FUNCTIONALISM VERSUS CAPRICE IN STONECUTTING

The Case of the Nativity Chapel in Burgos Cathedral

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ABSTRACT: Starting from the inaugural text of Philibert de l’Orme, stereotomic treatises and manuscripts are subject to the opposing forces of reason and fancy. The Nativity Chapel in Burgos Cathedral provides an outstanding case study on this subject. It was built in 1571-1582 by Martín de Bérriz and Martín de la Haya, using an oval vault resting on trumpet squinches to span a rectangular bay. Bed joints and rib axes are not planar curves, as usual in oval vaults. This warping is not capricious; we shall argue that it is the outcome of a systematic tracing method. As a result of this process, the slope of the bed joints increases slightly in the first courses, but stays fairly constant after the third course; this solution prevents the upper courses from slipping. Thus, in the Nativity Chapel of Burgos Cathedral, the constraints of masonry construction fostered a singular solution verging on capriccio. It is also worthwhile to remark that the warping of the joints is not easily appreciable to the eye and that the tracing process does not seem to start from a previous conception of the resulting form. All this suggests that we should be quite careful when talking about the whimsical character of Late Gothic and Early Renaissance; in some occasions, apparent caprice is the offspring of practical thinking.

Patronal whimsy and masonic pride

Thus, from the very start, stereotomic treatises seem to be subject to the opposing forces of functionality and caprice, reason and whim. In one page, they argue for the utility of skew passages or trumpet squinches to solve planning problems; in the next one, they boast about the cunning of the architect that placed a corner.
THE NATIVITY CHAPEL IN BURGOS CATHEDRAL

Foundation and construction of the chapel

On 26 April 1570, the Chapter of Burgos Cathedral concluded an agreement with Ana de Espinosa, widow of Pedro González de Salamanca, concerning the foundation of the Nativity Chapel. With that purpose, the Chapter granted a lease of the chapels of Saint Martin and Saint Giles, allowing Espinosa to demolish the wall between both chapels, provided that neither the pillars nor other walls were damaged; besides, the design of the new chapel was subject to approval by the fabriquero and master mason of the cathedral. Also, the founder should provide the chapel with an altarpiece, a grille, a sacristy, choir stalls, organs and funds enough to maintain a main chaplain, four lesser chaplains and two acolytes, all of them appointed by the cathedral chapter. (AHCB a).

A tablet on the chapel wall reads “Anno Dni 1571”, indicating quite probably the starting date of actual construction. In fact, on 4 June 1572, Ana de Espinosa signed her last will, confirming the foundation of the Nativity Chapel, and stating her wish to be buried on the camero or crypt of the chapel, which was being built at that moment according to an agreement with the master Martín de Bérriz (AHCB b; AHCB c; Rico 1985, 367). On 14 January 1576, Martín de Bérriz won an important contract at the Escorial; along with Juan de la Puente he took charge of the construction of the north tower, on the left side of the narthex of the basilica or main church. (ABMSLE a; Bustamante 1994, 434). He could not carry out the commission to the end, since in January 1578 he was dead and the King dispensed his heirs from the obligation to refund the money given to Bérriz in order to build the tower. (APSL a; Bustamante 1994, 497).

On 11 July 1590, an inventory of the ornaments of the chapel was made. On 1 February 1591, the cathedral chapter commissioned Jerónimo de Herrera and Juan de Ochoa Corcuera to visit the chapel; their report makes clear that the chapel was finished and furnished with gold, silver and ornaments (AHCB d; AHCB e; AHCB f). What is more, on 1 March 1592, the chaplain Miguel Martínez presented a full series of accounting...
The vault in the Nativity Chapel

Although the extinct chapels of Saint Martin and Saint Gilles stand at the beginning of the cathedral ambulatory, it is easy to surmise that they had rectangular plans, with their shorter sides along the aisle wall, such as the present-day Main Vestry of the cathedral, which stands at the other side of the presbytery. The union of both chapels gave as a result a rectangular area, with its longer side along the ambulatory wall. The pillar at the intersection of the dividing wall with the aisle wall was of course to be kept, resulting in a double entrance from the deambulatory.

