

Heritage and Identity: Evolution and propriety in Catalan Gothic Architecture

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ABSTRACT: Differences between Catalan and International Gothic Architecture are apparent, though seldom proved with objective parameters. Three aspects seem relevant: A) Interdisciplinary reading of Heritage constructions unveils features, made clear in computer-assisted surveys. B) Pragmatics of daily life implicit in meetings of master builders to choose structural solutions sketched possibilities, rather than a final formula. Use of original Gothic measures, and not meters, unveil modulations in whole-numbers and simple design procedures. Sustainability was tantamount to viability, saving expensive scaffolding, use of only one set of wooden stencils, handy sizes of stone, etc. Preservation should proceed equally. C) A holistic approach seems relevant, advancing typological series to unveil the genealogy of forms, which constituted an ethical attitude, in the double sense: deepening in what was relevant, and leading to an ethos, to the essence of the posed question.

1 INTRODUCTION

Catalan gothic architecture (AGC) and the Catalan constructive tradition are intertwined. Some ergonomic measure units were spread in this area, allowing flexible and versatile uses that, together with the avoidance of unnecessary loads and the inclusion of modules,

An initial interest in Catalan gothic architecture (AGC) appears early, when deepening in Catalan constructive tradition. Ergonomic measure units in this area allowed flexible and versatile uses that, with the avoidance of unnecessary loads, the introduction of modules and flexible building systems constituted an ethical attitude, in a double sense: going further in what was relevant, and leading to an ethos, to the essence of the posed question. The savings achieved thus made some buildings viable in times of scarcity, which, otherwise, would have never been built.

Influences in both directions of the Pyrenees produced a talent for the proposal of new structures that did not subordinate AGC to its international counterpart, as it happened in the previous period, now subject of intense research. Existing works in the South of France and the old kingdom of Aragon (Catalonia, Valencia, Majorca,...) were studied, by measured surveys, The evidence provided series of constructive systems classified according to their genesis.

A reasonable answer to the questions posed articulated several values: rationality inseparable from of a deep sensitivity towards space, economic means and a sense of constraint, appearance of bigness though surveys show that most constructions were rather modest, contrasting with great engineering landmarks (as the cathedral of Girona and Palma), adjustment of the materials to their function, flexibility to welcome several activities.

The method applied in the search of objective results is simple (understanding of the buildings studied, adjustment of new technologies for accurate survey but with original measure unit, and classification and genetic exposition).

2. READING OF BUILDINGS

a. Collections of Field-work sketches established a direct relation with the building.

A copy is kept in “Gabriel Ferrater” Library at the UPC, directly accessible at the TDX webpage: www.tdx.cbuc.es , URN TDX-0328103-121420.

b. Gothic measures (canes) used in the area were applied at surveys.

Since meters did not exist in medieval times, their use today for these structures is the force of daily habit. But distances in meters hide the constructive modules that become translucent when measured with original units. These units are approximately two meters (Toulouse cane is 1,79 m, Montpellier cane is 1,98 m.), some units stand out.

The Barcelona cane (1.555 meters, divided in 8 hands, each one of them divisible in 8 fingers, and these in 8 lines) exemplifies the reiterated division in halves. It has an equivalence with the destre cane (2.80 m.) - multiplying by 9/5- then its divisions vary accordingly (the destre cane is divided into 12 destre hands, and these in 12 destre fingers and these in 12 destre lines) producing more versatile units, since we operate with “more than perfect numbers” (those who are smaller than the sum of their divisors), that is, the combination of smaller units adds constructive qualities, as in Le Corbusier’s Modulor series.

Indeed, 5 destres (or 9 canes) are the measure between columns of the best known construction, Saint Mary of the Sea (Santa Maria del Mar), taken between edges of a column and the external face of the opposed one, which is how Prof. Connant indicated one should proceed in medieval buildings, considering structural cuttings within elements. In synthesis: geometric versatility is constructive possibility, as well. A collection of units used in the South of France and the Kingdom of Aragon is included in fig. 1.

