Building a Brazilian climate in Paris: the Case of the House of Brazil (1953-1959)

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The relationship between climate and the built environment has been a matter of intense debate in architectural theory. Starting from the early theories of climatic control through greenhouse structures in the eighteen century, up to the contextualist turn of Modernism with the so-called Critical Regionalism in the 1950s (Frampton 1998), controversies concerning architecture and climate have influenced cultural, political and scientific spheres (Jankovic 2010). By examining the discussions around the material production of microclimates in the design phases of one modernist case study, the *Maison du Brésil*, or House of Brazil, in Paris (1952-1959), this chapter inquiries into the manifold ways in which the notion of climate intervened directly and indirectly in the discussions between the main architects of the building, Lucio Costa (1902-1998) and Le Corbusier (1887-1965). This research is based on the analysis of professional and personal letters, books, notebooks, plans and reports from the archives of the *Fondation Le Corbusier*, the *Acervo Lucio Costa* and the French National Library.[1] The results show, on the one hand, the differing ideas on how to produce microclimates in architecture and their influence in the design process: Le Corbusier understood climate control as a representation of human independence; whereas Costa explored climate interaction as a representation of the ties between local climate and traditions. This contributes to understand how twentieth-century ideologies on climate interfered with architectural discourses in a broader perspective. On the other hand, this chapter discusses the architectural means implemented to interact with climate in their theoretical and material facets. In the House of Brazil, the architectural expression suggests a Modern sensitivity to climate inspired by previous experiments in geographical contexts like India (Chandigarh) and France (Marseilles, Rezé).[2]

Long time after the erection, the anthropologist C. Brum has studied the community of the House of Brazil, raising interesting questions on cultural representativeness and sensation of homeyness through architecture (Brum 2011). Her work reminds us that ultimately, the House of Brazil became, not least via the construction of microclimates, "a metaphorical machine that evokes the places of origin of the students" (Gargiani and Rosellini 2011, 119).

A NEW ARCHITECTURE FOR BRAZIL

In the 1940s, the new Brazilian regime embraced architecture as an instrument of propaganda for the construction of the modern Brazilian identity. The social and political conditions of Brazil made the country especially sensitive to a process of metabolization of the modernist principles (Le Roux 2004). At a time when politics resembled architectural expression and ideology, the colonial past was perceived as a means of articulation between tradition and the definition of the new nation; a "national style of modern architecture" was therefore promoted (Banham 1962). Such as colonial architecture did, the

[1] I gratefully acknowledge the support and generosity of the *Fondation Le Corbusier* for the access to their documentary resources. I also thank Ivania West for Portuguese-English translations.

[2] So far, architectural historians have considered the House of Brazil as a minor work of Le Corbusier. The articles have addressed the history of the works (Puppi 2008; Demillac 2011), the authorship issue and design negotiations between Costa and Le Corbusier (Choay 1959; Ragot and Dion 1987; Joly 1987), as well as the refurbishment works of the building in 1996 (Toulier 1999; Bauchet and Rio 2001).

modern codification of Brazilian architectural atmospheres naturally rooted in climate conditions and cultural traditions (del Real 2012).[3]

Brazilian modernists also assimilated the theories of the *Homme Nouveau* of the Global North countries (Guillén 2004). For instance, Minister G. Capanema claimed that the goal of the new Ministry of Education and Health was "to prepare, to compose and to perfect the man of Brazil" (Lissovsky and Sá 1996, 230). Accordingly, the new building for the ministry represented this image, it was "monumental, without any shadows, deep, bright, strong, and decisive".[4] The modernist architectural expression of sunlight and open air represented in Brazil the accomplishment of the modernization promise.

FIG. 1: THE MINISTRY OF EDUCATION AND HEALTH IN RIO DE JANEIRO (HITCHCOCK 1977, 520)

Generally speaking, the transformation of modern architecture into the Brazilian paradigm passed through a special focus on topography, harsh light and a warm-humid climate. Brazilian architects revisited *brise-soleils*, *pilotis*, free-plans and roof-terraces for incorporating features of climate-responsive design inherited from colonial architecture: blinds, lattices, wood screens or ceramic tiles allowed sunlight control, hygrothermal regulation and cross-ventilation (Lehmann 2016).

