi circumferences, the vault needs to be a spherical shell. We mean that the vault shown and recommended by Rodrigo Gil is spherical, or, preferably, a pendentif vault built with nervatures.

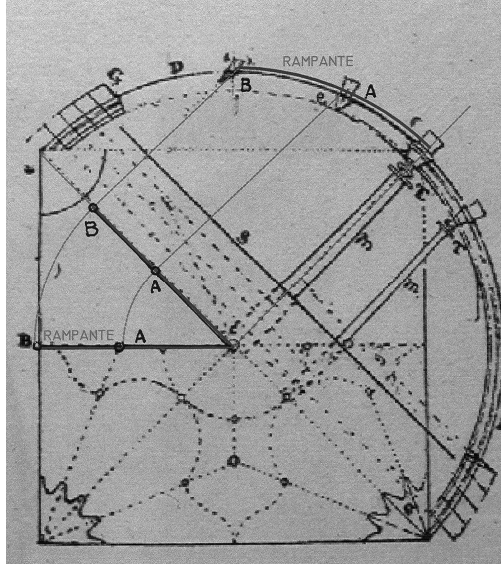


Figure 5. Drawing of Rodrigo Gil showing the construction of a ribbed vault. In the lower half, the elevation of the diagonal rib and, in the upper half, the elevation of the ridge rib obtained by transferring from the plan.

Conclusion: the coincidence between the diagonal and the ridge rib means that it is a spherical vault.

Cathedral of Salamanca. Ambulatory: chapel of Santo Cristo de las Batallas. Juan de Ribero Rada 1525-1600, on drawings by Rodrigo Gil (?)

Although the construction of the cathedral of Salamanca finished in the ambulatory at the end of the seventeenth century, it is widely recognised that this part is the result of the design and impulse of the architect Ribero de Rada, who is also known as being deeply respectful of the work done by his predecessors in the fabric: the Hontañón architects.

As a proof of his respect for the teachings of his predecessors, we propose the study of this chapel's vault which, as we will soon ascertain, turns out to be, not only in the laying of its ribbed work but also in its volume, the vault explained by Rodrigo Gil (Picture in **fig. 6**).

We face a quite rectangular chapel in which, besides the crossing of ogival arches, there is a set of tiercerons in each direction, a central circle and a quatrefoil. The drawing of this nervature is notably similar to the vault explained by Rodrigo Gil; as can be seen in **fig. 6A**, the bosses of the tiercerons are placed in the middle of the lierne ribs, while the position of the other secondary bosses is in alignment with the bosses generated by the central circle.

When drawing the curvatures of the arches (**fig. 6B**), we realize that, for the diagonal to be a semicircular arch, it must be raised upon about 56 centimetres upon the impost line, aspect that can be perceived at first sight. Once done the measuring, is drawn the curvature of the ridge lines which

coincide with the diagonal semi circumference, resulting in a vault completely spherical. Then, on drawing the tiercerons 2 and 4, we see that both are coincidental in an arch whose centre, C2/C4, is situated on the impost line; both tiercerons have, therefore, identical curvature. Lastly, when we design the two former arches 3 and 5, we realize they are two semi circumferences, also raised.

Thus, this vault is a faithful representation of the principles advocated by Rodrigo Gil. **fig. 7** shows its volume and in it we notice some interesting details which draw this vault closer to the theoretical model of Rodrigo Gil. We are referring to the form of the bosses. As shown in the detailed representation, the bosses are orientated towards the centre of the vault, just like the bosses drawn by Rodrigo Gil. Finally, let us observe the impeccable masonry of the panel work (Photo, **fig. 6**) placed, following the French way, as a groined vault. Let us recall that, being a spherical vault, most logically its masonry should have been by circular courses.

