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Rediscovering ecclesiastical architectural gems: Silvio Galizia's unseen concrete thin-shells

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Abstract

Silvio Galizia (1925-1989) was a Swiss architect who worked in Rome, Italy, primarily between 1953 and 1985. He designed and built several thin concrete shell roofs for ecclesiastical commissioners and patrons. Due to their location within close-walled monasteries, these buildings are rarely seen by the general public. As a result, Galizia's oeuvre has not to date been adequately studied as a local interpretation of the better-known experiments on reinforced concrete shells developed during the post-World War II period. Recent research through Galizia's professional archive (ASG), which is being progressively reorganized and digitalized, reveals that he was an experimenter of concrete shells and pursued his own design methods, balancing between the rationalization of the construction process, optimization of architectural form, and structural performance. This paper will also discuss five of Galizia's churches in Rome, characterized by using a local interpretation of the cable-net shells. Galizia's experience is also of interest in the landscape of spatial structure design as he did not solely rely on physical models, mathematical equations or graphical statics. Instead, Galizia implemented a more informal design process, capable of dialectically considering the different known approaches to the design of concrete shells, but at the same time able to emphasize the aesthetic and symbolic dimension of space that is of importance in the ecclesiastical use of his works.

Keywords: Architectural Design, Concrete Shell, Ecclesiastical Buildings.

1. Introduction

Silvio Galizia was born in 1925 in Muri, Aargau, from a father of Friulian descent and a Swiss mother. He studied from 1944 to 1949 at the Federal Technical University of Zurich (ETH Zurich), supporting himself through merit scholarships. Galizia's education at the ETH had a pivotal influence on his formation and novel approach as a future architect. He was a student of Siegfried Giedion along with his architectural colleagues that included Eduard Neuenschwander, Justus Dahinden and Christian Norberg-Schulz with whom he shared, among other courses, an excursion with Prof. Hans Hofmann to Rome in 1947. Along with Neuenschwander and Norberg-Schulz, Galizia was also actively involved in the CIAM Young. In the same years Heinz Isler, who later was assistant professor with Pierre Lardy, studied at ETH. The relationship between Galizia, Isler and Dahinden is currently being reconstructed by the authors.

In Zurich Galizia was an active member of the "Renaissance Gesellschaft", an academic Jesuit group that studied the aesthetics of liturgy and religion. Based on his participation and contributions, Galizia was commissioned to design a new pontifical university in Poona, India (1952). Here he applied new liturgical principles, anticipating some of the modernizing contents of the 1962 Vatican Council, such as allowing for the liturgy to be held toward the parish.

He then returned to Europe in 1953 and worked at the engineering firm of Riccardo Morandi in Rome. During this period, Morandi's firm designed and realized some of the greatest Italian structural engineering of the time. At Morandi's firm, Galizia met Sergio Scalesse, a structural engineer, who would later form a partnership with Galizia and support him on several notable projects, starting with the Seminary Church in Poona (inaugurated December 1957). In 1957 Galizia was also enrolled in Rome's guild of architects (trad. *Albo degli Architetti*). His work projects focused primarily in Switzerland, India and Italy.

Following his first defining work of the Poona seminary, Galizia received large-scale contracts for rectory houses of several religious congregations in Rome. These initial works were characterized by large spans expressing the liturgical dimension and Galizia's novel use of concrete shells. Galizia was a prolific worker and experimented to push the design for liturgical expression combined with an intense professional and artistic quality.

Most of Galizia's shells are located behind closed monastery walls and difficult to visit. Some of them – notably the Ivrea Chapel (1971-1973) and the Chartres Chapel (1966-1968) – have been featured in architectural guides [1]. The few existing studies on these buildings have highlighted their distinctive architectural quality, peculiar ecclesiastical purpose, and expressive use of reinforced concrete.

In this paper, we will discuss five of Galizia's churches in Rome. This will include the Camilluccia chapel (1957-58), a double-curved shell; the Verbiti church (1959-1962), four close-to hyperbolic paraboloids around a central plan; the Paoline chapel (1960-1963), a close-to cylindrical double-curved shell; the Collegio Pio Brasiliano (1962-1966), an array of three parallel shells; and the Chartres chapel (1966-1968), a seamless double-curved pointed sail. Most of these churches offer differing interpretations of a common construction technique characterized by pouring concrete on the form generated by hanging cables, therefore minimizing the use of formworks. These examples show a prolific example of experimentation on shells with geometries, concrete, and innovative construction technologies.

