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Validation of Wladimiro Acosta´s Helios System

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Abstract: Wladimiro Acosta s architectural practice shows him to have been a pioneer of passive design back in 1930, but his work is little known and has remained unstudied by the environmental research community. His approach to designing with climate is described in his book "Dwelling and the City" published in 1936. It introduces Acosta's "Helios System", a design method for architectural solar control that precedes Olgyay's by some 20 years. It allows designers to size vertical and horizontal building elements providing solar protection in combination with design strategies for window sizing and operability. The paper presents a critical review of Acosta's system using current computational tools to assess his solar control devices for two buildings he designed in Buenos Aires. Computer models were assessed by hourly simulations of incident solar radiation on windows and sun penetration indoors. The results are compared to Acosta's original criteria and designs. The analysis shows that the principles established by Acosta are still valid for Buenos Aires. His climatic assessment was accurate and informative. The Helios System is well-founded and compares with the tools we have today. On close examination Acosta's designs are well informed.

Keywords: Wladimiro Acosta, Helios System, Solar Control, Environmental pioneer

Introduction

Wladimiro Acosta was a pioneer in the use of meteorological science for architectural purposes. He was a Russian architect who emigrated to Argentina in 1920's. At his arrival, modern architecture was starting to spread in Latin America. He valued the functionality and scientific approach of modernity, but was critical of replicating it without local adequacy. Instead, he analysed vernacular architecture of Buenos Aires –old colonial buildings- as examples of efficiency and comfort. He considered that to do a proper design he needed to "study the physical and human geography of the place, its characteristics, its technology, its construction techniques, the indigenous ways of living, and find an architecture that belongs to the place." He did research on solar studies, Buenos Aires climate, and the incipient comfort theories which he used to inform his practice. Acosta's approach to designing with climate is described in his book "Dwelling and the City" (1936). It introduces his "Helios System", a design method for architectural solar control that precedes Victor and Aladar Olgyays' "Solar Control and Shading Devices" by some 20 years.

The climate

Buenos Aires 's climate, according to the Koppen-Geiger classification is temperate or sub-tropical, moist all seasons (average ranges from 43 to 91%) with mild winters, and hot summers. The annual average temperature is of 17.6^{o}C, with predominant winds coming from N, NE, and E. Over the warm period, cloud coverage is low, whereas in the cold period days are mostly cloudy. Rainfall is fairly distributed along the year with a mean possibility of 30%.

Methodology

Both Acosta's theory and application will be reviewed in this paper. His principles will be offset by contemporary authors, whereas his application will be tested through simulations comparing his intentions with actual performance. Solar radiation, shadow masks, and shadow studies were conducted using Ladybug for Grasshopper.

Fundamentals of the Helios System: the scientific approach

Climate and comfort research

Acosta used historical weather data supplied by the Direction of Meteorology. In his essay Urban Climate (Acosta, 1936), he details the concept of the Urban Heat Island in Buenos Aires. His findings were supported by studies performed by Goldmerstein and Stodieck (Acosta, 1936), with similar concepts as the ones explained by Gartland in Heat Islands (Gartland, 2008). This phenomenon was confirmed locally by Figuerola-Mazzeo only in 1997. Also, Acosta points out the necessity to account for trees and green spaces inside the city to mitigate UHI, later confirmed by the LA studies of Akbari (2001). He based his design consideration on his notion of thermal comfort which included air and radiant temperature, humidity and air movement, introducing a topic that Fanger developed only 34 year later (Fanger, 1970). Also, he was well aware of the notion of comfort band and the scarcity of means to quantify it there were at that time. He followed the state-of-the-art of the studies performed by several scientists of the epoch (Acosta).

Acosta´s thorough studies of climate, its influence on the city and architecture, and consequently on human comfort prove that his vision of the topic was not only accurate but also well ahead of his time as it compares to the contemporary approach of environmental design.

Solar studies

Acosta acknowledges the sun as the main source of energy, and solar studies as a starting point to initiate a building design. With the geographical positioning of Buenos Aires (34^{o} South), he derived the most relevant solar angles that would inform his architecture (Figure 1). Also, he tempted to create a way to represent them in 2d, preceding Hand's charts (1948) mentioned by Olgyay by some 16 years.

