

Study about Design of Reinforced Concrete Shells for Public Markets in Dominican Republic: Case Study of 12 Markets Built During the '12 Years of Joaquín Balaguer' (1966 to 1978)

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1. Introduction

In this study, the marketplaces built in the 60's in Dominican Republic, their space, form and its origins are researched, as well as the political, historical and cultural circumstances that gave them shape. 12 Public Markets are included and were selected based on three premises: the type of structure, which is concrete shells; the time frame; and the political frame, being all built in the first governmental period of the president Joaquín Balaguer from 1966 to 1978. What is interesting about these markets is that only from 1965 until 1978, all the markets built with reinforced concrete, used shells, vaults or parabolic structures. Also, these were all casted by hand with concrete made in situ and using wood formwork. The main question to answer is how these public markets came into existence in this particular time, and why the concrete shell structure was used to conform 'a market image' throughout the country. For this paper, the 7 main cases will be briefly explained, and 2 of the more relevant will be more detailed.

2. Purpose

The main purpose is to trace the origin of the use of concrete shells and hyperbolic structures in the design of the public markets built in the 60s and 70s. Also, it was intended to dig into the reasons for originally using this particular structure specifically for markets.

3. Methodology

The followed steps were as follows: 1. background and previous research review and revision of national archives, 2. determination of the markets to include in the research and search for existing drawings, 3. physical visits to the markets, 4. measurements of the buildings, 5. making of drawings and details, 6. analysis of relation between background situation (architectural and historical) versus the situation found in the markets at the moment of research, and finally, 7. conclusions.

4. Findings and Results

4.1. History of Markets in Dominican Republic

The evolution of the market places since its origins was explored based on old narrations, documents and pictures from the national archives. The first evidence of market activities dates from the colonization period, being influenced by the slaves brought to the island. The dynamics changed through time, going from these to the so-called 'lodgings', then 3 examples of steel structures, and finally the introduction of concrete structures for this typology.

4.2 External Influences Regarding Shell Structures








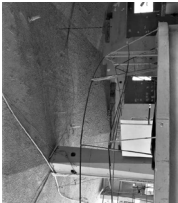






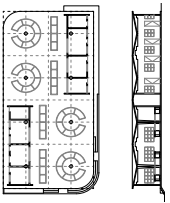
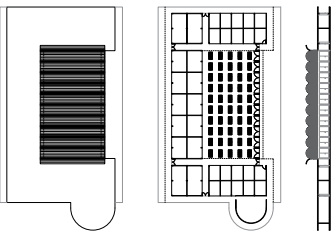
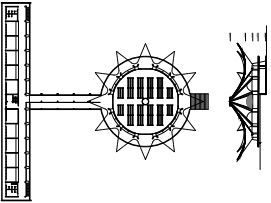
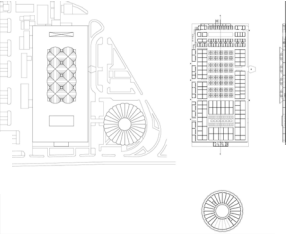
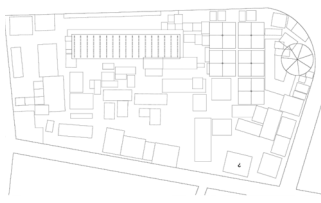
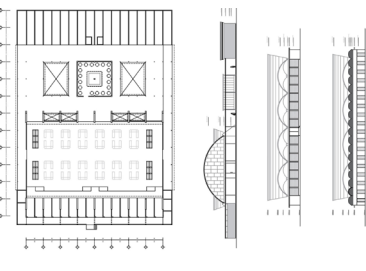
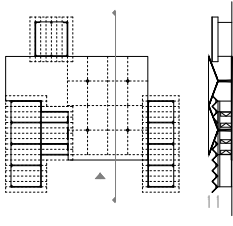
Many of the architects that designed these markets studied abroad, some of them even under the supervision of Pier Luigi Nervi, renowned for shell structures. Also, concrete shells was trending in Latin America since the 30s, particularly with Felix Candela's work, being very influential on the architecture in Dominican Republic only after a decade later. These were considered efficient in terms of economy.

