

Stone Claddings in the Corporate Real Estate Enterprises Citicorp Center and Rochaverá Corporate Towers in Sao Paolo, Brazil

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Abstract: This article deepens the theme treated in other¹ that approaches the evolution of the productive chain and of the technology of application of stone cladding in Sao Paulo, Brazil. For the study of this productive chain it is noticed that there takes place growing improvement of the quality of these claddings. Now two important buildings are analyzed: Citicorp Center (1986) and Rochaverá Corporate Towers (2012). This work is in the context of extensive research for realization of the thesis of doctorate of the author in the Faculty of Architecture and Urbanism of the Mackenzie Presbyterian University, Sao Paulo, Brazil,² where is valued the quality of contemporary projects, executed in the last 30 years, which adopted claddings with stone plates in his facades and relevant aspects of the productive chain of the industry of the rocks.

Key words: Stone cladding, corporate building, architecture, rocks, facades, civil engineering.

1. Introduction

The process of technological advancement of the engineering and architecture in Brazil, when compared to the carried out ones in the developed countries presents similarities that are shown up in the studied corporative constructions. The way of use of the stone plates of cladding is developed with the advancement of the society, which demands the most appropriate use of available technical resources and the gradual incorporation of the most recent technologies in Brazil, as the pre-fabrication of plates of concrete with attached stone cladding.

The professional exercise of the engineer and of the architect was altered in the last three decades with the reduction of the role of the State and appearance of new bourgeoisie associated to the international capital. The responsibility for the advancement and innovation is transferred to the mechanisms of market and competition, in a preponderant attitude of the real estate market, with elitist projects and of growing international quality [1]. The up-to-date contemporary architecture has a repertoire of forms, materials and techniques at his disposal. The followed way of the modernist cube to volumes and complex geometries was great transformer. Today the use of digital technologies, as in the project as in the production, generates still more innovatory constructions. In them it is possible the financial system to look for accented profits in the income, with the exemplary and exclusive buildings, which express the limit of the technique and of the materials. This superior real estate typology constitutes a small piece of the market, a vanguard that escapes from the seriation and the massification of the modernism and that turn round to the differentiation

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² FLAIN, Eleana Patta and RIGHI, Roberto (Adviser). Desenvolvimento da cadeia produtiva como fator de qualidade dos revestimentos pétreos em fachadas de edifícios corporativos contemporâneos. 2017. 313 f. Thesis (doctorate), Mackenzie Presbyterian University, Sao Paulo, 2017.

and exclusiveness, producing bigger differential income and symbolic capital of the business identities through new strategies of marketing, branding and design. The global crisis of 2008 constituted a brake for this architecture added by the growing production of the virtual space, on behalf of another more sustainable or green architecture [2]. Despite everything, it is possible to affirm that the exterior surface (covering) has an exceptional importance in the esthetics of the “packing”, in case of the chosen real estate product, the corporative building. For so much, the stone claddings mark a more luxurious architecture, like being “monuments” of the present. In this critical perspective are analyzed two relevant projects of application of stone plates of cladding of facades: the first one is a pioneer in Sao Paulo, Citicorp Center projected by Aflalo and Gasperini Arquitetos, in 1983. The building was concluded in 1986. The second case is the most recent of the cutting out of the original research, Rochaverá Corporate Towers, also projected by the same office, in 1999. The building was concluded in 2012. The long interval of time of 26 years between the projects of the same author allows to show the transformations that took place in the productive chain of the rock and in the technology of construction, which are analyzed in the sequence.

So, the forms and adopted architectural solutions materialize two quite complex programs, chosen from a more spacious research related to technological innovations in the engineering and architecture. These enterprises are unique, representing a globalized condition of the production, with distinction in the urbane scenery and image identity, besides important hole in the real estate segment of the city.

The stone claddings adopted in these constructions are in growth in Brazil, with use of great diversity of rocks in varied uses, with good esthetics, as result of the effort of technological updating and in the adoption of up-to-date criteria of projects [3]. This bigger use is due to quantitative and qualitative factors that involve the whole productive chain of the stone plates, which

results from the technological development and from growth of the industry of the rocks used for cladding [4].

2. Method and Materials

For the proposed research were chosen two important contemporaries buildings, covered with plates of rocks, existent in the city of Sao Paulo. Such buildings were built in two different moments in three last decades, marking the evolution in the productive process of the sector. There were carried out visits to the studied buildings for the acquiring of data. Besides, there were consulted archives of the office and sources of reference on the processes used and carried out analysis of the data obtained in the buildings.