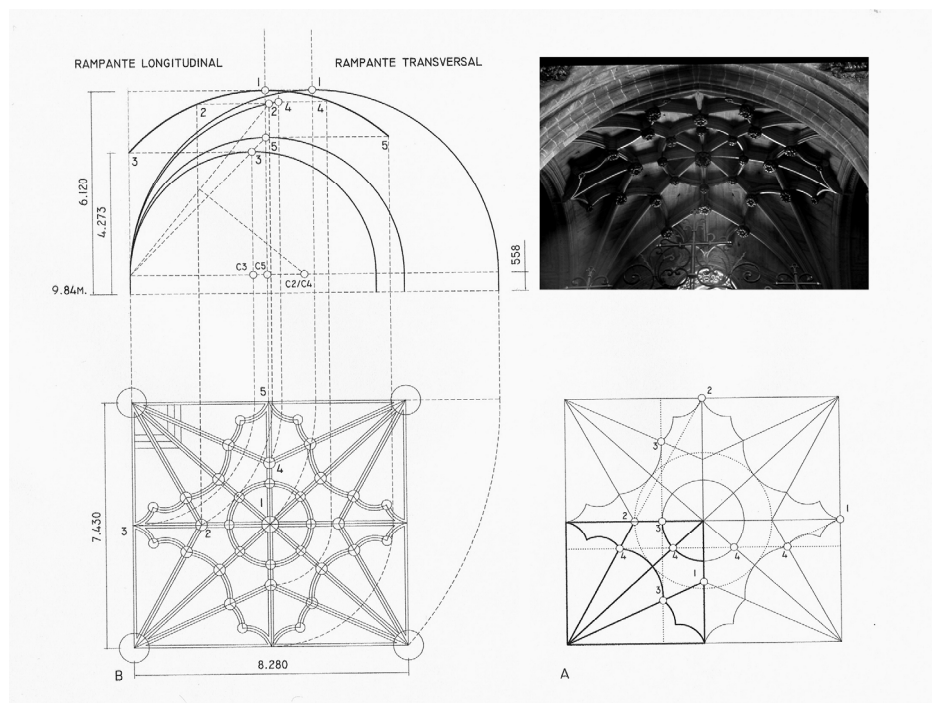


Figure 6. Salamanca cathedral, picture of the vault of one of the chapels in the ambulatory; A, drawing showing the pattern to establish the design of the nervatures; B, Plan and elevation of geometrical method followed to obtain the curvatures of the ribs. Conclusion: it is a spherical vault slightly raised from the impost plan.

OVAL RIBBED VAULTS

Cathedral of Segovia. Vaults in Sacristy chapel. Rodrigo Gil. 16th century

Although the oval ribbed vaults seem to be more present in Andalusia, the Castilian region is not deprived of this type of vaults, of which a good example is the Sacristy in the Cathedral of Segovia

(picture in **fig. 8**). This imposing chapel, which must have been one of the last contributions by Rodrigo Gil to this cathedral, is perfectly documented and even its original drawings are preserved.

The sacristy is covered by three rectangular vaults of *sesquicuarta* proportion, that is to say 4:5. The drawing of its nervature consists of two diagonal ribs and a pair of tiercerons in each direction. On this plan is superimposed a design of secondary curved ribs which form one of the characteristic quatrefoils of the Hontañón; its leaves form an ogee towards the main axis and are circular in the minor. The centre is occupied by a polygon whose sides are concave and convex (**fig. 8A**).

The whole design, apparently complex, is established when subdividing the vertical axis in nine parts. As shown in **fig. 1**, the most relevant bosses and intersections find their position with this grid; the rest, such as the boss no. 6, is placed by alignments.