The Brazilian architect Lucio Costa involved himself in this modernization by way of an extensive investigation of colonial architecture. His interest was in neither preserving nor making populist allusions; rather, he aimed at naturalizing the ties between colonial and modern architecture by placing Modernism in the historical continuity of traditional architecture. For instance, Costa described Le Corbusier's ribbon windows as a progression towards an increasingly open façade: "in the 18th century, the voids and solids remained in equilibrium, and in the early 19th the voids frankly predominated […] after 1900 the façade is almost wholly open" (Costa 1939).[5] Costa's Brazilian Pavilion for the New York World's Fair (1939), in collaboration with Oscar Niemeyer, enhanced architectural openness that blurred internal and exterior spaces, creating a connection to climate that was essential for the Brazilian atmosphere.

FIG. 2: L. COSTA AND O. NIEMEYER BRAZILIAN PAVILION AT THE WORLD'S FAIR IN NEW YORK (PAPADAKI 1960, FIG. 57)

BUILDING A BRAZILIAN CLIMATE IN PARIS

A few years later, Costa explored again the representation of Brazilian modernity through architecture in the project for the House of Brazil in Paris. In 1952, he was mandated by the Brazilian Heritage and National Artist Service (SPHAN)[6] to design the building for the new Brazilian Pavilion at the International University Campus of Paris. The architect was simultaneously involved in the preliminary design of the UNESCO Headquarters in Paris as a member of the "Committee of Five" (Costa 1995, 103). By the end of 1952, he sent the project statement in a personal letter to his friend Rodrigo de Andrade (1898-1969),[7] director of the SPHAN. This document described the intimate expectations of the architect concerning the relationship between climate and architecture for the House of Brazil.

[3] In 1943, the exhibition at the MOMA "Brazil Builds: Architecture New and Old, 1652-1942" emphasized this exploration for connecting new and old.
[4] Speech by G. Capanema at the opening of the MESP (Ministério da Educação e Saúde), 3 October 1945 in Gonçalves Quintil (2016, 257).
5 English translation from Gonçalves Quintil (2016, 258).
[6] SPHAN (Serviço do Patrimônio Histórico e Artístico Nacional).
[7] L. Costa, Letter to Rodrigo nr. 17, 1952, Archive Casa Lucio Costa, VI.A.03-01754.

The letter of Costa began arguing in favor of changing the original name of Brazilian Pavilion to "House of Brazilian Students" or to "House of Brazil."[8] According to him, the term pavilion was unpleasant and inappropriate, whereas the term house would inspire both a feeling of homeliness for students and an image of an open institution for spreading Brazilian culture in Paris. The building, as Costa said, showed Brazilian modernization by means of an architectural expression of regularity and lightness. The building materials would create a dialogue between modernity and tradition; iron, glass or concrete were mixed with a cladding façade on the ground floor and with walls painted in "Brazilian colors."[9] Surprisingly, the formalization of this Brazilian identity strongly recalled the image of Le Corbusier's neighboring Swiss Pavilion (1928-1931). The set of preliminary plans attached to the letter provides evidence of such similarity, especially the elevations and the exterior views. This project could be considered "a Brazilian version of the Swiss Pavilion, but it would be one that at least values and confronts it, rejecting the quota of Brutalist anticipation" (Puppi 2008, 163). What is more, the Brazilian building was bigger: 103 rooms, 56 meters long, 21 meters high and from 12 to 17 meters wide.

FIG. 3: LE CORBUSIER'S SWISS PAVILION (LE CORBUSIER AND JEANNERET 1934, 87)

FIG. 4: COSTA'S PRELIMINARY DESIGN FOR THE HOUSE OF BRAZIL, FLC 12981 (©FLC-ADAGP)

Costa's preliminary design reveals his approach to the notion of climate, which would be directly or indirectly present in a number of subsequent discussions throughout the design phase. Climate acquires two main meanings in the words of Costa: on the one hand, the functional interaction of the building with the French climate; on the other hand, the representation of Brazilian identity via indoor microclimates for both students and visitors.

