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Guillermo González Zuleta and the Emergence of Shell Construction in Colombia

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Abstract

Guillermo González Zuleta (1916-1995) was one of the most prominent figures in the field of structures in Colombia during the second half of the 20th century. As a civil engineer, his collaborations with architects and builders marked a period of radical structural invention through the efficient use of materials, the resourceful transformation of local means and methods of construction, and the pursuit of elegant and expressive structural forms. González Zuleta's career spanned over 40 years and encompassed the design of structures for a wide range of building types, including office buildings, churches, market halls, stadiums, and airports. Despite such an expansive oeuvre, this paper focuses on his contribution to the world of thin concrete shells, which remains relatively unknown today. While much of the research on structural art in Latin America has centered exclusively on the work of Félix Candela in México and Eladio Dieste in Uruguay, this text aims to expand current scholarship on the history of shell structures by exploring the ways in which González Zuleta adapted the principles of structural expression to the local context in Colombia, creating an impressive body of work despite demanding economic and technological constraints.

Keywords: history of thin shell construction, structural form, spatial structures in Latin America, reinforced ceramic shells, Guillermo González Zuleta, twentieth-century shell design.

1. Introduction

The late 19th century and the first half of the 20th century saw the widespread incorporation of modern architectural and engineering principles in countries around the world. This involved the use of new materials like reinforced concrete, steel, and glass. The adoption of a new design language introduced by modern architecture was seen as a way to reflect changing societal identities and cultural values. It was also seen as a means to improve living conditions for an increasing urban population and to bring order to what was previously considered an outdated world. This was particularly significant for Latin American countries, which were eager to showcase their embrace of industrialization through their public architecture, in line with the principles of the International Style and the *esthétique de l'ingénieur* [1]. The transition towards modern architecture in Colombia began in the 1930s, despite having an underdeveloped and lagging construction industry. Buildings such as the National Library of Colombia in Bogotá (1933-1938), the Children's Theater of Parque Nacional (1935-1936), and the campus for the National University in Bogotá (1936-1939), are a few important examples that reflected this transitional period when local architecture strived to align itself with a clear modern identity [2].

During the 1930s, Europe witnessed intense experimentation in structural design, particularly in the nascent field of shell construction. This period was characterized by an exploration of the plastic and structural qualities of reinforced concrete to create structures that were materially efficient, structurally sound, and highly expressive. These explorations were an organic extension and expansive development

of the pioneering work on concrete vaults and domes at the end of the 19th century by Monier, Hennebique, Schlüter, and Habrich [3]. Remarkable feats such as Eduardo Torroja's La Zarzuela Hippodrome in Spain (1935), Pier Luigi Nervi's hangars in Italy (1936-1939), and Robert Maillart's Cement Hall at the Swiss National Exhibition (1939) were all groundbreaking achievements that inspired engineers, architects, and builders worldwide who sought a new formal vocabulary to embody the progressive ideals brought about by modernity. Encouraged by these pioneering experiments in structural design, Guillermo González Zuleta was among those eager to infuse his own work with the spirit of these new ideas.

González Zuleta came from a family of engineers. His passion for structures was undoubtedly inherited from his grandfather, Juan N. González Vásquez (1838-1910), and his father, Fabio González Tavera (1885-1947), both of whom were highly respected engineers in Colombia. Juan N. González Vásquez was among the first Colombian engineers to receive an education abroad at the École Centrale in Paris. After completing his studies, he returned to Colombia to establish the Colombian Association of Engineers (SCI) in 1887, later serving as its president. His contributions to the engineering field were invaluable, particularly in developing the country's incipient railway network. Similarly, González Tavera followed in his father's footsteps, becoming president of the SCI and being active in academia, teaching at the National University. His professional expertise as a civil engineer was notable, and like his father, he played a crucial role in the construction of railroads. This was the stimulating environment in which González Zuleta grew up, observing from an early age the engineering accomplishments of both his father and grandfather, which were helping to transform the country at the turn of the century.

