The static model in Bernardo Antonio Vittone architecture: The Santa Chiara and San Leonardo churches in Turin

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ABSTRACT

The study aims to analyse the two **static models** most widely adopted by **Bernardo Antonio Vittone**, through the comparison of two churches in Turin: Santa Chiara and San Leonardo. They are **double envelope** buildings, with central dome, respectively 10 and 15 meters in diameter, supported by eight pillars and surrounded by a continuous ambulatory. The static model of Santa Chiara provides the internal pillars that play the main structural role and cooperative outer envelope: the dome transmits his loads directly to the interior pillars. The walls and vaults of the lateral chapels have an important role, arranging themselves around the main dome, like a ring of containment of the horizontal thrusts induced by the dome itself. Also the choirs, that Vittone places in smaller spaces behind the pillars, play an important static role: their horizontal structures connect the pillars with the rear wall, which thus offers its collaboration to contain the horizontal thrusts.

The church of San Leonardo has a reverse operation, with the dome that rests on the outer walls, while the internal pillars support only a raised gallery.

Through **three-dimensional info graphics models**, the study shows that the entire structure is designed as a **discretized system**, which replaces the traditional structure based on continuous wall and uniformly distributed loads. The brick vaults are **ribbed structure**, in which arches and ribs convey loads on the pillars or in precise high-resistance points of the external masonry. This feature makes the space open to the light; also reduces the masonry mass, saving material and reducing construction costs.

The **formal representation** of structural components agrees with the effective static operation of buildings: the decoration on the surface of the dome indicates the presence of ribs. The groins are hollow and open in order to highlight the condition of non-load bearing element.

INTRODUCTION

The central plan churches designed by Bernardo Vittone and represented in his treatise of the "Istruzioni Diverse" [1], show features that remain constant throughout the career of the designer and offers a view of the formal aspects, typical of its architectural design.

In all churches designed by the Piedmontese architect, the polar space is constituted by a single baldachin, generated by a dome or vault, resting on vertical supports, free standing or inserted in the sculptural articulation of the wall; in the first case, the supports are free columns or pillars; in the second one, pilasters and columns are partially embedded in the wall structure.

In double shell buildings, the isolation of the supports makes the figure of the baldachin even more clearly readable. In all versions in which it is proposed, that element is characterized by the marked development of the vertical axis: this is achieved through the geometric shape of the elements that compose the roofing system; through the same proportions of the space to be covered, as well as by the use of complex systems of domes, vaults and overlapping lanterns. On one hand, the adoption of domes with elliptical vertical section is frequent; on the other hand, there is a superimposition of domes with a perforated headstone to allow the bottom view of the more external domes and especially the entry of light inside. The overlap of lanterns might be very common, as well. All these elements reproduce, in their articulation, the same accentuation of bearing structures. Finally, the central domes rest frequently on tholobates, which can reach, in some cases, slender proportions: if we look at the lanterns we can notice that their vertical structures are the fluid connection between the ribs of the dome and the bearing structures of the underlying space. With regard to double shell buildings, the ambulatory is clearly identifiable as a unitary space only through reading the planimetric scheme; the analysis of the internal space highlights the fact that the secondary spaces are differentiated by a plurality of factors, which induce a hierarchy between the spaces themselves.

THE REPRESENTATION OF THE STATIC AND CONSTRUCTIVE SYSTEM IN THE ARCHITECTURE OF BERNARDO ANTONIO VITTONE

In all the projects by Bernardo Vittone, especially in double shell buildings, it can be recognised as a static system visually similar to a discretized structure. The structural line-forces are accentuated; the loads seem concentrated in higher resistance points, rather than uniformly distributed along the wall. The masonry-walls takes on the role of defining the space, rather than to support the loads. All the elements of the architectural grammar, put in place to meet the static requirements, are used to provide the physical transposition of this representative intention.

The arrangement of the bearing elements is the first interesting fact: their absolute vertical continuity seems to accompany the load above the dome or above the overlying structures, up to the underlying levels, in a downward movement.

The decoration of the intrados surface of the dome suggests the presence of resisting structures where the static loads are concentrated: in fact, the surface is articulated, with rare exceptions, by bearing ribs and ideally non-bearing vaults. The first one extends on the dome the supports of the lower level, possibly linking up with the structures of the lantern. The vaults are often perforated and open, in order to highlight the condition of non-load bearing element; their surface is kept smooth or articulated by decorations that recall reveals and oculi. In projects, where the surface of the intrados of the vault is articulated through coffered ceiling (which traditionally refer to a uniform distribution of loads), expedients that mitigate this effect are adopted: the decoration seems to continue behind the ribs, and assumes the shape of a diamond or hexagon, instead of the subdivision into meridians and parallels inspired by the Pantheon.

