How the masters designed pinnacles

Adapted from a review of *Gothic Design Techniques* by Lon Shelby, in
The Architectural Association Quarterly, xi 1979, 55-59.

There were no measurements!

John James

With one exception, none of the great masters of the Middle Ages wrote about their work until the very end of the period. Only then, just as the world that produced Gothic was giving way to the simpler rationality of the Renaissance, the masters began to open up. Perhaps they felt, in some intangible way, the winds of change that were to dismember their age forever. In a burst of candour one master after another printed his 'tricks of the trade'. Lechler and Rixner, Hosch and Master WG, and the two discussed by Shelby, Roriczer and Schmuttermayer. All were published within a few decades of 1500.

Shelby has investigated the lives of both men, one the master of a number of large buildings in southern Germany, and the other a goldsmith, and presents them to us so that Roriczer (about whom we do know a great deal more than Schmuttermayer) begins to come alive.

But why would a goldsmith be writing about building matters, and why would either of them wish to concentrate on pinnacles for their only works on design techniques? One aspect of the goldsmith's art was the creation of enclosures for reliquaries, and these were often fashioned as little chapels, complete with arched openings and flanking pinnacles. The scale of some of these reliquaries is miniscule, yet Schmuttermayer shows that every part was set out from a series of geometric steps, proceeding in a sequential way from the base so that nothing was left to chance. The small leaves up the sides might be individual, but their position, and even their projection, was determined geometrically.

That a goldsmith working in tenths of an inch could insist on the most rigorous determinism shows how all-important geometry was to the period; and because both masters used the pinnacle to illustrate the fundamental rules of their craft, the understanding of this element may have been the first task of an apprentice. Just as modern architects usually make their first quarter-size details of the eaves of a house, and Beaux Arts students began by drawing from classical models, so the medieval student may have cut his teeth (chisel?) on the structurally least critical part of the building, the pinnacles.

Shelby, after carefully considering the way the two pinnacles were designed, concludes that the techniques were arbitrary, because Roriczer took 234 steps to design his pinnacle, with little apparent reason or logic for any of them.[1] Yet one wonders how geometry could have become so important a part of medieval designing if it were such a non-rational and arbitrary business. Shelby felt this when he wrote,

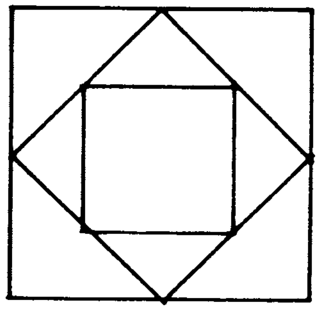
"Roriczer began his description of the technique with the sentence 'if you want to draw a base plan for a pinnacle according to the stonemason's art and according to the correct geometry', and he closed his pamphlet with the statement, 'thus ends the booklet concerning pinnacle correctitude'. He obviously thought there was a right and a wrong way to do it, and the correct way was the one that he was setting forth."

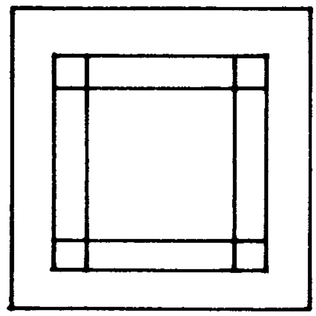
Yet behind these apparently arbitrary steps I discovered a beautiful order. Neither master shows any understanding of this, and while we might expect that from a goldsmith, Roriczer's reticence is more disturbing. I can only conclude that Roriczer was not one of the more gifted men of this period, competent at his trade no doubt, but lacking the philosophic and speculative turn of mind that can be found within the geometry of the pinnacle itself. He was a craftsman, not a geometrician. The fact that Roriczer gives no reasoning for the steps he recommends so puzzled Shelby that he concluded that geometry was "nothing more than acquired techniques."

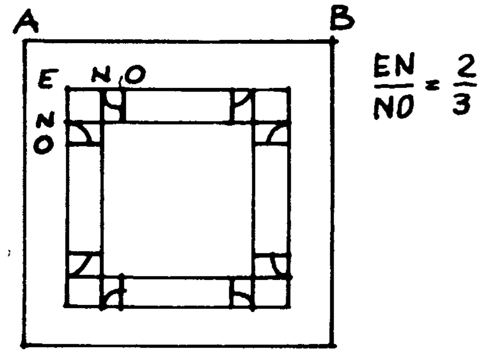
'Acquired' is true, for each pupil learnt from his master, and the better ideas were handed down from one generation to another. Both Roriczer and Schmuttermayer claim that their methods were "from the old-timers who knew this art, the Junkers of Prague" probably referring to the Parler family. This suggests that they did as they had learnt. They admit this, which may be why their techniques smell of rote learning.