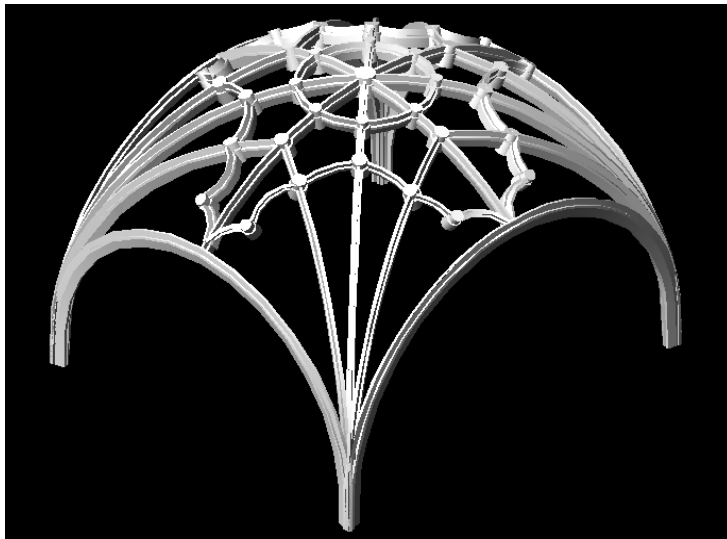


Figure 7. Three dimensional reconstruction of the precedent vault in Salamanca cathedral in which one can notice the domical shape of its shell, in fact, it is a pendentif vault.

To analyse this vault, it will be necessary to carry out a geometrical study, in plan and in elevation, of all its ribs (**fig. 8B**). Let us begin by laying the diagonal and draw, as reference, a semicircular arch; when transferring to the drawing the real height of its central boss, we realize that it remains lower than the one of the semicircular arch. Taking into account that in the springing all the vault arches are tangential to the vertical, the diagonal arch must be a three-centred arch.

Even with real measures, it is difficult to draw this arch with precision. We have drawn it on the basis of one of Serlio's ovals, the one of the equilateral triangles; thus, we have obtained the centres C1 and C1' and, with them, an oval which might well be the real one.

Then, being known the height of bosses 3 and 2, we have drawn the former and transverse arches. The former is a slightly pointed arch centred in C3, while the transverse is again an oval arch centred in C2 and C2'.

The bosses of the tiercerons 4 and 5 are determined by the curvature adopted by the ridge ribs; once the real measures are known, the ridge ribs have been drawn in both directions and also the heights of the bosses 4 and 5; with this information we can proceed to design these arches.

Given the height of these bosses and taking into account that both tiercerons spring tangential to the vertical, both arches should be portions of ovals. The regular drawing in Gothic construction as a whole leads us to think that it is, most likely, the same oval as the diagonal. Therefore, both tiercerons in their springing use the circumference centred in C1, with which was drawn the diagonal. Then, the other segment of the arch, centred in C1', is rolled over the circle C1 until it meets points 4 and 5; this action moves the tangent point T of the diagonal oval to T' in the new oval. Thus, both the diagonal and the tiercerons are drawn with identical curvatures and that largely simplifies the design of the vault.