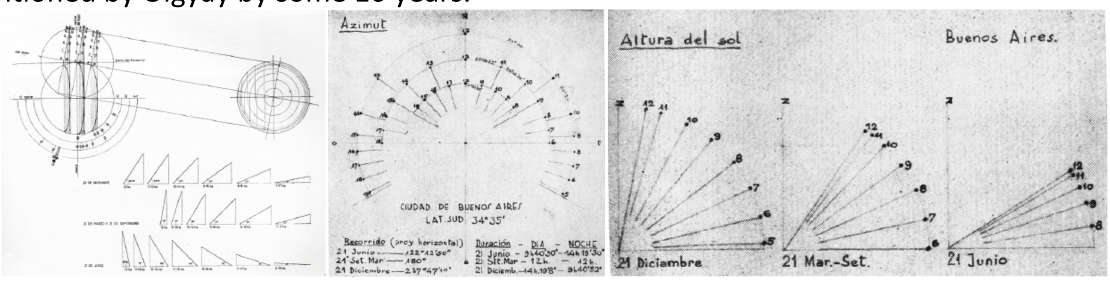

Figure 1. Solar angles' studies (source: La Arquitectura Helios, Acosta)

For Acosta knowing accurately the path of the sun was essential to deciding on the orientation of a building. He advanced many effects of the contemporary building physics such as solar radiation, radiant temperature, and heat transfer. He evaluates solar contribution for the climate of Buenos Aires as "detrimental during summer, since it adds to the hot atmosphere, and beneficial during winter, because it can compensate the cold from the exterior", demonstrating a perfect understanding of the physical implications. Recognising the importance of solar control, and knowing the right angles at a set time of the year, Acosta investigated several systems of regulation depicted in Figure 2a, before reaching the optimal which he called the Helios System (Figure 2b). Also, he used solar angles to test his designs (Figure 2c) and show the operation of the system, preceding Olgyay's "Solar Control & Shading Devices" by some 30 years. Acosta understood the relevance of solar control, studied it scientifically and made it the leitmotif of his architectural practice.

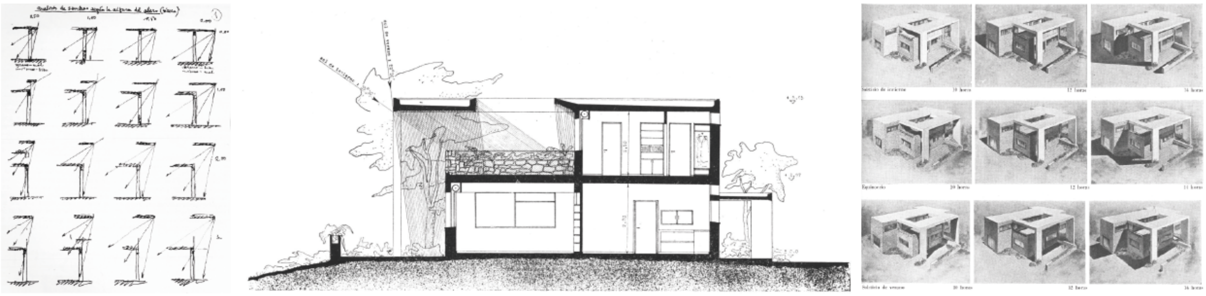

Figure 2. Solar studies on architecture (source: Vivienda y Clima, 1936)

The scientific approach to design is completed with the post occupancies studies he did, taking photographs of the buildings after completion to confirm his theory, verify sun angles and building use at different times of the day and year (Figure 5). He used these images as a way of explaining his work.

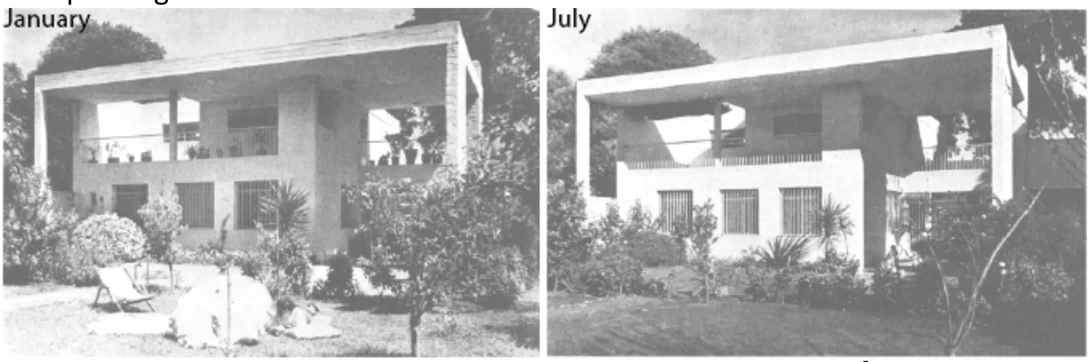

Figure 3. Documentation of built work (source: Nuestra Arquitectura n° 202, 1946)

Helios System

The main points of the system are summarised in Figure 4.

