

A Detailed Look at Ceramic Façade Systems in Bogotá

Searching Innovation Opportunities

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Abstract

The tradition of ceramic façades in Bogotá dates back to more than a century ago. However, this tradition has been characterised by keeping a conventional construction approach, without any considerable evolution. This paper focuses on significant turning points in Bogotá's tradition that have led to improvements in the construction environment, leading to possible paths for innovation with new proposals for ceramic façades. The central turning-point cases discussed are: Torres del Parque, the North Tower-Hilton International Hotel, brick façades for buildings that emerged after the Colombian Earthquake-resistant Building Standard (NSR-98), and the extension of the Santa Fe Foundation building. Through a detailed focus on these four cases in terms of their technological and morphological solutions, this paper aims to yield innovation opportunities for developing ceramic façade systems within an earthquake prone region.

Keywords

Ceramic façade systems, Bogotá, historical review

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1 INTRODUCTION

The use of ceramic in Bogotá is a history that has lasted more than a century, in which technological and morphological evolution has been minimal. This paper refers to technological evolution as the level of productivity that can be achieved in the façade's construction, in order to improve the efficiency of the overall construction process of the building. Morphological evolution places concern on those metrics which determine the relationship between the façade and the building's structure, as these comprise the interdependence between the two systems, along with the façade's slenderness and weight. The lack of development in technological and morphological matters is due to the use of this material as an element of the constructive tradition in which architects and builders have repeated their conventional solutions with very limited critical vision. This situation, added to the complexity of responding to the current demands of seismic behaviour of façades, has led to a limited level of innovation in ceramics. Manufacturers, along with some architects, have made efforts to search for new applications and alternative systems that are generally shown at local construction tradeshows, but the takeover by industry-leading architects and engineers has been minimal. Some of the conventional solutions have become the default answer for any project and have been standardised by manufacturing requirements, leading to constant repetition.

There are some cases that have left this repetitive path, introducing unconventional solutions for ceramic façades, which are labelled in this paper as "turning points". These examples are Torres del Parque, the North Tower-Hilton International Hotel, brick façades for buildings that emerged after the Colombian Earthquake-Resistant Building Standard (NSR-98), and the extension of the Santa Fe Foundation building. These projects make evident the need for creating a line of research that allows for proposals for new and better ways of using ceramic as a contemporary material. Furthermore, innovations must be coherent with a high seismic risk area where the displacement of heavy façades (built with brick and reinforced with concrete and steel reinforcing) by lightweight façades is becoming more and more common.

Taking into account the fact that there is a disconnect between the tradition of ceramic use in Bogotá and its technological and morphological evolution, this paper aims to provide a detailed description of the turning points, and then compare these with each other in order to determine which innovation lines of technological and morphological aspects presented by these cases can be taken into consideration to add value to ceramic façades in Bogotá. Chapter 2 explains the methodology applied to identify the turning points and to establish the comparison axes between them. In Chapter 3, a brief context of the tradition of ceramic façades in Bogotá between 1920 and 1980 is provided, given that the most significant transformations in the application of this material occurred within this time period. Chapter 4 deals with key parameters to determine when a project can be considered as a turning point within the tradition. Finally, Chapter 5 gives a detailed description of the turning points and makes a comparison between them. In the conclusion section, a hypothesis is put forward in terms of an innovation path that might overcome the disconnect between the tradition of ceramic use and its technological and morphological evolution.

2 METHODOLOGY

The article's methodological steps taken to identify turning points within Bogotá's tradition of ceramic façades and compare them to each other are undertaken in the following order: Firstly, a description of the tradition is developed through a review of the state of the art of ceramic façades.

Secondly, understanding the tradition and its minimal evolution in technological and morphological aspects, a definition of these two qualities is made to use them as indicators for detecting turning points within the tradition. Thirdly, a baseline that represents the tradition is described in order to establish a starting point for the technological and morphological indicators. By this means, a façade that presents a different degree of technological or morphological development to the one presented in the baseline, is recognised as a turning point. The chart below (Fig. 1) is used to make a detailed description of both the tradition baseline and the turning points. The chart's recorded description of each case is put together in a single table in order to make a comparison between the tradition baseline and the turning points. Finally, the information gathered through the turning point's description and comparison, is used as an input to outline innovation opportunities for developing ceramic façade systems within an earthquake prone region.

PROJECT NAME	SLENDERNESS	INTERACTION BETWEEN FACADE AND STRUCTURE
FACADE PHOTO	$s = a/t$ $a = -$ $t = -$ $s = -$	Interaction by _____
CONSTRUCTION EFFICIENCY <input type="checkbox"/> Automation <input type="checkbox"/> Mechanization <input type="checkbox"/> Rationalisation		FACADE DETAIL AND FORCE DIAGRAM
CERAMIC COMPONENT		
FACADE'S CERAMIC PIECE PICTURE	WEIGHT	
	_____ kg/m ²	

FIG. 1 Description template for the turning points.

3 BACKGROUND: STATE OF THE ART

The first brick production factories in Bogotá were established at the base of the Monserrate and Guadalupe hills because these are clay extraction areas and there is easy access to wood for furnace fuel (López & Gossens, 2018). The beginning of production came with the Calvo brick factory around 1859. However, the use of brick didn't increase until the end of the nineteenth century, when it became one of the most common materials for house façades.

After the opening of the Moore brick factory in 1906, the clay industry was consolidated in Bogotá. Saldarriaga and Fonseca (1986) describe the trajectory of brick and the implementation of the material in architectural façades, in their article *El Ladrillo y la Arquitectura Bogotana* (The Brick and the Architecture of Bogotá). They describe four periods: a period of transition between 1920 and 1940, a formative period between 1936 and 1948, a consolidation period between 1948 and 1960, and a period of diversification from 1960 to 1980. The most significant changes occurred in the first three periods, while in the fourth period, constructive solutions were established and have continued repeatedly up until today.

The transition period began in the 1920s when Bogotá's elite began to move to the north of the city and settle there. In this process, the *Teusaquillo*, *La Merced*, and *Quinta Camacho* neighbourhoods were founded, where the English style was adopted for the design of houses and brick began to be used as a gesture of social identity (Fig. 2). This strongly influenced the aesthetic and technical appreciation of this material, which, in the 1930s, motivated an exploration of different visual languages for the exposed brick façades. The respect for brick also became an urban issue as neighbourhoods began building with this material, creating a homogeneous visual landscape.