2. New material, new horizons: Concrete shell design in Colombia

In 1940, Guillermo González Zuleta graduated from the School of Engineering at Universidad Nacional in Bogotá. At that time, various factors converged to enable the first explorations in thin concrete shells in Colombia. One such factor was the availability of new construction materials. Reinforced concrete was not a commonly used material in the country during the early 1900s. According to Vargas and Ortega [4], its introduction was slow due to Colombia's relative isolation and the significant technical and economic challenges involved in importing machinery and setting up factories. However, this changed by the late 1930s, when several local cement plants combined their resources and collaborated to increase production to a level that could meet the growing demand.

Another significant contributing factor was the presence of Leopoldo Rother, an influential figure in the Colombian architectural community during the early 20th century. Rother, a German architect who immigrated to Colombia in 1936, played a pivotal role in advocating for the use of reinforced concrete to advance a modern architectural language. Notably, Rother was the first in the country to fully harness the structural capabilities of reinforced concrete when he led the design of the stadium grandstand at the Universidad Nacional campus in 1937 while serving in the Department of National Buildings of the Ministry of Public Works.

The third factor contributing to the development of shells was the growing academic focus on the topic. The year prior to González Zuleta's graduation from the University, the magazine of the School of Engineering at the Universidad Nacional, *Ingeniería y Arquitectura*, began publishing articles on shells. These articles, which included contributions from local faculty as well as international experts, helped to spread the concepts and techniques of shell design to a broader audience. Additionally, one of Gónzalez Zuleta’s professors, Enrique García-Reyes Seoane, a Spanish engineer exiled in Colombia, had close personal and professional connections to Eduardo Torroja, the renowned innovator of thin concrete shell structures. Together, Torroja and García-Reyes had founded the magazine *Hormigón y Acero* in 1934 and had maintained an active exchange of ideas over the years. García-Reyes’ presence during González Zuleta’s time at the School of Engineering would have undoubtedly exposed him to the latest developments in shell design theory and the most recent applications in projects built at the time.

3. Beginnings: The Ministry of Public Works

In the early years of his career and before becoming an established structural engineer, González Zuleta worked for the Department of National Buildings of the Ministry of Public Works. In his role, he actively participated in the design of various infrastructure projects across the country, including major public buildings spearheaded by the government. These projects, of different types and scales, reflected the vision promoted by the central administration at the time. In fact, during the mid-20th century, the Ministry of Public Works was responsible for the construction of several noteworthy structures that played a key role in the country's development, which were also pivotal in advancing modern architecture in Colombia. The Ministry brought together some of the country's most prominent architecture and engineering professionals. The group included established figures like the Europeans Bruno Violi, Leopoldo Rother, and Ernesto Blumenthal, as well as recent local graduates like González Zuleta, J.M. García, Solano, Martínez Sanabria, Vieco, Burbano, and Gaitán. In addition to their expertise, they brought a fresh perspective and renewed energy to the design and construction of buildings [5]. It was in this highly collaborative and interdisciplinary environment that González Zuleta gained his first experience as a structural engineer. It is worth noting that Rother's influence in the Department of National Buildings was crucial in leading the group to use reinforced concrete, exploring the benefits of structural expression and new structural types, particularly thin shell construction. This proved to be especially important for public buildings that demanded an innovative visual identity to signify the beginning of a new era of progress.

3.1 The Girardot Market

Rother, González Zuleta, and their team at the Ministry of Public Works seized the opportunity presented by a project to design a new building for the public market in the city of the Girardot to showcase on an unprecedented scale their transformative ideas on the expressive potential of reinforced concrete structures. The market's construction represented a significant milestone in architectural and construction history in Colombia because it is recognized as the very first concrete shell building to be erected in the country [6]. Girardot is a small city located 140 km southwest of the capital city of Bogotá. Due to the hot and humid climate, the design of the market needed to offer maximum shade to the vendors while also taking advantage of cross-ventilation to create a more comfortable environment for the public.

