Double Skin Facade Buildings: Configurations and Technologies in Brazil

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Abstract. Among the possibilities of intelligent buildings facades, Double Skin has been used more frequently in the construction industry. The application of this type of facade in tropical climate countries such as Brazil is recent. This indicates the need for further research on the subject, mainly to establish guidelines for achieving better quality of buildings that incorporate such technological solution, as well as for the well-being of end-users. The objective of this paper is to characterize double skin facades and how they are being used in the Brazilian context. The methodology included literature review to identify the types of second skin being used in these facades in Brazil, and multiple case studies to identify and analyse their configurations. Results pointed out that the characteristics and configurations of the systems are like the classification of double skin facades used in countries with mild climates. However, its main function in the Brazilian context is to serve as an element for shadowing and protection of the building. Due to the lack of information related to this type of facade in the Brazilian architecture, this research expands the possibilities and stimulates other evaluations on the theme. It is believed that more in-depth knowledge of the characteristics of this system will contribute to guidelines for designing double skin facades in hot climates.

1. Introduction

Facades are buildings elements that separate the internal and external environments of a building, which can be an absorption attenuator, adjusting its gains and losses inside the building, SACHT [1]. One of its main functions is to create favorable living conditions for the building, protecting the interior environment against the undesirable action of acting agents such as heat, cold, sun, rain, wind, humidity, noise among others, BAROZZI [2]. In addition, the facade can be responsible for much of the energy savings in buildings by acting as a selective barrier to weather conditions, enabling interior comfort conditions without the use of mechanical climate systems.

Based on these principles, advances in facades have significantly increased, featuring a variety of configurations and materials to be used, including the pursuit of passive solutions, double glazing, sun protection and ventilation systems. Due to the increasingly complex level of improvement in facades, the term “Smart Facades” or “Intelligent Facades” has emerged. Ochoa and Capeluto [3] states that the intelligence of these facades may be related to the performance it provides to the building envelope.

Thus, architecture has been facing the growing change in the concept of facades, which are becoming increasingly intelligent due to the ease of adapting to any exterior environment. This facade system differs from the traditional system by using elements capable of controlling and allowing the building envelope to be adapted as a moderator of external conditions.
Among the possible configurations of intelligent facades, one that has been prominent in building designs, becoming an important architectural element that harnesses passive solar systems is the Double Skin Facade. It is a system that uses transparency as an aesthetic feature and is known for being used in colder climates like in Europe. This facade system has several advantages, such as reducing heating and cooling, good acoustic insulation and greater protection against air pollution, MAZZAROTTO [4].

Although most studies on double skin facades focus on the use of glass as the second layer, other materials than glass have recently been considered, in Brazil, such as: textile membrane PAECH [5] and ZHANG et al [6]; perforated metal sheet BLANCO et al [7]; reticulated screen of stainless steel cables, AECWEB [8]; steel rebar ARCHDAILY [9]; polymer concrete panels ULMA [10]; and wood, STAZI et al [11].

This paper aims to present how these facades are being built in Brazil, identifying their configurations and other materials that are being applied as a second skin, besides glass. Considering climate change and having identified different materials being used in double skin facades, the role of materials and embodied energy becomes very relevant, however, the scope of this paper do not include this discussion. It focuses on the big Brazilian scenario of double skin facades, which will allow further and specifics studies on each type of façade.

2. Concept and Classification of Double Skin Facade

The term “Double Skin Facade” became widespread from 1990, and used extensively in Europe, especially in corporate buildings. This trend was driven by the exploration of transparency in architecture and technological innovations of the glass. According to Barbosa e Tibúrcio [12 p.122], “the double façade is generally composed of a glass layer placed at some distance from the inner layer, forming a cavity, allowing air to circulate between them”. The cavity formed by these two glass skins acts as insulation against extreme temperatures, strong winds and noise POIRAZIS [13]; MAZZAROTTO [4]; BARBOSA e TIBÚRCIO [12]. This facade system is characterized by a glass that covers one or more floors of a building, composed of several layers, where the skins may or may not be watertight, MAZZAROTTO [4]. Figure 1 shows a building in Germany that uses this system.