3. State of the Art

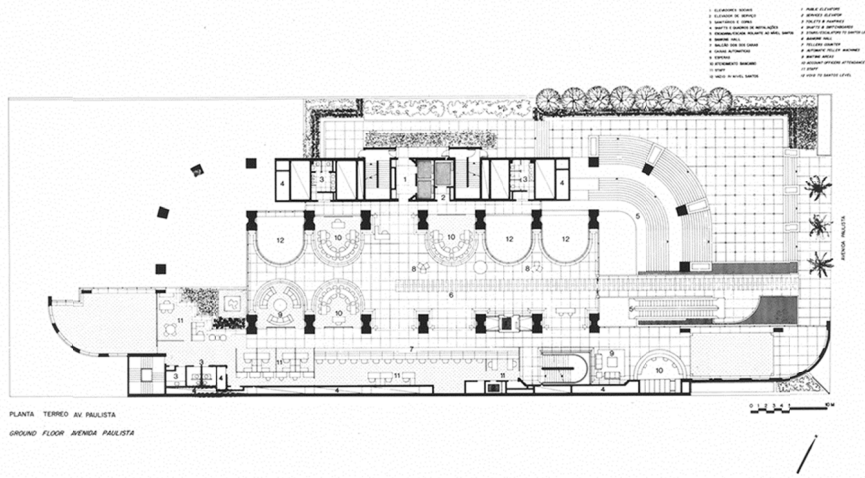
3.1 Corporative Constructions: The Process of Architectural Project and of Conception of the Cladding with Stone Plates

3.1.1 Citicorp Center

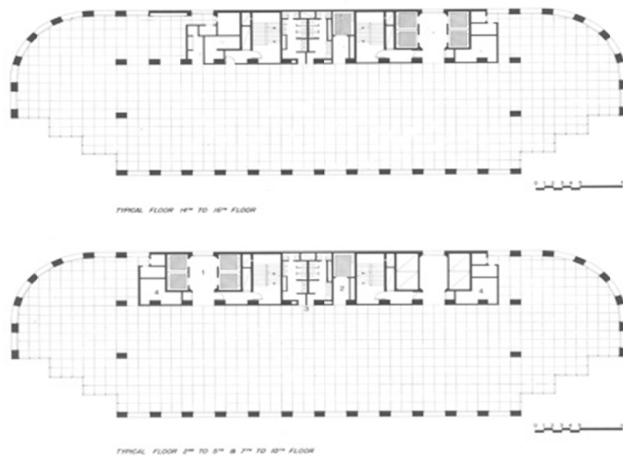
Citicorp Center was projected in 1983 by Croce, Aflalo and Gasperini Arquitetos, one of the most important offices of architecture of Brazil and inaugurated in 1986. It is located in the Paulista Avenue, which is a large-scale road axle, and comprises part of the financial life of the city. The building is a landmark in the avenue and in the city up to today. He has 18 floors for offices, besides basement and a bank agency in the ground level. His conception breaks with the compromise between the form of the building and the format of the lot, potentializing his presence in the scenery. His architectural composition is based on structural grids, without loss of the formal freedom, with curved solutions on plants and elevation (Fig. 1). Still, it shows great stilts that define the internal volumes, with presence in the mass of the building in the ground level.

As Ref. [5], for the innovations in technologies and in the adopted finishing materials it is one of the more significant office buildings of Sao Paulo. The offices of

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Ground level



Typical floor

Fig. 1 Plans of the ground level and of the typical floor (useful area of 1,100 m²) [6].

architecture of the time were finding resistance of his clients to project and to build buildings not traditional. Citicorp Center was a landmark in the formulation of a new paradigm. As Gasperini, quoted in Horschtz ([5], p. 83), “So soon we manage to break with this resistance of the client, the Citibank appeared. And then the concrete was removed at once”.