Figure 1. Interior of the Girardot market (Photo by the author)

The distinctive design consisted of a large, thin canopy that seemed to levitate over the market stalls. It comprised a series of interconnected concrete shells punctuated by glass blocks in their central area to provide natural illumination to the covered space. It was an extraordinary structure that blended aesthetics, efficiency, economy of materials, and invention. Its striking elegance not only set a new

standard for the use of reinforced concrete but also helped to show the formal possibilities of the material, serving as a source of inspiration and reference for González Zuleta's future projects.

The design phase of the project began in 1946, and construction was completed in 1948. The market structure, still standing and in use, boasts a grand canopy measuring 63 m by 55 m. It consists of 198 cylindrical shells that are 7 m in length and 2.5 m in width, rising 60 cm with a slim thickness of 5 cm. These shells are hung from 10 beams that are 55 m in length and 70 cm in depth, running perpendicularly to the direction of the shells to provide further stiffening and stability to the structure. The beams are supported by 8 V-shaped columns that minimize the area of contact between the building and the ground, enhancing the dynamism of the roof (Fig. 1).

One of the main innovations featured in this structure is the use of hollow ceramic pieces embedded within the section of the shell, an ingenious method that reduces the dead load of the overall structure [7] making it perform more efficiently. This pioneering strategy in shell design was also driven by a more pragmatic fact: the relatively poor quality of the cement produced locally, which, based on Rother's account, required a longer than usual curing time. The use of ceramic units offered a resourceful solution to the problem, allowing for a structurally stable composite to be created in a shorter time than the typical shell, with cement serving mainly as a binding agent. Additionally, hollow bricks presented the advantage of working with a familiar, cost-effective, and readily available material. It's worth noting that earlier explorations in structural ceramic tile vaulting had occurred in Colombia all the way back to the late 18th and early 19th centuries [8]. As explained by Ochsendorf, the Spanish tradition of ceramic tile vaulting arrived in South America in the form of a treatise on masonry construction methods first published in 1639 by Friar Lorenzo de San Nicolás. When Friar Joseph Pascual Domingo de Petrés arrived in Colombia in 1792 to help with rebuilding after a major earthquake in 1785, he brought a second edition of the treatise from 1667. Domingo de Petrés used his knowledge of structural tile vaulting in at least two buildings of interest in Bogotá: the Santa Fé National Observatory and the Primate Cathedral.

It is uncertain whether González Zuleta and others in the team working on the project for the Girardot market were familiar with these historical precedents, as structural tiles were typically hidden underneath layers of plaster. Still, it is unquestionable that ceramics were a material that had been part of the local building tradition for centuries. To some extent, the way in which González Zuleta incorporated hollow bricks into his designs resembled the impressive reinforced ceramic structures of his contemporary, Eladio Dieste, in Uruguay. However, there exists a discernible difference in their respective approaches. As noted by López et al. [9], Dieste used brick as the primary material for his vaults because of the technical advantages it presented and the particular aesthetic expression achieved by leaving it exposed. This was a strong statement favoring local solutions to construction and engineering challenges instead of resorting to materials and methods coming from more developed countries abroad. In contrast, González Zuleta viewed brick as a necessary but secondary component in the structure, concealed within the assembly of the thin shell of the market, emphasizing its utilitarian function above any aesthetic qualities. Instead, he chose to showcase exposed concrete as the finish material, possibly influenced by Rother's guidance and his desire to project the image of a truly modern structure in communion with the principles of the International Style. González Zuleta's inclination to hide the ceramic pieces and obscure their fundamental role in the structures he designed eventually changed in some of his later projects.