FIG. 2 Quinta Camacho neighbourhood façades, 1930. (Photograph by Faculty of Architecture & Design, Universidad de los Andes)

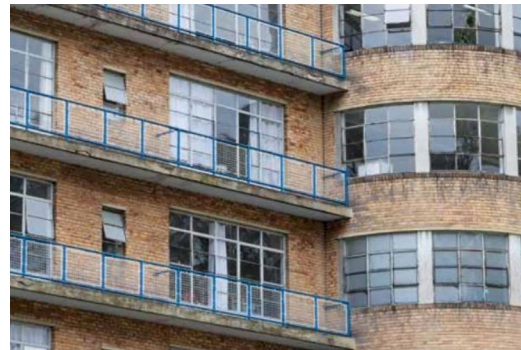


FIG. 3 San Carlos Hospital Building by Cuéllar Serrano Gómez architects, 1948. (Photograph by Faculty of Architecture & Design, Universidad de los Andes)

The formative period refers to a stage of brick experimentation between the traditional eclecticism of the time and the new modern international models that were being adopted in Bogotá. Examples of brick façades of this period reflect a mix between the new and the traditional, both in form and technique, as demonstrated in the San Carlos Hospital Building of Cuéllar Serrano Gómez, constructed in 1948 (Fig. 3). It is said that influence of modern architecture on brick use is evident in some hints, since the culture, construction techniques, teaching and practice of architecture, was at that time in Bogotá traditional in relation to new models expected to be adopted.

Subsequently, during the period of consolidation, political, economic, and social factors led to an urban renewal at the end of the 1940s. As a product of this wave of modernism, marked by Le Corbusier's visit to Bogotá, materials such as concrete began to compete with brick as the favoured material for the façades of contemporary buildings. However, firms such as Cuéllar Serrano Gómez, as well as other architects, kept exploring and using brick, thus boosting the brick industry (Fig. 4). The use of blocks and hollow pressed bricks began under this evolution.



FIG. 4 North-east façade of the Tequendama Hotel by Holabird, Root, and Burgee office, and Cuéllar Serrano Gómez firm, 1951. (Photograph by Faculty of Architecture & Design, Universidad de los Andes)



FIG. 5 Building of the Colombian Society of Architects by Rogelio Salmona and Luis Torres, 1974. (Photograph by Faculty of Architecture & Design, Universidad de los Andes)

By 1960, a period of diversification had begun, in which architecture went through a stage of institutionalisation and commercialisation as architects began to practice in public and on commercial entities, leading to a diversification of the profession. Consequently, different kinds of buildings (especially of a greater height than those previously built) began to be produced, where the expressive potential of ceramic was demonstrated (Fig. 5). From 1970 to 1980, the 'brick school' began to consolidate as the application of the material spread throughout all levels of professional work. Saldarriaga and Fonseca (1986) referred to the years following 1980 as a period during which ceramic prevailed in the constructive tradition. The preference for using exposed brick is attributed to the influence of architects such as Fernando Martínez Sanabria - a trend that began to position itself as the universal language of Bogotá's identity and led ceramics to a higher level of appreciation. "What in previous decades had just been a search, from 1980 onwards was already a fad" (Saldarriaga & Fonseca, 1986, p.12).

This appreciation for using brick as a façade material in Bogotá is still maintained, however, there is no remarkable difference between those examples built 40 years ago and those that are being built nowadays, neither in technological aspects of construction nor in the morphology of the façade. The construction of ceramic façades in Bogotá continues to be carried out manually by one or more operators, and in the case of brick, pieces are assembled one by one. In morphological terms, ceramic façades continue to be typically associated with the use of brick and therefore, maintain a minimum thickness of 12 cm. In general terms, ceramics are part of the visual landscape of Bogotá but new needs have arisen and an alternative to the traditional façade has not yet been introduced to meet emerging demands.

4 KEY PARAMETERS TO DETECT TURNING POINTS WITHIN THE TRADITION

Since construction needs have evolved, while, on the contrary, ceramic façades have remained the same over the years, technological and morphological parameters are key aspects to determine the degree of a ceramic façade's evolution in Bogotá's architecture. This is due to the fact that integration of certain characteristics of these two parameters enables a solution to keep in force ceramic façades when facing current challenges such as practical construction methods for high-rise buildings, and optimal structural performance in case of earthquakes. These happen to be challenges the traditional ceramic façade in Bogotá has not yet solved, and therefore, a proposal which provides a way to overcome these issues through either a technological or morphological solution, can be considered as a turning point. To address the façade's technological aspect, a description will address the efficiency of the building's construction stages. Regarding the morphological aspect, the description will address its slenderness, weight, and level of interdependence with the structure.

4.1 CONSTRUCTION EFFICIENCY

Given that the current demands of the construction sector are mainly focused towards high-rise buildings, it is common to see construction techniques that save time and reduce costs on ceramic façade systems. Alfonso Del Águila (2006) defines some levels of construction efficiency that can be achieved through different techniques for saving time and reducing costs. In first place, there is the stage of rationalisation that refers to the set of strategies which seeks to improve production methods. At this level, basic tools are used, such as modular and dimensional coordination of materials in order to reduce improvisation. In second place, rationalisation may be taken into a higher level called mechanisation when people are freed from manual tasks through specialised tools that allow more production while investing less time and effort. At this level, we are no longer talking only about the manufacture of the façade components, but also about mechanising their operation and assembly. Finally, efficiency can be further improved by automation with advanced technologies, when using computerised systems or elements to control machinery and industrial processes that replace human operators. The scope is greater at this level than in mechanisation, given that even intellectual human activities are replaced by technology.

Taking this into account, for this particular case, construction efficiency will be measured, taking into account the following parameters: we refer to a level of rationalisation for traditional façades made of brick, which are built using a technique for which no specialised tools are needed. Bricks are manufactured with defined measurements in order to fit within a certain modulation of the building, however, this type of façade requires a construction methodology that implies a wet assembly whereby an operator must build piece by piece, and therefore, it is not a process that stands out for its efficiency. In order to step further into a level of mechanisation, we make reference to façade systems that consist of prefabricated panels manufactured on-site or off-site, at the same time as other construction processes are being carried out. These systems incorporate specialised tools to assist workers, involve a dry assembly, and also enable the overlap of the façade's construction with other on-site construction processes. Although the ideal scenario is to reach a higher level of construction efficiency through automation, there is not yet an example of a ceramic façade in Bogotá that serves as a reference for this methodology.