In addition, to reinforce the impression of a concentration of the loads in the ribs, in the majority of the buildings, the impost of the dome is not marked by a continuous horizontal cornice: the opening of windows or oculi, placed precisely at the impost, breaks up the cornice in a succession of curvilinear parts. The same effect is obtained by the big arches which identify the major and minor chapels of the lower level. This creates the impression that the vaults are brought by these arcs; the latter are to be connected to the ribs of the dome itself, transferring the loads and reinforcing the image of a ribbed structure.

This representation of the static model coincides with the constructive reality of the buildings designed by Vittone, actually based on a discretization of resistant structures, which are to replace the traditional structure based on continuous wall masses. As demonstrated by the analysis of buildings and available construction documents, the vaults designed by Vittone are actually configured as ribbed structures. Relieving arches and ribs transport the loads at specific points, corresponding to the vertical structures of the tholobates; hence, the loads are carried on the pylons of the lower level. Ultimately, the structural design of Vittone reveals Gothic reminiscences, perhaps sorted by Guarini experience, and that generates a dual effect: on one hand, as expected by Vittone, it allows eyes and light, not to meet structures that obstruct path, making permeable the space; on the other hand, reducing the wall mass, ensures a saving of material, with consequent decrease of construction costs.

In Vittone architectures, there is an absolute continuity of the entablature, which runs continuously on the walls, turning in the side chapels. This continuity shortens the perceptive distance between the elements of the composition, always keeping a strong relationship between baldachin and external walls. This is a characteristic of all the protagonists of the Italian architectural scene, even those such as Borromini and Guarini, whose style has more references to the Gothic architecture; testifies, moreover, the iron will not ever deny completely the load-bearing function of the wall.

With regard to the structural model of the buildings, there are two possible variations: these relate to the role played by the baldachin, and thus by the internal structures, with respect to the loads received from the dome or vault. In fact, within the group of buildings that show double shell schema, it is possible to distinguish two structural types: in the first case, the internal walls have main load-bearing function, while the outer-shell is only cooperative. The second variant has a bearing outer-shell, while the internal supports are mainly subject only to the action of the vertical loads: the polar space is configured so as carried element. Basically, in the first case, the dome transmits its loads directly to the isolated inner supports; in the other case, adjusts itself to the external masonry, free the latter from the primary structural function, engaging the outer-shell. From the above, it follows that, in the first case, the external structures will present themselves relatively lighter and with greater possibility of introducing openings; conversely, the inner structure of support for the dome will be more massive, generally constituted by pillars. In the second case, the relations are reversed, with an outer-shell that tends to be more heavy and opaque, and inner supports consisting of free-standing columns. Consequently, the central space is transparent, structured by light and discretized elements, as if the space was conceived as a single compartment with a thin diaphragm that separates the ambulatory. Actually, the inner vertical structures are never fully independent from the external masonry, which are linked through different solutions, depending on the conformation of the main space.

In tri axial scheme buildings, the choirs and the galleries that are arranged in smaller spaces behind the pillars supporting the dome acquire a critical static role. Their horizontal structures (generally flat slabs on the first level and segmental vault to the second level), join in the middle and at the top with the vertical load-bearing structures, linking them to the external wall; the latter one, therefore, offers its cooperation to contain the horizontal thrust.

In the projects based on four axial schemas, the will to connect the major and minor chapels involves the introduction of connecting spaces, in the form of trapezium; these spaces are generated by the variation of geometric shape between polar space and outer shell:, in fact, an increase in the number of sides, that pass, for example, from eight to sixteen in buildings characterized by an octagonal main space it is common. These spaces, on two levels, are located behind the pillars, and connect them firmly to the external masonry by means of its horizontal structures. In the latter category of buildings, minor diagonal chapels and lateral connecting spaces, seem to be a single resistant block: the resulting image is almost that of a dome resting on four large diagonal pillars, within which are carved out smaller spaces.

The adopted static model confirms the geometric pattern, consisting of the superposition of a Greek cross and an octagon. This scheme generates the hierarchy of spaces and the inability to detect the ambulatory as a unified and continuous space.