3.2 Baseball Stadium in Cartagena

At the Department of Buildings, González Zuleta became the lead structural designer for a new baseball stadium in the coastal city of Cartagena. Following the unique experience with the design of the Girardot market, the baseball stadium presented a subsequent opportunity to investigate further the potential of reinforced concrete and apply the principles of economy, efficiency, and elegance that characterized the work of structural artists [10]. As he had previously done, González Zuleta collaborated with a team of architects, including Gabriel Solano, Jorge Gaitán, Alvaro Ortega, and Edgar Burbano, to create an impressive structure that received immediate national and international acclaim. Notably, Solano had studied architecture abroad under Gropius at Harvard, while Gaitan had spent his formative years at

Yale and Ortega at McGill. Their international education and experience certainly had exposed this group to the latest developments in the use of concrete and the application of the principles of modern architecture. As Botti highlighted, Colombian architects' education abroad played a crucial role in the introduction and development of modernity in the country and helped to develop a new formal and material vocabulary.

The stadium, which received the prestigious National Engineering Award in 1947 for its outstanding engineering and architectural achievements, was widely published in specialized publications, including the July 1948 issue of Architectural Record [12]. Despite the scale and complexity of the project, the design and construction were completed with incredible efficiency, lasting only nine months. The structure itself consists of twelve reinforced concrete "C" shaped frames, each with a span of 10.75 m, supported by a grid of two parallel columns that elevates it above the ground (Fig. 2).