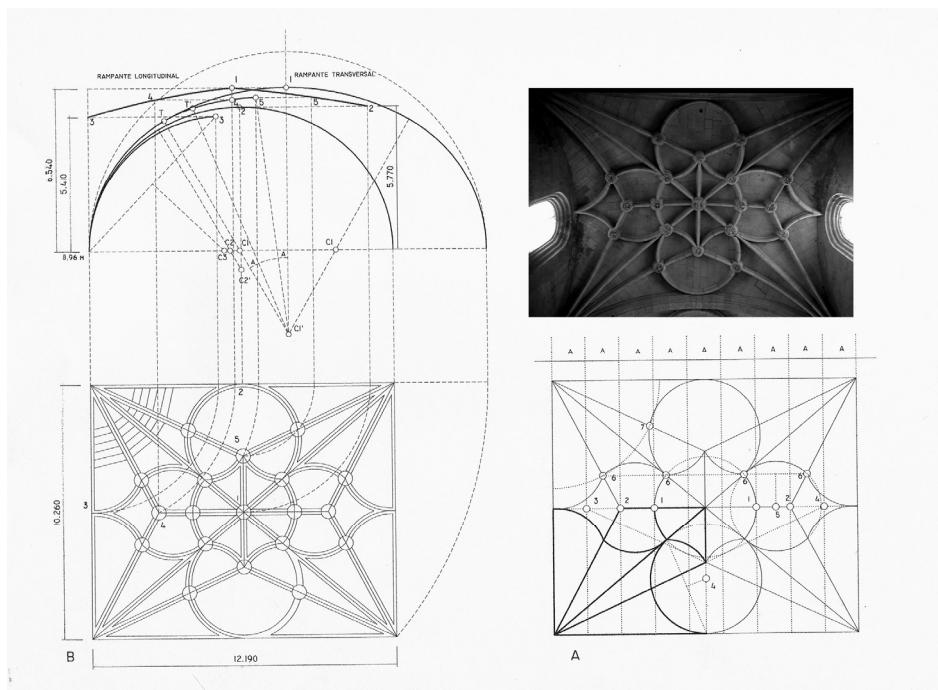


Figure 8. Segovia cathedral, picture of the vaults of the sacristy; A, drawing showing the pattern to establish the design of the nervatures; B, Plan and elevation of geometrical way followed to obtain the curvatures of the ribs, the diagonal rib is a three-centred arch from which the tiercerons arches are obtained.

The transverse arch is a three centred arch too.

It would be logical to think that standardisation of the ribs' curvatures entails placing the bosses at a precise height and, therefore, the curvature of the ridge ribs is a result of the strategy followed in the drawing of the ribs. **fig. 8B** shows the curvature of the ridge line in its main axis. In it have been drawn the panel courses which, unlike what is frequent in Spain, is laid out the English way, that is, by horizontal courses.

The three-dimensional study shown in Fig. 9 shows that our assumptions may have been correct, since the vault can be erected perfectly; the image shows very clearly the method chosen by the architect to carry out the vault. We can observe its transverse arches and vertical bosses, following the strict Gothic canon. In Fig. 9 one can see the grid of ribs which constitute the spatial shape of the sacristy. Finally what remains is to extend over them panels. The proximity of the ribs makes unnecessary the use of any kind of centring.

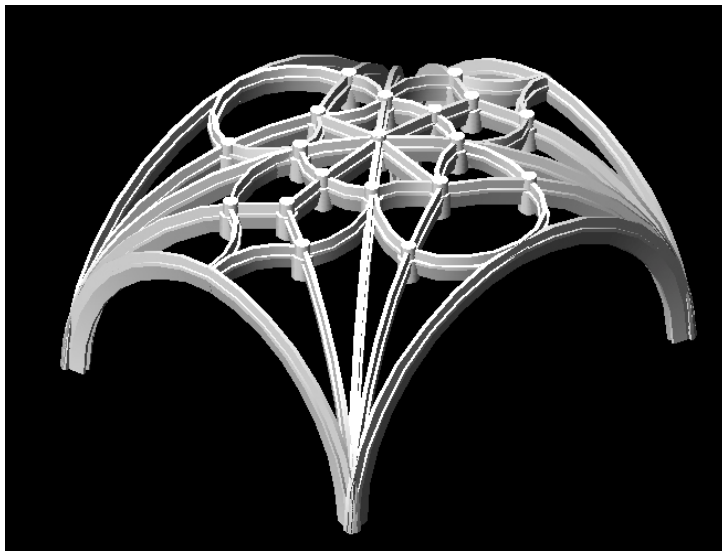


Figure 9. Three dimensional reconstruction of the precedent vault in Segovia cathedral in which is possible notice the particular shape of this oval vault.

LOWERED VAULT

Colegio mayor de Fonseca. Vault of the vestibule. Rodrigo Gil

The vault, attributed to Rodrigo Gil, covering the vestibule of the Colegio mayor de Fonseca in Santiago de Compostela is an example of the use of segmentary arches to build lowered vaults (picture in **fig. 10**).

We are dealing with a rectangular plan vault, moderate in dimensions (**fig. 10A**), displaying a traditional tracery, with its four pairs of tiercerons, its ogival ribs and a quatrefoil very much

appreciated by the Hontañón family. As we can see, the tiercerons are placed on the bissection of the angle formed by the ogival and former arches; the diameter of the central circle is a third of the length of the longer side of the vault, and, as it is often the case, the secondary bosses, with which the quatrefoil can be drawn, may be obtained by alignments.

Let us go on to draw the curvatures of each arch according to the measures of the vault taken (**fig. 10B**). We start off with the plan and, as usual, we begin by laying out the diagonal line. As we have done in previous occasions, a comparative semicircular arch has been designed using the span of this arch. Then, when introducing the real height of the central boss 1, we notice that it remains $\frac{1}{3}$ below the semicircular arch's height; that is, therefore, the measure of the lowered level obtained with this vault.