Costa evaluated in detail the orientation of the building. The architect explained that he could only decide the orientation for the students' rooms after discussion with residents of other houses on the campus. As he said: "they were unanimous: north, forget it; south, good in winter, but very hot in summer; west, windy with rain; south-east ideal".[10] Although his proposal neglected the street alignments of the master plan, the local climate experience of the students counted more for him. Costa's report also paid attention to climate when describing the interior of the students' rooms. He designed ribbon horizontal windows of 1.05 meters high that would be divided into two sides, one half sliding, with transparent glass, and the other half fixed, with opaque glass. For daylight control, the architect suggested installing external rolling blinds in front of the sliding part: a functional and cheap solution inspired by the traditional blinds that he had seen during his trip to Lisbon in 1952. For the fixed half, he suggested installing an indoor curtain. Lastly, Costa went on to explain the rooms heating system through a radiator installation integrated in the parapets of the aforementioned windows. He exposed that the radiator system was simple and practical: "from my experience I know that it is very convenient when you arrive wet from the street to have a place to put coats and shoes to dry".[11] This preference stood against the radiant heating systems that prevailed in the European modernist discourse from the late 1930s onwards.[12]

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[8] Casa do estudante brasileiro or Casa do Brasil.

[9] Colors for the façade: grey, blue, red and white. Colors for interior walls: blue, pink, aqua green and lemon yellow.

[10] L. Costa, Letter to Rodrigo, *op. cit*. Author's translation.

[11] *ibid.*, author's translation.

[12] The radiant heating systems represented modernity in environmental control: they were invisible or totally integrated in architectural design, they regulated indoor climates in the healthiest way, transmitting heat to bodies keeping the air in the room still and cold (Marino 2014; Brunner this volume).

At the beginning of 1953, Costa entrusted André Wogenscky (1916-2004), the chief assistant of the Atelier Le Corbusier (L. C.), with the development of the construction project and the management of the construction works. The intervention of Le Corbusier in the design was not expected because at the same time he was focusing his mind on the projects of Chandigarh, Ahmedabad and Ronchamp.[13] However, the opinion of Le Corbusier and his collaborators imposed several modifications on the preliminary design up until the end of the building works in 1959. Finally, political pressure to start the construction led Costa to approve the plans without restrictions in January 1956, even if he no longer considered himself the project's author. The final design was neither a Costa project nor a creation of the Atelier L. C.; its origin was in fact multiple – a "palimpsest written with several hands" (Puppi 2008, 192).[14]

NEGOTIATING THE CLIMATE OF PARIS

By the end of 1953, the Atelier L. C. had taken over the direction of the project, although Le Corbusier's first intervention was not until March 1954.[15] His first comment on the plans, hitherto faithful to the original project, stressed a different understanding of the interaction between architecture and climate. The Atelier L. C. drew up a new version that preserved the siting, the building orientation and the overall shape; yet the original glazed façade (S-SE) was replaced by a *loggia brise-soleil*, or sun-breaker, inspired by the one at the *Unité d'habitation* of Marseilles. According to Le Corbusier, the *loggias brise-soleil* were "justified in Paris, and they also have the considerable advantage of serving as a rain-breaker (*brise-pluie*) for the façade."[16] In November 1955, the assistant André Maisonnier drew up a new version of the project that added a long balcony to the central part of the campus façade (W-NW). By the end of the year, the architects finished the third version of the project along with the technical sections, and they sent it to Costa for approval. This triggered an epistolary debate that highlighted their differences, including on their rhetoric on climate. In February 1956,[17] Costa explained his dissatisfaction with the final project of the Atelier L. C. He stressed the importance of designing a building where Brazilian students "would feel comfortable, at home;"[18] yet it should also represent Brazilian culture despite being in the climate of Paris: "it is a house for Paris, no doubt, but it is addressed to the Brazilian government and for Brazilian people […] it should not be designed nor built by translating a spirit and an intention that could be considered anti-Brazilian."[19] Costa especially refused the *loggia brise-soleil* designed by the Atelier L. C. right from the start. On the contrary, his thesis for the new Brazilian architecture focused on the link between inhabitants and sunlight through architectural devices, such as balconies or *brise-soleils* (del Real 2012, 140); as Costa framed it: "with our climate […] the fact is that balconies, when properly oriented, are the best place to stand; and what is a balcony, after all, if not a room completely out of doors?" (1939)

Indeed, Costa's housing projects in Brasilia and Rio de Janeiro, just like other Brazilian architects, employed Le Corbusier's *brise-soleil* as a modernist interpretation of the traditional verandas and *mashrabiya*. Meanwhile, Le Corbusier insisted in the necessity of the *brise-soleil* in the Parisian climate in order