3.1.2 Relevant Architectural Aspects of the Facades

In Citicorp Center (Fig. 2) the facade is complex, accented by the proximity of the nearby buildings. This produces a strong presence in the scenery and the

affirmation of the corporative image. Citicorp Center was an innovative building, with approximately 47,000 m² built, having accented functional and plastic coherence of the building, besides intense urbane integration. His technological innovations and of materials in the engineering and architecture are detached, representing the insertion in the globalized quality and in the demand orientated for far-reaching projects. Also, it represents the changes in the languages of the time, marked by the transition of the modern rationalism for post-modernism. In this new



Fig. 2 The Citicorp Center building is situated at the Paulista Avenue, 1111, financial center of Sao Paulo. Source: Archive and photo of the author, 2017.

line, he presents classic components as: colonnades, repetitive rhythms of the structural modulation, tripartition, distinction in the urbane scenery, new relations of the public and private space, identity with differentiation of accesses and facades, colors and materials and esthetic distinction [7].

In the more detailed form, the construction of the Citicorp was innovatory in several aspects. In distinction, for the structure in the form of already above-mentioned peripheral grid, for the finishing

materials of the facades (pink granite and blue glass) that gives contrast in the facades, the integrated systems of installations and of automatic actuations and the use of apparent white concrete. It deserves attention: the way of fixation of the glasses (silicon glazing)³ and of the stone plates⁴ that were innovative,

³ A process of collage of glasses in square frames (internal structure) utilizing silicone that forms great glass panels.

⁴ Fixation with the use of kerf clips leaving a space between the stone plates and the face of the building.

for a far-reaching construction, in the city of Sao Paulo and in Brazil. The fixation system of the stone plates was the kerf anchor type.

3.1.3 The Choice of the Pink Granite

The choice of the stone cladding happened in function to avoid frequent maintenance along the useful life of the construction. The client demanded, also, the use of the most modern technique of placing stone, with utilization of kerf clips, because with the use of the conventional mortar, in the time commonly used for this aim, there would be alteration of the characteristics of the rock, besides the risks inherent in this alternative. In the choice of the appropriate rock the colors were discussed: ash, beige color, brown or the red. So, the choice of the rock was concerned with his color and his petrographic characteristics and physical-mechanical properties. The final choice went to the rock called Rosa Biritiba whose petrographic and physical-mechanical characteristics are presented in Table 1. In the decision was taken in consideration the contrast between the “pink granite” and the blue of the glasses as shown in Fig. 3, one image of the time of conclusion of the building. This rock is originating from a quarry in Biritiba, in Mogi Mirim, in state of Sao Paulo, distant 82 kilometers of the building. Unfortunately, this quarry was already extinguished.

3.1.4 The Fixation System of the Plates

The way of application of the stone plates in the

Citicorp Center facades was an innovation for the time, since it was leaving a space of approximately 7 cm between the stone plates and the structure of support, besides the fixation to be carried out through kerf clips of stainless steel. The technology had been already applied in Brazil, in the Bank Sudameris building, in Rio de Janeiro [8].

The system adopted for the fixation of the stone plates in the facades of the construction was known as “the American System”, where the socket of the metallic component fits in a groove in the stone plate. In case of Citicorp Center building it was known, also, as “the System Granifix” in regard to the responsible company (Moredo) by the project and manufacture of the components ones.

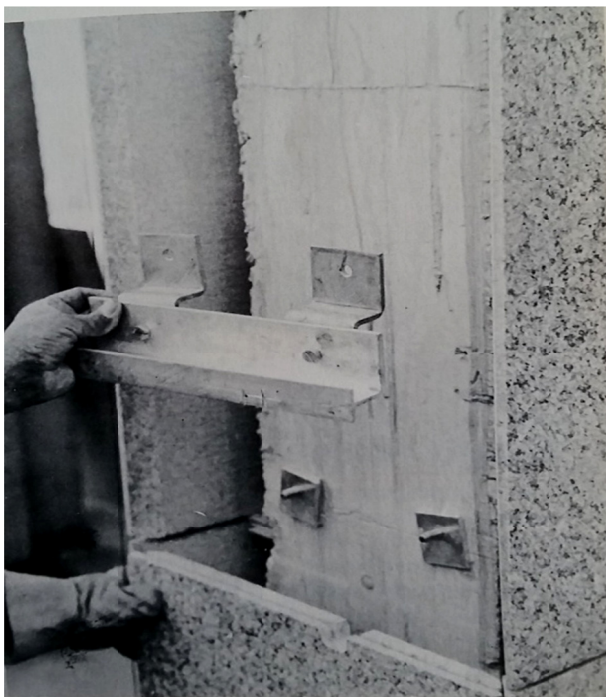
The plates were previously cuts with much precision in the marble and granite store, then were numbered according to the project. The execution of the cladding was carried out from the inferior floors to the superiors, following the numeration of the project. Fig. 4 presents details and elements of fixation. Then grooves were carried out in the thickness of the plates for the introduction of the metallic component. In case of pillar claddings, as it shows the same figure, a component of bigger dimension was used and with that certainly there was bigger consumption of materials compared to other systems of fixation, as for example, the used in Rochaverá Corporate Towers presented in section 3.2.