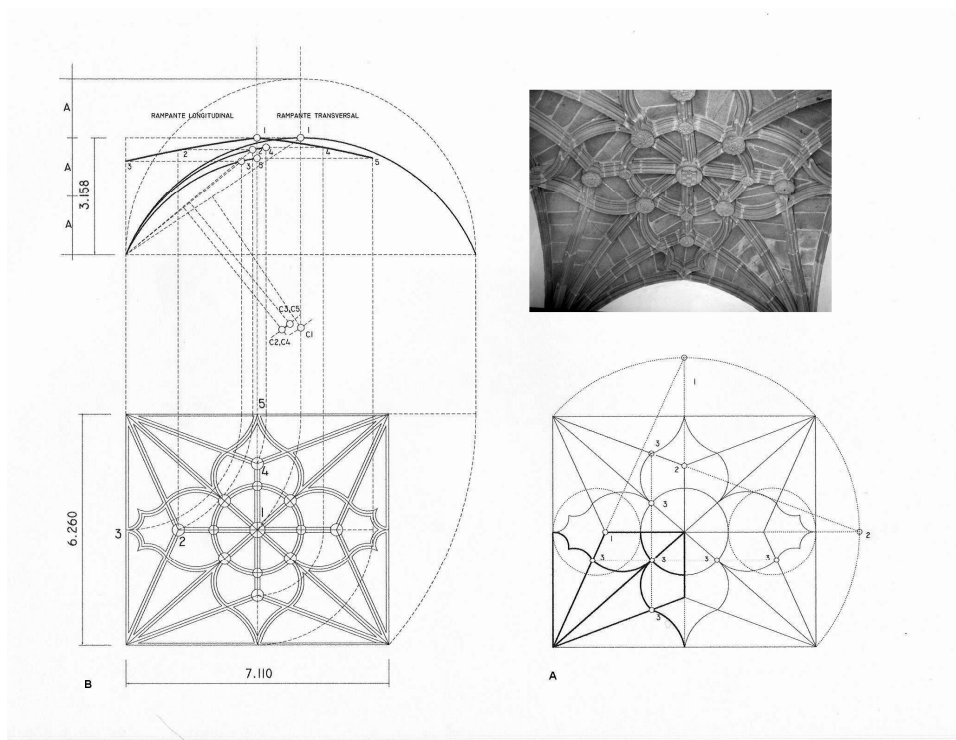


Figure 10. Santiago de Compostela, Colegio mayor Fonseca, picture of the vaults of the entrance hall; A, draw showing the pattern to establish the design of the nervatures; B, Plan and elevation of geometrical method followed to obtain the curvatures of the ribs, the diagonal rib is a segmentary arch, other arches are obtained with the same curvature by changing the position of its centres.

With the height of the central boss and the span of the diagonal, a segmentary arch centred in C1 can be laid out. To design the curvatures of the other arches we will resort to the method used in the vault referred to above, which, let us recall, consists in tilting the diagonal arch to reach the height of

each boss. Let us start with boss 4; its height is situated over the transversal ridge line; so, from the springing up to that point, we will lay out a segment of arch with the same curvature as the transverse arch; this one is centred in C4.

Then, we have done the same thing with boss 2, and, surprisingly, its height coincides with the curvature of the arch C4, which leads us to conclude that the tierceron 2 is actually a part of tierceron 4 and the centres C4 and C2 are coincidental; that means that both tiercerons spring with the same angle. Later, when designing the plan of former arches 5 and 3, we are faced with the same coincidence: former 3 is a segment of former 5 and both start off with the same angle. Summing up, the whole of the vault is built with just one arch, the diagonal; the tiercerons and former arches are just pieces of this arch. In their springing, both tiercerons set off with the same angle and so do the two former arches.

Fig. 11 shows the volume of the vault designed with these assumptions; we see how all its segmentary arches fit perfectly and create the spatial pattern which allows building the vault.