Consequently, the conformation of the isolated pillars that support the dome, provides two possible variants: the pillars thicken along the radial direction determined by the circumference of the main central space; alternatively, the pillars themselves become wider, assuming the appearance of sections of masonry that follow the geometric shape of the main space. It is not possible to ignore the static function performed by the masonry and by the vaulted structures of the side chapels: arranging themselves around the main dome, the latter one constitute a containment ring to horizontal stress induced by the dome itself, through its actions of counterforce. Furthermore, the adoption of an elliptical profile for the section of the dome has the advantage, not negligible, to reduce the horizontal component of thrusts exercised by dome itself on the underlying structures.

Church of Saints Marco and Leonardo in Turin

Short historical notes:

The building was constructed in place of an existing church, demolished and rebuilt several times since the fourteenth century. The task was entrusted to Vittone in 1740; construction work began between 1741 and 1742. This date is documented by a petition of the parishioners. The latter, to finish the work, due to the lack of economic means, applied to take advantage of waste material owned by the King, having yet to build the sacristy and the choir.

The demolition of the church built by Vittone was made necessary by the construction of the bridge over the river Po, whose project was commissioned in 1807 to the engineer Joseph Pertinchamp. Historiography has always placed the destruction of the building in 1811; Luciano Tamburini [2], after careful archival research, has documented how the church was still standing in January of the following year, and has postdated the pulling down in 1813. In that year, precisely on September 1, chairman of the board of the parish of the Annunziata and St. Marco asked the mayor to take advantage of a home in order to award the demolition works, whose starting price, including the sale of the materials, was of 4400 francs.

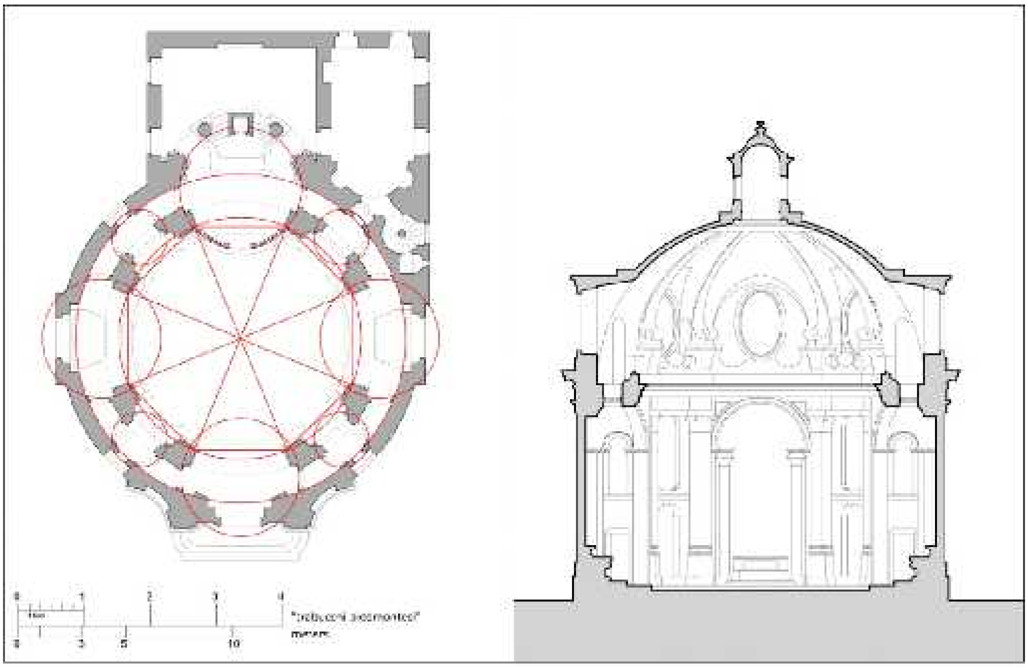

Figure 2 Church of Saints Marco and Leonardo: plan with geometric model, and section

Geometric model

The polar space, identified by eight pillars, is a circle of diameter equal to 3 “trabucchi”[1] and 4 feet, that is 11, 30 meters. Its diameter does not coincide with that of the dome: in fact the latter one is not supported by pillars, but it is set on the rear wall that defines the exterior of the building, exceeding 15 meters in diameter (5 trabucchi).