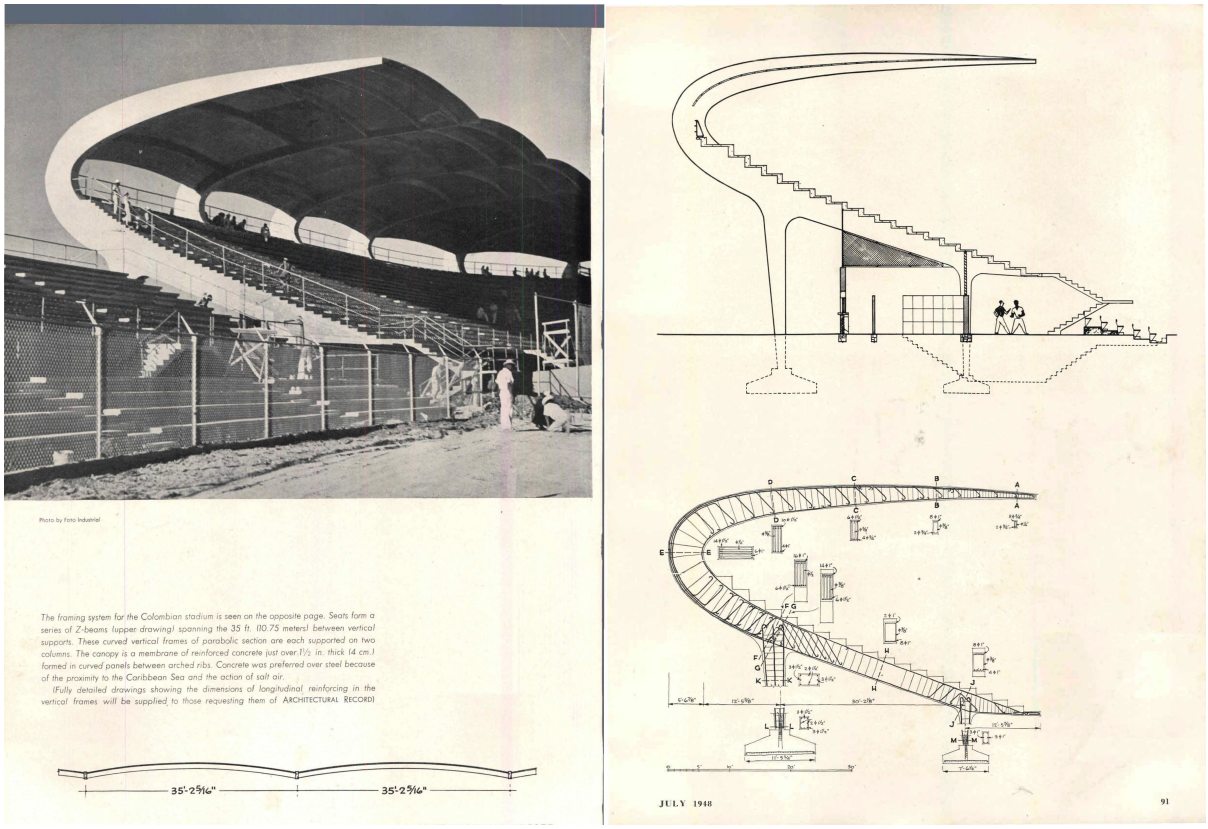

Figure 2. Baseball Stadium in Cartagena (Photo by Foto Industrial. Architectural Record, July 1948)

Eleven elliptic parabolic thin shells span between the frames, with a thickness of only 5 cm. These shells are stiffened by the insertion of five concrete arches, completing a cantilevered roof that projects 16.5 m [13]. For comparison, La Zarzuela Hippodrome, designed by Torroja, features a cantilever of almost 13 m. and a thickness of also 5 cm. The vigorous figure of the baseball stadium's structure captivated the public's imagination and the construction industry's attention. One of its most attractive features is the coffered undulating roof, visible from the grandstand under the canopy (Fig. 3). The patterned texture on this surface emerged as a direct result of the strategy used to enhance the roof's structural performance by reducing as much as possible the material required and the overall weight of the cantilever shell. During the design phase, two approaches to address this issue were considered: first, embedding hollow ceramic pieces within the shell section, as with the canopy for the market in Girardot, or second, the more traditional option of using wooden coffers to cast the concrete. Despite the higher construction costs associated with the latter option because of the material expensed in building disposable coffers, it was chosen as a solution due to concerns about the relative experimental use of ceramics in shell design. Rather than applying a finish layer after removing the wooden coffers, the concrete surface was left exposed to showcase the particular and unique traces of the construction process, a testimony of

sorts to the honest use of materials. It could also be argued that, to a certain extent, the use of exposed ceramic blocks would have contradicted the image of a genuinely modern structure by featuring a material associated with the past and with old construction methods. The novel expression and inventive engineering solution for both the Girardot market and the project for the baseball stadium in Cartagena solidified González Zuleta's reputation as the leading designer of shell structures in Colombia.

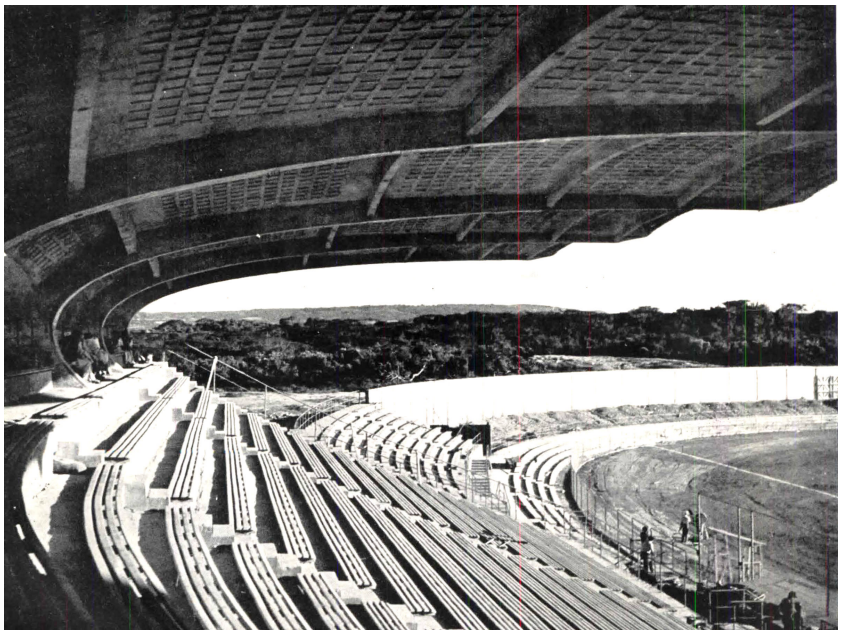

Figure 3. Baseball Stadium in Cartagena (Photo by Foto Industrial. Architectural Record, July 1948)