**Figure 1.** (a) Exterior view of the double skin facade of the administrative building of the insurance company Deutscher Ring in Hamburg, Germany. (b) Internal view of the double facade cavity of the same building
Source: LUFTBILDSUCHE [14]

Generally, the most common outer layer is glass, Lee et al. [15], whereas the inner facade layer is made up of fixed or operable windows. However, the literature categorizes them according to three parameters: ventilation type, cavity geometry and air flow path within the cavity, YILMAZ and CETINTAS [16]; ALBERTO, RAMOS, ALMEIDA [17]. In addition, it is also possible to differentiate them from secondary factors such as cavity width, facade height or whether the air inlets are automated. Figure 2 shows these parameters and how double facades are divided into each category.
The concept of double skin facade of the building is given by the combination of the criteria listed above. However, some combinations are common, and some concepts are better suited to a specific type of climate than others.

3. Metodology
This is a qualitative research, with exploratory-descriptive character which uses literature review and multiple case studies to identify the configurations and new materials that have been applied as second skins in Brazilian buildings. The evaluations were made first using an electronic survey to find the buildings and collect qualitative data.

As delimitation of the study area the whole Brazilian territory was taken, since the research seeks to understand how this concept has been applied in tropical climates. Brazil is such a large country formed by the Federal District and 26 states, IBGE [18]. For searching buildings with double skin facades, all states were considered, aiming to identify cases in all the climatic diversity that the country presents.

The research had as strategic focus the identification of the configurations and materials that are being used as second skin in the double facade buildings in Brazil. Only buildings with a continued double skin façade as conveying in Figure 3(A) were considered. Electronic research supported the data collecting by searching keywords more adherent to the theme, which were used as input to database of ArchDaily Brazil and Arcoweb sites and in bibliographic databases.

Figure 2. Parameters Diagram for Double Skin Facades Classification  
Source: Authors, 2019

The same expressions were used in online platforms of Elsevier and Science Direct Books: “Double Skin”, GRATIA; DE HERDE [19], “Double Skin Facades”, ALBERTO, RAMOS,
ALMEIDA [17], “Building Envelope”, GHAFFARIANHOSEINI [20], “Facades with second skin”, “Double facades for the tropical climate”, BARBOSA; IP; SOUTHALL [21].

With this search and the identification of the architectural typology it was possible to find the 26 buildings with a variety of double skin facades in different Brazilian states and cities as presented in Table 1 in the next section.

4. Results and Discussion
Twenty-six cases were found, and their identified configurations and materials applied as second skin facade in Brazilian buildings are presented in Table 1. This table is organized from “Case 1 to Case 26” presenting technical information such as authors of the project, the type of building use, its location and region.

Table 1. Identified Buildings in Brazil

| Case   | Authors                          | Use            | Local          | Region  |
|--------|----------------------------------|----------------|----------------|---------|
| 01     | Luiz Volpato Arquitetura        | Corporate      | Curitiba, PR, 2013 | South  |
| 02     | Baglio Schiavon Arquitetura     | Corporate      | Curitiba, PR, 2013 | South  |
| 03     | Team of Arquiteto Ruy Rezende   | University and Corporate | Rio de Janeiro, RJ, 2008 | Southeast  |
| 04     | Jaya e Lago Mengini             | Commercial     | São Paulo, SP, 2008 | Southeast  |
| 05     | Colapso Monteiro                | Commercial     | São Paulo, SP, 2015 | Southeast  |
| 06     | Daniel Corr., Dani Haran e Renald | Corporate     | Goiânia, GO, 2012 | Midwest |
| 07     | Grupoq + Luciano Mergatto       | Corporate      | Brasilia, DF, 2010 | Midwest |
| 08     | Mira Arquitetos                 | Corporate      | Brasilia, DF, 2016 | Midwest |
| 09     | Techne Arquitetos associados    | Commercial     | São Paulo, SP, 2014 | Southeast |
| 10     | Eduardo de Almeida, M. + Loeb + Dotto | University | São Paulo, SP, 2013 | Southeast |
| 11     | Base Urbanas, E. + F. Arquitetos | School         | São Paulo, SP, 2014 | Southeast |
| 12     | Bernardes Arquitetura           | Corporate      | Rio de Janeiro, RJ, 2013 | Southeast |
| 13     | Daniel Corr., Dani Haran e Renald | Institutional | São Paulo, SP, 2009 | Southeast |
| 14     | Escritório CGPA                 | University     | Campinas, RS, 2014 | South |
| 15     | Luiz Volpato Arquitetura        | Corporate      | Curitiba, PR, 2013 | South |
| 16     | Escritório StAA                 | Corporate      | São Leopoldo, RS, 2009 | South |
| 17     | Siegfried Zanettini             | Corporate      | Brasilia, DF, 2011 | Midwest |
| 18     | Pedro Taddei e Francisco Spadori | Educational centers | São Paulo, SP, 2013 | Southeast |
| 19     | Studio Prudencio                | Corporate      | Belo Horizonte, MG, 2016 | Southeast |
4.1. Glass skin