Looking at the plan of the building, it captures as the secondary spaces are treated as a circular ring which surrounds the central space, generating a continuous annular path.

In fact it is possible to identify eight cells, four arranged at the main axes, and four placed along the diagonal axes, connected by trapezoidal space with curved sides. These cells are circular in shape and are interpenetrated by the main space. The first ones have a diameter of 1 trabucco and 5 feet (5.60 meters), the latter have one lower than 5 feet, namely less than 2.50 meters. Among the largest, the three hosting the altars and the entrance are also intersected from the wall that borders outside the building; their circular shape is made intelligible only from the masonry, these widely perforated, which separates them from the joining spaces.

The cell that serves as a presbytery is segmented by the prevalence of polar space; its shape is made intelligible by the presence of the step and the balustrade that describe the circular pattern, leaning in the main space.

[1] The “trabucco” is an ancient piedmontese unit, equal to 3,0826 meters. It consists of 6 feet; each foot is divided into 12 ounces.

The altar, flanked by two free-standing columns, behaves similarly: it marks the circular profile of the cell within the rectangular choir. The smaller cells are interpenetrated only by the polar space, and develop up its circular shape within the enveloping space of the ambulatory.

An additional factor introduces a hierarchy between the spaces of the ambulatory: the cells hosting the altars develop in height up to the impost cornice of the dome and are illuminated through the openings in their vaults. The smaller cells are structured once again as two levels galleries. Consequently, the first ones appear as dilatations of the main space, the others ones are overshadowed also from different lighting conditions in which they are located.

Structural model

The elements of novelty that differentiate the building from the others ones designed by Vittone, consist of the static model and the structural functioning: in fact, the dome is set on the external walls of the enveloping space, freeing up the internal isolated supports from their load-bearing function. The latter ones, articulated by pilasters on pedestals, supporting a continuous diaphragm; that element hides the impost of dome from the bottom view, causing a visual effect of expansion of the dome.

Deep ogival lunettes cut the dome surface, conveying the weight of the vaults on the ribs; the latter ones, approaching to the impost, bend itself in the shape of volutes, joining itself to the pillars of the central space. It restores the continuity of the bearing elements, which are pervaded by a dilatation effect: in its upward path, reached the entablature of the main order, the structure appears to bend in the volutes of the ribs, expanding in the space behind. Here, narrow passages, formed in the thickness of the ribs themselves, generate a continuous overhead space; this one is not entirely practicable, due to the openings placed in correspondence with the keystone of the vault of the underlying major chapels.

Church of Santa Chiara in Turin (unrealized project)

Short historical notes:

The church was built in place of an earlier, already degraded. The archival records available made it possible to reconstruct with high accuracy the design stages, from the assignment to the realization. Information was collected also on compensation paid to the architect, 900 lire in total, and about the companies involved in the construction for the supply of bricks, mortar, iron, glass, wood and painting.

Geometric model

Even in the unrealized project of Santa Chiara, the central circular space is marked only by the six free-standing columns supporting the high dome. The circle shape features all the elements that generate the internal morphology of the building.