Let's see whether there is an unspoken, (and for these two men an unknown) geometric evolution in these pinnacles. In studying their steps I find a logic and, more importantly, a constructional intelligence.

Roriczer begins his design with the three inscribed squares which are in the ratio of 2:√2:1 [r1]. He then aligns them to one another and joins the sides of the inner one to the outer [r2], and lastly he extends the latter so that ON/NE = ⅔ in [r3]. This last drawing forms the base plan from which everything in the elevation will be derived, through all 234 steps. It seems a lot of steps to remember and to repeat in each part, but when we analyse them carefully we find that they all derive from only four modules;



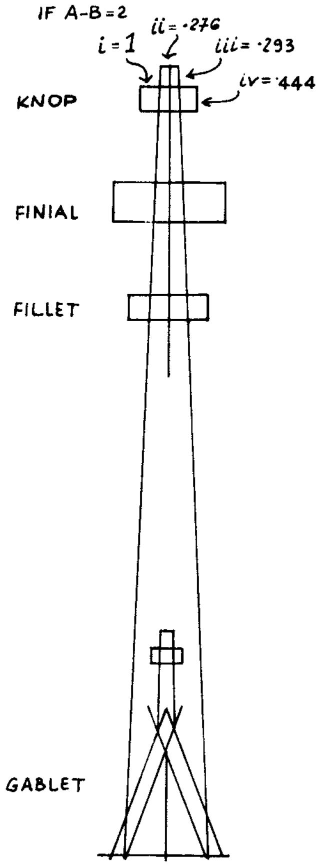




1. The squares in the base plan. AB is the most important module, for six give the height of the lower part and seven the height of the cap.
2. The space between the inner two squares, and its third derivative.
3. The space between the outer two squares.
4. The ninth of the outer square, used only in the knop, finial and fillet at the top of the cap.

So there are only four basic dimensions altogether, increasing to nine with their multiplicands, from which every part of the pinnacle will be derived. It is the same in Schmuttermayer's pinnacle, though he derives his dimensions in a simpler way.

All nine dimensions are formed from the three squares except for the last, and there is a nice correspondence between the four-sided squares and the eight lengths derived from them. I am sure you would also notice how the ninth dimension is also a ninth part of the square. None of this appears to be clear to Roriczer, who could have simplified his description if he had understood it. He is like the bureaucrat just repeating the rules with little sense of their deeper purpose. The reaon that I feel that his teachers, the Junkers of Prague, understood, note the following;



a. You can draw an imaginary box around the pinnacle. The square that established the base is repeated around the edge of the gablets, and in the silhouette of the finial, marked the drawing of the cap in [r4]. The edge of the gablet exactly marks the mid point between the base and the top of the finial and is six units from either end.

b. All four modules are used in the knop, the uppermost decorative item. The tip is therefore a summary, where all systems are extended and reconciled. Surely there is a philosophy here?

c. The plinth is the same height as the base, and so is the knop to the top of the finial. The gablet was set out as one and a half times the base in height. The three form the agreeable pattern of 2-3-2.

d. In the three upper elements, the knop-finial-fillet, both masters use all three squares from the base plan forming widths of 1:2:√2 (another pleasing rhythm). In the gable over the window the finials have width in the ratio of

√2:4:2. The elements on the pinnacle relate to those on the gable as 1:√2, 1:2 and √2:2. Very nice, geometrically!

e. The use of the three squares from the base plan for the dimensions of the top of the cap is found in both schemes, and used consistently in both pinnacles and gables. This is no longer an arbitrary step, but an essential and meaningful one without which the earlier parts could not be brought together into a whole.