4.2 SLENDERNESS AND WEIGHT

The façade's slenderness and weight are linked concepts, which, depending on their value, influence the structural behaviour. A lightweight façade implies advantages for the building's earthquake resistance, by decreasing the overall weight of the construction system. However, ceramic façades in Bogotá made of bricks do not fit within this trend, because the traditional offer has been above 100 kg/m². This aspect can be attributed to the fact that the 6 x 12 x 24 cm brick has remained the most common component of ceramic façades in Bogotá, without presenting any evolution that marks a difference in the façade's morphology. Given that a variation in any of these two aspects can mean a disruption of tradition, the self-weight of the façade and its slenderness will be taken into account for the description and comparison phase.

$$s = a/t$$

s = Slenderness

a = Façade's vertical distance between supports

t = Façade thickness

4.3 INTERACTION BETWEEN THE FAÇADE AND THE STRUCTURE

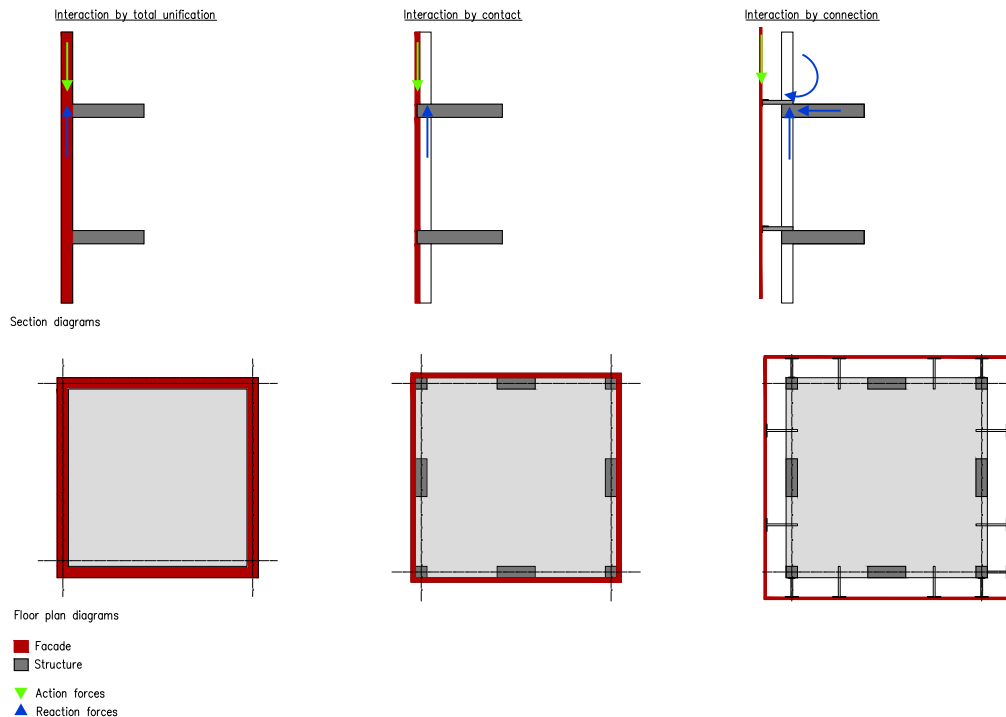


FIG. 6 Levels of interdependence between façade and structure.

The façade interaction with the building's structure is a fundamental factor in dictating the behaviour of the entire system in event of a seism. Based on the connection levels between the structure and the exterior envelope described by Richard Rush (1986), three levels of interdependence were considered in this methodology to describe the façade interaction with the structure (Fig. 6). Firstly, there is interaction by total unification, where a single element works as an enclosure and structural system. Secondly, there is interaction by contact, where the façade rests directly on the building's slabs, transmitting the vertical compression loads to the main structure. In this configuration, the performance against horizontal loads depends on the capacity of the anchors and the bending behaviour of the façade wall. And thirdly, there is interaction by connection, where the façade passes in front of the structure and transmits the loads through specific fixings. In this case, the performance against horizontal loads is defined by the flexural capacity, either through a metallic substructure of posts that supports the enclosure, or through the resistance of the panel itself.

5 THE TURNING POINTS: A DETAILED LOOK AT CERAMIC FAÇADES IN BOGOTÁ

As explained before, Bogotá's tradition has been repetitive and static in terms of a constructive evolution. However, at some stages in its history, there have been turning points demanded by contextual needs, which (when carefully reviewed) can yield interesting guidelines for this research and new lines of innovation. In this paper, we have selected four relevant examples of innovative contributions regarding façade construction systems, which are described and compared below, along with a representative case of the tradition.

5.1 DESCRIPTION

Baseline: Colinsa Building by Fernando Martinez

The Colinsa Building by Fernando Martinez happens to be a suitable representation of Bogotá's tradition in ceramic façades and is used as a baseline for this methodology. This building, constructed in 1969, reveals an alternative that has still been applied until recently. The building is constructed wholly in-situ, where construction workers manually place the bricks with a running bond. This means that constructive efficiency only reaches the level of rationalisation. The outer face of the façade is composed of solid pressed brick (5.5 x 12 x 24.5 cm) with mortar joints and the inner face is made of another type of brick called "Bloque #4" (10 x 20 x 30 cm). In some sections, part of the façade rests on a bracket and other times, it continues straightforward without interruption (Fig. 7). There is no doubt that since 1960, Fernando Martínez's work represents a breakthrough in ceramic used for façades in Bogotá. However, Martínez's constructive solution for exposed brick façades has been reproduced repetitively throughout Bogotá's subsequent history, from the 1980s onwards without any consideration given to the emerging needs at the time.



FIG. 7 Colinsa Building west and south façade, 1969, Bogotá, Colombia. (Photograph by Faculty of Architecture & Design, Universidad de los Andes).