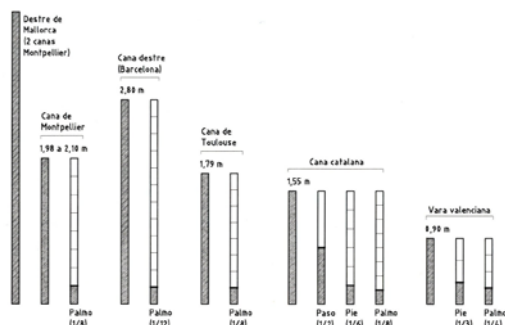


Figure 1. Measure units used in Catalan area of influence.

c. Application of new technologies to topographic surveying “on site”.

A laser theodolite allowed the transfer of data to archives dwg, dgn, operating with a minimum error (non greater than of 10 mm), in order to realize later all the operations necessary to read the diagonal arches in real size and draw conclusions.

This procedure avoided a photogrammetric survey, costly and unnecessary. Elevations measured to scale enabled a comparison of buildings, then ordered in typological series (in canes, meters or graphic scale), thus clarifying the evolution, and allowing superimpositions of different temples sectioned to establish relations among them.

The measurement of the arches (easy, three points suffice) provided additional information when we added a few more points to the initial reading: cant arches, structural deformations or forced constructions were then detected. Ruled surfaces appeared at junctions, providing an advance of later uses, as it happened within Modernism (1875- 1920).

Some observations were relevant. Taking Santa Maria del Mar as paradigm, we observed that:

- four out of five arches (all except the transversed arch at side naves) have the same curvature, this implies only four alternatives for arches of wider span and bigger height.
- work with the same model or previous models to construct centerings,
- reduction of angles and equipment for tracing, measure and transportation of angles,
- use of a single centering, establishing a standard system of support for the whole structure,
- use of a single type of voussoir in arches, standard stone cuttings, equalling the amount of mortar in wall constructions, with savings of time and transport (since quarries were usually close to building sites)
- in synthesis, with adequate previsions work rate was economic, in the multiple sense of saving costs, building rhythm, viability and... sustainability.

3. CONSTRUCTION OF ARCHES AND VAULTS. FIRST APPROACH.

The following step is the study of arches and its systems. A comparison of arches “de terç”, “de quint”, as well as the elliptic, parabolic and pointed forms lead to calculate horizontal and vertical thrusts following Heyman and Ungewitter, and an evaluation by means of graphical statics, only for the purposes of comparing several structures and the conditions of balance of supports. The condition of equilibrium entails that vault thrusts should be equivalent to reactions on their supports, once considered a security coefficient. In other words, an equilibrium of forces (vertical and horizontal) as well as that of turning moments.

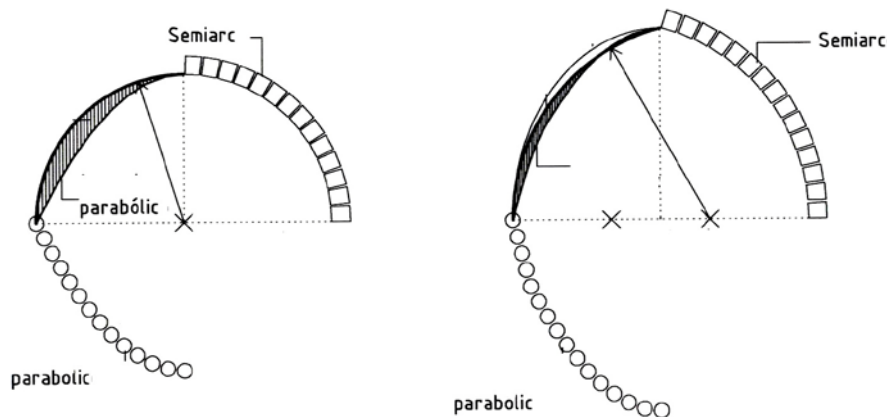


Figure 2. Semicircular and pointed arches compared with parabolic/ catenary.

For any arch we can consider the shape of a chain only subject to its own weight (the catenary arch); then, alternative arches compared with it. As we see in Fig. 2, where a semi-circular arch and a pointed arch (an arch “de quint”) are compared, the bigger the area between a pointed arch and an hypothetical catenary, the bigger the distortions produced in an ideal compressed behaviour. The relative position of such areas to the arch axis provide information about how this arch tends to deform, opening itself by the extrados at their springing, or opening the intrados at its crown.