4.3 Construction of the Markets

According to documents found in the National Archives, it was confirmed that the public markets were part of President Joaquín Balaguer's Construction Program (National Planning Office, 1968; National Budget Office, n.d.). These finally had the objective of integrating the peasant into national economic activities, redistributing income, increasing consumption and ultimately improving the economy through the improvement of the quality of life of the population. The 12 markets included in this research were built in a very chaotic political atmosphere. Balaguer's policy of dynamizing the country's economy by constructions, together with an 'austerity law' and the high demand of infrastructure and social appliances, needed the architectural projects to address the situation in the cheapest, fastest and most efficient way possible, and according to the interviews made (Arch. Julio Hernandez; Arch. Rafael Hernandez), this was key in the selection of the type of structure since it was proving to be efficient in terms of costs in other countries in Latin America (Hitchcock, H. R. 1955). See chart 1. Half of the markets (6) are based on a design from 1966. These were repeated with slight modifications. See case study B for details and chart no. 2 for the details of these variations.

4.4 Case Studies.

To answer the questions about the structure of the markets and the reason for the design of each one of them, case studies were carried out. To the reason why constructions in concrete started in the 50s, it was due to a historically famous hurricane San Zenon. This hurricane razed with almost all the constructions in the country, where the main material as wood. From here, Rafael Trujillo, president at the time, started politics that fomented the use of concrete for constructions instead of wood (information obtained by the mentioned interviews, it is also mentioned by More, G., et. al., 2008.

Chart 1. Specifications and data relation of markets included in the research. Source: Author										
Market	A. Municipal Market	B. Honduras Market	C. Municipal Market	D. New Market of Duarte Av.	E. Market of Los Mina	F. Central Market of Pueblo Nuevo	G. Public Market			
Location	San José de Ocoa Province	Santo Domingo	Puerto Plata Province	Santo Domingo City	Santo Domingo	Santiago Province	Bonao Province			
Area	454.40 m ²	1,869. 15 m ²	3,376.80 m ²	9,842. 65 m ² (m.e)	1,402.35 + 1,025.10 m ²	4,556.40 m ²	1,049.65 m ²			
Year	1966	1966	1968	1968	1968	1968	1968			
Architect	Unknown	Arch. Rafael T. Hernandez	Arch. Julio A. Hernandez	Arch. Rafael Calventi	Arch. Jimmy Durán	Arch. Amaury Matos	Unknown			
Materials	Reinforced concrete, concrete blocks.	Reinforced concrete, concrete blocks, clay open block for ventilation.	Reinforced concrete, concrete blocks, wood paravols	Reinforced concrete, concrete blocks, concrete open block for ventilation	Reinforced concrete, concrete blocks.	Reinforced concrete, concrete blocks, steel pillars, concrete open block for ventilation	Reinforced concrete, concrete blocks.			
Structure	Simple structure of 8 hyperbolic umbrella structures.	Flat roofed, columns and beams structure, with a main hall roofed with 10 parallel vaults 12 cms thick, 36x23m and block enclosures.	Round building made up of 12 hyperbolic paraboloids + Rectangular volume of columns and beams structure	xm vault, reinforced concrete shell, columns and beams with block enclosures.	Two structures: one a pavilion compounded by 5 parabolic umbrellas; and another one with parallel vaults supported on beams and columns.	54x27m vault, reinforced concrete shell, columns and beams, steel pillars for an contiguous flat roof.	4 parts. One main space covered by 4 umbrella structures; and 3 attachments of beams and columns and an accordion roof.			
Appearance										
Roof structure										
Drawings										

4.4.1 Case A: Municipal Market of San Jose de Ocoa (aprox. 1966)

The structure of this market is a simple roof structure consistent of 8 reinforced concrete umbrella structures, under which 8 agriculture produce selling modules, and two concrete block volumes are found. It has similarities with Case E and Case G, which was designed by Arch. Jimmy Duran in the 1968. This is also one of the smallest and simplest of the cases, being located in a small town. See chart 3 for the dimension comparison, and chart 4 for the area relation.

4.4.2 Case B: Market of Honduras (1966) - National Pattern

Designed in 1966 by the Architect Rafael T. Hernandez, who worked as the Presidency designated architectural-engineer during all of Balaguer's ruling. The market project is compound of a wide space, with selling modules for agriculture products, rentable rooms for meat shops in the surrounding of this space, and miscellaneous, grocery and handcraft shops towards the exterior. This is structured into a flat roofed U-shaped volume of rentable spaces for shops, surrounding a main large space with modules, roofed with 10 parallel vaults. Five replicas were made in other provinces, see chart 2 and 3 for details.