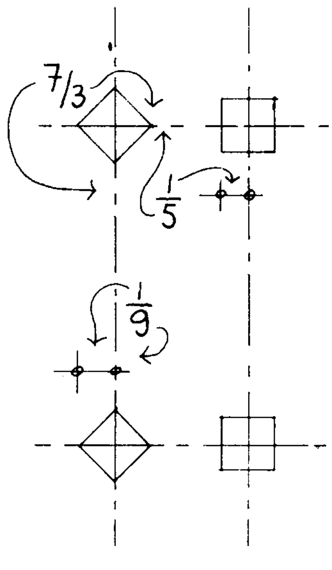
f. It is significant that at one stage both Roriczer and Schmuttermayer stop using the modules that have been employed everywhere else, and introduce a new dimension. It appears in the topmost part of the cap, being also the last step in the design. If the knop is the summation of the geometry, then a part of that summary is the use of modules not used elsewhere, but which still stem from the base square. It is like saying that the uppermost parts represent something different to the rest, while still being related to it. Without such a 'stray' length the geometry could not have been reconciled. This is the process of circularity .

There seem to be meanings of some sort underlying each of these arrangements. The idea of summarising the modules used in the geometry in the knop, of introducing a ninth length for the last step in the design, of enclosing the whole within a set of boxes all indicate an underlying philosophy or set of rules. But what is directing the master as he makes the design for the first time? It must be something, for otherwise there would be no discernible logic in the geometry, let alone ideas that are common to both masters.

Whatever the reasons, be they symbolic or structural, the choice involves pattern. The satisfaction we get from recognising the use of the three squares in the upper elements in purely aesthetic, as is the 2-3-2 harmony in the heights, and the summary in the knop. We feel a justness in the selection, and if we had drawn it up ourselves we would get the same kick from the pattern on paper as we would from good music or a fine painting. The use of geometry to form artistic patterns pleasing to the eye and to the intelligence seems to be a major reason for their design techniques. Pattern is in essence an art form. There may be logic in the order, and the steps may be rational and intelligent. But in the end we judge it for its beauty.

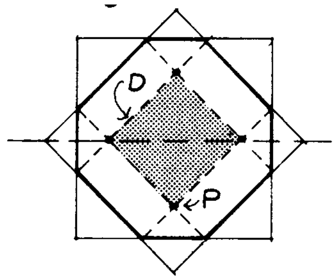
The interlacing patterns of geometry used to create the western rose at Chartres is a set piece within the structure, like a cadenza, and is generated from interlocking triangles, squares, octagrams and dodecagrams.[2] Like Arabic wall tiles and intricate plaster ceilings they are abstract arrangements created for their own beauty, and owe nothing to functional or structural necessity.

But designing the structure of the building is another matter altogether. You dare not play with that if you want to be certain that the building is going to stand. One of the commonest rules is to make the size of the pier equal to a square whose sides are one fifth of the bay. No account is taken of the height of the building, so the actual weight of stone being supported by the pier is ignored. Similarly. the span of the aisle, and hence the mass of the vaults over the piers, is also ignored. Slenderness ratios are also excluded. The same fifth was used at Nevers where the piers are five metres high, and at Cirencester where they are twelve.



Yet the piers were intended to act structurally, for at Chartres the one-fifth square was transformed into a cylinder having the same cross-sectional area. This was done by the old trick of increasing the side of the square by one eighth to obtain the diameter of the drum. The drum would therefore have been able to carry the same load as the square. That is a neat method, but still does not express the weight the pier was to carry.

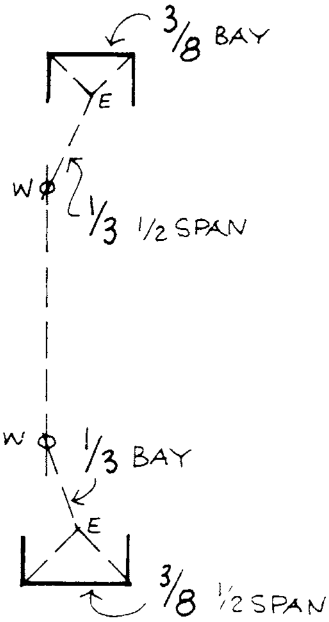
In Chartres the span across the nave was made seven units where the bay alongside the aisles was made three, giving a proportion of 7:3. The span was then divided into fifths which formed the square of the pier plinth [r], and the combination of these two produced the irregular octagon which became the foundation stone, at floor level, for the pier. This was then reduced through diagonals D in [r1] to locate at P the centres of the four shafts which surround the drum. But the diamond so formed, shaded, is the same fifth as was used to divide the bay! This fifth is then modified by 9/8 to produce the circular drum.



Geometrically it is an amazing achievement to derive this from a rectangle of 7:3, subdivided by ninths and fifths into a composite figure whose corners represent nothing found in the original rectangle, and which are then reduced by diagonals that represent √2 to produce the fifth division of the bay that was used at the beginning. Mathematically there is the tiniest error, but for practical building geometry it worked perfectly.