Such balance of supports, could be compared by means of two coefficients:

- a geometric coefficient or form factor, quotient between half of the base of the stirrups and the eccentricity. It showed whether the pushes were can be gathered within the abutments in an effective way, and
- a mass coefficient or mass factor (relation between the push of the rib vault and its relatively opposed, that is, that of the wall plus the abutment) where the resistance of the used materials is considered.

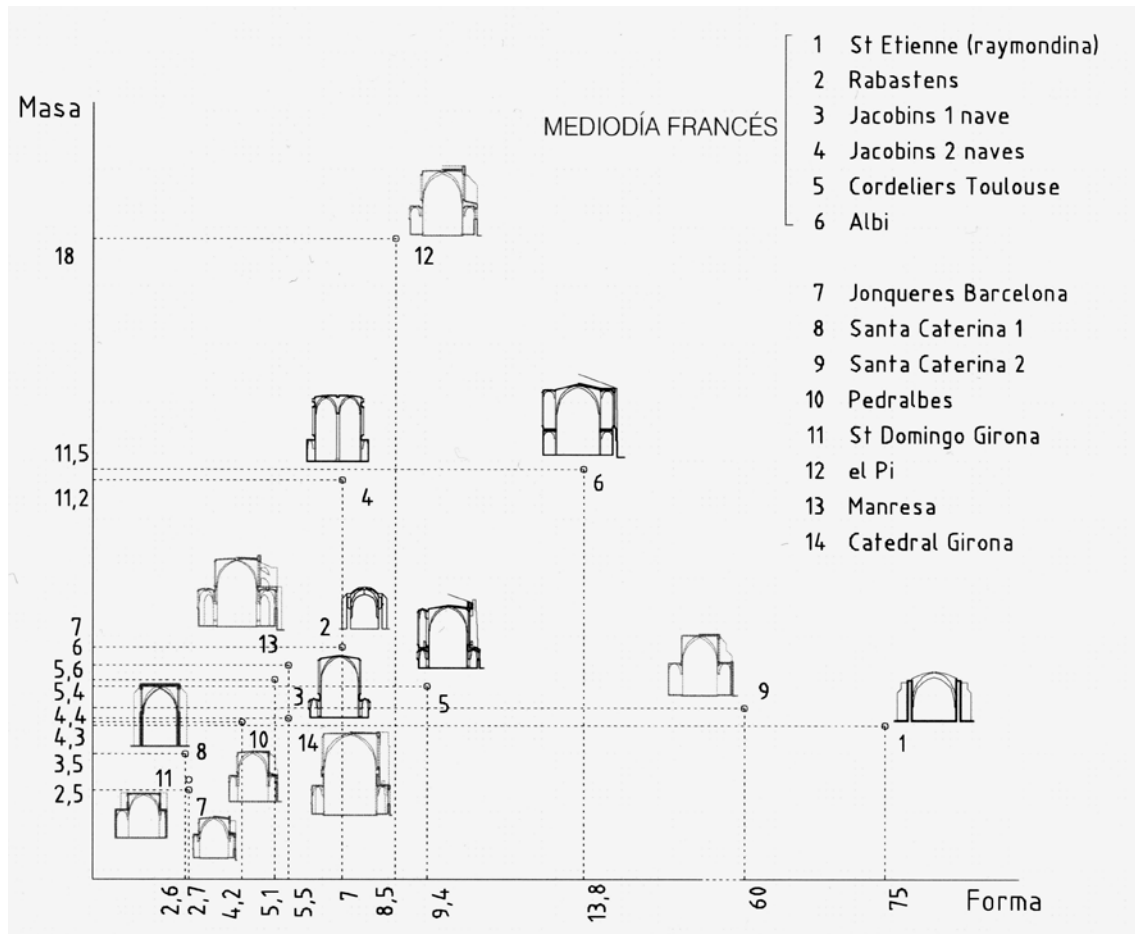


Figure 3. Form and mass factors.