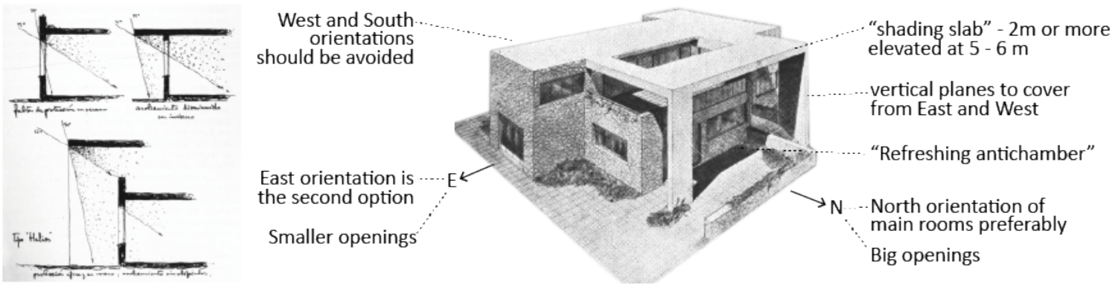

Figure 4. Helios System (source: Nuestra Arquitectura n°168)

The starting point is the orientation of the building for which the decision is subject to solar access, breeze capture, and moisture regulation. He recognises North as the most advantageous orientation for its solar properties, and the predominance of NE winds in Buenos Aires. Following, he marks a difference between East and West. East receives breeze and morning sun, which he considers "excellent in winter and bearable in summer". However, West orientation should be avoided as it "receives afternoon sun when the atmosphere is already hot" (Acosta, 1936). Acosta realises that although the amount of incident radiation is even, the earlier exposure weighs for East. Regarding moisture, he mentions North orientation is still the most advantageous because high levels of humidity can be dried by the sun.

The fixed shading devices, which he calls "shading slab" are the most recognisable feature of the system. The best solution is to protect both walls and windows already north oriented with a "combination of large projecting slabs of 2m or more, elevated at a double height of 4,50 to 6m, and vertical protections N-S oriented". This creates a "refreshing antechamber": a transitional space used as protected entrance, shading device and as an element for architectural composition. A shading mask was performed (Figure 4b) overlapped with the overheated period, considered when the monthly mean temperature is higher than the lower comfort limit (Szokolay, 1996). If the room is facing due north, the system entirely covers the overheated period, and lets the sun in the entire winter. However, if the facade starts to deviate (Figure 4c), the overhang lets the sun in near midday and covers either early in the morning or late in the afternoon during winter. For the system to work, the maximum acceptable deviation from due north is 20°.

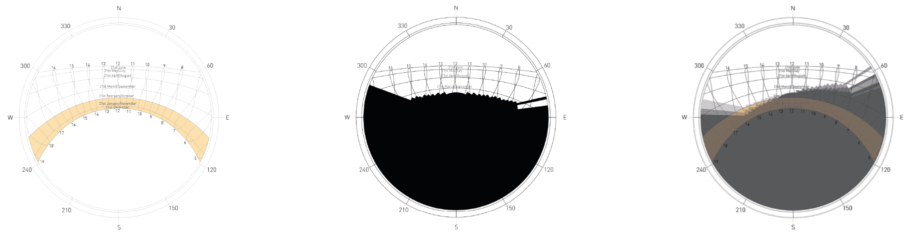
Figure 5. Helios System shading masks

With reference to the openings, Acosta points out the necessity of adjusting the size according to orientation for the purpose of solar control, maximising openings to the north and minimising them to the south and west. Also, he acknowledges that different shapes and positions can modify daylight distribution, and points out that the higher the window, the further the light enters the room. Finally, suggests that all the windows should have an operable upper part for ventilation purposes.

With regards to adapting to a denser urban situation, where orientation is conditioned by narrow plots, Acosta states that solutions are reduced beforehand, and that the architect can only "remedy the adverse circumstances". Therefore, the system is intended to relatively open areas where choice can be made, and does not specify how to deal with more unfavourable conditions.

Acosta put the well-being of the users at the centre of his design procedure, considering all the aspects to establish a design methodology for Buenos Aires. His theory compares with the contemporary approach of environmental design.

System's application: 2 case studies

The design and direct application of the system will be reviewed in this section in two case studies: a detached house, and a high-rise building. Solar control will be assessed by the system's capacity to limit solar loads and to protect against direct irradiation (Kuhn, 2000).

Case study 1: Helios House in Villa del Parque

This is a detached house on a large plot with very few constraints to design with. The proposal is fully designed according to environmental principles.

