Part 7 of the Royal Portal Series

Chartres Royal Portal - the central tympanum

John James

The Chartres portals were the most complex in their time, and took six years to build due to delays in the towers that flank them. This article attempts to answer some of the intriguing questions posed by the central tympanum.

In the northern France there are still ten *Maiestas Domini* tympani with this design. Two were severely mutilated during the Revolution. The arrangements are the same: Christ sits enthroned inside a mandorla holding the Book in the left hand, with the right hand raised in benediction; surrounded by the four Evangelists. There is evidence to suggest that all ten tympani were carved before the Second Crusade.[1]

In major pieces such as these, many men could have been involved in the carving, either under the direction of a master or to an approved design. The major examples are similar and represent a single simplified uncluttered arrangement that may have been designed by one person but executed by many.

We are realising that large sculptural pieces could be the product of more than one man. The template may be the same, but not the

Links to the Series
Click bold items for completed pdf

Chartres west portal central tympanum

Bourges south portal tympanum

Angers west portal tympanum

Saint-Loup-de-Naud porch tympanum (netted)

Dijon Saint-Benigne tympanum

Le Mans south porch tympanum (damaged)

handwork. This is illustrated in the heads of the *Maiestas* tympani that conform to the same template while every face is subtly different [a].

Check the square-cut solidity of Saint-Loup and Le Mans, the low forehead of Bourges and the high temple at Chartres, the wavy hair with or without a central parting, the moustaches that hang, or sweep beyond the ears at Le Mans. The ears are different, the beards are longer or shorter, the lower lip undercut or incised, and the eyes!

All the finely wrought details are individual. Each is a personal statement. The subtle variety in the heads is reflected in the details of hands and clothing. Many carvers, one image.

Looking over the enormous literature on large sculptural commissions, be they column-statues or tympani, the search for the 'Head Master' has been frustrated by this multiplicity of hands.

The documents tell us little. We do not know whether one person executed the entire figure or whether many were involved. We do not know whether it was policy that a single carver complete an entire piece, though we suspect otherwise. And we have no idea how that person or persons was chosen. Was he the leader of the team or the best carver or the most spiritual? Did it depend on who was available, did they compete or draw lots or ask the donor or the priest?

It is possible that the carving of the five panels in the tympanum at Chartres may have been spread over more than one campaign. If so, could we ever identify the actual *imagiers*?

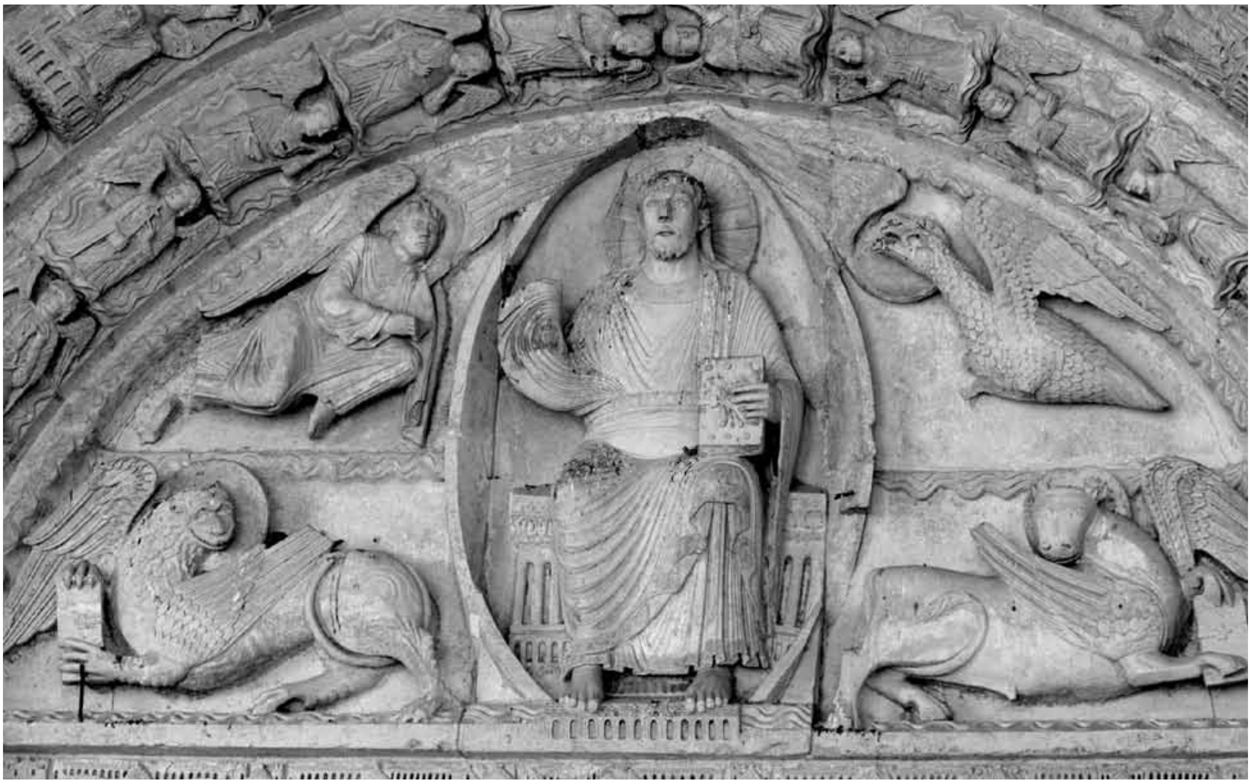
The myth of the Head Master

This raises the theory of the 'Head Master' at Chartres, an issue so loved by an impressive line of art historians from Wilhelm Vöge onwards. Peter Kidson rightly called it "nothing but the creation of a sustained effort of wishful thinking".

He went on to clearly express the conclusion that best fits the situation: “Because his superiority was transparently obvious to anyone trained to appreciate the expressive power of great art, as that was understood in the first half of the twentieth century, it was inconceivable that his contemporaries should have thought otherwise; and because Chartres stood at the hinge between romanesque and gothic he was, *ipso facto*, the key figure in deflecting the course of western sculpture into new channels. This was one of those great and splendid simplifications that everyone could understand; but it was a fiction, not history. .... There is no reason to think that the ‘Head Master’ was more than a member of a team - *primus inter pares* at best; and if he contributed anything to the formation of a gothic style of sculpture a lot of hindsight is needed to spot it. The man emerged out of a romanesque milieu which can be pinpointed with precision. There was no dramatic epoch, just a sensitive artist responding to a different cultural atmosphere with an appropriate adjustment of style. The implications are far reaching, not to say daunting.”[2]

I would go further to add that we are not talking about a man except in so far as someone continued the design for a tympanum arrangement that had been around for many years. The other similar *Maiestas Domini* portals show that in the decades before Chartres one individual mason or priest or committee, had made the original maquette or cartoon that everyone followed. We would like to know who that was, for sure. A key fellow, if he could be found. Finding him is going to be troublesome, to say the least. It is clear there was a design that most of the carvers followed, with their own interpretations sprinkled in, and so in the end it is going to be more meaningful in large-scale works like the tympani, to separate the template-maker from the carver.