Therefore, the different models can be compared to detect extreme cases and to judge their suitability, from the archetypal systems, which lead to analyze series of related structures.

4. ESTABLISHMENT OF SERIES.

4.1. CISTER, FIRST MERIDIONAL GOTHIC

A quick visit to Fontfroide let us see the similarities of Poblet, Santes Creus, Vallbona de les Monges, and Piedra, among others: the dormitory buildings and churches are specially comparable. All linked to Grandselve, not preserved, although the sources indicate their magnitude, next to the raymondine nave of St. Etienne Cathedral in Toulouse. The comparison of dormitories in Fontfroide, Poblet and Santes Creus shows the containment of Poblet with respect to Fontfroide, as shown in fig. 4.

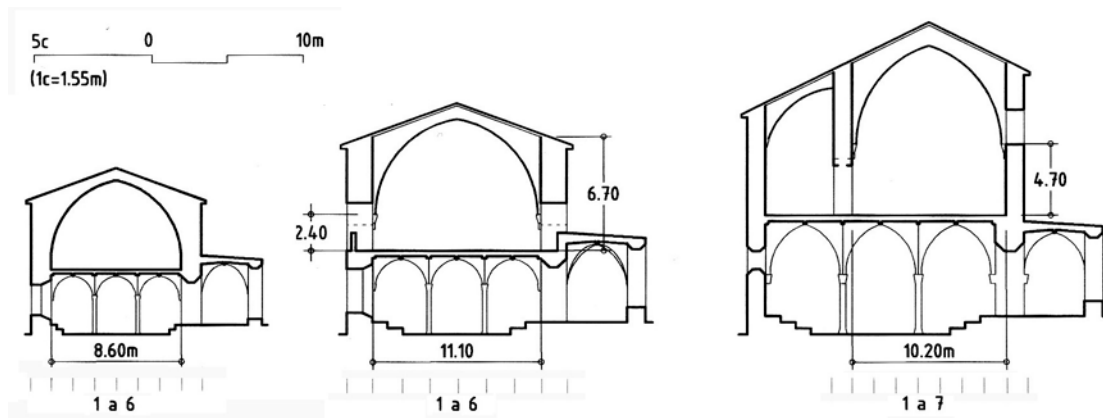


Figure. 4. Basic structure of dormitory buildings at Fontfroide, Poblet and Santes Creus.

When Cister failed in its treatment of albigeois heterodoxy, the smaller orders (Dominican and Franciscans) received papal confidence, specially the first ones. These looked for simple structures, even codified with a norm non respected in later prosperity. We can see the simplicity and relevance of arches as generators of new constructive systems. Fieldwork directed the investigation towards related buildings. In the arrangement of series “what you see is what you get” (“wysiwyg”), providing real discoveries, at the very building.

4.2. FROM TOULOUSE TO RIVER TARN

Between the primitive nave of St. Etienne in Toulouse and the first minor churches (first half of century XIII) until the beginning of the cathedral - today basilica- of Albi some initiatives kept awake the new attributes of the AGC:

- The search of magnitude in wide naves incorporated to previous programs (St. Michel de Gail-lac, St. Alain de Lavaur, Nôtre Dame du Bourg de Rabastens) happens simultaneously with a fortification appearance, that remains in great works. Its size is the necessary one to lodge the population of the place, a non disclosed function.
- The importance of St. Etienne and the church of the monastery of Grandselve is derived from the constructive parallel and its measures. A detailed elevation of St. Etienne allowed to detect variations in the modules, especially those close to the main façade and variations of constructive measures which keep alive the hypothesis that was formed originally by four modules. It is easily perceptible that the Cister arch, formed by diverse curvatures, was already surpassed here, and the constructive difficulty can be seen in the geometric maladjustments of keystone levels between diagonal arches and differences between wall and transverse arches, as well as a cupola effect in each section to improve the stability.