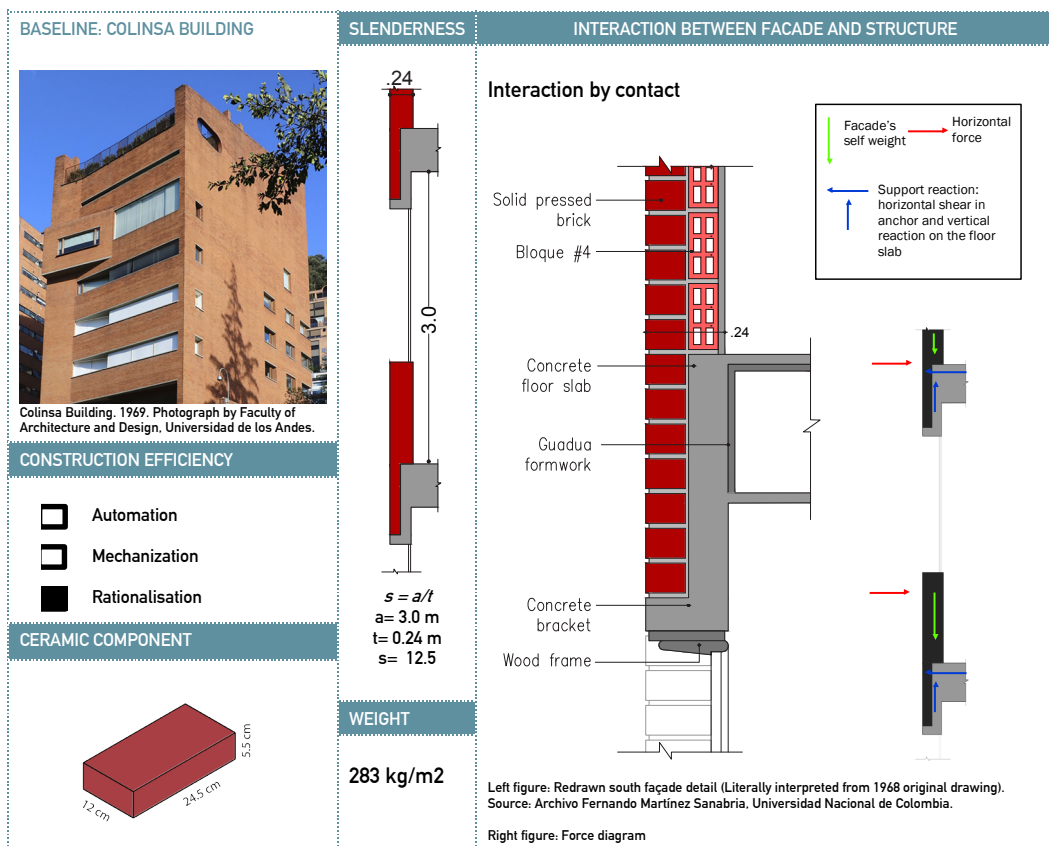


FIG. 8 Baseline description chart

Torres Del Parque

The 1950s was a period of increased production in architecture, implying that the housing unit scale increased to the neighbourhood scale (López & Gossens, 2018). Taller buildings began to be conceived in the city, with the Torres del Parque being one of the first examples of this trend. This residential project was designed by the architects Rogelio Salmona and Urbano Ripoll, and the engineer Doménico Parma. Its construction began in 1968 and ended in 1970.

Architects opted for a design that would keep in harmony with the context, using the exposed pressed brick as a façade material (Urrea, 2014). As Urban Ripoll points out, "A detailed study was devoted to the likelihood of the brick wrapping all structures. (...) Large horizontal windows were used to divide the 'brick belts' between one floor and the next; it was possible to make the brick enclosure work in conjunction with the structure in the event of an earthquake, preventing the non-structural elements from being subjected to stresses for which they are not designed." (Urrea, 2019). The façade's construction method is not different from the baseline since it was carried out in a traditional and rustic way, placing brick by brick manually, and using a wet assembly of pieces with mortar. Compared to the constructive detail of Fernando Martínez, the façade is made up of a single layer of ceramic, and thickness is reduced to 12 cm. The new lightweight façade was supported by a concrete bracket or corbel. In the corners, some walls functioned as buttresses to avoid the façade overturning (Fig. 9). In this way, the Torres del Parque project marks a turning point within Bogotá's tradition, as it addresses the challenges and demands of high-rise construction in an earthquake-prone region.



FIG. 9 Photograph of Torres del Parque light façade wall that works as a buttress, 1970. (Photograph by Faculty of Architecture & Design, Universidad de los Andes).

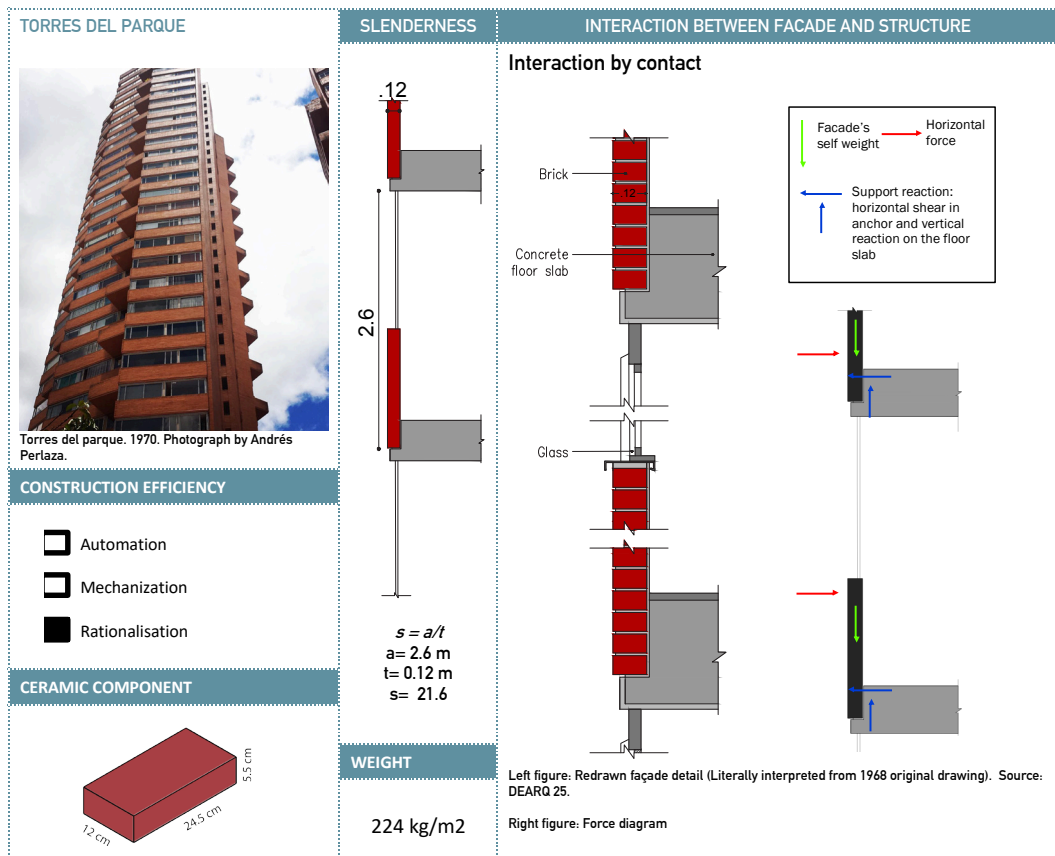


FIG. 10 Torres del Parque description chart.