4. Structures for the People

In 1950 González Zuleta left his position at the Ministry of Public Works to establish his professional practice as an independent structural engineer, relying on the valuable knowledge and experience he had acquired with the projects in Girardot and Cartagena. Most of the projects he worked on independently continued to be more significant public buildings to meet the demands of rapid urbanization in Colombian cities. These projects included, among others, sports facilities, transportation buildings, and religious buildings. Although all of these commissions resulted from fruitful collaborations with teams of architects, Gonzalez Zuleta always played a pivotal role in shaping their expression, capitalizing on his growing recognition as a pioneer in creating a new, compelling structural vocabulary that challenged pre-established disciplinary paradigms. During this time, he continued to imbue architecture with a formal potency that reflected the delicate balance between the rational distribution of internal forces and a bold desire to test the limits of equilibrium and material thinness.

4.1 Bus Terminal in Bogotá

Between 1950 and 1953 González Zuleta became the lead engineer for a new bus terminal planned for Bogotá. The project was a collaboration between González Zuleta, Alvaro Ortega, and Gabriel Solano, two of the architects who had worked with him previously in the design of the stadium in Cartagena. The terminal, which has already been demolished, comprised five structures: an office building, fueling station, repair shop, storage, and maintenance area. The structure's design drew direct inspiration from the system developed for the Girardot market, using an array of thin cylindrical shells and stiffening cross beams. In the case of the bus terminal, the most significant and largest of the structures was the roof above the shops, which was resolved with three cylindrical shells measuring 2 m in length by 16 m in width and 5 cm thick, supported by arches whose ends were tied by a metal rod to prevent buckling. The arches rested on circular columns and rose 2 m [14]. Fourteen lower thin vaults of 4.8 m by 8 m completed the enclosure next to the shells (Fig. 4). Remarkably, and contrary to the strategy utilized in Girardot, hollow ceramic blocks used to lighten the shells were left exposed underneath the vaults. These tiles were spaced 20 cm apart and were covered with a concrete layer of 5.75 cm thick. The project

rapidly gained recognition and became another referent for shell design. It was included as part of the Museum of Modern Art's exhibition on Latin American architecture in 1955 [15], and was featured in the 1954 issue of Architectural Forum that reported on the celebrated international conference on thin shell construction organized that same year by the Departments of Civil Engineering and Architecture at the Massachusetts Institute of Technology [16].