On the next two pages I illustrate those similar to Chartres, and a few others from further south with additional angels holding the mandorla.[3]



Bourges south portal tympanum 1120s

Saint-Loup-de-Naud, west porch tympanum

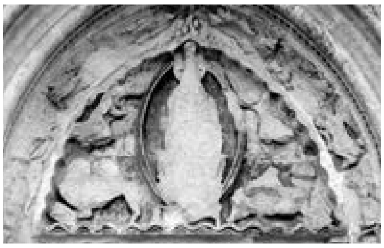
Angers cathedral, west portal tympanum

Le Mans, south porch tympanum

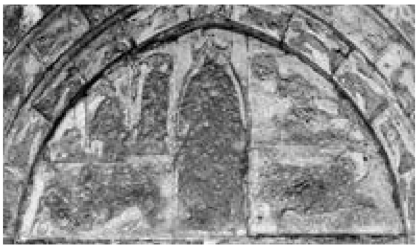
Dijon, Saint-Benigne tympanum

St-Benoit-sur-Loire, south portal tympanum

Vermenton, drawing 1739 of south portal tympanum.



Compiegne Saint-Pierre, remains of west portal tympanum

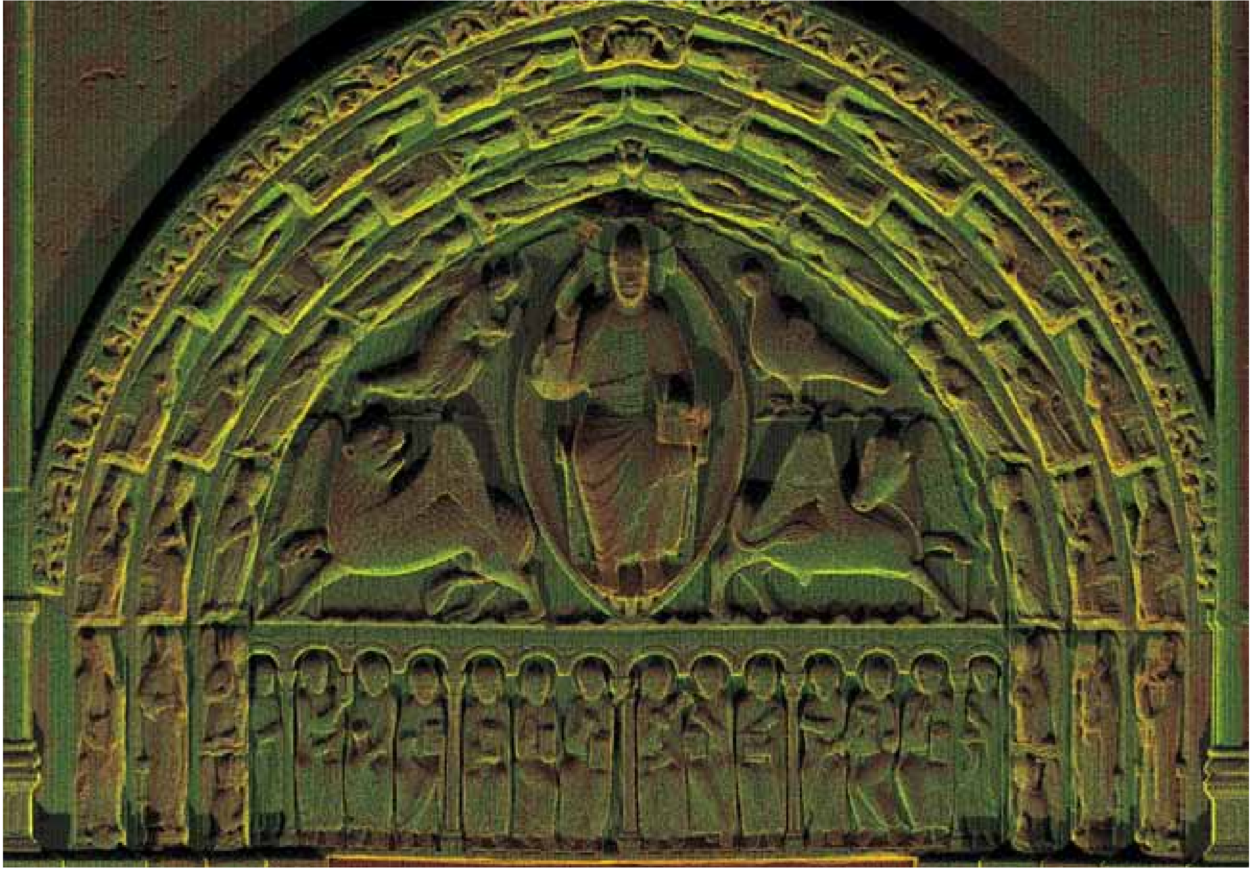


Chalons-en-Champagne, Notre-Dame, remains of south porch tympanum

Charlieu, west central tympanum

Til-Chatel, west central tympanum

Chassenard, south portal, restored.



Scan of the Chartres central tympanum

The design geometry

The tympanum was assembled from five stones. The largest, the central figure of Christ in Majesty, is 2.2 metres high by 1.2 wide and with an assumed thickness of 40 cm would weigh around 2½ tons. This is estimating the weight of limestone as being 2.7 tons per cubic metre. The stone in the tympanum probably came from the quarries on the Oise or Seine near Paris, a distance by barge and cart of almost 200 kilometres.[4]

The mind boggles at the sheer difficulty of getting these massive stones up the hill to the cathedral site from the most upstream loading dock by Saint-André. It would have been a herculean task even by the least steep and most roundabout route. On arrival they had to be placed under cover in a position that was accessible to the sculptors.

The lintel was even heavier, being almost 4 metres long and over one metre high by the thickness of the door jamb. It would have weighed about 4 tonnes, an astonishing size to lift and place without damage. One can understand why it was the last lintel to be erected.