North Tower - Hilton International Hotel

The North Tower of the Hilton International Hotel in Bogotá arose with the purpose of complementing the first tower of this hotel (South Tower), following an increase in tourism during the 1970s. The North Tower was born from an architectural contest in which Medardo Serna Vallejo and his collaborators, architects Jorge Moreno García, Jaime Moreno García, Holabird, & Root, and the engineer Doménico Parma were chosen as the winners on January 28th, 1980 (PROA, 1980). According to the project's documentation, in order to maintain a harmonious language with the surroundings, it was decided to use the same façade material as the hotel's South Tower (ESCALA, 1982).

For the North Tower, Doménico Parma presents a suspended façade solution composed of concrete prefabricated modules clad in ceramic tiles by *Ladrillos Moore*. This new façade proposal was intended to solve the problem of the detachment of ceramic tiles, which was a problem in the South Tower. In an interview with Jean-Guy Moggio (director of *Ladrillos Moore*), he reports that according to a study by Obregón and Valenzuela, the complications of the South Tower's façade (Fig. 11) were due to the insufficient expansion joints which failed to resist the substantial temperature changes (personal communication with Jean-Guy Moggio, November 27, 2018).

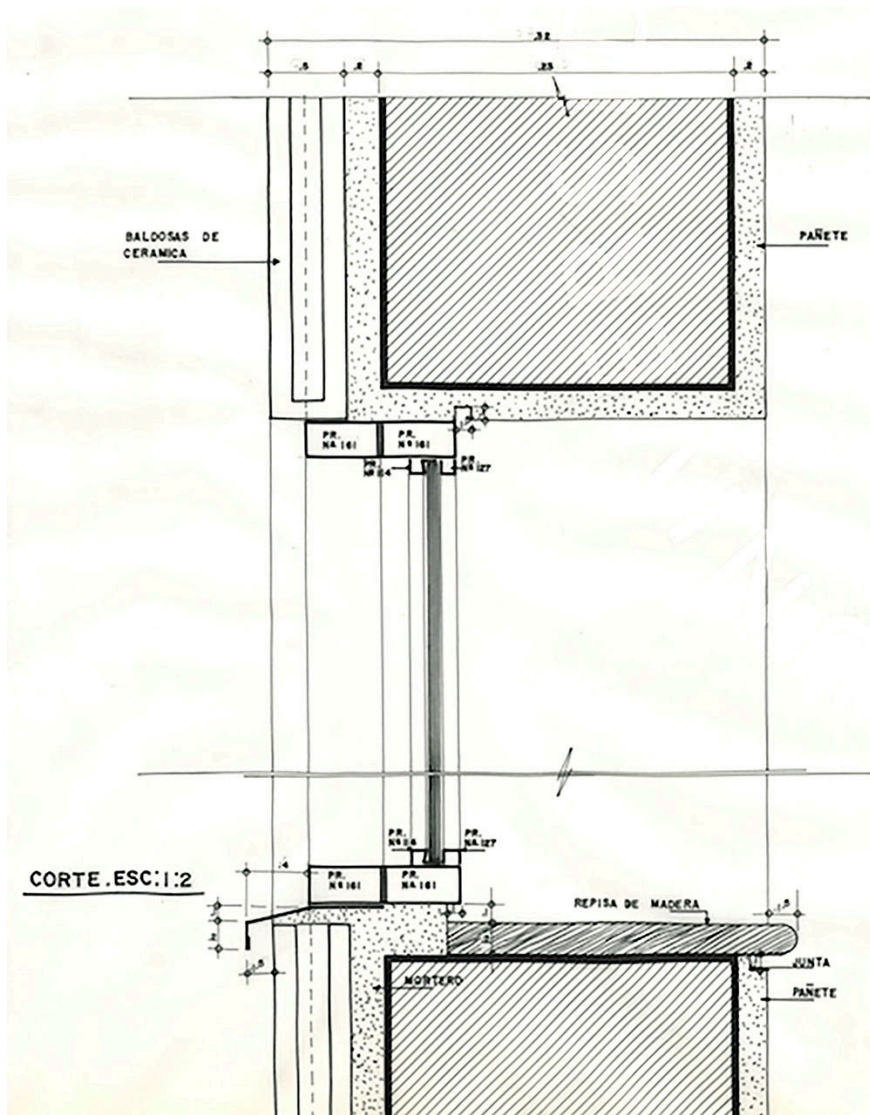


FIG. 11 Constructive detail of the South Tower's facade, 1963. (Source: Archivo Fernando Martínez Sanabria, Universidad Nacional.)

The relationship of the North Tower's façade to the floor slab turned out to be a novelty at the time since there were no precedents of suspended ceramic façades in Bogotá. As part of the anchoring system of the façade to the structure a metal profile is incorporated (Fig. 12), which also has the function of preventing the panel from bending. According to the construction records written by Parma (*Archivo Doménico Parma - Universidad de los Andes, 1986*), this element was considered essential to withstand the eccentricities of the façade, and at the same time, it could be used to place the central scaffolding elements. For this reason, t value in the slenderness calculation is taken as 18 cm thickness, because it has a 10 cm metallic profile for the panel's support. If this additional support did not exist, this facade's slenderness would be 34.7. This project represented an important innovation in Bogotá's construction at the time, taking on the challenges of incorporating ceramic façades to high-rise constructions. Doménico Parma introduced an industrialised ceramic façade solution, this being one of the main factors for considering this building as a turning point. Construction efficiency reached a level of mechanisation with a design of prefabricated ceramic and concrete panels that involved dry and practical installation through crane towers.