From this research emerges a particular way of using concrete shells in the design of buildings in which symbolic-ecclesiastical aspects are predominant. Galizia, through a design approach informed by artistic values, explored various established methods for designing concrete shells, such as the use of physical models, mathematical equations and graphic statics.

2. Existing studies on Silvio Galizia oeuvre

The figure of Silvio Galizia has been of interest in different occasions and contexts. The first documented interest of his work dates back to a 1957 monographic issue of *Architecture d'Aujourd'hui* devoted to "*Jeunes architectes du monde*". His collaboration with Christian Norberg-Schulz on the novel saddle shell of the Church at Via della Camilluccia is mentioned as a notable achievement [2]. After his premature death in 1989, new attention was devoted to Galizia's oeuvre through the inclusion of his archive in the Italian SIUSA (Unified Information System for Archival Superintendencies, trad.: *Sistema Informativo Unificato per le Soprintendenze Archivistiche*) [3] enabled by Arch. Tommaso Dore and Arch. Francesca Marsico. The archive is included in the "*Guide to Architectural Archives in Rome and Lazio*" [4].

A broader interest in Galizia's complete oeuvre is found in a first dissertation entitled "Silvio Galizia 1925-1989," carried out in 2014 by Luca Conoci and supervised by the architectural historian Giorgio Muratore [5]. In 2023, Tobia Valentini devoted part of his doctoral thesis in *Architecture and Building Construction - History of Construction* to three works of Silvio Galizia [6] that was anticipated by a 2021 publication of parts of the same works [7]. In 2023 Roberta Lucente published an article titled "*Silvio Galizia and the experimentation of complex structures: Norway intersections*" in *Metamorfosi – Quaderni di Architettura* [8]. Here she introduced the first mentions of Silvio Galizia's education and subsequent apprenticeship at Riccardo Morandi's firm.

Below, is a recent overview of the Galizia Archive, that recognizes those projects in which he adopted spatial structures.

Table 1: List of Galizia's built projects containing spatial structures.

Year	Place	Work	Type of spatial structure
1951-1957	Bombay, India	Pontifical University and Seminary Church in Poona, India	Concrete folded plate roofing
1955-1956	Rome, Italy	Elevated church of S. Monica and S Rita Chapel of the Collegio Internazionale Agostiniano	Concrete folded plate roofing
1957-1958	Rome, Italy	Generalate and Chapel of the Suore Missionarie dello Spirito Santo (Via della Camilluccia Chapel).	Cable-net concrete shell (1 paraboloid-like vault)
1959-1962	Rome, Italy	Church S. Giovanni Battista and generalate of the Missionari Verbiti in Nemi, near Rome.	Cable-net concrete shell (4 paraboloid-like vault)
1960-1963	Rome, Italy	Generalate and chapel of the Suore Paoline (originally built by Suore della Divina Provvidenza)	Cable-net concrete shell (1 paraboloid-like vault)
1962-1966	Rome, Italy	Chapel of the Pontificio Collegio Pio Brasiliano	Cable-net concrete shell (3 paraboloid-like vault)
1964-1968	Rome, Italy	Generalate and chapel of missionary brothers and sisters from Mariannhill	Concrete ruled surface shell (investigation in progress)
1966-1968	Rome, Italy	Generalate and chapel of the San Paolo of Chartres sisters	Cable-net concrete shell (1 paraboloid-like vault)
1967-1969	Rome, Italy	Church of Santa Maria degli Angeli (originally built by the Franciscan Sisters of Dillingen Donau)	Concrete ruled surface shell (investigation in progress)
1971-1973	Ivrea, Italy	Church of the Suore della Carità e dell'Immacolata Concezione di Ivrea	Concrete freeform ruled surface shell
1982-1988	Lomè, Togo	University college and church Jean Paul II, Lomé, Togo	Concrete folded plane roofing

3. Silvio Galizia's concrete shells design and construction principles

The concrete shell design and construction process adopted by Galizia, allows for the identification of various principles that are adjusted to different boundary conditions and balance the expressive, functional, and technical needs of each structure. How these principles are adopted can be reconstructed through redrawing and re-modelling activities, based on iconographic sources of the project, such as drawings preserved in the Galizia Archive, historical site photos, and some reports. In particular, Galizia and Sergio Scalesse have described the design and construction process for the Verbiti church [9] and the chapel of the Brazilian college [10]. In these reports, we can find several references to principles of descriptive geometry, construction processes and structural engineering that remind us how the design of a spatial structure requires an interdisciplinary approach between architecture, engineering, and construction.