Andrew Tallon kindly provided images derived from his laser scan of the portal. The following analysis is based on his work.[5] The laser-derived image of the portal elevation is an orthogonal projection without the optical distortions normal in photographs taken from below or to the side. It is a low-resolution image and is not precise enough for accuracy greater than a centimetre as the dots in the image are measurement points, and are not distributed in a grid, as are pixels. Andrew suggested it would have an accuracy only within 4-5 mm. This level of imprecision applies especially to the form of the curves even when measured over the length of the arc, and affects the radial measurements and the location of the centre points. For this reason all dimensions will be given in centimetres. We also complimented these measurements from those from the 2 mb photos taken by Chris Henige.

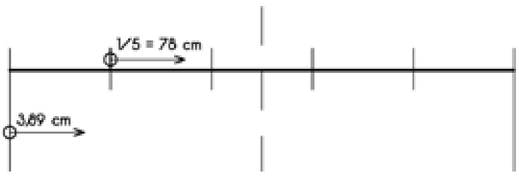
What follows has been produced through Neal Mortensen's expertise with CAD and with the dimensions taken from Andrew Tallon's scan.

From it we read the width of the central tympanum at 3,89 cm, and the height at 2,26±1 cm, depending of course on which part of the stonework was measured. It was hard to gauge accurately as the lion panel on the left has shifted clockwise by 9 cm, dropping in the right corner. The right-hand panels have slightly twisted the opposite way by a couple of centimetres. The apex under the voussoires is more than a centimetre to the left of the axis through the figure of Christ, and there seems to be a small gap at the top where the mandorla panel has dropped a little. The shifts also affected the vertical axis through Christ. To make it more difficult, the apex was obscured by a bird's nest. These movements are probably linked to the crack in the lintel that opened a discernable space under the centre of the tympanum.

If the scan had been precise to a part of a millimetre we could have made a more accurate analysis, but in this scan no matter how carefully we laid out the arcs in CAD so they were carefully laid as precisely as possible over the arcs of the scan, the radii and the location of the centres remained uncertain. To limit the uncertainty, we searched for an easy and consistent geometry for locating the centres and the arcs as we imagined would have been needed on site. Too much complexity would only have delayed the works and opened the possibility for error.

We scaled the exposed width of the lintel at 3,89 cm and the width of the pedestal under the mandorla measured 78 cm. This is a 5th of the overall width of the base. Here was a simple way to set out the baseline [r1].

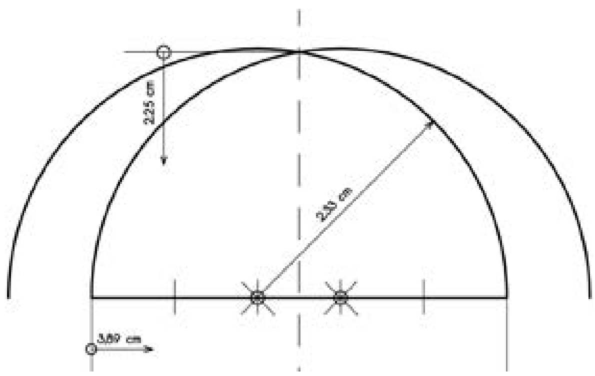
The arcs of the tympanum frame were set out from each end of the pedestal. The radius of these arcs was calculated as 2,33 cm and the height of the apex was derived by measurement at 2,25 cm. This uncomplicated and straightforward arrangement looked like the first step [b1].



The visible width of the lintel divided into fifths.

The second step could have been to locate the two largest design items in the tympanum, the arcs for the mandorla around the figure of Christ. The apex of the mandorla does not quite meet the crown of the tympanum [b2]. The difference is about 11 cm.

In the tympani with round arches of Bourges and Dijon, the tip of the mandorla meets the frame. By inserting a gap under where the framing arches are pointed, as in St-Loup-de-Naud and Le Mans, there is small space for the delicate wings to stretch over [b2].



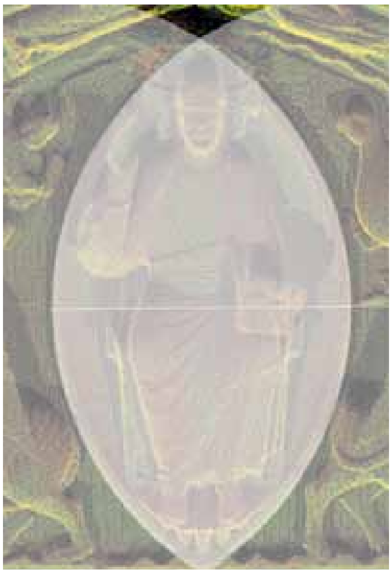
The two arcs from the fifth points that located the apex.

Apex of the tympanum with space left at the top for the tips of the wings

Determining the geometry

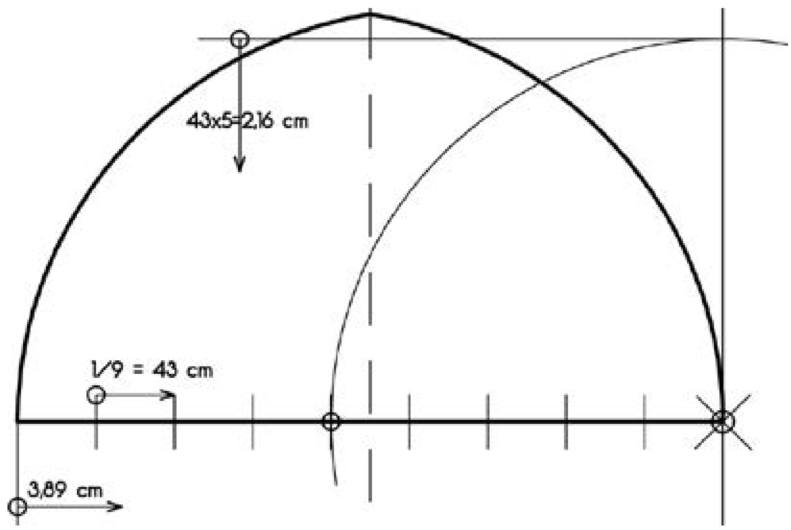
Using CAD we measured the encasing arcs of the mandorla from the scan and located the centre points [r1]. With the same measure of uncertainty as before, the centres lay at the top of the lower stones with the Lion and the Bull. In other words, the horizontal division in the masonry located the centres for the mandorla arcs. The height from the base to the joint between these stones measures 1,08 cm [b3].

However, the centres do not lie on the circumference of the opposite circle, as one could expect, but slightly outside. By measurement the gap between the arc and the centre is about 6 cm. We tried numerous alternatives to avoid this "discrepancy", but came to realise this was a problem in our minds, not in the mason's.