I call this circularity. It is a process of verification, for it 'justifies' the steps in the geometry, like a stamp of approval. It was obviously an important ingredient in the design process, for it occurs again and again in medieval design and had nothing inherently to do with structure or with function. It was a well-integrated aesthetic device that is fundamentally artistic in its effect on us, and presumably on the designer as well.[3]

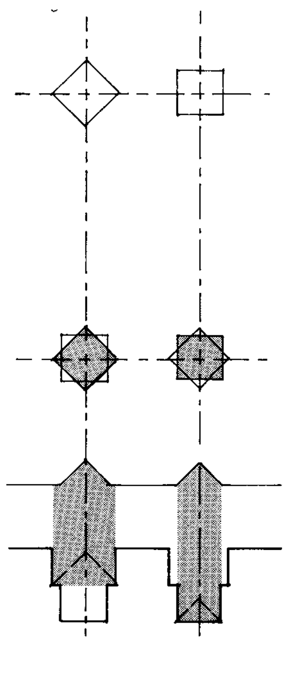
Symbolically, every step in the design of a sacred building is itself a devotion. The 7:3 ratio used in the nave employs two of the most meaningful numbers in Christian thinking. The span was divided into ninths and nine is one of the Virgin's numbers, to whom the Cathedral had been dedicated. The bay was divided into fifths, and five is the number of Christ as the consecrated man.



Weaving proportions across the major elements of the portal, first

The use of inscribed squares in the next step may have symbolised the transformation from number to structure, made at the floor level where the piers that are to support the building first appear. Was the master working consciously in applying these numbers, or from his gut? The question may not be the answerable, but from other work by the same man I believe he was conscious of what he was doing.[4] But even at this level the design is artistic rather than rational, a thing of beauty rather than of engineering.

As a last illustration of pattern, examine the two eastern buttresses of the Chartres choir, [r2]. For various reasons, by the time the work had reached the level of the aisle windows, the southern buttress was wider than the northern, but it did not project as far.[5] It was also out of alignment with the shafts in the inside of the wall. Faced with this situation, the master who designed the buttress above the walkway cornice began by placing the epicentre E in relation to the wall W, and then fixed the width around the centre. E-W was made one third of the bay in the south and one third of the half-span in the north, [r3].

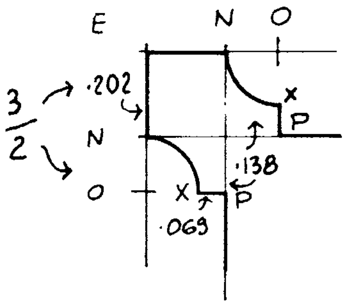


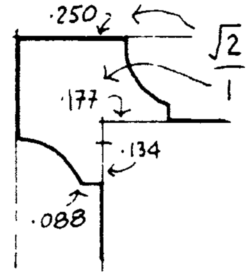
He then reversed the procedure, and made the width 3/8 the half-span in the north and 3/8 the bay in the south. The 1/3 and 3/8 ratios were constant, but he reversed the originator. This contrapuntal arrangement has nothing to do with structure. If one side had to be balanced by the other, as in a house of cards, it might have made some sense. But in a static part of the structure which is only withstanding loads from higher up it made no sense at all – except as pattern, as a beautiful contrapuntal arrangement of proportions that one sensed as good. Music in stone.

It is not necessary to give more examples to illustrate that the decisions made in medieval geometric analysis are, at heart, artistic ones. In this sense there is nothing 'arbitrary' about the geometry they described. It is as orderly and as rational as a Moslem tile pattern or a Celtic scroll.[6]

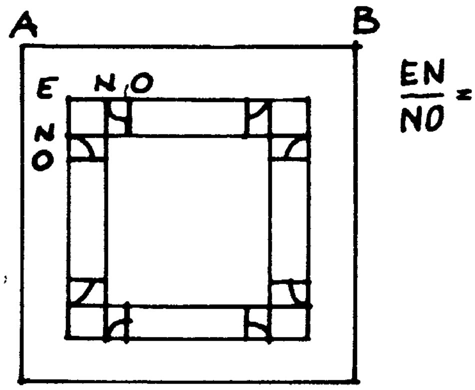
When we understand this, we might ask whether there is any advantage in pursuing our investigations into medieval geometry any further. If it is just pattern, and if it is as unrelated to real structure as it seem to be, why spend time to go deeper? Besides the intrinsic fascination that pattern has there is an excellent historicist reason for understanding geometry as profoundly as possible.