Table 1 Petrographic and physical-mechanic characteristics of the rock Rosa Biritiba. Source: Janasi and Ulbrich, 1995, apud [9]; p. 79 adapted by the author.

City of occurrence	Trade name	Petrografic classification	Geology/petrography		
Biritiba-Mirim—SP	Rosa Biritiba	Biotite granite 3b	Porfiriticgranitoid, rosy, with abundant feldspatics megacrystals. It seems to correspond to a type of augen gneiss (gneiss of rude granularity).		
Mineralogical composition Quartz (30-35%); pertiticmicroclinic (30-35%), plagioclase (oligoclase) (20%); biotite (5%); zircon; titanite; apatite; epídote; muscovite-sericite; clorite, iron hydroxide(5%).					
Recommended use claddings and internal and external floors					
Dry apparent specific gravity 2,624 kg/m ³	Apparent porosity 0.80 %	Apparent water absorption 0.31 %	Amsler wear value(1,000 mm) 0.81 mm	Impact strength test 35 cm	Uniaxial compressive strength 140.0 MPa
Bending test (Modulus of rupture) 12.8 MPa	Module of elasticity or Young's Module 38,644 MPa			Thermal linear expansion coefficient 0.0096 ± 0.0005 mm/m °C	



Fig. 3 Overview of the building Citicorp Center facades. Source: CBPO, 1986 apud Rodrigues (2004) [10].



(a) Positioning of the metallic component (called in the time as kerf bar)



(b) Manual adjustment of the metallic component

Fig. 4 Details of the placing of the metallic component for the fixation of the stone plates in Citicorp Center[11].

3.2 Rochaverá Corporate Towers

3.2.1 Differentials of the Interprise

The Multifunctional Complex Rochaverá Corporate Towers is also a project signed by Aflalo and Gasperini. It is constituted by four differentiated office towers, with approximately 248,000 m² built. The construction was finished in 2012. The first phase comprised two similar towers with mirrored plant, of 17 floors each, with 58,000 m² built. He is located near the marginal avenue of the Pinheiros river, important road axle that gives access to the south-west region of the city, with easy metropolitan connection (Fig. 5). It also has integration with the station Morumbi of the Metropolitan train, interconnected with the line four of the Subway. It is inserted in the district Itaim Bibi, having connection to great commercial centers. The complex is an enterprise of category triple A, in other words, it integrates the most categorized segment of the corporative offices.

The Multifunctional Complex Rochaverá Corporate Towers enterprise presents a differentiated conception, since its implementation is constituted by a composition of buildings situated around a square of semi-public character, opened to the pedestrians. By consider requisites of sustainability it received one of the first certifications LEED (Leadership in Energy and Environmental Design) of Brazil. Also, the complex received in 2008 distinctions like the Prize AsBEA⁵ in the category buildings of services and the Prix d'Excellence as sustainable project granted by the FIABCI (Federação Internacional das Profissões Imobiliárias).

3.2.2 Relevant Architectural Aspects

The Multifunctional Complex Rochaverá Corporate Towers presents bold architecture, with a volumetry of impact that makes it an example of innovative office buildings in Brazil. The project program consists of four buildings, A and B (with 17 floors each one), C (with 31 floors) and D (with eight floors), that were

implemented around a central square for access to each building, be for pedestrians or cars. Three other garden areas are formed as a result of the location of the buildings, shown in Fig. 6.

3.2.3 Facades with Prefabricated Reinforced Concrete Panels with Stone Cladding

The facades of the buildings of the Multifunctional Complex Rochaverá Corporate Towers combine prefabricated elements of reinforced concrete covered by plates of polished granite (using a system of inclined dowel anchor in stone), interspersed by aluminum structure and closure in glass (curtain wall). Fig. 7 shows the execution of the facades with prefabricated panels, where the structure is being executed and the panels mounted. Fig. 8 shows the perfect current state of the facades.