[13] L. Costa, Letter to Rodrigo, *op. cit*.
[14] Le Corbusier recognized the shared authorship in his Complete Works. He added to the title the note "in accordance with Lucio Costa" and he explained that "the first plans were designed by Mr. Lucio Costa, Arch., Rio de Janeiro, but the final project was carried out by the Le Corbusier staff" (Le Corbusier 1965; 1957). The House of Brazil went slightly unnoticed in both volumes, being accorded just two pages (6th) and nine pages (7th).
[15] A. Wogenscky, letter to L. Costa, 19 March 1954, FLC K1.8.197.
[16] *ibid.*, author's translation.
[17] L. Costa, letter to Le Corbusier, 7 February 1956, FLC K1.8.199.
[18] *ibid.*, author's translation.
[19] *ibid.*, author's translation.

to control the weathering of the façades. This awareness had resulted from his problems with the façades of the building for the Salvation Army and the Swiss Pavilion, both in Paris. He clarified that "the climate in Paris is not that of the tropics; it is treacherous. It freezes and it rains in this country and the sky of the Ile-de-France is beautiful when it is blue but it is not every day."[20] Le Corbusier also argued against Costa's lack of criticism about the International University's approach, which promoted national pavilions copying the architectural style of each country. For that reason, he continued, most of them did not fit into the climatic context of Paris: "despite the particular tastes of each nation, the climate of Paris is imperative and my building, which is intended to stay up, should be constructed to stay up."[21] Finally, Le Corbusier disapproved the creation of a Brazilian atmosphere to accommodate Brazilian students in France; rather, he argued in favor of accommodating Brazilian students in the local way of life. In May 1956, Costa wrote a letter to Le Corbusier to calm tempers and to facilitate the beginning of the works.[22] This letter was the last exchange between Costa and Le Corbusier on the design of the House of Brazil.

Methods of climate control

The construction of the House of Brazil relied much on the experience of the Atelier L. C. in residential buildings after World War II. In particular, the *Unité d'habitation* of Rezé (1953-1956), which reviewed the early experiment of Marseilles (1946-1952) in line with the economic constraints of a private commission for social housing. The project for Rezé established the feasible model that would be repeated afterwards in Le Corbusier's residential works – for instance, the designs for the structure, windows, or heating systems were permanent. Microclimate control in the House of Brazil replicated the way of life imagined by Le Corbusier for the *Unité d'habitation*, idealizing the life under the sun of the French Riviera. However, the Brazilian building revisited it through the lens of a renewed climatic awareness that was raised after the Indian works. In fact, the project represented his early attempt to translate into the European context the knowledge developed for the *Grille climatique* (Climatic Grid), a climate-inclusive design method tested in Chandigarh (India).[23] Although the method disappeared from the works of the Atelier L. C. in 1952, the attached architectural design guidelines oriented the climatic approach of his successive works.

Fig. 5: Sketches attached to the Climatic Grid file (©FLC-ADAGP).

The Climatic Grid was part of a wider framework renewing the hygienic ideas of early Modernism. By the mid-1930s, new research on occupational medicine and environmental control systems aimed at rationalizing individuals' environment in order to control health and social productivity.[24] Environmental

[20] Le Corbusier, letter to L. Costa, 23 February 1956, FLC K1.8.202. Author's translation.
[21] *ibid.*, author's translation.
[22] L. Costa, letter to Le Corbusier, 14 May 1956, FLC K1.8.232.
[23] In November 1951, Le Corbusier sent a letter to Missenard explaining that Chandigarh was for him the opportunity to investigate experimental procedures without the constraints of European laws. He asked for the engineer's advice on developing a design method that could operate with any particular set of climatic conditions. From December 1951 to February 1952, there was an intensive exchange that resulted in a design method called the Climatic Grid (Siret 2005). It was "a graphical means of presentation which permits the enumeration, coordination and analysis of the climatic conditions of a place in order to direct architectural research towards solutions in accordance with human biology". It dealt with "the rectification and setting in order of the excesses of extreme climates in order to achieve, by means of architectural dispositions, conditions capable of assuring comfort and well-being."
[24] The modern environmental control systems made it possible to standardize the rhythms of life and production of modern society. Indeed, by controlling individuals' bodies through environmental regulation, the air conditioning disciplined human beings and influenced the social order (Mumford 2010).