The design idea of these shells is embedded in the prior construction of boundary elements onto which a cable net will be anchored and support the thinner nets that form the negative of the concrete shell. By adjusting the spatial configuration of the boundary elements and the weave of the cable network, a wide range of geometries can be achieved, including positive and negative Gaussian curvatures.

Understanding Galizia's design process requires an awareness of its technical aspects. It is therefore necessary to discuss its construction, geometric, and structural aspects in order to be able to ultimately frame its design process.

3.1 Construction aspects

The construction process described and adopted by Galizia and Scalesse can be divided into three phases.

In the first phase, the casting of the boundary beams of the shell is executed using traditional formwork, generally laid on the boundary walls. A series of rebars presenting a threaded end is embedded in these boundary beams, following regular and predetermined intervals. Once the beams are cured, a cable net is installed, consisting of a first order of cables (usually in the direction of greatest length) and a second order orthogonal to the first. These cables are then connected to the aforementioned bars embedded in the perimeter beams using common threaded sleeve joints. The cable net assumes a deformed configuration due to its own weight. The geometric nature of this deformed configuration will be discussed later. This deformed configuration is partly controllable by changing the tensioning of the cables via the threaded sleeve. Following the installation of the main cable net (which, for example, in the Verbiti church has a grid size of 50 cm x 50 cm), two additional nets are installed. Above the main net a welded mesh is laid (which in the Verbiti church and the chapel of the Brazilians has a grid size of 12.5 cm with Φ6 rods), while below is hung a very tight mesh, commonly used for plastering. The latter will form the negative of the shell, without the aid of formwork, or otherwise adopting more cost-effective point supports.

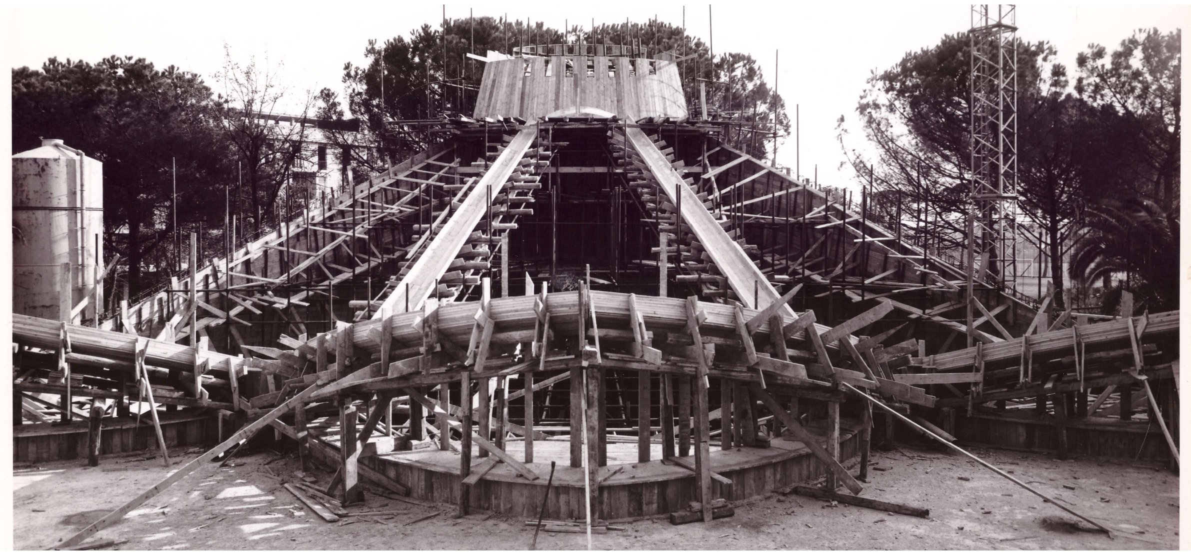

Figure 1: Formwork of the boundary beams in the chapel of the Brazilians. Courtesy of ASG.