Glass is one of the main materials used as second skin in double facades. In Brazil, six buildings were identified, located in the South, Southeast and Midwest regions of the country.

Figure 4 shows that the most commonly used configuration for double glass facades resembles multiple floor geometry in that they have a continuous surface with no horizontal divisions for each floor. The configuration is usually shaped by panels with spacing of up to 0.05 m between them, fixed with spider fittings. The most used glasses are laminated, tempered and screen printed in white.

![Figure 4: Results of the characteristics in buildings with double skin facades made of glass](source)

The most frequent measurements for the cavity range from 0.25m to 1.20m, but those from 0.50m to 1.20m are the most used. In no case was any kind of internal shading device or windows for openings in the outer surface. However, as a solution to filter solar radiation all buildings, except Case 3 that used Low-e glass, used screen printing on the outer skin, mostly white.

Artificial ventilation is commonly used in these buildings, with the intention of achieving adequate conditions of internal comfort for the occupants. However, Case 2 and 5 opted for mixed, natural and artificial ventilation.
4.2. Metal Sheet skin

Ten examples of buildings using metal sheet as a double façade were found and, as shown in Table 1, the cases found are in the South, Southeast and Midwest of the country.

As shown in Figure 5, the most commonly used configuration for double metal sheet facades is multi-floor geometry. Measurements of these cavities range from 0.30m to 2.50m, but those of 1.00m seem to be more widely used. In no case was any kind of shading device implanted inside these cavities, except Case 12 which used flower bibs to help control the environmental conditions of the site. These flower bibs filter out the solar radiation and the air received on the double façade, helping to improve the building’s internal bioclimate, lowering the temperature and improving air conditions.

The surface compositions of these facades are usually formed of white perforated metal sheet panels, fixed in a metal frame and side by side, forming a single skin and cannot be opened. Cases 07, 11 and 15 allow these facades to open because they have a surface formed by vertical panels that can be rotated to the desired angle. All cases found have a degree of perforation in the plates, which allows natural light and ventilation between the facades, but Case 11 presents plates 100% impermeable to wind and the passage of solar radiation. For light and air input in Case 11, the plates can be moved to the desired angle.

All buildings feature integration with natural and artificial ventilation, except Case 10, which does not allow opening the internal windows of the building. Although these buildings have the possibility of opening the internal windows that allow natural ventilation to the building environments, the use of air conditioning is present in all cases.

4.3. Stainless steel cable skin

Three Brazilian buildings in the Southeast and Midwest were found using Stainless Steel Cable as second skin of the double façade.

Figure 6 shows that the most used configuration in double facades with stainless steel cable presented in this study are similar to the multi-floor cavity geometry divided by maintenance grids. In addition, all cases opted for natural and artificial ventilation.
The surface that makes up the double facade is composed of a curtain formed by stainless steel cables extended over the entire facade area of the building and have the natural grey color of steel. This curtain has cable spacing making it possible for air to pass through and other natural agents. The dimension they appear far from the inner skin of the building ranged from 0.80m to 1.20m, and no case had any kind of internal shading device other than the second facade.

Figure 6. Results of the characteristics in buildings with double skin facades made of stainless steel
Source: Authors, 2019

4.4. Textile Membrane skin
Three Brazilian buildings were found using membrane and plastic fabrics in the double facade, one in the Midwest and two in the South of the country.

Figure 7 shows that the multiple-floor configuration is the most widely used of textile membrane cases. These facades are 0.30m to 2.00m apart, and neither has implanted any type of shading device in the cavity. In addition, natural allied to artificial ventilation was also present in all these cases.