control systems made it feasible to bring order to climatic anarchy by maintaining perpetual spring conditions indoors and assuring a feeling of thermal neutrality all year through. Physicians and engineers sought to create indoor microclimates where inhabitants "do not experience any unpleasant thermal sensation (neither too hot, nor too cold), and are kept in the conditions that are more favorable for the normal exercise of their activity and the maintenance of their health" [Author's translation] (Ghilardi 1939). In general terms, two major approaches prevailed: the production of immutable indoor microclimates and the creation of perfect natural microclimates indoors. Even if the first one has been largely studied (Ackermann 2002), the second approach was crucial to understanding the point of view of European architects. Two outstanding engineers supported this point of view – André Missenard (1901-1989), founder of the "Science of Artificial Climates" and collaborator of Le Corbusier, and Ernest Tunzini (n.d.-1976), the French pioneer of the "Atmosphere by Air-conditioning" according to L'Architecture d'Aujourd'hui (1935).

Both engineers argued in favor of applying modern techniques to reproduce natural climatic conditions indoors, or even improve them (Missenard 1937). According to them, indoor microclimates must prevent thermal neutrality and recreate the natural heterogeneity, which would contribute to train the human thermoregulatory system and to strengthen the immune system of the body.

FIG. 6: COVER OF MISSENARD'S *L'HOMME ET LE CLIMAT* AND COMMERCIAL LEAFLET OF THE ETS MISSENARD-QUINT (1957), FLC Q1.15.259 (©FLC-ADAGP).

In Missenard's words: "we expect to create artificial conditions to replace the natural climate" [Author's translation] (Missenard 1937, 253). Such a preventive hygienic approach centered on environmental determinants was disseminated through French elites characterizing eugenics in France (Rosental 2016). Le Corbusier had been familiar with this theory since the publication of Missenard's manifesto "Man and Climate" (*L'Homme et le climat* 1937). The architect's library included a copy of the book with a number of handwritten notes linking the engineer's assertions with his urban theory *La Ville radieuse*, or The Radiant City (1934). In July 1961, he stated in a lecture at the Faculty of Medicine of Paris that architecture should respect the natural rhythms of life, adaptive and variable, which contrast with the monotonous rhythms imposed in the machine age. "All that is human alternates: walking, eyes flickering, talking, the lips that speak, whatever you want, I do not care, it is alternating, whereas the machine, it is continuous."[25] The perspective of restoring the conditions of nature did not refer to naturalist, moral or hygienist values (Rouillard 2004); rather, it responded to the modernist aspiration for returning to an idealistic relationship with nature through the use of the machine.

Since the publication of "Man and Climate," Missenard had collated climatic studies with the study of modern environmental control techniques to create the basis of the "Science of Artificial Climates." As mentioned above, the engineer thought that indoor microclimates should stimulate inhabitants' bodies to promote active health by controlling air quality and temperature. To do so, Missenard suggested some determining characteristics for indoor microclimates. Firstly, to keep inhabitants' living conditions close to those of their natural climate, which prompted the best physiological performance of their vital and social tasks. Le Corbusier's notes in "Man and Climate" contextualized this assertion: "To return to the wild state and to sleep in a cave? Or, then, create the compensations nevertheless, by a reinforcement of the active life, oscillating, anti-sedentary. Conditions for the VR (*Ville Radieuse*)? To achieve the

[25] Le Corbusier, Lecture at the Faculty of Medicine of Paris, July 1961, FLC, C3.10.46. Author's translation.

natural conditions."[26] Secondly, Missenard argued that artificial climates should break with the trend of sensory neutrality disseminated by the thermal comfort standards of air-conditioning, which would weaken the human immune system (Missenard 1940). Thirdly, the "Science of Artificial Climates" aimed at strengthening inhabitants' thermo-regulatory system via continuous and unconscious thermal training all day through and across the building. Indoor temperatures should be coupled with outdoor ones to maintain the natural thermo-regulatory adaption. In addition, thermal conditions had to be adapted to the function of the space and the metabolic needs of inhabitants. By doing so, bodies would have been in a state of continuous reaction.

Although Missenard did not mention the transfer of the "Science of Artificial Climates" to his projects, the technical projects for the House of Brazil reveal a number of interferences with Atelier L. C.'s design methods. Three main issues deserve to be highlighted: the environmental control systems, the regulation of sunlight and the openness to air.