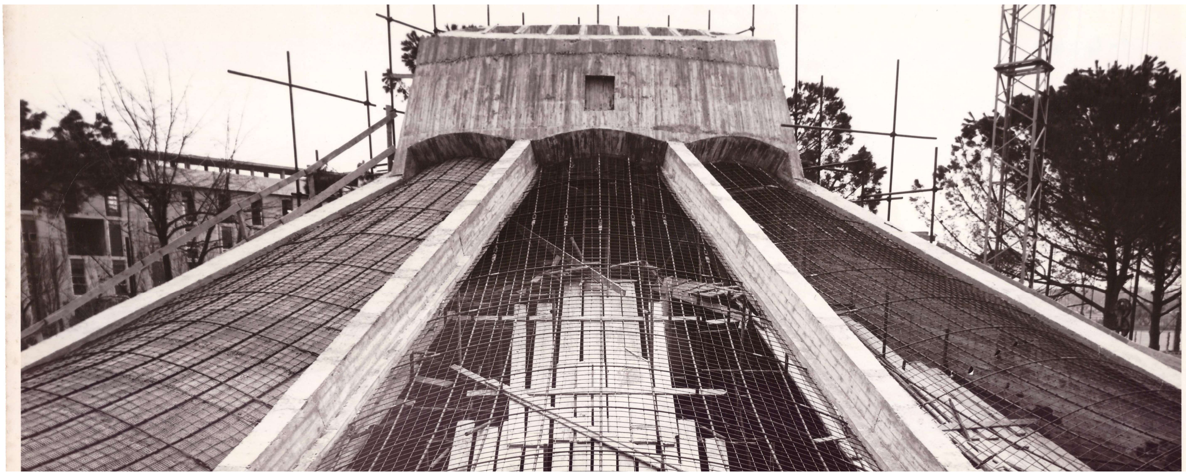

Figure 2: Installation of the cable net in the chapel of the Brazilians. In the left shell, the plastering mesh is visible. Courtesy of ASG.

In the second phase, concrete is poured "in successive rolls" [9] [10] until the final thickness is reached. This thickness is dictated by the need to cover all layers of the cable net.

In the third and final phase, after the curing of the shell is completed, it will be subjected to overloads, which account for about 50 percent of the entire weight of the shell (in the Verbiti church the overloads of plaster, waterproofing, vermiculite insulation and snow account for an additional weight of 170 kg/m^2).

3.2 Geometric aspects

The construction process described generates a double-curved surface, composed of a dual order of resistant fibres which bears opposite stresses. The first order of cables, laid generally in the longitudinal direction of the surface to be covered, will sustain deformation due to its own weight. These cables, as stated in the design reports, assume the shape "*practically of a second-order parabola given the modest size of the deflection*" [10]. Again, in the reports, it is explained that if this first order of cables takes the shape of a catenary, the second order of cables, resting on the first ones, takes a shape close to an inverted catenary. Galizia defines this geometric conformation as a "*vela tesa*" (trad. stretched sail) which is close to, but not coincident with, the saddle of a paraboloid. Indeed, the vertical segments of a paraboloid exhibit a parabolic curve, whereas the horizontal segments take on a hyperbolic curve [11]. In Galizia's construction principle, instead, the vertical section of the shell is close to a catenary curve, whereas the horizontal diverge from conical curves.

3.3 Structural aspects

The structural behavior of Galizia's shells evolves in the different construction phases previously described and is closely related to its geometry and overloading processes. As explained in the design reports, following the pouring of the second phase, "*the weight of the concrete will be supported by the parabolic elements alone which are arranged according to the stretched fibers*" and transferred back to the supporting structures [10]. It follows that in this phase the roof works as a shell stretched on funicular elements, despite being a double-curved surface.

In the third phase, following the hardening of the concrete and the application of the overloads, a double curvature membrane behavior is established: part of the load is absorbed by the stretched fibers in the longitudinal direction working in a predominantly tensile regime and part of the load is absorbed by the transverse fibers working in a predominantly compressive regime.

A particular importance is assumed by the relationship between the shell and the boundary elements. This relationship is heavily influenced by the spatial conformation of the boundary elements. The calculation reports states that the perimeter elements are subject to actions in their plane and normally to it, as well as to torque actions due to eccentricity between the point of application of loads and the center of mass of the edge beam section. It follows that the boundary elements are subject to longitudinal and transverse bending actions, longitudinal and transverse shear, torque and normal stress. However, again in the reports, it is explained that generally these longitudinal bending moments are modest, while the transverse bending moments are generally balanced by the own weight of the edge elements.