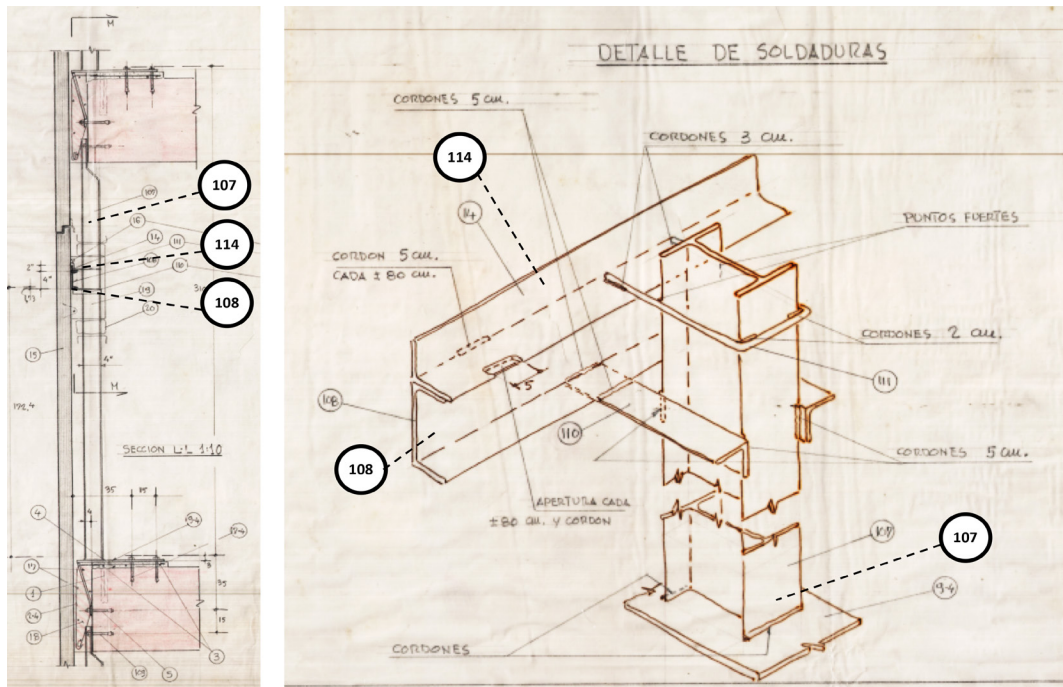


FIG. 12 Constructive detail of the North Tower's façade and welding detail of the supporting metal profile, 1986. (Source: Archivo Doménico Parma, Universidad de los Andes).

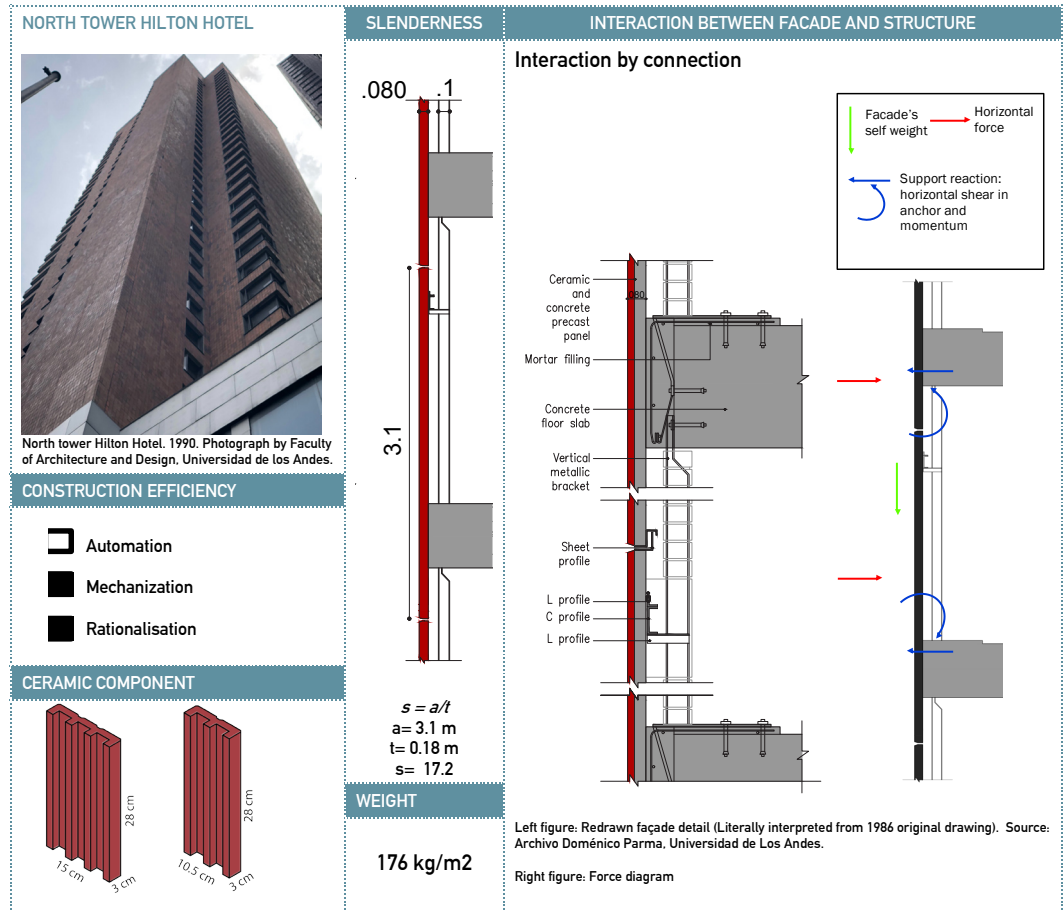


FIG. 13 North Tower Hilton Hotel description chart.

The first step in regulating earthquake-resistant constructions in Colombia took place in 1984 with the introduction of the Colombian Earthquake-resistant Building Code (Camacol, 2012). Prior to this point, architects had no responsibility for the behaviour of non-structural elements. In 1998, this code was reformed (NSR-98), and one of the main modifications established, Section A.9, refers to the regulation of structural calculation and liability of non-structural elements, where façades are included. Subsequently, a second update was made in 2010 (NSR-10) forming the document that is currently used. The NSR-98 set up a framework for brick façades among the requirements for earthquake resistance that had not previously been taken into account, and therefore, buildings with brick façades that addressed this regulation marked a turning point within the tradition.