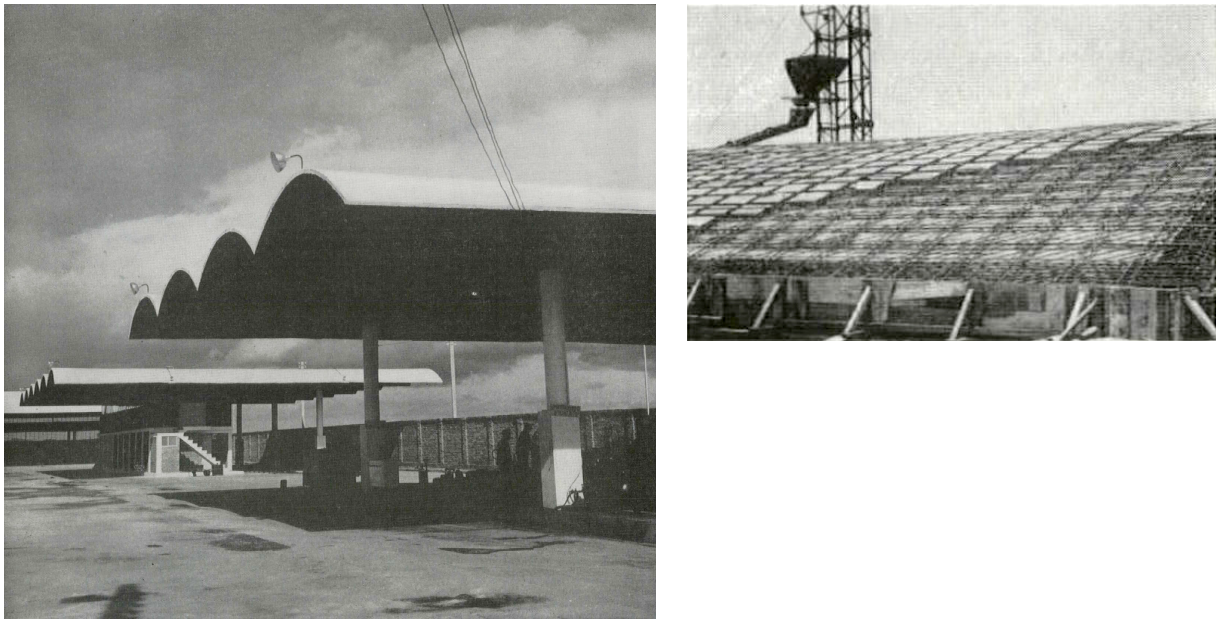

Figure 4. Bogotá Bus Terminal (Architectural Forum, August 1954)

4.2 Volkswagen Showroom

The showroom for Volkswagen continued González Zuleta's exploration of the rich universe of light concrete shell design, maintaining a strong connection to the lineage of structural art. The building, designed in collaboration with the recognized Italian architect Bruno Violi, boasted a welcoming two-story structure for the public with a double-height first level. The second level was covered by six continuous cylindrical shells measuring 23 m in length and 5.9 m in width, with a depth of 1 meter and a thickness of 5 cm, which was a similar dimension to the one used by González Zuleta in previous designs. These shells were supported by three parallel arches that were 40 cm wide and tied together by a horizontal beam 15 cm in depth [17]. The cantilevered edges of the shells extended one meter on each side of the building, enhancing the overall sculptural expressiveness of the complex.

Two additional spaces were covered by separate sets of shells, one with 9 and the other with 8 shells, all measuring close to 9 m in length and 4 m in width (Fig. 5). To further illuminate the first floor, these shells were built with embedded glass block pieces, which further amplified the airy atmosphere of the space. This desire to challenge the perceptual heaviness of concrete by perforating the shells and allowing daylight to penetrate into the interior space was a continuation of a strategy González Zuleta had previously deployed with the roof design for the Girardot market (1946-1948). Equally noteworthy in this regard are Félix Candela's experiments in México with glass blocks, which he first used in the High Life Textile Factory (1954-1955), or Gilberto Gatto Sobral shells at the Central University in Ecuador (1952-1959) [18]. Remarkably, González Zuleta's first work with glass blocks embedded in shells predated that of both Candela and Gatto Sobral.

5. Conclusion: González Zuleta and the commitment to a new structural ethic

Thin concrete shells are regarded as one of the most remarkable accomplishments in modern engineering and architecture [19]. Despite the widespread publication, exhibition, and discussion of extraordinary shell examples from around the world during the peak of their success and popularity, most contemporary research on the history of shells has tended to concentrate on the work of a few well-known traditional figures such as Eduardo Torroja, Pier Luigi Nervi, Heinz Isler, Eladio Dieste, and Félix Candela. This paper contends that many lesser-known builders, architects, and engineers from countries considered to be on the periphery of the global mainstream construction and engineering industry also made significant contributions to the field of shells, which merit reexamination today. One such pioneer is the Colombian engineer Guillermo González Zuleta. His remarkable body of work encompassed various building types and programs over a long career throughout most of the 20th century. Through his work, he exhibited a devoted commitment to exploring innovative, cost-effective, and refined structural solutions. Recognized as a leader and highly collaborative innovator, his influence was transformative in establishing a new engineering language that contributed to the advent of modernity in Colombia. Despite the constraints of an underdeveloped local industry, González Zuleta proved to be a visionary who relentlessly pursued structural clarity and explored the novel aesthetic possibilities offered by the use of thin concrete shells. His legacy deserves a more comprehensive study as a prominent example of one of Latin America's shell masters, an individual capable of harnessing his structural expertise and creativity to uncover a new expressive and powerful vocabulary that turned local constraints into opportunities for radical structural innovation.