Environmental control systems

The design of the heating system for the House of Brazil can be seen as an attempt by Missenard to integrate the "Science of Artificial Climates" into architecture. Missenard's company (Ets. Missenard-Quint) joined the design and construction team in July 1957. At this point, they sent the document "Description of Works" to the Atelier L. C. with their proposal for heating and ventilation systems – in fact, they never considered the radiator system suggested by Costa.[27] According to the document, the heating system adopted three complementary strategies. The first one was to heat the building up to a base temperature using their own heated-slab system. Missenard's patent,[28] granted in 1953, guided the design for a "floor heating system at a normal temperature and with a heterogeneous coating."[29]

Fig. 7: Scheme of the *Systeme Missenard* and its implementation in a room of the House of Brazil (©FLC-ADAGP).

It would operate with two different circuits – one for the rooms, the other for the ground floor. For those spaces with higher heat losses, like the first and last floors, the engineers designed a network of convectors installed in the room partitions with special yellow niches. For the ground floor theatre, with intermittent use, they decided to install a blown air heater, which would not be operative until November 1961 due to electrical problems.[30] Asides from natural ventilation, the system also permitted mechanical ventilation of the space during warm periods. Lastly, the technical spaces of the basement floor were heated by normal radiator installations.

The temperature of each space appears to be adapted to the activity, and a thermal transition takes place between the inside and outside. The engineers' report shows the gradient: the room floors with 18°C; the indoor corridors with no heating achieving a slightly lower temperature; the ground floor with 15°C; lastly, the small glazed entry box that finishes the transition towards outdoors; the theatre, considered independent, would be heated up to 18°C. The report also explains that the engineers designed a thermal sensor to control the operational temperature of the system, depending on the outdoor

[26] Le Corbusier's personal copy of Missenard's "L'Homme et le climat," FLC, p. 253. Author's translation.
[27] Ets Missenard-Quint, Devis descriptif des travaux, 25 July 1957, FLC K1.5.277.
[28] Ets Missenard-Quint, Panneau rayonnant de sol. Brevété A. Missenard, 11 February 1953, FLC K2.6.296.
[29] Ets Missenard-Quint, Devis descriptif des travaux, *op. cit.*
[30] F. Gardien, Certificat de reception definitive, 6 October 1961, FLC K1.16.331.

temperature. Engineers did not anticipate any intervention of inhabitants as the system would automatically regulate indoor temperatures depending on outdoor ones.

In the House of Brazil, as well as in other of Le Corbusier's projects of the same period, the floor assumed a special relevance. If it was already important from structural and aesthetic points of view, Missenard's floor heating system also enhanced the sense of touch and the thermal sensation in general, leading to a different sensory perception of the space. Accordingly, the architects unveiled this complexity by studying the singularity of flooring aesthetics. For the room levels, they chose a modern vinyl flooring of Bulgomme with fake marble grain. For the ground floor, they designed a composition in strips of black slate sheets in different sizes, punctuated by the grey cement of the thick joints. The company Bertocchi installed the slate sheets, as they did at the same time for the chapel flooring at the Convent of la Tourette, built in 1959.[31]

FIG. 8: PLAN FOR THE GROUND FLOOR SLATE FLOORING, FLC 12630 (©FLC-ADAGP).

SOLAR REGULATION

Several publications have discussed in detail how, from the 1930s onwards, Le Corbusier paid special attention to the interactions of architecture and society with sunlight (Siret 2012; Barber 2012). In the Radiant City (Le Corbusier 1934), his manifesto for a modern urbanism, he introduced the threefold strategy of "sunlight, fresh air and greenery" and promoted a way of life regulated by the *Twenty-Four Solar Hours*-theory. In this regard, the *brise-soleil* became an architectural device through which the building could interact technically, aesthetically and functionally with sunlight. Le Corbusier developed two proposals with different objectives: the regular *brise-soleil* implemented in non-residential buildings mainly, which aimed at protecting from sunlight and controlling daylight level indoors; the *loggia brise-soleil* applied in housing projects, which aimed at "enter[ing] the sun in the dwelling" (Le Corbusier 1946, 109) in order to provide inhabitants with additional spaces to live under the sun.[32] The material aspects of both devices were crucial in the thermal response of architecture.