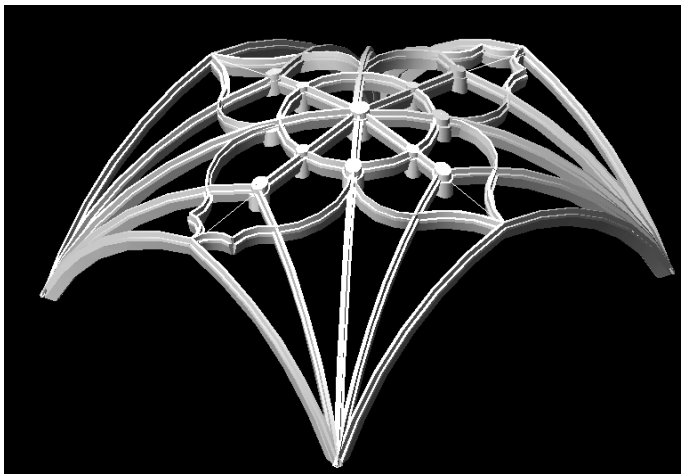


Figure 11. Three dimensional reconstruction of the precedent vault in Santiago de Compostela in which one can see the lowered shell obtained.

CONVEX VAULTS

Iglesia de San Martín. La Mota del Marqués, Valladolid. Rodrigo Gil 1540-1550

Rodrigo Gil is, undoubtedly, one of the most noted Spanish builders of all times; he planned large and important works, but also plenty of small parish churches mainly located in the Castilian region. In most of them, vaults are carried out by means of an elegant tracery in the form of a four lobed, the trademark of the Hontañón architects, always performed with a great variety of types and interesting hues.

In la Mota del Marqués, Rodrigo Gil and his assistants undertake the construction of a provincial church of substantial proportions. It is a three aisle church, the three at the same height. In the vaults of its central aisle, of square plan, we find once again the tracers' drawing so cherished by the Hontañón architects, a quatrefoil of pointed conopial leaves, but, when looking carefully at the shape of the vault shell, we realize that we are dealing with a most singular vault (Picture in **fig. 12**).

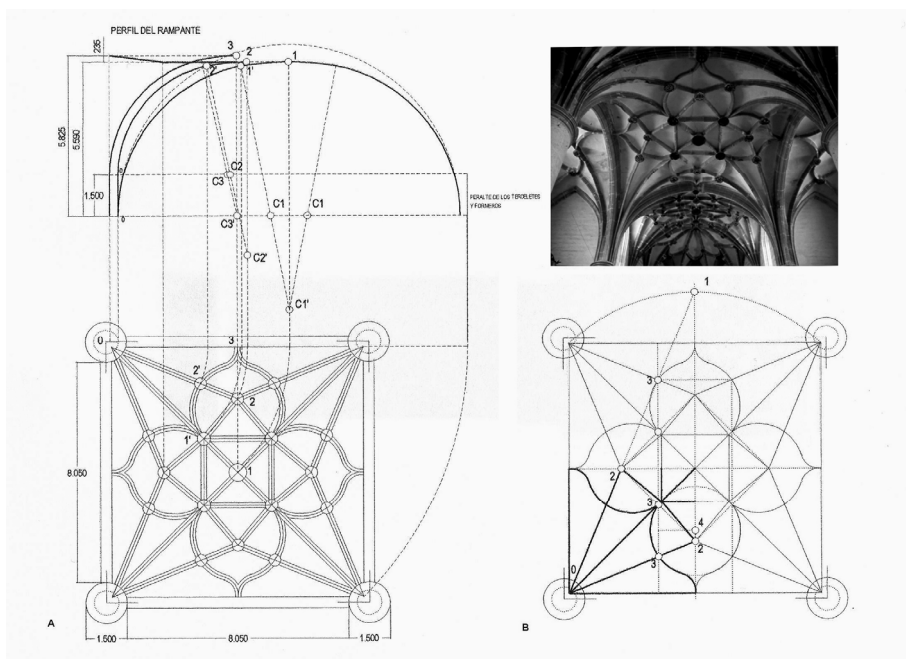


Figure 12. Valladolid, La Mota del Marqués, Iglesia de San Martín, picture of the vaults of the central aisle; A, drawing showing the pattern to establish the design of the nervatures; B, Plan and elevation of geometrical method followed to obtain the curvatures of the ribs, the diagonal rib is a three-centred arch and the four former arches are raised semicircular arches, as a consequence the shape of this vault is a convex shell.