The builders of the chapel choose to span this rectangular plan with an oval vault over a low drum, using four trumpet squinches to solve the transition between the rectangle and the oval. These squinches are decorated with ribbons with rollwerk endings and medallions of Saint Augustine, Saint Jerome, Saint Ambrose and Saint Gregory. At first sight they resemble asymmetric trumpet squinches or pechinas en viaje, which are fairly common in the literature and the building practice of the period (BNEa, f. 3; Vandelvira c. 1580, f. 8v - 9v; Palacios 1990, pp. 30-31), but in fact the intrados surfaces of the squinches are cones of revolution and the asymmetry only comes as a result of their intersection with the oval cylinder of the drum. Besides, our survey has confirmed that the intersection line is planar, in accordance with the theory of quadric surfaces.

Over these squinches, the drum supports an oval cornice. The actual oval vault springs from this cornice; it is decorated by radial ribs and four rich panels of the Evangelists. However, careful inspection of these coffers, or a photograph taken from the centre of the chapel floor, show that the ribs which divide the vault into coffers are warped and do not follow vertical planes, as usual in coffered vaults, such as the ellipsoidal vault in the Seville chapter hall. Although this feature seems at first sight capricious, we should take into account that this layout allows the ribs to meet the bed joints at approximately right angles, preventing dents in voussoir edges.

The pillar that was not to be damaged according to the 1570 agreement intersects the cornice and the vault in an awkward manner. An oval oculus gives way to the light that falls from the lantern, which is hexagonal in plan and decorated with a rich lattice, resembling at a lesser scale the well-known vault over the cathedral crossing or cimborrio praised by Charles V.
The geometry of the vault

We have carried out a survey of the vault, using a Riegl LMS-Z420i long distance 3D laser scanner to gather point clouds representing the geometry of the intrados surface of the vault, using the coordinates of a number of retro-reflective targets, taken with a Leica TCR 1105 laser total station in order to reference mutually and join these point clouds. Additionally, a number of significant points, such as those on the ribs and joints, have been taken manually using the total station.

The intrados surface of the vault measures 10.2 m long, 7.2 m wide and 4.0 m high. It is not easy to put forward a simple geometrical model of this surface, such as an ellipsoid or a surface generated by the revolution of an oval, since the ribs which divide it stand below the coffers, and besides, the panels of the Four Evangelists make the tracing of straightforward longitudinal and transversal sections quite difficult. However, it will not be essential to our reasoning to ascertain the exact nature of the surface; as we will see, most probably the vault tracing was based in a number of control points.

The survey puts into evidence a number of unusual facts. The apparent bed joints are not horizontal lines, but rather warped curves, with their highest points placed along the longitudinal axis of the vault, as the longitudinal section and the transversal section in Fig. 6 show clearly. These warped curves are fairly symmetrical about both planes of symmetry of the vault, longitudinal and transversal; thus, the warping of the bed joints does not seem to be caused by movements of the vault nor from settlements of the foundations. Other details suggest that the warping of the bed joints is intentional. If all the points that represent bed joints in the survey are rotated along a vertical axis and brought to the same plane, they are fairly collinear, as shown by Figs. 3 and 4; in fact, considering separately each quadrant of the vault, the collinearity is almost perfect. That means that the apparent bed joints are placed at the intersection of a number of cones of revolution with the intrados surface of the vault. This leads us to think that bed joints are surfaces generated by the rotation of a straight line around a vertical axis, although of course this cannot be checked without dismantling the vault. The masons could have used a cintrel, that is, a rope or wooden bar attached to a central pole placed at the vertical axis of the vault, to control the shape of the bed joints (Fig. 5). Besides, the slope of the generatrices of the cones increases slightly in the first courses, but stays fairly constant after the third course. If the vault was built without a strong centering, this limitation of the slope of the bed joints could have prevented the courses from slipping. However, there is another fact that can explain this strange progression of the bed joint slopes. If we consider the meridian sections that pass through the starting points of the ribs and divide these meridian sections into equal parts, the division points fit into the bed joints within reasonable tolerances. Although this explanation is rather simple, it is not obvious, since the meridian joints are not materialized by the ribs, which are not placed in vertical planes as we have seen.