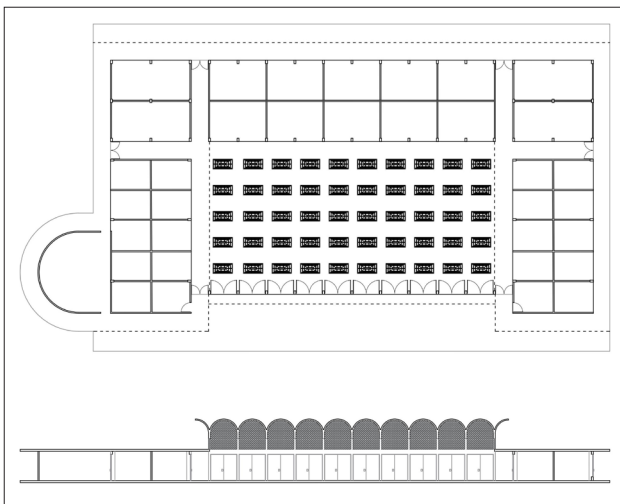


Figure 1. Floor plan and longitudinal section of the Market of Honduras. Source: Author.



Figures 3-4. Main facade and interior photos of the Market of Honduras (after renovation works done in 2014). Source: Author.

4.4.3 Case C: Municipal Market of Puerto Plata Province (1968)

The project consists of three main parts: a circular Pavilion for vegetables, composed by 12 hyperbolic paraboloids joint in the top by a 'ring' or 'flat disk'. These were divided to allow natural light into the space. Diameter is 30m, and it has two levels. The second piece is a rectangular volume for textile shops, meat shops, and administrative offices. And third, a slope that connects the two parts. The architectural engineer, Mr. Julio Hernandez, claimed not having a particular concept for the building. The idea arose and the main aim was to give answer to a need, similarly was in Case B. The sellers abandoned the pavilion, going back to the streets in rustic stalls. The pavilion reminds of the 'Los Manantiales Restaurant' in Mexico, by Felix Candela in 1958.

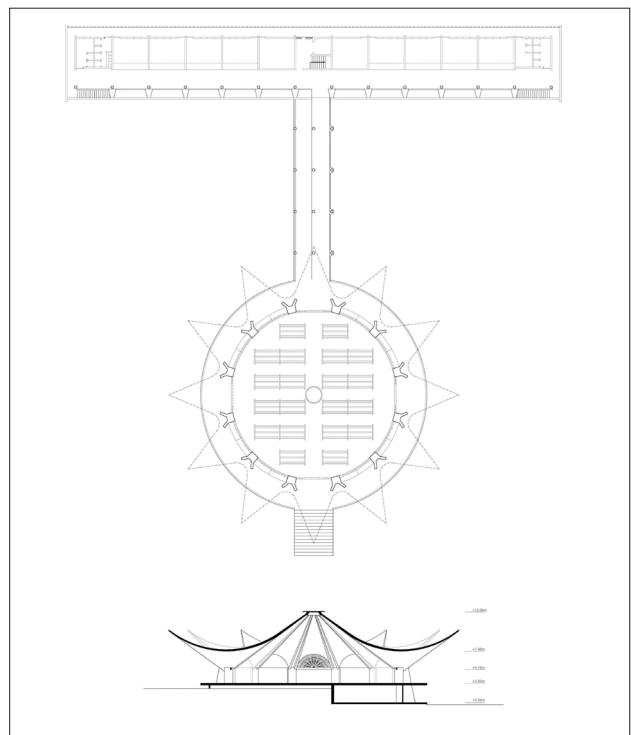


Figure 5. Floor plan and longitudinal section of the Market of Puerto Plata. Source: Author.



Figures 6-7. Main facade and interior photos of the Market of Honduras (after renovation works done in 2014). Source: Author.

4.4.4 Case D: New Market of Duarte Ave. (1968)

This market was designed by the architect Rafael Calventi, who studied in Italy under Nervi's supervision. It was built of prefabricated materials, concrete blocks as enclosures, and a reinforced concrete parabolic roof. It is a flat slabbed floor and roof of 9,426.9sq.mts. in between which

rectangular volumes are distributed. The parabolic roof is an independent structure that roofs the agriculture produce selling hall of 1,811.30 sq.mts, supported by 15 columns (see chart 3 for dimensions). Here again, most of the vegetable selling activities have moved to the surroundings of the building instead of the hall.