3.4 Design aspects

The design process adopted by Galizia is informed by its construction process. The latter permits the introduction of several simplifications to the building site, but at the same time distances Galizia's shells from the known and widespread achievements of other authors who have made wider use of formwork.

The first and most important complication is the incapability of expressing designed surface through the well-known equations of spatial ruled surfaces. Thus, the design surface is not imposed by Galizia, but rather is "*determined by trial-and-error, depending on the geometric boundary conditions*"[10]. These trial-and-error attempts can be made upon the introduction of several simplifying assumptions that "*in a series of [...] roofing already designed by [Galizia and Scalesse] have been found to be reliable*" [10].

Galizia, therefore, assigns to the longitudinal stretched fibers the profile of a parabolic curve that is more precisely determined from geometric congruence conditions such as: "*height of extreme points of the cable, trajectories of support beams, deflections compatible with that of a vault*" [10]. Hence Galizia's design approach is not entirely mathematical as it considers different physical aspects. Once the profile of the longitudinal cables has been defined, it is possible to derive the design length for each of them, which can also be adjusted in site through the use of sleeve-tensioners.

For the transition to the two-dimensional problem, Galizia introduces additional approximations: "*the congruence of the deformations under load of the stretched fibers and the compressed fibers, taking into account the difference in the deformation modulus of the concrete in the two cases*" [9]. This allows

Galizia to derive the axial stresses in the two directions for a limited number of points, later extending the results to the entire shell. From this process, "*modest stresses in the concrete of the transverse compressed fibers*" and "*increased stresses in the tensioned parabolic fibers*" are found [10].

However, the reports recognize that the proposed modeling involves some "*uncertainty of behavior*" which is countered with the introduction of some safety assumptions [10]. In fact, Galizia assumes a hypothesis that does not allow the membrane behavior of the shell to be fully exploited: the entire overload is assumed to be supported by the stretched cables alone, ignoring the contribute of the compressed cable.

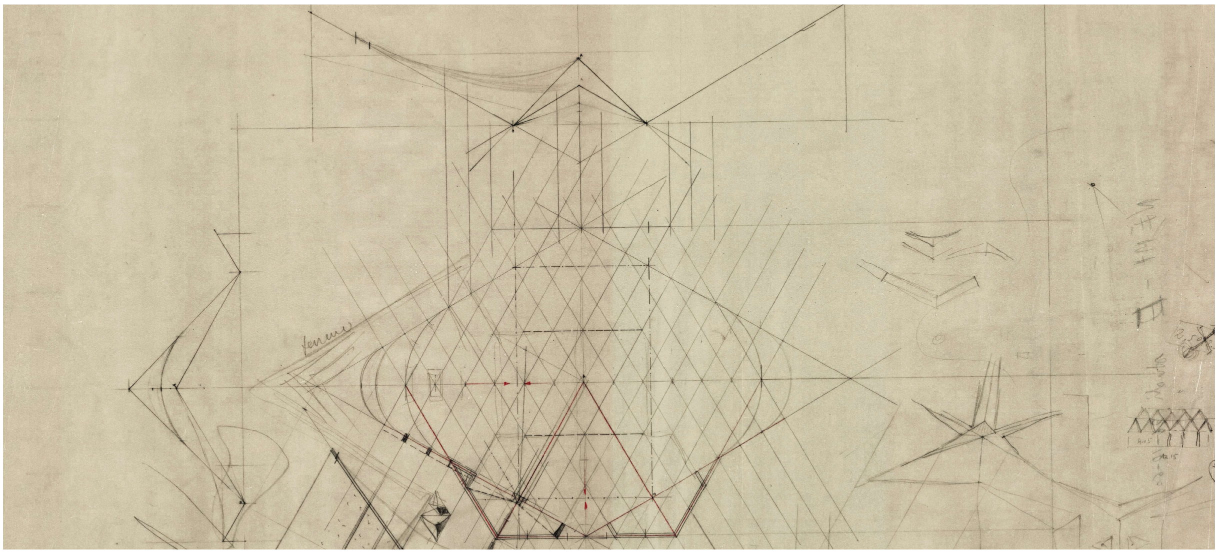

Figure 3: Graphical and iterative approach in the design of the Verbiti Church's shell. Courtesy of ASG.