Fig. 2: Point cloud depicting the longitudinal section of the vault over the Nativity Chapel in Burgos Cathedral
Warped versus planar curves

Thus, the stereotomical solution of the Burgos vault departs clearly from the models for oval or elliptical vaults in sixteenth- and seventeenth-century treatises and manuscripts (Vandelvira c. 1580, f. 72r - 78r; Derand 1643, p. 398-400; Frézier 1737, 2, 400-405). By contrast, it resembles at first sight Gaspard Monge’s solution for the National Assembly of the French Revolution (Monge 1795; Leroy [1844] 1877, pp. 254-256, planche 44). Monge devised a solution for a vault whose intrados surface was a half-ellipsoid with three different axes; that is, an ellipsoid that is not generated by the revolution of an ellipse nor, in fact, any other figure. Besides, Monge added two constraints on the problem: bed joints should be orthogonal to the intrados surface and materialize non-warped surfaces; in geometrical terms, the bed joints in Monge’s solution are developable ruled surfaces generated by normals to the intrados surface. As Rabasa has stressed (1996b, pp. 32-34; see also Sakarovitch 1997, pp. 309-313), both constraints are not strictly necessary in terms of stonecutting technique. Orthogonality between intrados and bed joints is advisable, to prevent dents in voussoir edges during the placing process, but of course, strict perpendicularity in each point of the edge is not necessary; a fairly large angle is sufficient. Developable bed joints allow the use of flexible templates in these joints; however, a fair number of stonecutting treatises suggest or imply the use of flexible templates in intrados faces (Gelabert 1653, p. 90; see also Rabasa 1996a, p. 429 and Calvo 2002a, pp. 338-342) but not in bed joints. Of course, the builders at Burgos surely did not think in such abstract terms as Monge; in fact, their solution departs from Monge’s one in some important aspects. To start with, the higher points in the bed joints of the Burgos vault are placed at the longitudinal section, while in Monge’s solution they lie on the transversal section. Besides, in Burgos the revolution surfaces in the bed joints generally do not seem to intersect the intrados at right angles; in other words, the need to keep the centering at a minimum has prevailed over the convenience of preventing dents. By contrast, the builders seem to have tried to prevent dents in the edges where each voussoir meets the next one in the same course, playing with the tracing of the vault ribs.

Besides, we have seen that the bed joint surfaces seem to be cones of revolution, which are developable surfaces. However, this trait does not seem to derive from the wish to use flexible templates. As we have seen, Spanish stonecutting manuscripts use flexible templates based on cone developments for the intrados of trumpet squinches and even for hemispherical vaults, substituting cones for portions of the sphere (Vandelvira c. 1580, f. 60v-61v; Rabasa 1996a, p. 429-431); however, they do not use cone developments for bed joints, that were usually dressed with a square with a curved arm, the cintrel or wooden bar use to dress the voussoirs before their placement and also with a desire to simplify tracing procedures, as we shall explain in the next section.

A hypothetical tracing for the vault

Thus, no stonecutting treatise or manuscript, nor any tracing or written description, gives a hint about the tracing method used by the vault builders. However, the geometry of the vault offers enough grounds to put forward a hypothesis about these tracing procedures. Fig. 3b shows points from the apparent bed joints transferred to a meridian plan by means of a rotation around a vertical axis. As a result of this operation, all points from the same joint are collinear, that is, they are placed over the same straight line. Thus, the apparent bed joint, although warped, belongs to an inverted cone of revolution. Quite probably, the actual joint surface, starting from this line and going into the interior of the masonry, is also a part of this cone, although of course we are unable to check this fact empirically.

The horizontal projections of the apparent bed joints are a number of fairly similar ovals or ellipses; in this case, it is not easy to ascertain which kind of curve was used in the tracing process, since it is possible to construct an oval which fits quite closely an ellipse of the same proportion between axis lengths. Besides, Renaissance masons used both four-centre ovals and a number of affinity-based constructions which furnish points of an ellipse (Dürer 1525, C3v; Serlio 1545, pp. 13v-15r, 17v-18v; Calvo 2002b; Huerta 2007, pp. 222-233; Alonso et al., in prep.). Thus, the apparent bed joints can be understood as intersections of oval or elliptic cylinders with the inverted cones of revolution.