As for the color used, there was no frequency between the cases, each adopted a different color palate. However, cases that have adopted light colors will have less thermal absorption and, possibly, dissipate more heat off the facade. Regarding the visual permeability of the material, the perforated meshes are coated with PVC and can reach up to 90% transparency for those inside the building.
4.5. Wood skin

In Brazil, two cases using wood that resemble the double facade were found, one in the Southeast and one in the Midwest of the country.

It can be observed in Figure 8 and 9 that the two cases have different characteristics, even using the same material. Case 23 adopted a multi-deck configuration with vertical brises that can change angle creating small openings. Case 24, on the other hand, used a horizontal wooden profile screen and its facade is also configured as multiple floors.

Figure 7. Results of the characteristics in buildings with double skin facades made of textile membrane
Source: Authors, 2019

Figure 8. Results of the characteristics in buildings with double skin facades made of wood
Source: Authors, 2019
4.6. Steel Rebar skin

In Brazil, one building was identified with steel rebar and is located in the South region. The facades of this building feature side walkways that push the building from its limits, giving the feeling that the glass blocks float. Its outer surface features two types of fencing.

The Northwest and Southeast facades are made up of patina steel plates, and the Northeast façade is made up of a layered rebar mesh that supports the natural landscaping under developing. An external circulation with floor grids on the sides of the floors forms walkways that connect all environments. These walkways allow air to circulate when the doors of each room are opened. Its dimension is approximately 0.50m to 0.70m, according to the graphic scale of the consulted projects. Figure 10 summarizes these details more schematically.
4.7. Polymer Concrete skin
This product is currently found on paneled building facades. In Brazil, one building was identified in the Southeast region using this material as the second skin of the facade.

The west facade of this building is a double-façade system made of polymer concrete, consisting of a three-dimensional mural composed of 15m by 15m modular plates, in six shades of black and white. The surface of the façade is 1.5m away from the inner wall, and its panels were fixed using metal profiles bolted to the concrete. Due to its continuous configuration this façade can be considered as a multi-storey façade. Figure 11 shows a scheme of these characteristics.

![Diagram of polymer concrete skin](image)

Figure 11. Results of the characteristics in buildings with double skin facades made of polymer concrete
Source: Authors, 2019

4.8. Considerations
Based on the results presented above, the features of the outer skin that most appeared in the case studies has shown that the most used material among the studied cases is the white perforated sheet metal. In most cases they allow the user to control the opening of windows as needed. These surfaces typically feature over 90% of glazed area with full-air windows and sliding doors. Laminated and colorless glasses are the most used ones. It is possible that the cavity width is being adopted due to the space that is required for the maximum-air windows to be opened as well as for the maintenance circulation of the facades.

The multi-deck configuration is the most widely used, and its cavity ranges from 0.50m to 1.20m wide. These facades do not have opening windows and no internal shading device in the cavity. However, some cases have adopted their own external skin for this function, allowing openings with movable brises that allow different angles. The facades are naturally ventilated through the perforation of the material, but nevertheless the buildings are artificially air conditioned.

5. Conclusion
This research has shown that, although double skin facades are widespread in countries with mild temperatures, in tropical climates such as Brazil, this system has also been used in recently. In addition to the use of the conventional double glass façade, in Brazil, another 6 different types of materials have been used for this second skin facades in buildings.

The facades identified in the Brazilian territory presented a large constructive variety of double skin facades. The region with higher concentration of double façades were the Southeast, which has the largest number of buildings and the largest diversity of materials used in this system.

The most commonly used double facade configuration found is that of multiple floors, usually formed by panels attached to a light metal structure, almost imperceptible from the outside. This solution helps reduce loads on the structure, but it requires attention to the quality of labor at the time.
of application. When this system is not well known, as it is new in tropical climates, it can generate buildings with great thermal discomfort and high consumption of cooling and maintenance.

These facades have proved to be a very flexible element that allows the incorporation of intelligent technologies and strategies to improve the quality of building environments.

One aspect that raised from the investigation is the perception of the end-users, thinking for example about the visual barrier these facades can create, which could become a unsatisfaction for users, which is a suggestion for future studies.

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