In the facades of the Multifunctional Complex Rochaverá Corporate Towers were used plates from polished granite known commercially as Bege Ipanema. The geological characteristics of this rock are presented in Table 2 [12].

4. Results

Regarding the study and analysis of the facades of two enterprises here treated, Citicorp Center, in spite of having been finished in 1986, presents the current general aspect of his facades practically unchanged, which proves the quality of the final cladding in respect to the choice of the rock for extern area associated to the process of fixation and to the rigorous quality control of execution, between other factors.

In case of Rochaverá Corporate Towers, the facades were recovered with prefabricated reinforced concrete panels with stone cladding, in which, at present, no pathology is observed. Such a fact is owed to the adequacy of the utilized rocky material associated to the constructive process with panels of reinforced concrete with attached stone plates, besides the rigorous quality control of all the involved processes. Besides, it is a more recent work in which projects have great technical rigor.

⁵ Brazilian Association of the Offices of Architecture.



Fig. 5 The Rochaverá Corporate Towers situated in Dr. Chucri Zaidan Avenue, Morumbi, Sao Paulo [13].



Fig. 6 Overview of the central square between the constructions and the access for cars [14].

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Fig. 7 Overview of the execution of the facades. Source: Archive and photo of STAMP supplied to the author, 2016.



Fig. 8 The facades of Rochaverá Corporate Towers presents no stains. Source: Archive and photo of the author, 2017.

Table 2 Characteristics of the rock Bege Ipanema. Source: Sardou Filho (2013, p. 164) adapted by the author [12].

City of occurrence	Trade name	Petrographic classification	Geology/petrography		
Muniz Freire—ES	Bege Ipanema	Gneiss monzogranitic	Rock with orientated and banded gneissic structure with fine to medium-course grained and very light-gray color.		
Mineralogical composition Microcline (35%); plagioclase-oligoclase (30%); quartz (30%); biotite (5%).					
Recommended use Claddings and internal and external floors					
Dry apparent specific gravity 2,637 kg/m ³	Apparent porosity 0.55%	Apparent water absorption 0.21%	Amsler wear value (1,000 mm) 0.73 mm	Impact strength test 44 cm	Uniaxial compressive strength 106.1 MPa
Bending test (modulus of rupture) 10.37 MPa		Uniaxial compressive strength after freeze and thaw 105.9 MPa		Thermal linear expansion coefficient 0.0052 mm/m°C	

5. Conclusions

The analysis of the stone claddings of the existent constructions is an important contribution for the improvement of the process of production of these claddings, serving as a feedback for the stage of project. The process helps the choice of the most appropriate rocks, with minimization of pathologies, avoiding damages to the esthetics of the cladding and to the stability of the set. The buildings with stone plates contribute to improving the urbane scenery, with advantage for the real estate market, with good esthetic and technical result maintained along the time.

The minor occurrence of pathologies generally is due to the adaptation of the characteristics and properties of the stone claddings, together with the adoption of control of the whole chain of production, leading to the biggest quality, to the best performance and to the biggest durability of these claddings.

When it opts for stone claddings it is believed that these will have bigger durability, reflecting solidity and nobility to the construction. Therefore, they present bigger initial costs, with some advantages along the time like the reduced maintenance and the elevated esthetic quality. However, in some constructions in Brazil, there can still be pathologies incident in floors and facades, being translated in losses of the initial characteristics and compromising of the stability, contradicting the reasons of the option for these claddings. The pathologies in the stone claddings result from several factors: (a) production process, with lack of project or deficiencies; (b) unsuitable specification of the materials; (c) lack of knowledge or of mastering of technology of application; (d) use of not qualified labor and (e) deficiency or non-existence of control of the production [15].

The quality of the stone claddings can be altered by several anomalies. In the doctorate work its reduction is detected along the time and up to abolition in the far-reaching works, subjected to technical proceedings of high performance.

Independently of the type of fixation adopted for the stone claddings, the nature of these materials is important, in the compositional aspect and in the physical-mechanical characteristics [16]. There must always be compatibility between the characteristics and properties of the rocks with the fixation system.

By the physical-mechanic characteristics presented in Table 1 and Table 2 it is considered that the rocky material, Rosa Biritiba and Bege Ipanema, employed in the buildings in reference, correspond to the necessities and to the conditions of use, in accordance with the technical specifications of the project.

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