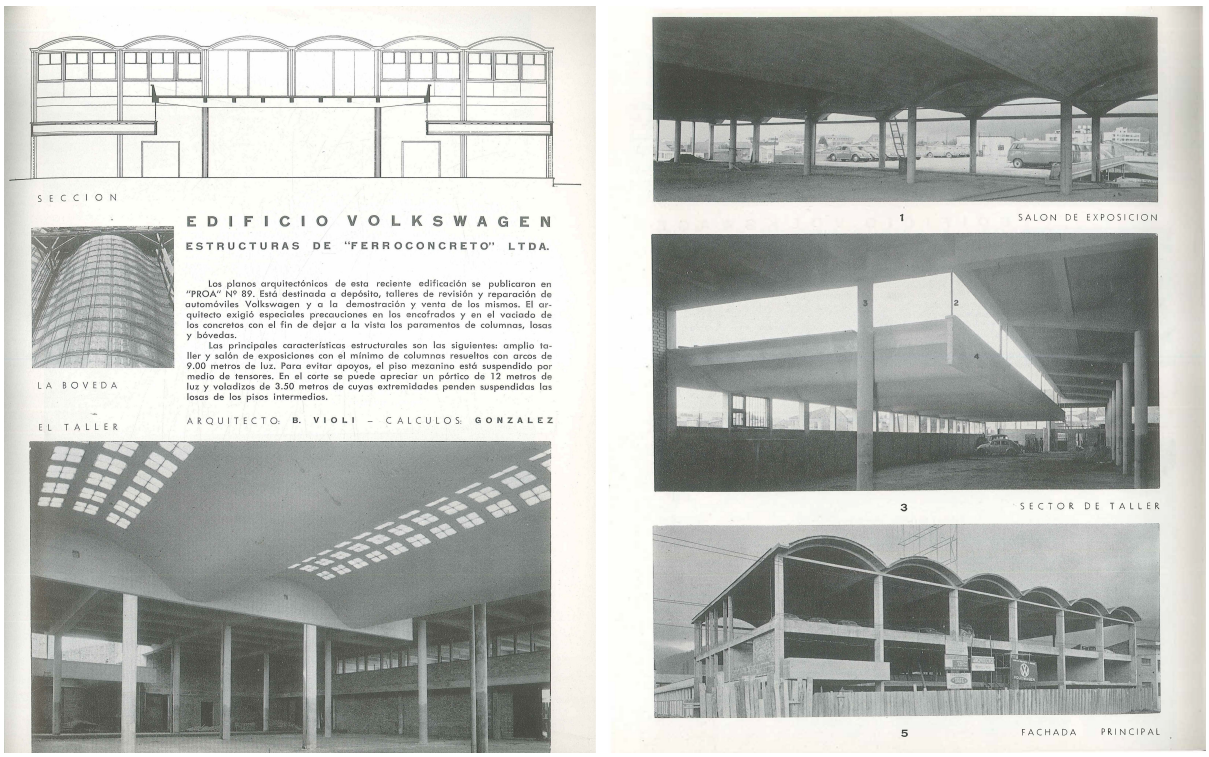

Figure 5. Volkswagen showroom (Revista PROA 93, 1955)

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