Taking all this into account, we can put forward a hypothesis for the design and execution process (Figs. 3 and 4). As a first step, the base line can be traced in plan, either as a four-centre oval or by means of an affinity-based construction. After doing this, we have constructed a cross-section and a longitudinal section, dividing each of them in an equal number of parts, leaving aside the oculus of the lantern. Once this is done, we have brought these divisions to the plan, in order to determine the axes of the ovals or ellipses which represent the horizontal projections of the joints. The result of this operation is a series of almost exactly similar ovals or ellipses. If we transfer both sections of the vault to the same vertical plane, by means of rotation (Fig. 3c), the lines that join the division points furnish the slopes of the cones of revolution. This diagram, joining the longitudinal and transversal sections of the vault in the same plane, furnishes a method to determine the spatial location of any point of the warped lines, in combination with the plan (Fig. 4). Taking the position of the point from the plan, it can be rotated around a vertical axis in order to transfer it to a frontal plane; then, the point can be brought to the elevation and raised to the slope line that corresponds to each bed joint, in order to determine its height.
This procedure is quite appropriate for the Burgos vault, since the vault coffers are not placed along meridian planes. Besides, this operation can be carried on physically, using a cintrel and a plumb line; the cintrel can be used also to check the dressing of the bed joints. Thus, this method can be used to control the execution in place and, at the same time, to determine the spatial position of each corner of the voussoir. Using these locations, the mason can compute the distances between voussoir corners, and construct a template for the intrados face of the voussoir (Vandelvira c. 1580, f. 75 r.; Palacios 1990, pp. 172-173).

We have carried on this process graphically; the result, shown in Fig. 6, includes a series of warped lines which resemble clearly the actual lines in the vault. In spite of the presence of sculptures and the projecting cornice, that do not allow determining exactly the geometrical shape of the vault, in particular the plan and the longitudinal and transversal sections, the result of our hypotheses fits closely the points gathered in the survey. The entire process is independent from the nature of the starting lines, either elliptical or oval. In fact, it is not easy to put forward any hypotheses for the shape of the longitudinal and transversal sections. Probably they do not meet in a point at the top of the vault; of course this is not a problem, since this area is taken by the lantern. All this leads us to think in the design process for the vault strictly as a method for the spatial placement of points and lines, which does not start from the conception of a prior geometrical shape for the whole member; in particular, the process does not involve the pre-conception of an ellipsoid, an idea that was not known in the period.
CONCLUSIONS

Thus, in the Nativity Chapel of Burgos Cathedral, the constraints of masonry construction - the convenience of limiting the slope of the bed joints and, at the same time, keeping voussoir faces as orthogonal as possible - fostered a singular, idiosyncratic solution verging on capriccio. This explains two remarkable traits of the vault and its tracing process. First, the warping of the joints is not easily appreciable by the naked eye. Second, the intrados surface does not seem to correspond with a clear-cut geometrical form, such as an ellipsoid or a surface generated by the revolution of an oval shape, but is rather the result of a “blind” process that does not envisage the final form. If there is any whimsy here, it belongs to the tracing process, as in so many Late Gothic examples, and not to a pre-conceived result.

These practices should be added to the sources of strange stonecutting solutions outlined at the beginning of this paper. Thus, apparent caprice can be the result of patronal whimsy, as in the chapel of Anet or the Murcia and Jerez spiral vaults; of masonic pride and desire for self-promotion, as in Plasencia and León vaults and the Granada oposiciones of 1577 and 1631 and many others; of the constraints of actual working-site problems, as in the Burgos chapel; and of the desire to find a practical application for an abstract mathematical result, as in Monge’s ellipsoid. Of course, all these factors can be intermingled. At the Anet vault, patronal whimsy combines with typically Philibertesque boasting: the curved ribs in the Burgos vault prevent dents when placing the voussoirs, but can be explained at the same time as an expression of exotic richness, right below and a few decades after the jewel of Charles V. All this suggests that we should be quite careful when talking about the whimsical character of Late Gothic and Early Renaissance; in some occasions, apparent caprice is, at least in part, the offspring of practical thinking.

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