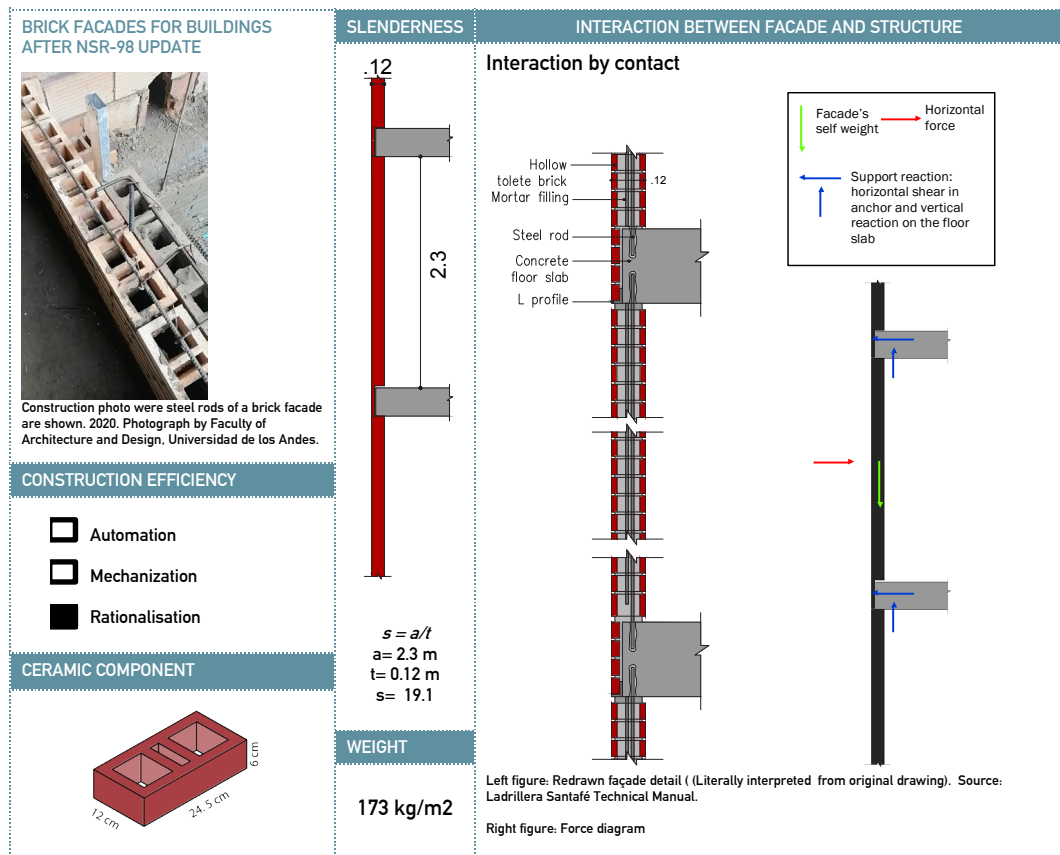


FIG. 14 Brick façades for buildings after the NSR-98 update description chart.

The outstanding factor that these cases represent is the incorporation of a perforated brick block through which steel reinforcements are introduced and, subsequently, these cavities are filled with mortar. The variation in the construction of this type of façade in contrast to the baseline or Torres del Parque examples, is the procedure that must be carried out to integrate the reinforcements of the façade. Brick-setting with a running bond, mortar application, along with the placement of steel bars, are undertaken by bricklayers in an artisanal and manual way. The façade's thickness remains around 12 cm, where bricks are supported on the floor slab and the edge of the slab is covered with ceramic cladding of smaller thickness. Reinforced brick façades established a "standard" alternative that most of the residential buildings adopted, and which is currently incorporated in catalogues of ceramic façades, as is the case in the Ladrillera Santafé technical manual.

The Extension of The Santa Fe Foundation Building

Santa Fe Foundation is a private hospital in Bogotá, which extended its headquarters with a building for its university hospital. This extension began in 2012 with an architectural contest, of which a central requirement was to maintain the brick identity of the existing building. The contest was won by the Equipo Mazzanti, with a proposal using a brick façade that was unprecedented in Bogotá. The façade design was informed by Rolformados, the company that provided details of the system and managed its construction. On November of 2016, the twelve storey building for Santa Fe Foundation extension was launched, having as its façade a thin layer of ceramic pieces with different patterns, along with a special synergy between the interior and exterior of the building in terms of natural lighting and visuals.

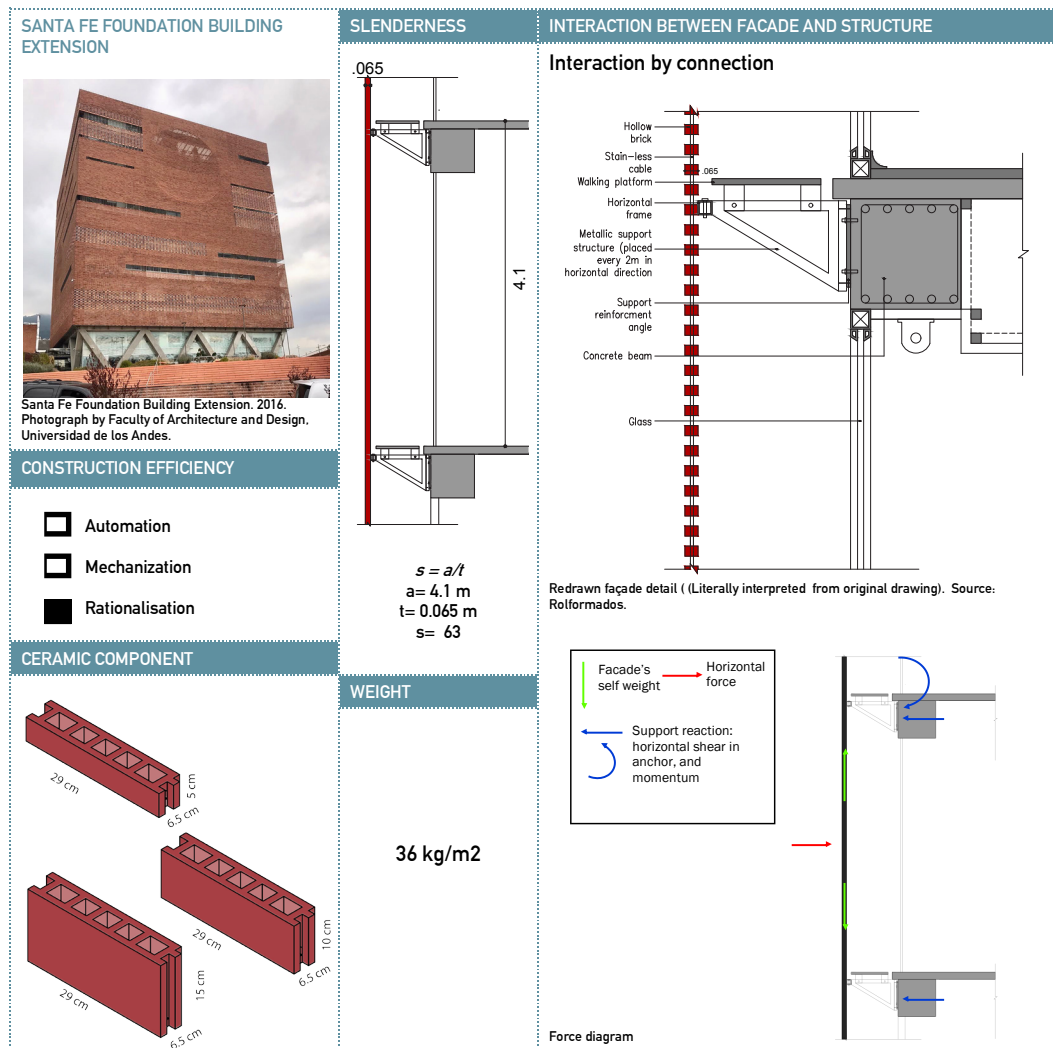


FIG. 15 Santa Fe Foundation Building extension description chart.