As we have just mentioned, the central aisle is covered by some square plan vaults of 8 metres span. When drawing its plan in detail (Fig. 12A), we notice that the two tiercerons are placed on the crossing between the former and the ogival arch; its design helps placing the four bosses of the tiercerons. Thanks to them, one can draw a square with sides parallel to the ogival arches which, in crossing with the diagonal, define point 3. This point by alignment fixes the lobe form centred in C4. Rodrigo Gil prefers to break this triangle's sides with a certain concavity to convert it into a star, of which the concave vertices allow him to place a small central square parallel to the vault sides. Lastly, this is another of the many variants of the same patten by Hontañón.

The most interesting aspect of this vault shows up when planning the curvature of its ribs (**fig. 12B**). Let us start by laying out the diagonal and, first of all, with the span of the ogival arch, let's draw as

reference a semicircular arch in elevation. When we place the real height of the central boss 1, we notice that it remains below the height of the semicircular arch, which means that the ogival arch needs to be a three-centred depressed arch, an oval curvature. At first sight, we notice that the arch springs, on the impost line, tangential to the vertical, so we have drawn it with centres C1 and C1'.

As one can see at first sight, the four perimeter arches which limit the vault are also depressed and, besides, raised, that means that the arches, from the impost line, spring with a raising of approximately 1.50 metres height. Thus, the former and transverse are three-centred and raised arches which, once known the height of their bosses, have been designed with the centres C3, C3'. At that moment we appreciate the particular feature of this vault: the diagonal are depressed arches springing from the impost line, and the perimeter arches, which are also depressed but raised, have their bosses higher than the central boss. This set-up leads us to imagine a vault which, necessarily, has a convex shell, that means lower in the centre than in the sides.

When defining the shape of the tiercerons, the assumption is confirmed. At first sight, we notice that again we are dealing with raised arches; when placing in **fig. 12B** the height of its boss, we ascertain that it is half way between the height of the central boss and the perimeter's ones. The curvature of the tiercerons has been drawn with the oval centred in C2, C2'.

As in past occasions, some three-dimensional drawings have been made to help us visualize such a peculiar volume. In **fig. 13** one can appreciate the convexity of the vault, as well as the three-centred diagonal arch, the tiercerons, the raised former ones and the oval arches.

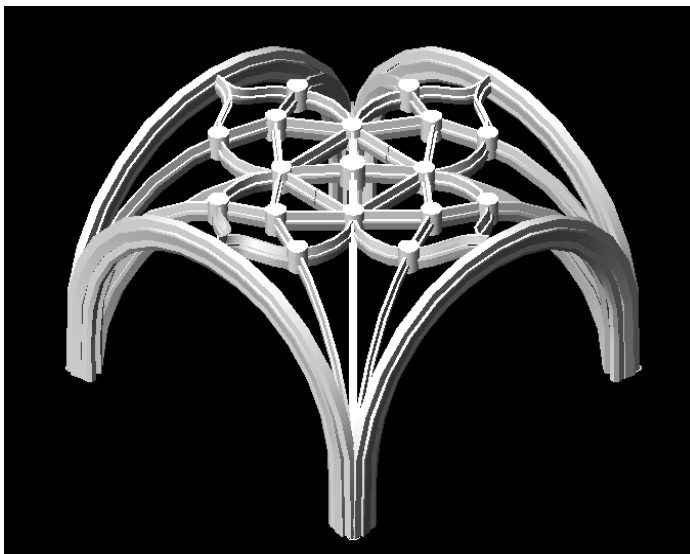


Figure 13. Three dimensional reconstruction of the precedent vault in Valladolid in which one can notice its convex shell.

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