4.4.5 Case E: Market of Los Mina (1968)

The market was design by the Dominican architect Jimmy Duran in the 1968. It consists of a volume of 5 reinforced concrete umbrella structures, and another volume of parallel tunnel vaults. The umbrella volume is referred by the sellers as “The Pavilion” and was aimed to hold the agriculture produce sellers. The second volume was supposed to hold shops, and it is conformed by 16 parallel vaults. At the moment of research, the pavilion was fully modified and subdivided into small shops of various sort. The second volume was then the space for vegetable and meat selling.

4.4.6 Case F: Central Market of Pueblo Nuevo, Santiago Province (1968)

The design was made by the Engineer-Architect Amaury Matos Sánchez. The building is a reinforced concrete vault of 54 meters long by 27 meters wide where 24 modules for selling agriculture produce, 12 shops, and a commercial area with 16 rentable spaces. The vault has columns of 40 centimeters thickness. which grow to 4 meters at the back and bottom of the column to hold the oblique forces, being the shell 20 centimeters thick. The design has overall congruence with a structural module of 6 meters x 6 meters. Similarly to other cases, at the moment of research the main hall was empty of vegetable sellers who moved outside.

4.4.7 Case G: Public Market of Bonaó (aprox. 1968)

It is a simple structure compound of a pavilion of 4 concrete umbrella structures with 4 volumes attached. The volumes have an accordion shaped roof. The name of the architect or any other official documentation was not found. Similarly as Case E, the open pavilion has been subdivided and enclosed, and the main farmer market activity has been taken outside.

5. Conclusions

The main question was how these public markets came into existence, and why the type of structure was used to conform ‘a market image’ throughout the country. As for this, three main reasons came as a result. The first one, the need and the use: the markets were part of Joaquin Balaguer’s construction programs that aimed to address tangible and urgent need of the population at a very unstable political and economic moment. This kind of structure was considered efficient to cover the big spaces that were thought to be suitable for a market. Based on the information gathered from the interviews, there was no conceptualization further than the resolution to give answer to existing conditions and put an order to it. The beauty

and achievements of the structures was then given by its efficiency and were posible due to the architects having an engineering formation besides their design skills, knowing what was posible and how forces transfer within the shape. Shapes and patters repeated over and over again were due to the gathered constructive experience, the initial idea was working and had a defined budget, which was fundamental. Second, external influences and architects’ academic background. Even though all the architects were dominicans, the experimental activities with shells and parabolic geometries in Latin America at that time, became a trend in all region. The influences of Pier Luigi Nervi are specially relevant since the director of the first architecture

Main Market Hall Roof Dimentions							
Case	Length (m)	Width (m)	Min. Height (m)	Max. Height (m)	Thickness (cm)	Structural Module (m)	Total Area (m2)
A	28.80	14.40	3.70	4.35	12	(8) 7.20x7.20	414.72
B	29.50	15.65	4.30	6.20	7	(10) 2.95x15.65	461.675
C	-	27.90	2.20	10.50	20	(10) 14.75x15.35	537.20
D	34.00	65.50	3.00	6.70	7	(8) 14.5 x 17.20	1,811.30
E	15.77	64.30	4.50	6.10	12	(5) 16.00x16.00	1,280.00
F	48.00	26.80	4.10	11.20	20	- *	4,098.40
G	22.00	18.00	3.00	5.00	12	(4) 9.00x11.00	396.00

Chart 2. Main hall roof dimentions. Source: Author.
* Vault is supported by columns in the periphery.

Case B Variations - Main Market Hall Roof Dimentions							
Case	Length (m)	Width (m)	Min. Height (m)	Max. Height (m)	Thickness (cm)	Structural module (m)	Total Area (m2)
B1	29.50	15.65	4.30	6.20	12	(10) 2.95x15.65	461.675
B2	18.90	15.20	4.30	6.20	12	(6) 3.15x15.20	287.28
B3	29.50	15.65	4.30	6.20	12	(10) 2.95x15.65	461.675
B4	29.50	15.65	4.30	6.20	12	(10) 2.95x15.65	461.675
B5	31.50	23.10	4.30	6.20	12	(10) 3.15x23.10	727.65

Chart 3. B Case variations of main hall roof dimentions. Source: Author.

school in Dominican Republic, Rafael Calventi, studied under Nervi’s supervision while in Italy. Actually, all architects studied abroad with the exception of Arch. Rafael T. Hernandez. And third, the source of the material and permanency. Concrete was the main construction material since the 50s, due to the frequent hurricanes in this geographical area and due to government politics. Steel was not yet produced locally.

6. References

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