Apex of mandorla lower than apex of tympanum

If the apex of the mandorla had coincided with the peak of the tympanum and if the centres of the mandorla had lain on their arcs the overall impression would not have been significantly different. The Evangelists would have been a tad smaller and the mandorla a little fatter; differences that would have been hardly noticeable. So, why the complexity? Why bother to avoid placing the centres on the arcs? From a practical point of view it may have been to create enough space at the top so the stones of the two upper Evangelists would not end in points, and therefore less likely to be damaged. Or to narrow the figure of Christ so he would appear more ethereal. But in an age when all precision was obtained through compas and rule there may be another reason that I will allude to later.



Divide the base into 9 parts, and use 5 to locate the topof the mandorla.

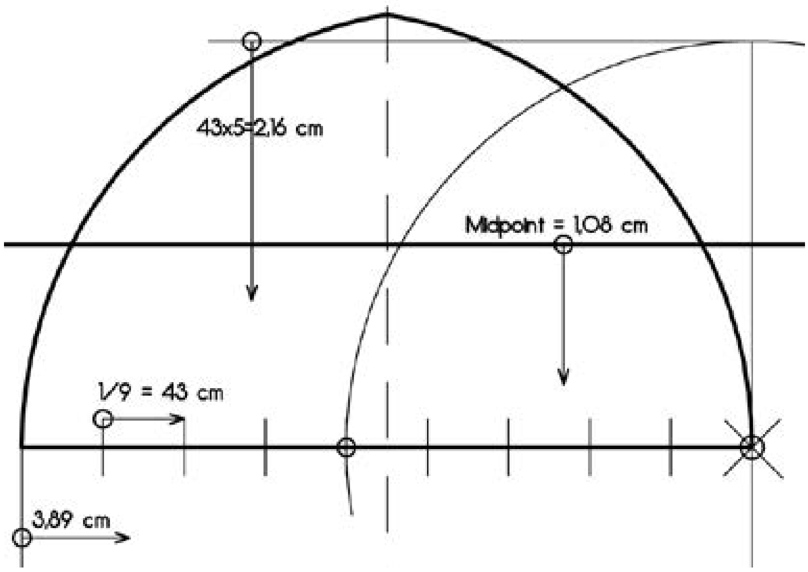
After many trials I suggest the following process in laying out the tympanum through a series of easy-to-construct steps that not only worked on the scan, but more importantly for us, is precise by calculation. It a sensible arrangement that could be easily handled amidst the dust and mud of a building site.

As above, the first step was to determine the outer form of the tympanum by dividing the base into five parts and striking arcs from the two middle parts. In the second step the base was redivided into 9 parts of 43 cm. Five of these were used to locate the height of the mandorla [r2].

Though the top is hidden behind the halo the laser scan shows that the apex of the mandorla coincides with the top of the halo. By calculation the height from the base to the apex of the mandorla measures 2,16 cm. The midpoint is exactly 1,08 cm, which is the vertical measured from the scan to the upper edge of the lateral stones with the lion and the bull [r3].

3,89 ÷ 9 = 43 x 5 = 2,16 ÷ 2 = 1,08 cm

Horizontally by measurement the centres of the two arcs of the mandorla lie 67 cm from the central axis of the tympanum. Yet the arc is only



Duvude the height of the mandorla to locate the central mortar joint

61 cm from the axis, leaving a gap of 6 cm. We might say that by not placing them on the arcs the centres were hidden from view [r1].

I have tried many alternatives, always looking for a geometry that would be easy to establish on site and with ratios that would be known and determinable at that time.

One straightforward way to locate the centre from the middle axis was to divide the height of 1,08 cm by the Golden Mean.

1,08 cm ÷ φ = 67 cm

The arcs for the mandorla would then have been struck from this centre, and the radius the distance from that centre to where the axis met the base [r1]. Thus the centre was derived in a roundabout, one might even say, accidental manner, and not directly from the base.

Though there are no contemporary manuals, mason;s squares show they were designed with arms of different lengthes that would make it easier to use favourite ratios. There was no need to construct this ratio geometrically each time, for it could have been marked on the instrument.[6]

If the procedure sounds confusing, it is. In order to draw the frame for the mandorla the master began with 5ths, then 9ths, divided that in half and then used the Golden Mean.

Another possibility was to draw a square on the 9th along the base. On that square mark the diagonal that measures 61 cm, which is the width of the mandorla. The height was 5 of the 9ths, the width the diagonal of the ninths. Neater, but a little more difficult way to locate the centres and draw the arcs.

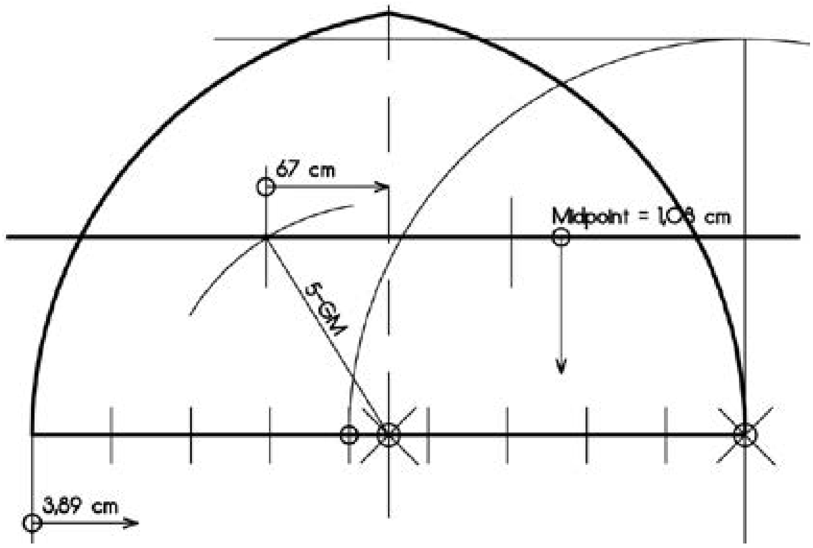
3,89 ÷ 9 x √2 = 61

When fully drawn the circumference of the circles of the mandorla touch the sides of the square on the base. In other words, the distance of the centre from the axis of the mandorla plus its radius is half the width of the tympanum [r3].