To communicate his ideas to the mason cutting the stones, the master produces templates. He does this in his own way equally to details like door jambs and mullions as to large elements like piers and towers. The template is the key to the master's identity. And as it is constructed geometrically, we shall be able, by analysing it properly, to identify him more surely by his geometry than by any other item. Some masters use the golden mean, while others never do. Some use the irrational in sequence like √2:√3:√5, while others use nothing but harmonic inter-relationships of whole numbers, or numbers coming from squares or pentagrams. These differences are obvious in the work of Roriczer and Schmuttermayer too. Superficially their pinnacles look alike, if only because they are the product of the same place and time, being southern Germany around 1500. But Schmuttermayer, the goldsmith, uses his compass less, and his dividers more for the modules, is more concerned with planes than arcs, and does not bother to express the interior geometry in the details. Even though these are things that we would expect if we think about the goldsmith's techniques and the scale of his work, they still show underlying differences in style that are the mark of the man.





There is a good example in the plan for the corners of the gablets [r1]. In the upper gablet by Roriczer this is point E [r2]. The corners N express the inner square, the faces OP express the 2/3 NE, and the small fillet XP is what is left over after the arc has been drawn. In Schmuttermayer's, being the lower gablet in this figure, suitable modules have been picked for the widths of all the flat surfaces so that the size of the inner square is lost, and the arc is not a true quarter circle. Therefore, for Schmuttermayer the purity of the curve, and the expression of an inner geometric form is less important than for Roriczer. This gives us clues about the geometric 'personality' of each man.

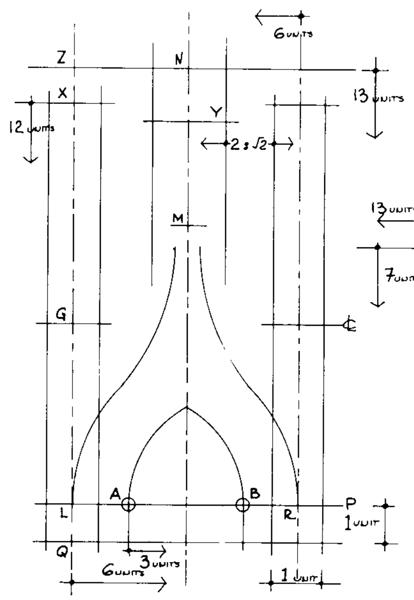


At Chartres it seemed significant that the first master extended the ninths and fifths used to set out the 'octagon' to the outside of the building to determine the widths of the buttresses. In that process the Chartres master was working with the same mindset as Roriczer.

I am fascinated by what was not described by these two masters, for

scheme Master-11.

the geometry that was left out seems much more interesting than what was included. Roriczer provided a drawing of the gable framed by two pinnacles. Though the evolution of the latter was described in enormous detail, with all 234 steps, of the gable and the overall proportions that relate one part to the other there is not a word. Why did he leave out the grander parts of the system, and include only the least important? What was being hidden? I have shown some of the possible relationships [r3].



One has the impression that as the elements of medieval geometry are understood – not just the greatness of the plans, but the smaller parts as well – we will find that similar concepts and modes of approach will apply throughout. I have assembled some of these in earlier chapters, for they provide inestimable clues to the way the masters approached their art.

1. Lon Shelby, *Gothic design techniques, the fifteenth-century design booklets of Mathes Roriczer and Hanns Schmuttermaye*r, Carbondale, 1977
2. John James, "Medieval Geometry: the western rose of Chartres cathedral", *Architectural Association Quarterly*, v 1973, 4-10.
3. John James, "26 Measuring and extracting", *In Search of the unknown in medieval architecture,* 2007, Pindar Press, London.
4. John James, "The canopy of paradise", *Studies in Cistercian art and architecture,* lxix 1984, 115-129.
5. John James, *The contractors of Chartres*, Wyong, ii vols. 1979-81, chapter X.
6. Albarn, J. M. Smith, S. Steele, and D. Walker, *The language of pattern,* London, 1974; Keith Crichlow, Jane Carrol and Llewylyn Vaughn Lee, "Chartres Maze: a model of the universe?", *Architectural Association Quarterly*, 1973.