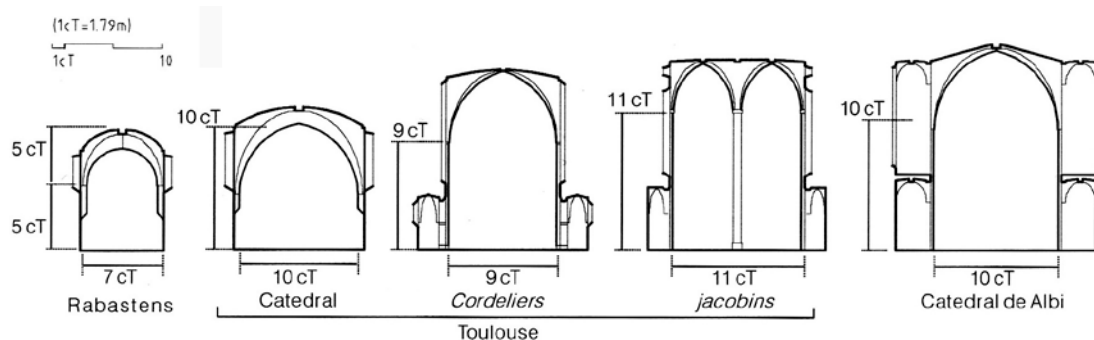


Figure. 5. Evolution and growth model of churches based on Toulouse canes.

- The temples of minor orders in Toulouse (Jacobins for the Dominican, and Cordeliers for Franciscans) show the limits of experimentation. This, together with the control of magnitude mentioned in St. Etienne and Grandselve and the fortifications next to the Tarn River result in the great work of Ste. Cecile d' Albi. The context determines the structural possibilities: Jacobins, constructed in the limit of the city does not have space to increase its width and is subjected to transformation towards the interior with his "palmier". Cordeliers evolves from a fortified structure, supported in abutments to the continuity of the diaphragm wall in its full height, producing the characteristic chapels not only near the ground, but up to the roof. This gesture, perceivable in its section explains how Albi's typology was generated, but it offers a good example of double façade produced at an early age.

4.3. MAJORCA AND PERPIGNAN

Interior spaces in churches follow strictly the pattern of the period in their territory: the small size of Santa Margalida in Majorca is reproduced in more primitive structures. But when Franciscans, protected by Majorcan queens, decide to build their new convent, they will adjust the size to 7 Montpellier canes, which consolidate as a most common measure, not very often surpassed: the church of Carme in Perpignan, of diaphragm arches, that of Holy Cross in Majorca or even the apse of the cathedral by means of vaults, have their supports separated a distance of 8 canes.

But the greater innovation happens in the same cathedral when, modifying initial plans, the limit is fixed in 9 canes. Thus, the apse space in the cathedral of Majorca can be understood as a unique nave that follows one of the models common in Southern Gothic Architecture, continued later by a new plan with spans and heights never assumed before.

As it happens in the cathedral of Girona, the plane of transition from apses to naves will have in Majorca the interest of translating old and new geometries (a transition already experienced in Sylvanès, with primitive means. A transition between three naves with clerestory to a single unique space takes place in Girona, whereas in Sylvanès the wall translates a primitive gothic constructive system that uses the wall mass to support loads, which generates a constructive system which searches a complex balance of a central nave of great height by means of lateral naves, the flying buttresses upon these, and the chapel vaults, as well as an abutment wall starting from the base and loosing mass as we go up.