4. Framing Galizia's work in the design culture of spatial structures

The construction principle adopted by Galizia, his attitude toward the design process, and the particular ecclesiastical uses of his shells bring some difficulty in identifying anticipatory experiences to his work. In addition to these anticipatory experiences, however, it seems necessary to discuss contemporary developments that can be paired with his view of the design problem of spatial structures.

An initial framing can be done with respect to the design principles of thin shells. By looking at how Heinz Isler summarizes his design approach, we can recognize that the three methods he identified are present in Galizia's approach: an arbitrary approach that leads to "sculptural shells," a mathematical approach that leads to "geometric shells," and an approach by physical analogy that leads to "structural shells" [12]. As shown by what has been discussed so far, none of these aspects is predominant in Galizia's work, rather they are simultaneously considered and sometimes sidelined in order to achieve a different and personal architectural quality. In Galizia's approach, those principles identified by David Billington for the design, analysis, and construction of concrete shells [13] are also clearly identifiable: iterative form-finding, use of simplified and reliable rather than complex and uncertain analysis methods in the early design stages, attention to the study of boundary conditions, and use of easy-to-implement reinforcement patterns are all considered aspects in Galizia's design reports.

A second framing can be made with respect to the construction conception. The hanging cable systems adopted by Galizia are not only necessary to ensure the stability of hardened concrete. They are in fact beneficial in placing two-dimensional elements, such as very dense plaster nets, that make up the negative of the concrete casting. Emphasizing the importance of these two-dimensional elements, which are close to textile components, it is possible to consider the use of textile formwork [14] as an anticipatory experience of Galizia's work. In this field, James Hardress de Warrenne Waller (1884-1968) is considered a pioneer with his Ctesiphon system. In it, hanging fabrics take the form of a catenary surface and are used as formwork [14]. This system was also adopted by Felix Candela (1910-1997) in his first shell in 1951 [15], a few years before Galizia's experimentation on the Camilluccia chapel. It is possible to identify in the experimentations on hyperbolic paraboloids a further anticipatory experience of Galizia's work. However, Galizia is interested in the formal repertoire of paraboloid experiments rather than into the possibility of describing its form mathematically. Regardless, it immediately became evident that Galizia's construction principle was particularly suited to returning forms close to hyperbolic paraboloids while minimizing the use of formwork.

Contemporary experiments on cable-net shells can be considered as a new interpretation of Galizia's construction principle. Contemporary experiences with this building principle adopt several aspects anticipated by Galizia: the limitation of provisional works whose main purpose is to give the possibility of supporting cables, the adoption of a cable pre-tensioning system, and the use of a two-dimensional element as the negative of concrete casting. Recent experiences add to these principles features such as digital fabrication and reuse of provisional works, along with the possibility of achieving a much greater formal complexity [16] [17] [18].

5. Silvio Galizia built cable-net shells in the city of Rome

In his work in Rome, Silvio Galizia proposed various experiments that were architectural, spatial, structural and typological in nature. The latter was particularly important due to the peculiar nature of his buildings and clients. After his early success in India, Galizia captured the interest of various religious orders, which in those years were preparing to realize their new rectorates in Rome. Galizia became the designer of several religious complexes, featuring residential facilities and private chapels. These provided him the opportunity to continually develop and refine a unique personal design and construction technique for concrete shells. The fact that these chapels were largely private accounts for their excellent state of preservation due to the care devoted to them by the religious orders residing in the structures to which the chapels belonged.

Figure 4: Camilluccia chapel [left, photo by Till Forrer, Zürich] and Verbiti church [right, photo by Stefan Melchior, Berlin]. Courtesy of ASG.

5.1 Camilluccia chapel (1957-58)

In the shell of the Via della Camilluccia church that covers a span of 14.5 m by 12 m, Galizia experimented for the first time with the construction principles described in this paper. Consequently, it assumes the value of a prototype for investigating the different geometric, constructive, structural and spatial possibilities of this principle. Here, the boundary beams are placed on glass walls, a solution in line with the most important international experiences regarding concrete shells. Galizia’s later works, however, showed a preference towards masonry edge walls. Peculiar to this church is its relationship to the rest of the building, into which the shell is grafted. It follows that the shell is used to achieve a certain interior spatiality rather than to characterize the architectural envelope.