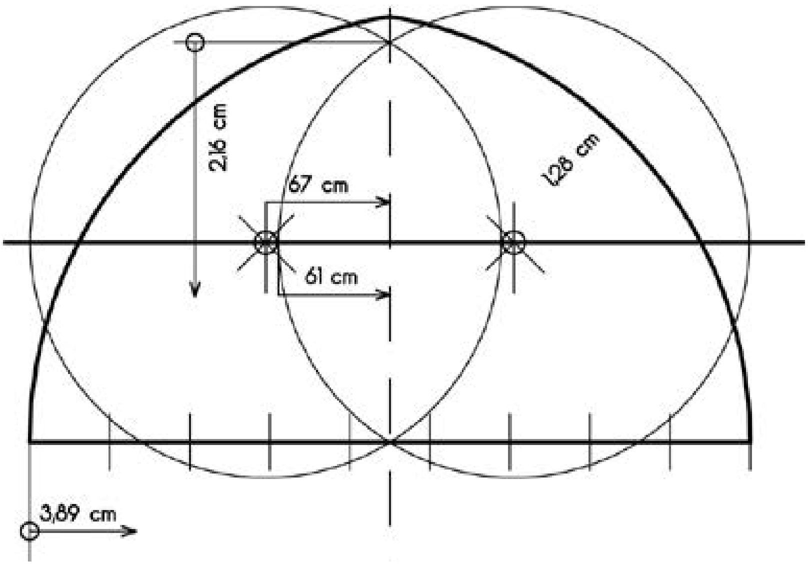
67+1,28 = 1,95 x 2 = 3,89

Did this seem like magic to them or was it simple geometric good sense (as it is to us)? The outsome is enormously satisfying, for once the right ratios are set into the major elements they keep appearing in the minor. For example, the small 6 cm distance between the arc and the centre is φ times the gap at the top between the mandorla and the top of the tympanum.

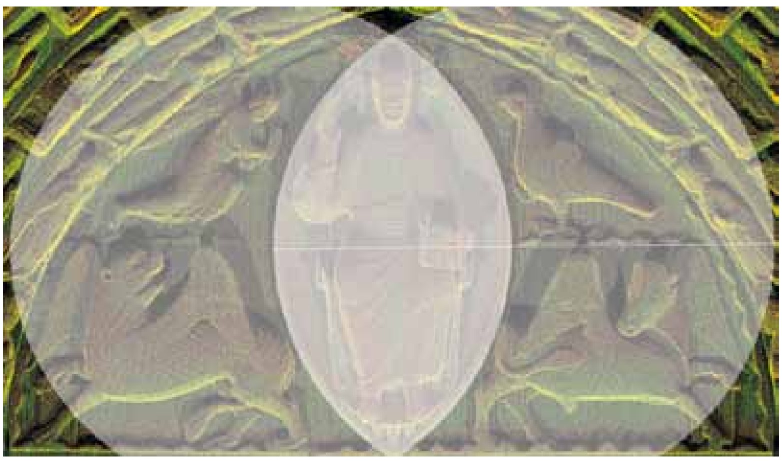
There are very slight discrepancies between the laser scan and the CAD drawing on both these interpretations, though this may be because the accuracy of the scan was limited and we were unable to measure the arcs of the mandorla with



Use the golden mesn from the hlway mark to locate the centres for the mandorla



Thus we located the centres and the arcs and avoiided contiguity


The two circles that form the frame of the mandorla, when extended, touch the sides of the base.

sufficient accuracy. We are seeking millimetres, and though carving could be accurate, setting out was scratched on the surface or taken from the side of a string with a measurable thickness that could have created errors.

However we look at this, the outcome from two mathematical, contradictory systems leaves a sense of wonder. Lengths derived from roots are not supposed to be commensurate with those based on whole numbers. Yet the observation that the radii of the arcs were set out from where the central axis of the tympanum met the base and were also tangential to the square on the base seems impossible. The arc radius was not derived directly from the base yet connects with it. The circles could not be drawn without first locating their centres that were themselves created via a Golden Mean relationship to the base, etc etc.


The centre for the mandorla outside the arc

The value of circularity

This is a process I call circularity. It is how the masters may have validated their own geometry.[7] Circularity is where two unrelatable geometric processes derived from a common base that should lead to disparate outcomes, instead lead back to where they started. Each figure passes through a separate sequence and no matter how divergent they still reconnect at the end. Circularity may be defined as a series of geometric steps involving ratios and figures which are irreconcilable with one another, and yet were evolved in such a way that one of the last steps will meet up with or repeat an earlier one. As a result it is not always possible to say where the geometry began as the first step could have been made anywhere.

In over three hundred geometric studies carried out with great care and to the most precise measurements, both at Chartres and elsewhere, circularity has been present in almost every one.

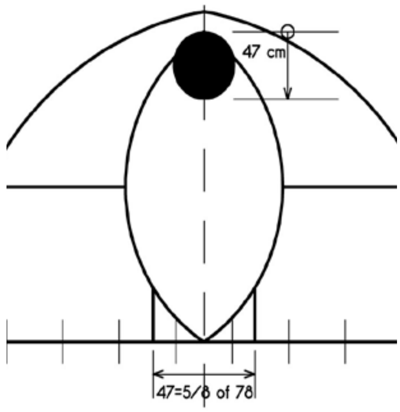
There is clearly no structural nor constructional purpose in going to all this trouble. It is pure aesthetic pleasure, the excitement of posing oneself a difficult problem and bringing it to a resolution. The process is not unlike scholastic philosophy in which a pair of opposites are disputed until there is a reconciliation. It seems to have reflected a mental attitude that permeated the psyche of the times: public disputations drew large crowds for a pleasure few would enjoy today. Among the masons we may surmise a similar fascination with geometry that went beyond utility by offering pleasure experienced for its own sake.

Over generations dialectic geometry became enshrined from master to apprentice until the attitude it engendered saturated every procedure in the building trade. It created passion and excitement in the noble art, with a solid basis in the methods they used every day for creating templates and laying out buildings. The reasoning behind their geometries would have evolved slowly, but even as early as the Tower of London we can discern the logic that directed the steps in the process.[8]

Not that every master understood the reasoning behind these procedures, as can be seen in Roriczer's manual where he repeats the steps taught him by his master Parler.[9] But for those who did understand, the pleasure in creating a problem and then engineering the solution must have been enormous. I have what must be a similar pleasure, as do some of my students, whenever we either solve the intricacies of their work or recreate it ourselves.

The actual process of evolving these additional relationships can be followed in the four little windows Bronze designed at Chartres.[10] He was not content with the first design, but went on complicating the design of the later windows until he could attach them geometrically to the rest of the building. It is only pleasure, and a drive for unity (dare we say, God?) that would push a busy man to spend time and effort in what seems like an unsatisfiable search for perfection, part of which was to connect all the parts into a single whole, and to encase every element in a web of ratios and figures with neither beginning nor end. Each process went in a circle, so that the last moment included some reflection of the first.