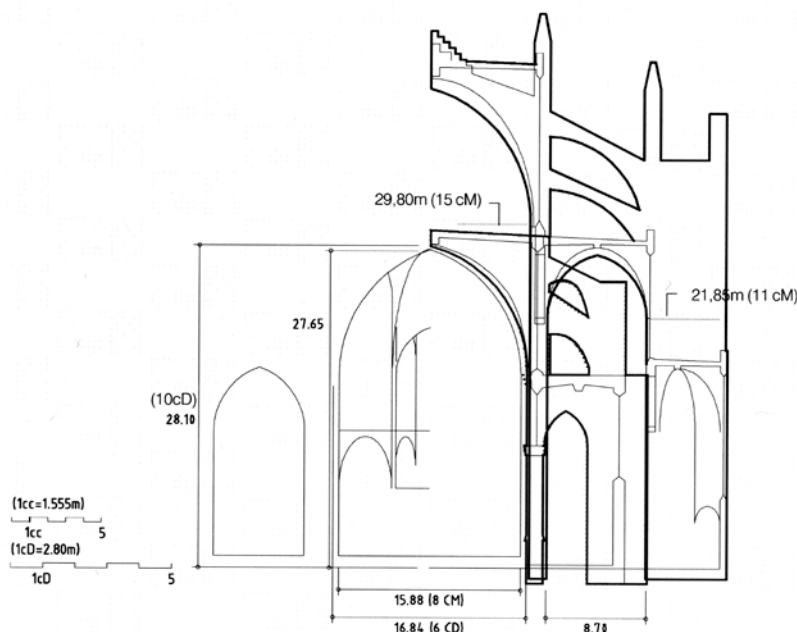


Figure. 6. Superimposition of Cathedral sections: Manresa versus Majorca.

The possible influence of Berenguer de Montagut (author of Manresa and Santa Maria del Mar) can be traced from measures. The span of arches in Manresa is 6 destre canes, within the dimension span of 8 to 9 Montpeller canes used in Majorca, so the rise would measure accordingly (as we can see at Fig. 6) where both sections are superimposed. Majorca side naves would correspond to Manresa total height, sizes are practically the same: 10 destre canes (28,00 m) equivalent to 14 Montpeller canes (27,81 m.).

After surpassing known formal and spatial references, we realized we were in front of a masterpiece that interprets the goodness of minor orders structures and looks for a new structural goal. This moment is as well, to our grief, the end of Southern gothic.

4.4. BARCELONA AND BERENGUER DE MONTAGUT

The construction of dockyards changes all the constructive experience here. First documented - between 1276 and 1285 - they will be extended and they will cause similar initiatives in Palm (1319) and Valencia (1338). The systematic constructions of several naves - up to 8 - is transferred inevitably to the new temples roofing structure. In words of B. Fuller "in art form is a name, in industry form is an action". Qualified action that also reflects the activity of navigation and trigonometric control in the production of Navigation Maps. Minor orders were active in Barcelona, up to the point of receiving prohibition to construct more convents within the wall of James I.

Research on S. Francisco is open, although it contributed to the slenderness of later constructions and reinterpretation in the kingdom of Majorca of Palace chapels (as in Perpignan and Palma), to the apses of the Cathedral and the extension of Santa Margalida. Saint Catherine exceeds the norm of the Order, as the General Chapter celebrated by the Order in 1261 ordered the demolition of the dormitory. It was an ambitious construction, of similar width as the span between the columns of Sta M^a del Mar, and similar boldness in height (keystone of side chapels close to half the overall height, fact that differentiates it from Northern gothic). The abutment form would ratify the construction in two phases, and the connection between chapels suggests construction in 3 naves, evoking bonds between Narbona and Manresa that produced fruitful results in Sta M^a of the Sea.