In the House of Brazil, the *loggia brise-soleil* reproduced the same form and materiality like in the *Unités d'habitation*. It was built with a reinforced concrete framework of 1.46 meters depth, with lattices, jambs and head made in pre-cast concrete finished in gravel. By contrast, instead of facing East or West, the one in Paris faced South-east and achieved a greater efficiency in sunlight control. The exposure of the concrete framework with high thermal inertia to the sun produces the indoor microclimate of the House of Brazil: it gains and preserves the solar heat energy, which later is transmitted inside, heating passively in winter afternoons and hindering comfort in summer.

The choice of the type of windows was crucial to achieve the feeling of living outdoors. The *loggia brise-soleil* in Marseilles enhanced the connection between indoors and outdoors through a system of full-height folding windows that totally opened up the façade of the apartments. Economic and climatic constrains in the House of Brazil led the architects to a different solution. The new façade design of Wogenscky, Barberis (carpenter) and Alazard (glazier) was called the Fourth Wall. It consisted of a wooden frame of 32 cm depth painted yellow with a sequence of compartments for two fixed windows,

[31] F. Gardien & G. M. Présente, letter to Ateliers d'Ardoiserie d'Angers, 21 April 1960, FLC K3.13.88.

[32] With regards to the *brise-soleil*, Le Corbusier wrote: "a range of small successive discoveries that allowed me to become and remain a friend of the sun and to bring, even to certain countries like Brazil and under the tropical sun, solutions that are the first to allow one to open up modern life" [Author's translation] (Le Corbusier 1946, 103).

which used the patented Thermopane double glazing, and two pivoted wooden panels: one to reach the loggia, the other to ventilate the space. It seems clear that such a solution simplified the construction procedure and guaranteed a reduction in air leaks, but it impeded to satisfy the aspiration of connecting the loggias with the indoor space.

Paradoxically, during the design phase, the architects of the House of Brazil never explained the necessity of the *loggia brise-soleil* in sunlight control or aesthetic terms. As mentioned above, Le Corbusier argued for introducing the *brise-soleil* mainly for its capacity to protect the building from the weatherizing action of the rain. Such as Wogenscky explained for Berlin, the *brise-soleil* "stops very little sunlight in reality […]" but it is useful for "protecting the whole façade and the windows from rain."[33] The controversy on the Marseilles device's efficiency against sunlight seemed to push the architects to find new reasons to justify it.

OPENNESS TO AIR

In addition to sunlight exposure, reflections on the buildings' openness to air appeared in Le Corbusier's works from the mid-1930s onwards. The early hygienic struggles on air renovation mutated in this period into a more complex imbrication of architectural form and air. According to the architect, the ventilation strategies ameliorated indoor microclimates; buildings must be ready "to receive any diagonal air current going from cold to hot"[34] allowing "the free passage of air."[35] The Climatic Grid promoted architectural strategies attentive to the "careful orientation of openings according to prevalent winds"[36] and to the "establishment or suppression of air circulation depending on sunny weather."[37] Even for the *Unité d'habitation* in Marseilles, the Atelier L. C. explained that the "natural freshness" of the apartments was a "consequence of the tubular form" (Le Corbusier 1953, 188).[38]

Despite the fact that Parisian climate was different, the House of Brazil benefited from Le Corbusier's experience with natural ventilation in North India. The façade design integrated a set of narrow ventilation doors along the entire surface of the building: the aerator (*aèrateur*). Carefully designed by Missenard, the aerator consisted of metallic or wooden panels of 27 cm width from floor to ceiling, resulting in a reduced surface exposed to the wind. This shape accelerated the air velocity and created what Missenard called an effect of vertical blade of air. "Depending on the season, the flow of this blade will be low or high […] this blade must act from floor to ceiling simultaneously […] ventilation of pure air operates perfectly on both sides of the blade, crossing the room."[39] Furthermore, the aerators were positioned to obtain "ventilation at a human height,"[40] which improved thermal comfort and allowed inhabitants to manage the indoor air flows.

FIG. 9: TECHNICAL DETAILS OF THE GROUND FLOOR'S AERATOR, FLC 12596 (©FLC-ADAGP).