Did they believe that circularity reflected God's creation, for wherever one turns there is God, and wherever the geometry leads there is the origin? In order to produce an "ultimate reconciliation of contradictory possibilities" circularity had to be involved. The dialectic spirit that created the philosophers also created the masters. The presence of a very sophisticated form of circularity in the White Tower,[11] perhaps as early as 1080, shows that concepts being promulgated by Anselm of Canterbury, and disputed by Roscellinus and Peter Abelard, were being simultaneously exchanged with the master builders.



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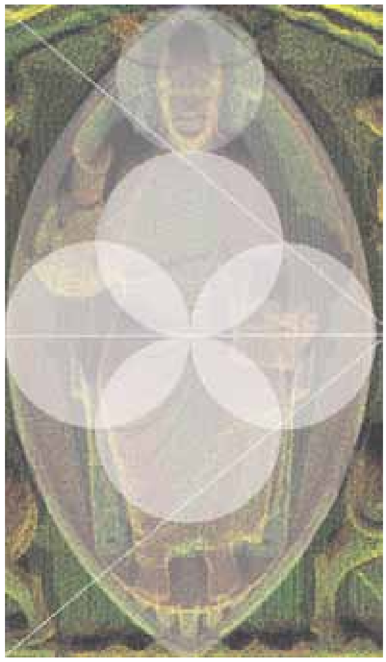


The four-part centre for the mandorla

Circularity demonstrates itself in other relationships that appear, as it were, unbidden. The scan shows that the top of the circular halo of Christ just touches the apex of the mandorla, though it does not appear so from the ground [r1]. As best we could measure it, the halo has a diameter of 47-48 cm. This could be either 3/5ths of the pedestal that was itself one 5th of the base, or one 8th of the base, or the base divided by the golden mean. I prefer the latter as it repeats the φ ratio used to locate the centres for the mandorla.

3,89 + 5 = 77.8 x 0.6 = 46.7, or 3.89 ÷ 8 = 48.6, or 77.8 ÷ φ = 48.1

Also, the distance from the halo to the centre is 61 cm, which is half the width of the mandorla. If we play with circles of diameter 61 cm we get this beautiful pattern [r2]. It would of course be extended downwards so that the space at the bottom around the feet would accept a circle equal to the halo at the top. Circularity again, an ecological process in which every part is connected to every other part. Yet, where is the beginning?

61+47 = 1,09 and 47 + 61 + 61 + 47 = 216

The figure of Christ may also have been included in some geometric guidance, as in the following three suggestions. Place the circle of the halo on the horizontal axis tangential to the arc of the mandorla and the adjacent circle between it and the other side of the mandorla seems to be the arc of the foot-rest [b1].

1,22 – 47 = 75

If we draw the circle for Christ's elbow it may give the circle around the outside of the book [b2]. From measurement, the diameter of the latter seems to be 29 cm, which could be the Golden Mean ratio to the halo.

29 x φ = 47

Lastly, draw the centres through the last two circles and a line at right angles may lie tangentially to the halo and the footrest [b4]. We could continue to create imaginary guidelines for the *imagier* as we wished.

Four suggested ways in which the geometry for the whole may have been applied to the layout of the parts.

Thoughts on the other similar tympani

There are five other *Domini Maiestas* tympani from this period. Bourges and St-Loup-de-Naud were from the 1120s, Angers and Le Mans from the 1130s and that Chartres was the last. They all have Christ within the mandorla accompanied only by the four Evangelists.

In three of them the stones are arranged in the Chartrain manner with five stones and the bottom of the mandorla is supported on a pedestal. Only in the south portal at Bourges and the west at Angers were the tympani assembled from rectangular pieces, and only at Bourges - set within a circular arch - does the apex of the mandorla coincide with the top of the tympanum. To fit the wings of the upper two figures so they hang above Christ they are laid over the top of the mandorla frame, obscuring it. At Bourges the tops of the lion and bull are below the centre of the mandorla, which reduces their impact, and the halo sits within the mandorla. The later solutions maximise the height of Christ.

Le Mans has the same masonry layout as Chartres, and the top of the mandorla lies below the apex of the tympanum. Yet the centres for the arcs seem to lie on the opposite arcs as it looks a lot wider than Chartres, and the Evangelists seem smaller. Of course, without a laser scan the photos still suffer from distortion. However, these observations suggest they were not all based on the same proportional system.

The foot of the pedestal at Le Mans seems proportionately wider than the one-fifth of Chartres, and from the photo measures closer to two-sevenths. Bourges and Saint-Loup also seem to have a two-sevenths pedestal while Angers may have used the *ad triangulum* of $\sqrt{3}$. Chartres is unique in narrowing the figure of Christ and its pedestal with the effect of increasing his apparent height.

The stones in the portal came from a number of quarries, some of which may have been far away. For particularly important items, such as the stones for the tympanum, I imagine the maaster went to the quarry himself, with his rod and square, and laid out his instructions on the spot. By giving exact instructions to the quarrymen he would have minimised the weight to make cartage easier. He may have had a rod prepared especially for this task to half the width of the tympanum, with whatever subdivisions his geometry required.

The stones would have taken time to prepare, and even longer to transport to the site. The master may have had to wait months for delivery, and after that he would have had to repeat the design in the shed to the same precision he had used at the quarry.

Geometry was the most accurate way to do that. There were no standardised units of measure, and with rod and dividers the masters had a practical way to replicate a design and maintain dimensional control across many places and over long periods of time. The steps had to be reasonably simple as the master carried the process in his head, and only in the fifteenth century were any of these geometric procedures put in writing.

If I had to set out this portal, I would certainly have built a large wooden shed and poured plaster across the floor. On that I would have inscribed the outline of the various parts. This would have provided a permanent form within which each carver could prepare his work. Then, as the pieces were carved, I would place them on the template to make sure everything fitted perfectly, piece by piece.