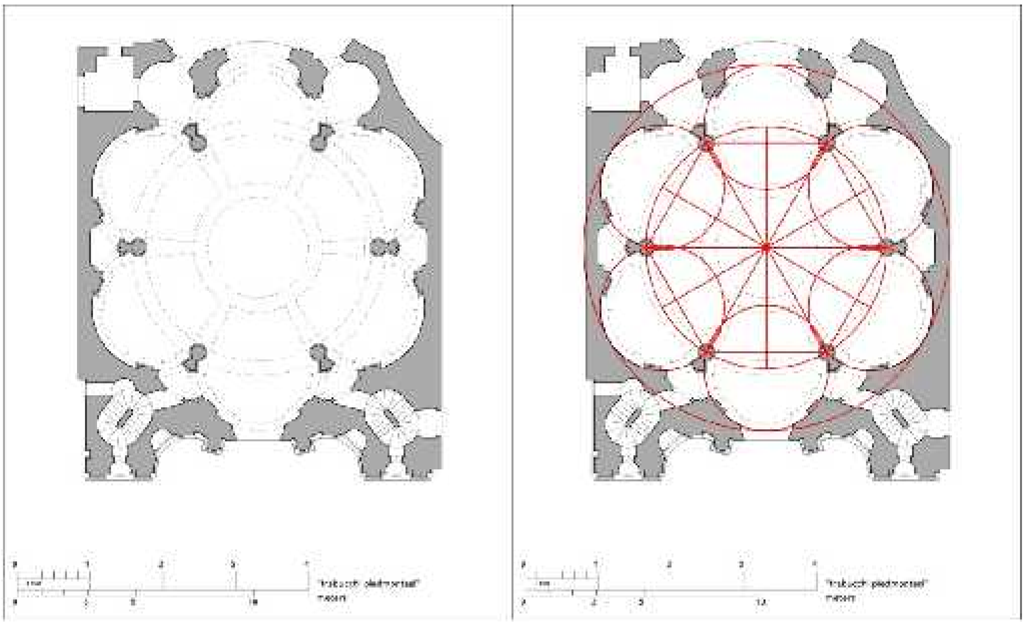

Figure 2 Church of Santa Chiara: plan and geometric model

The six secondary spaces that overlook the polar space and host the presbytery, the access opening and four altars, are all based on this geometry. Two levels galleries are located behind the columns, generating, between the chapels, connection spaces triangular in shape with curved sides. This creates a continuous ambulatory that surrounds the central space. The volume of the polar space interpenetrates the cells of secondary ones. The first one has a diameter slightly greater than 3 trabucchi, corresponding to 9.50 meters; the minor chapels instead have a diameter of 1 trabucco and 4 feet, equivalent to 5.10 meters. To differentiate the cell of the presbytery from the other, the first one presents a slight increase in depth, obtained through the insertion of a small elliptical space on the bottom of the chapel itself.

Structural model

Six columns identified in plan the central baldachin; on the back, these columns are matched to sections of masonry with concave sides, widely opened to give overlooking to a double order of raised galleries. The entablature runs uninterrupted along the internal hexalobular profile of the building, starting from the columns and articulating the rear wall of each chapel, after following the curved profile of the choirs. For each column, above the entablature, we may set low tripartite pillars; the latter ones, through corbels connected by volutes, supporting the three-dimensional arches on which sets the elliptical dome. The dome is enveloped in a hexagonal lantern, equipped with a elliptical window for each side; similar openings are found in the intrados of the dome itself.

The space between the extrados of the dome and the lantern generates a “room of light” that, through the refraction that takes place inside it, transforms the incident light into diaphanous: it would have created a subtle play of light gradation, since the dome would appear illuminated by a soft light filtered through the rooms behind; this soft light would be opposed to the great light intensity of the central oculus, obtained by the double lantern above.

The latter element, with cylindrical inner profile and hexagonal outside, is in fact quite transparent.

Figure 3 Church of Santa Chiara: section (with the baldachin) and cutaway perspective view

The intrados of the dome is divided into six sectors by ribs, with two reveals on each side. The smaller chapels are covered by a vault in the form of apse, broken by a three-dimensional arc: the top one looks to continue beyond the rear walls, while the lower part, surmounted by the three-dimensional arc, seems to have the function of figurative plugging. This unusual configuration may be motivated by the wish to suggest spaces virtually open, which expand beyond the masonry. The vault of the presbytery repeated, in a similar form, the decorative pattern of the dome.

Even the vaults of the side chapels offer a counterforce action and unload the weight on the back walls. The thrusts of the dome are reduced by the adoption of the elliptical profile that, in addition to accentuating the verticality of the space, is best suited to the slender supports. In this project, the lines, which represent virtually the geometrization of the bearing elements of the building, are continuous and uninterrupted: the succession of elements (column, entablature, pillar, three-dimensional arches, ribbed domes, pillars of the lantern), represents the supporting structure as a stone skeleton. The diamond shaped coffered ceiling, clearly derived from Roman architecture, contrasts with the perception of the ribbed dome, since, as is known, coffered ceiling suggest a uniformly distributed load. The three-dimensional arches that support the vaults, together with large openings inserted in vaults itself, however return an image more coherent with the representation of a discretized model.

Figure 4 Church of Santa Chiara: continuity of virtually bearing elements

CONCLUSION

Ultimately, through two exemplary projects, it has been highlighted that the architecture of Bernardo Antonio Vittone, have the following characteristics:
- the presence of two structural models, vary according to the role played by inner supports and external walls, which generates different formal and spatial outcomes;
- the continuity of the elements that virtually represent the load paths;
- the actual presence of a discretization of the structures, used to reduce the elements that could obstruct an uninterrupted visual perception of interior space.

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