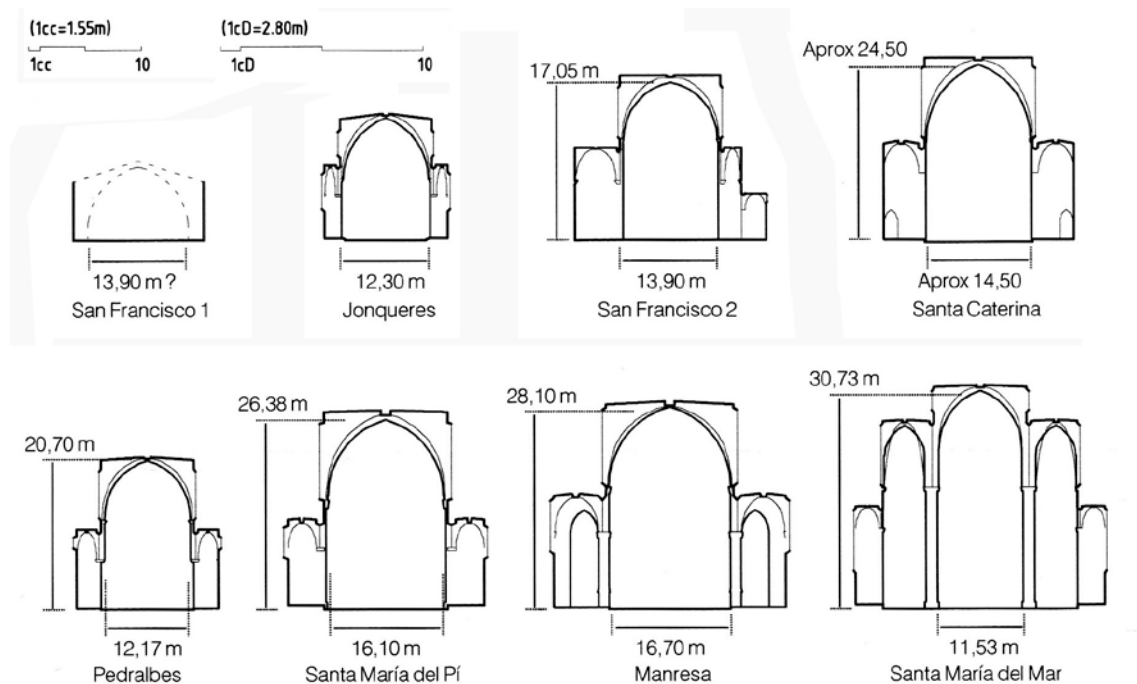


Figure 7: Evolution of Barcelona Gothic temples

A singularity would be Sta M^a de Pedralbes, protected by queen Elisenda de Montcada. Smaller than Sainte Catherine, the double windows of the apse are changed into a large window and bow window, which underlines the drum under the arches with link function and increased stability.

The system will be repeated in Saint Mary of the Pine, with measures increased and providing changes: the transverse rib is an arch of fifth, diagonal arches do not maintain the same radius, that can be understood by the increase of naves span to almost 6 destre canes, that master Berenguer de Montagut will retake in Manresa.

Great economic activity was developed in this city was developed (as the construction of bridges, the cathedral, constructions of minor orders and the beggars and the foundation of six guild show). Here Berenguer de Montagut had documented responsibility and influences between Manresa cathedral, Santa Maria del Mar and Majorca Cathedral provide an evolution which defines this architecture.

In the three cases we found a distinguishing fact: the destre modulation of two canes is observed with clarity in the tachometric data. In Manresa and Palma previous construction could be used as platform for new works, and geometric resources (two rotated squares in Manresa and Barcelona) show the use of systems “ad quadratum” and “ad triangulum”, fused in a unique operation.

The comparison of Manresa and Santa Maria del Mar makes us see that the end of the column in the first is in accordance with the beginning arches in Manresa, and the structure changes by means of a magnificent simplification: lateral stirrup go up top the roof, originating a lateral nave of great height. Rubió i Bellver characterized this operation as “the maximum space with the minimum structure”, greatly economical. And if we compare it with Palma Cathedral we will see how Sta. Maria can be inscribed with exactitude in its interior.

4.5. GIRONA.

The case of Gerona is inseparable from the consultation to several experts (or concilia), which allow a retrospective knowledge of construction procedures.

In the first concillium (1386) four masters from the Barcelona area confront their criteria with North masters. We can understand the confusion of canons before the plurality of answers, and, paradoxically, the decision taken was to construct a structure of three vaults, although the Barcelonese masters could already know the Cathedral, Sainte Catherine, Sainte Mary of the Pine, Saint Mary of the Sea,... with considerable spans.

In a second meeting (1389) most of the experts returned to show their preference for the three naves. But the master of the works, Guillem Bofill returned to defend the unique nave with memorable words: “it will be the most solemn disposition, more signalled and better proportioned in relation to the choir”. And, with surprise, it was continued from 1417 with a unique nave, although only five of the twelve experts (it must be said more that they were those from North Catalonia, with a tradition of established unique ship) gave a favourable vote.

CONCLUSION.

The scope of abilities is considerable: engineer installations of magnitude never assumed previously in Catalonia... Santa Maria of the Sea shows a structural economy never surpassed. It is not a surprise that masters of modern architecture drew attention to observe these unusual creations, where architecture and engineering, measurement and ambition, viability and good judgment are aspects of an only answer to the question formulated by the promoters.

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