[33] A. Wogenscky, letter to F. W. Müller-Reppen, 2 October 1956, FLC M3.13.144.
[34] Le Corbusier, letter to P. L. Varma, 22 May 1956, FLC P1.10.301.
[35] Atelier L. C., "Grille climatique C", FLC, 5627f. Handwritten note at the plan. Author's translation.
[36] Atelier L. C., "Grille climatique C", 1952, FLC, 5607.
[37] Atelier L. C., "Grille climatique C", 1952, FLC, 5602.
[38] The Atelier L. C. promoted in India a way of life in contact with the climate through architectural strategies: "the architecture that we do over there is to make shadows, freshness of air currents and contact with natural beauty." Chereau, Agnes. Interview Le Corbusier, 2 March 1953, FLC, U3.7.362.
[39] Le Corbusier, letter to P. L. Varma, 22 May 1956, FLC P1.10.301. Author's translation.
[40] *ibid.*, author's translation.

For the public spaces of the ground floor, the aerators were fitted in opposing walls in order to trigger a cross-ventilation effect for the open space. The architects installed eight colored metallic aerators into the façade system designed by Xenakis, the waviness glass pane (*pan de verre ondulatoire*). Together with the windows in various widths, this architectural envelope created a dynamic effect with sunlight, shadows, glares and airflows changing all day long. We could say that it connected the indoor space to the outdoor rhythms, capturing breezes and revealing the sun's movement in an aesthetic and multi-sensorial approach.

For the room levels, the technical service of the university rejected the natural cross-ventilation. According to them, the air running freely across rooms, corridors and kitchens would represent a fire risk.[41] The rooms were consequently provided with a different ventilation system already tested in the Chandigarh Secretary. A single wooden aerator was integrated in the Fourth Wall façade of each room to allow the entry of air. Then, to permit the release of stale air, a second aerator was installed near the shower. The air was expelled through vertical ducts placed along the corridor walls, which drew air upwards due to the thermal chimney effect, boosted by a mechanical exhaust system.

FIG. 10: SKETCH OF THE STUDENTS' ROOMS, FLC 12811 (©FLC-ADAGP).

CONCLUSION: CONTRASTING CLIMATE IMAGINARIES IN ARCHITECTURE

This paper has analyzed the design process of a modernist building through a focus on climate-relevant aspects of architecture. The analysis of the House of Brazil shows that the understanding of microclimates in Modern architecture cannot be considered univocal; rather, the comments and design criteria of Le Corbusier and Costa reveal different approaches. Le Corbusier aimed at manufacturing indoor microclimates that restored natural climatic conditions in architecture. To do so, he integrated passive and active environmental control techniques arising from his previous works in India and Marseilles. By contrast, Costa aimed at creating an architectural expression that represented the unique ties of culture and climate of the Brazilian traditions. Two main aspects catalyzed the debate on microclimates: the mechanization of indoor atmospheres using environmental control systems (heated slabs, radiators, blown air systems) and the regulation of indoor conditions by sunlight and wind control (*brise-soleil*, windows, curtains, aerators).

In the case of the House of Brazil, the designers' climatic imaginary referred to a number of material and immaterial issues. Firstly, indoor microclimates established an intimate link with outdoors climate through architectural devices for sunlight (*loggia brise-soleil* and waviness glass panes) and air (aerators). These microclimatic materialities intermingle architectural expression, by sublimating climatic phenomena, and inhabitants' practices, by permitting a moderate adjustment of indoor microclimates. Secondly, microclimates' design aimed at interacting with the physiological dimension of the human body. According to Missenard's "Science of Artificial Climates," the active and passive methods for environmental control in the House of Brazil offered microclimates that create a state of continuous thermal reaction. Lastly, the cultural understanding of the notion of climate influenced the way in which designers and inhabitants handled daylight, colors, textures, temperatures or air movements. These characteristics are still nowadays a matter of contradiction between European and Brazilian approaches of both visitors and residents.

[41] A. Wogenscky, letter to L. Costa, 19 Mars 1954, FLC, K1.8.197.

Le Corbusier, during his inaugural address for the House of Brazil in June 1959, remembered the link between Brazilian identity and climate: "this magnificent great country that invented this beautiful flag in green, yellow and blue: nature, the sun, the sky of the tropics" (quoted in Demillac 2011, p.5). This symbolism and the material manifestation of culture and climate influenced the design process of the House of Brazil. At a time when climatic rhetoric and architecture were deeply connected to politics, the selected case study reveals various approaches to the modernist project in the 1950s. Such controversy anticipates the divergent climatic discourses in the architecture of the 1960s and 1970s – e.g., air conditioned domes or bioclimatic autonomous houses. Consequently, the final project of the House of Brazil in Paris must be considered rather a synthesis of debates on architectural microclimates, than a confrontation of climatic paradigms.

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