This is what was done for the rebuilding of the Dean's rose at Lincoln. It lay on the floor of the transept and as each piece was carved it was


Bourges south portal tympanum, 1120s

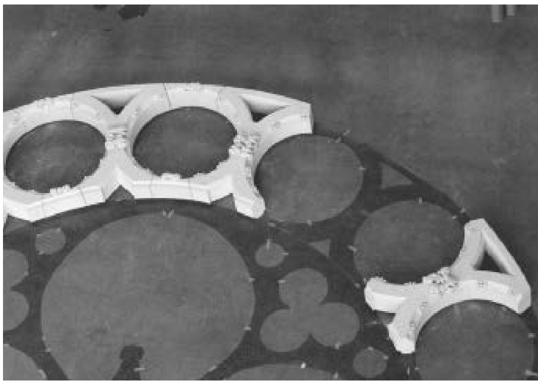

Saint-Loup-de-Naud west porch tympanum, 1120s


Angers cathedral west portal tympanum, 1130s


Le Mans south porch tympanum, 1130s


Chartres cathedral, west portal, central tympanum

added to the whole [r1]. When erected in place all the pieces were going to fit *in situ* because they had already fitted on the floor as an *in situ horizontalis,* as it were.


The stones for the north rose at Lincoln cathedral was placed over a full-size template that included attached cutouts for the stained glass that could be made at the same time.

It's hard to imagine there wouldn't have been a place to erect a full-size mockup. Over a period of time with a number of men it would have been the only way to ensure everything was executed properly and could be assembled as intended. As in Lincoln, the Chartres tympanum could have remained on the tracing floor for years until the whole was complete or the site ready.

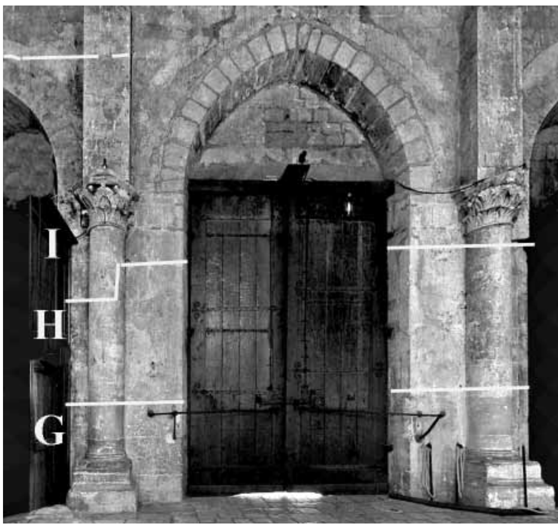
There does not seem to be any obvious symbolism in the ratios. They appear to be the practical and aesthetically pleasing steps a man would take to maintain dimensional control where measurement could not be used. There were no agreed lengths or units of measure. Each district and town, and each master, had their own. The consistency we expect from a nationally recognised foot unit was not available. Therefore, they devised a system that had no need for a unit of measure.

The teams that did the work and the masters who led them were changed on what may have been a seasonal basis. This was the situation on nearly every site throughout the Paris Basin until the mid thirteenth century. A later contractor had no choice but to work from what had already been built in order to determine the templates for what his men needed to carve next.

Were the master who designed the tympanum to arrive after the plinths had been placed, or after the lintel had been carved, he need not have used his foot unit at all. He could have marked what was already complete on wooden rods and drawn the silhouette of the doorway on the tracing floor, made a choice on which part to use for the width of the tympanum, and gone on from there.

Once sorted, his next step was to mark the arcs of the arch. He need not have divided the base into five parts, for there was no one universal outline for a pointed arch. He could have used sevenths or *ad quadratum,* or any other ratio. Fifths was his choice, and without needing a measure.

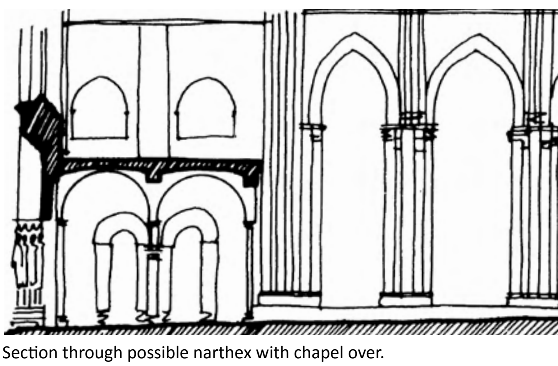
The later lodge books illustrate this, for in none do the masters mention a unit of measure. Hans Schmuttermayer begins with "make a square however large you wish," no size given, and then proceeded to evolve the design around a series of purely geometric steps.[12] The same measureless process was used at Chartres.



Interior of portal with arch on inside of tympanum

Construction issues

There would have been a pause after the erection of the embrasures while the interior arches were built followed by at least eight courses of stonework to the crown of the arch [r2]. This was part of the chapel over the narthex,[13] demolished centuries later to make way for an organ that was, in the end, built elsewhere [r3].


Section through possible narthex with chapel over.

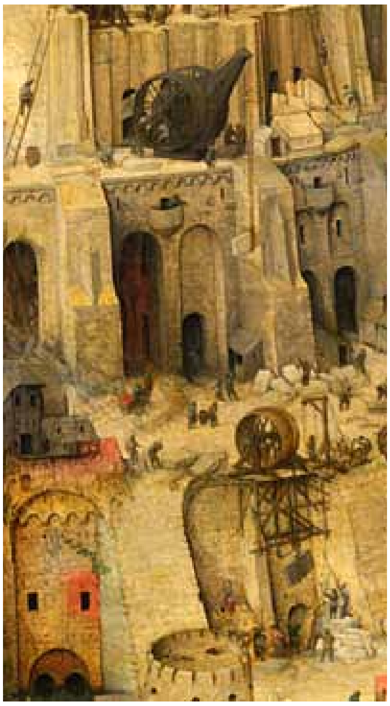
By building the arch and backup wall first the master had a structure that would support the cranes, secure the scaffolding and provide a foothold for the workmen. It rests on the inner skin of stonework and not on the outer embrasures. It was designed to stand on its own. So it may have been while these courses were being laid from inside the building that the erection gangs could concentrate on the more complex assembly of the colonnettes[14] and the column-statues from outside the building, followed by the capitals and imposts and finally the lintel and tympanum.

As a builder, I asked myself how would I have erected the lintel, the five stones of the tympanum and the archivolts around them? The lintel would be the first, of course. It is some 40 cm thick and would weigh more than three tonnes. and rested on the capitals and imposts. It would not have been hoisted with ropes, for even with protecting timbers along the delicate lower edges there would have been real danger of damage.

The Lewis bolt was known to the Egyptians, if not before, and described in Vetruvius. A hole is drilled into the stone and enlarged at its deepest part, and opposed iron wedges inserted.[15] It uses the weight of the stone to thrust the lever arms against the sides to create the friction needed to hold the stone [r1].