The façade system consists of 5 mm-diameter vertical stainless steel cables to which bricks are fastened by aluminium clips. These clips are supported on metallic bushings threaded in the cables, and their function is to keep the blocks in place horizontally, without supporting or transmitting any vertical loads. The cable structure has horizontal steel frames attached to metallic brackets that are anchored to the border concrete beams of the building, and horizontally spaced every 2.10 m. Certainly, this turning point presents significant modifications when compared with the baseline, considering that it uses a new language for brick when establishing a much more slender and lightweight façade. Furthermore, this façade suspended from the building structure achieves resistance to critical wind and seismic loading. It is not possible to speak of greater evolution regarding construction efficiency. Although this system involves a dry assembly of ceramic pieces, it was constructed on site and bricks were placed manually. Due to the fact that in contrast to the baseline the construction method used in this case does not present an increase in productivity, the degree of efficiency is also taken into account as a level of rationalisation.

5.2 COMPARISON BETWEEN THE BASELINE AND TURNING POINTS

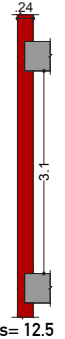
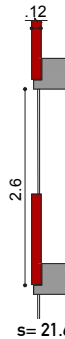
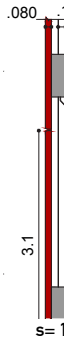

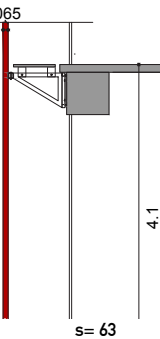
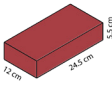
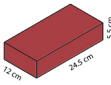
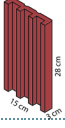
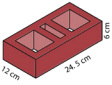
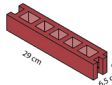
	Baseline: Colinsa Building	Torres del Parque	North Tower Hilton Hotel	Brick facades for buildings after NSR-98 update	Extension of the Santa Fe Foundation
Construction efficiency	Rationalisation	Rationalisation	Mechanization	Rationalisation	Rationalisation
Slenderness	 s = 12.5	 s = 21.6	 s = 17.2	 s = 19.1	 s = 63
Ceramic component					
Weight	283 kg/m ²	224 kg/m ²	176 kg/m ²	173 kg/m ²	36 kg/m ²
Interaction between the facade and the structure	By contact	By contact	By connection	By contact	By connection

FIG. 16 Comparison of the four turning points, together with the baseline case, according to their technological and morphological development.

The four cases mentioned above represent turning points within Bogotá's tradition because they suggest different innovations in the local context of ceramic façades. Torres del Parque project is one of the first precedents to use brick on high-rise building façades and provides a proposal for a more slender brick façade. The North Tower for the Hilton Hotel presents a particular alternative to industrialise the use of ceramics in façades. Although the constructive detail by *Ladrillera Santafé* has not evolved in its thickness or connection with the floor slab edge, it incorporates a fundamental criterion as it fulfils the earthquake-resistant requirement for the façade as a non-structural element. Finally, the extension of the Santa Fe Foundation building maintains a more significant slenderness and restores Bogotá's view of ceramic as a solid material by using it as a versatile and lightweight component in façades. Fig. 16 brings together the technological and morphological aspects of the turning points along with the baseline, in order to make easier the comparison between them and resemble the innovation paths these cases propose.

Taking the baseline as a point of comparison, the construction process of ceramic façade systems in Bogotá does not involve a developed level of efficiency since the standard and most used procedure is carried out manually on site, without using specialised machinery to increase productivity. In terms of performance, Santa Fe Foundation has two advantages: 1) It does not need glue, so even when it is installed brick by brick there is no glue placement or setting time; 2) As it is lattice, it uses half of the pieces. However, it is curious that the only turning point that presents a remarkable construction performance is the North Tower Hilton International Hotel built 35 years ago, with a proposal of "industrialised ceramic" by means of a mechanisation process for a suspended façade composed of prefabricated concrete panels with ceramic tiles. This case clearly exposes the need to incorporate a practical construction alternative for using ceramics in high-rise buildings. None of the turning points reached a level of automation, and just one works at a mechanisation level. The reason why the North Tower Hilton Hotel solution was not further developed in Bogotá is unknown. However, nowadays it could still be considered as an attractive proposal for the use of ceramics, due to the level of productivity that can be added to the construction stages.

Regarding the morphological matter, on the one hand, there has been a tendency among the turning points to increase the slenderness and reduce the façade's self-weight. In the exposed cases, the traditional solutions of façades supported on the structural slabs (Colinsa, Torres del Parque, and brick façades for buildings after NSR-98) produce heavier alternatives. This may be due to the fact that a greater thickness is generated to develop resistance to bending, and also because of the requirement to incorporate reinforcements within the masonry. Interdependence by means of a connection between the façade and the structure allows the appearance of prefabricated panels with a supporting metal substructure (such as the Hilton tower), or the tensioned façade of the Santa Fe Foundation. In both cases, horizontal forces are transmitted through the fixings, thanks to the flexural work of the support posts in the Hilton tower, or to the reaction of the cables that support the ceramic elements in the Santa Fe building. As a result, this allows for elements of lesser thickness and lower self-weight.

6 CONCLUSIONS

A detailed study of the turning points led to the identification of two trends: improvement of the construction techniques and lightweight thin façades that are resistant to bending. Both trends can be enhanced nowadays and become an innovation path for ceramic façades in Bogotá. On the one hand, the lack of productivity in manufacturing and assembly processes sets an opportunity to develop techniques that potentially improve construction efficiency in all of its stages. An advance of this technological matter is a key factor to maintain ceramics as a material which marks the identity of the city's façades and besides, exposes a competitive role in the construction field. On the other hand, the cases presented in this paper demonstrate a tendency towards more slender envelopes. However, the commitment to slender panels involved solutions with metal substructures in order to avoid the façade's bending. Therefore, an approach to a lightweight ceramic system with enough bending strength to withstand horizontal forces from wind and earthquakes is also an innovation path given that it may present a structural benefit by reducing the overall weight of the building. Besides, this will surely encourage an exploration of new morphological designs of the ceramic piece, as well as composite sections of the façade.

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