5.2 Verbiti church (1959-1962)

In the Verbiti church, Galizia proposes a personal interpretation of a typical spatial structure theme, namely the composition of 4 shell portions around a central plan. At the junctions between these portions and on their perimeters, Galizia places the beams on which the shell cables will be hung. This geometric conformation results in significant lateral thrusts, which are absorbed by 4 chapels in reinforced concrete that act as stiffening cores. Where these chapels are absent, thrusts are balanced using masonry perimeter walls with concrete pillars on which the roof shell rests. In this church, Galizia introduces the theme of the opaque masonry wall, vibrated by a series of pillars and detached from the shell to achieve a cut of light visible inside.

5.3 Paoline chapel (1960-1963)

The design of the Pauline Chapel is derived from that of the Camilluccia, but presents considerably larger dimensions and includes a large monastery. Here, several variations on the structures boundary conditions are introduced. The shell rather than being grafted into a boxy volume assumes the role of a compositional hinge between the two wings of the complex. This compositional principle permits the use of a perimeter wall similar to that of the Verbiti church.

5.4 Collegio Pio Brasiliano (1962-1966)

In the church for the Brazilian college, a different relationship between the chapel and the preexisting rectorate and seminary is proposed. Here, the chapel is detached and assumes the role of an independent object from the rest of the complex. Galizia proposes a radial arrangement of 3 shells which rest at the top on a stiffening core derived from the church apse and in the lower inner part on two pillars. The rest of the shell rests on reinforced concrete perimeter walls that have a slight angle of inclination to compensate for the thrust of the roofing.

Figure 5: Paoline chapel (left, photo by G. Galizia) and Brazilian church (right, photo by Stefan Melchior). Courtesy of ASG.

5.5 Chartres chapel (1966-1968)

For Chartres’ sisters, a chapel attached to the rectorate and monastery was proposed, similar to the Brazilian church. This private chapel is accessible mainly from within the monastery, and has a secondary external entry. The saddle-like roofing presents the largest dimensions among the shells presented here and, unlike the Camilluccia, its shape appears designed to distinguish its indoor and outdoor space. The perimeter walls, once again tilted to counteract the thrusts of the roof, have several sculptural movements into which the windows and the entrance to the complex are grafted. The prevailing compositional theme of this chapel is precisely the same relationship between the perimeter wall and the shell as the latter turns back on the former until it becomes a true element of the elevation. Furthermore, the theme of ‘cut-off of light’ between the shell and the perimeter wall was already present at the Verbiti and the Pauline strutures.

5. Conclusion

Galizia's unique designs demonstrate the possibility of starting form-finding from a symbolic dimension (a religious purpose) and develop the core architectural design from there, even in a situation that is apparently limited by its technical dimension, such as in the case of concrete shells. Galizia demonstrates full proficiency in this technical dimension, as he was aware of the possibility to cast concrete minimizing the use of formworks, of the use of catenary curves in order to achive an optimal gravitational behavior, and of the construction rationalization trought the use of ruled surfaces. However, he consciously decided to adopt only part of these principles in his work in order to reach an higher architectural quality.

The construction principle he adopted, characterized using hanging cables and nets as the negative of his shells, has limited previous experiences, while contemporary developments of this approach then became more numerous. Due to the inaccessibility of Galizia's structures within monasteries, the field of spatial structure design has not been aware sufficiently of Galizia's contributions to the development of the design culture of reinforced concrete shells.

While other authors seem to subordinate the composition of floor plans and elevations to the need for adopting optimal surfaces [19], such as those of hyperbolic paraboloids, Galizia assumes a different design attitude: in his works, it seems that the shells are to be adapted, through different iterations, to pre-existing compositional decisions. This is confirmed by critical review of his designs, personal descriptions, and reports that include that of the Verbiti church, where he devoted significant effort to compositional choices before seriously addressing their structural aspects. This reiterates that Galizia's unique design process was not tied to a precise principle, such as the use of either physical models, or graphic statics or mathematical equations, as any single one of them would fail to capture the artistic dimension of this Swiss architect.

Figure 6: Chartres chapel (photo by Till Forrer). Courtesy of ASG.

Galizia's experience is emblematic in framing those approaches where the design of a spatial structure is not placed at the genesis of a project for any reason, such as reduced spans, the inclusion of the shell in a larger design complex, or the need to consider symbolic aspects as in the case of ecclesiastic buildings.

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