Lewis bolt, the central plug is adjustable

An alternative could have been to cut U-shaped grooves at each end with ropes passed around the block that could be withdrawn once it was in place. But for something this size the ropes for such a load would have been 5-8 cm thick, and could not have been bent around the bottom of the groove. Alternatively, chain dogs could have been let into dog holes at each end of the block utilising the weight of the stone to pull the dogs in place, but at 4 tonnes the stone was too heavy for that.



Breugel the Elder, Tower of Babel, detail

One or more Lewis bolts fixed to the top or the sides would have worked in this situation. I have not found it in any contemporary illustration, yet I have seen holes prepared for such an overhead attachments, especially in large capitals.[16]

Then, what of the lifting gear itself? The ability to design and build machines to lift and move heavy objects was one of the most notable skills of the masters. It was recognised in Gervase's description of William of Sens, whose accident showed how essential it was to design and maintain strong support structures.[17]

The cranes were large, and would have been tread-wheel type to carry such weights. They also had to be turnable to pick up stones from one direction and lower them with precision into another [r2].

Were I the master, I would set the lion and the bull first and secure them to the backup wall, and then lower the mandorla into the space between them. And only when they were secure would I place the top two Evangelists with their delicate upper projections. The stones were all on edge and stability depended on being securely restrained against the backup wall by iron connectors similar to those used in the embrasures.

Though the lower archivolts abutted the face of the lintel, and the upper rested directly on the stones of the tympanum, I would not have placed any archivolts until the tympanum itself were firmly anchored. As this was the most sensitive part of the operation and as the tympanum had cost more in time and money than any of the archivolts, I would have cleared the site to make the erection of the tympanum as easy as possible. Cramped spaces create accidents. Once the tympanum was in place and locked into the backup wall, I would begin to assemble the archivolts.

This may help determine when the lintel broke. The first archivolt butts against the outer western face of the lintel, which clearly passes behind it [r3]. The lintel is like a tall beam with a height of 1,20 cm and a depth of about 40 cm. When it broke, the upper corners of the break would have acted like a hinge pushing the lower outer corners at each end deeper into the wall. Only the masonry set against the ends of the lintel could have stopped the lintel from rotating and collapsing entirely and bringing some 16 tonnes of stonework down with it. This masonry is hidden behind the lowest archivolts.

Junction between left archivolts and central liintel

The slippage of the angel block against the head of Christ shows it had to happen after all five tympanum stones were in place, for if before the blocks on the left could have been adjusted to close the gaps. Also, at the apex there is a gap between the top of the tympanum and the underside of the archivolts showing that the tympanum was displaced after the archivolts had been placed [r1]. All this indicates that the lintel broke some time after the portal had been erected.

Could there have been a trumeau? Jean Villette certainly thought so.[18] It would have narrowed the doorway making Chartres like Saint-Loup-de-Naud. The trumeau could have been removed in the sixteenth or seventeenth centuries during renovations that may have been preparing for a new organ loft in the west. However, there are no remnant indications on the underside of the lintel.

So much was being altered at that time that opening the doorway may have been part of a wider campaign that included the shafts and capitals in the corners of the interior, the egg-and-dart decoration over the openings into the towers and the removal of the narthex platform. It is intriguing to ponder whether it was the cracking of the lintel after the hypothetical removal of the trumeau that put an end to this campaign. Since then the gaps that opened up have been mortared over.

Detail of apex and empty space above the mandorla

1. The will be presented in COGA/Explore Carvers/articles as “Early Gothic carved portals”
2. Peter Kidson, review of Edson Armi, “The ‘Headmaster’ of Chartres....” in *The Burlington Magazine*, 136, Dec, 1994, 841-842.
3. In the Paris Basin I would also mention the remnants of two similar portals at Povins in St. Ayoul and St. Quentin. See www.fabricae.org for all the porches in France. The geometric process in the five is symmetrical and hierarchical. But the tympanum for the cloister of Saint-Benigne in Dijon displays a completely different approach. The footrest under Christ is not level. It should not be dismissed as a mistake for it is not the only element out of level. Without analysing in detail, the illustration shows that Christ’s eyes are also out of level and the line at right angles to that defines one of the figures on the right. The major angel on the left is defined by the line at right angles to the base. And so on in a veritable cats cradle of deliberately odd alignments. Schapiro has shown a not dissimilar approach in the story of Theosophilus in Souillac.
4. For map and discussion of possible sea routes John James, *The contractors of Chartres*, Wyong, ii vols. 1979-81, pages 83-86.
5. Andrew Tallon, Vassar College http//gothicstructure.org. The laser scan was funded by the Andrew Mellon Foundation as part of the Mapping Gothic project http://mappinggothic.org.
6. John James, “The tools of Hues Libergier, Master Mason of the Thirteenth Century”, *Architectural Theory Review,* ii 1997, 142-149, pdf in COGA/Explore Carvers/articles.
7. For circularity see John James, “Discrepancies in medieval architecture: careless or deliberate?” *Architectural Association Quarterly*, xiii 1982, 41-48, pdf in COGA/Explore Carvers/articles
8. As in note 7, and John James, review of *Gothic Design Techniques* by Lon Shelby, in *The Architectural Association Quarterly*, xi 1979, 55-59.
9. Lon Shelby, *Gothic Design Techniques*, Carbondale, 1977, 128.
10. In the lower stair windows in the Chartres transepts we can follow the way the master tweaked the design to include in the later window to make connections with the rest of the building that were not there in the first window. “Four identical windows”, *In search of the unknown in medieval architecture,* 2007, Pindar Press, London, pdf in COGA/ Explore Carvers/articles
11. As in note 7.
12. As in note 9.
13. John James, “La construction du narthex de la cathédrale de Chartres”, *Bulletin de la Société Archéologique d’Eure-et-Loir,* lxxxvii 2006, 3-20 and Part 2 of this series.
14. Study on the carved colonnettes in Part 4 of this series.
15. Gunther Binding, *Medieval building techniques,* 2004, Stroud.
16. F. D. Prager and G. Scaglia, *Brunelleschi, studies of his technology and inventions,* Cambridge Mass., 1970, 111-.
17. “He constructed ingenious machines for loading and unloading ships, and for drawing cement and stones. He delivered molds for shaping the stones .....” The English translation of *Gervasii Cantuariensis tractatus de combustione et reparatione Cantuariensis ecclesiae* is taken from Robert Willis, *The Architectural History of Canterbury Cathedral*, London: Longman, 1845, 32-62.
18. Jean Villette, “Le portail royal de Chartres a-t-il été modifié depuis sa construction?” *Société Archéologique d’Eure-et-Loir*, xxv 1970, 255-270.