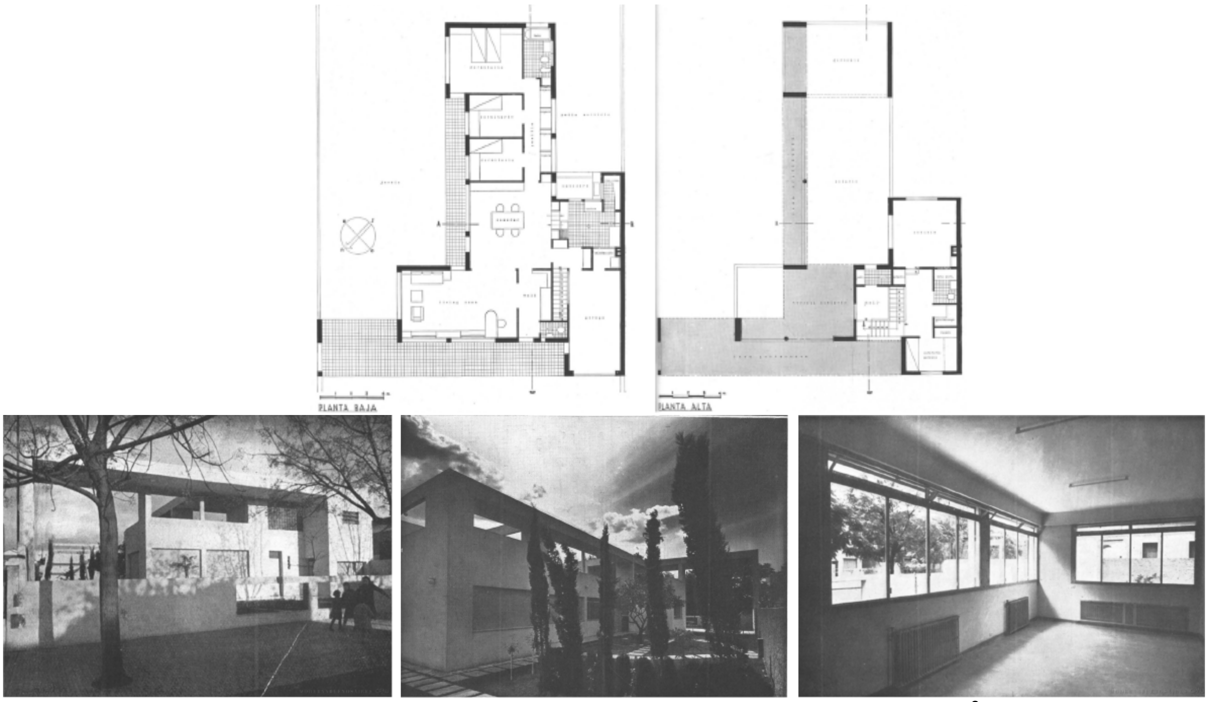

Figure 6. Helios House in Villa del Parque (source: Nuestra Arquitectura n°122)

The overall layout is clearly designed to optimise interior comfort. The main functions are located on the ground floor, where temperature is more stable and the system of overhangs is intended to work, leaving service functions -atelier, service room, gymnasium- on the top floor (Figure 6). Bedrooms, dining room and living room are NE oriented, which Acosta considered optimal, with big windows overlooking the garden. Special attention is given to the solar control of the windows, as the main feature of the Helios System. Overhangs –"shading slab"- are a fixed component, dimensioned to guarantee protection and allowance of the sun when needed. Also, there is a range of adaptive opportunities provided: night shutters, interior curtains, and an operable upper part for ventilation. Kitchen, garage, toilets and storage are SW oriented, with small unprotected windows, only intended for daylight and ventilation purposes with their corresponding mechanisms. However, the living room is facing both NE and NW, with windows on both sides.

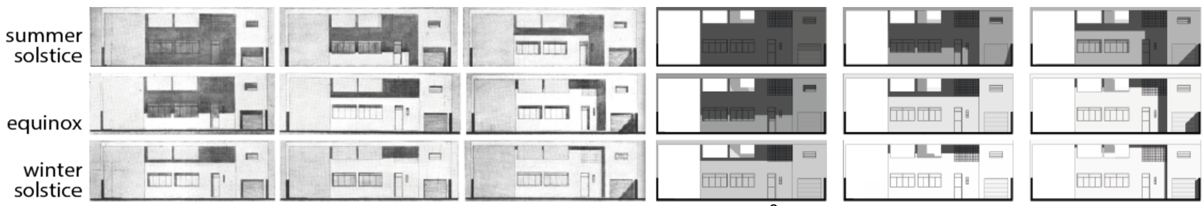

Figure 7. Shadow studies by Acosta (source: Nuestra Arquitectura n°122) and contemporary simulations

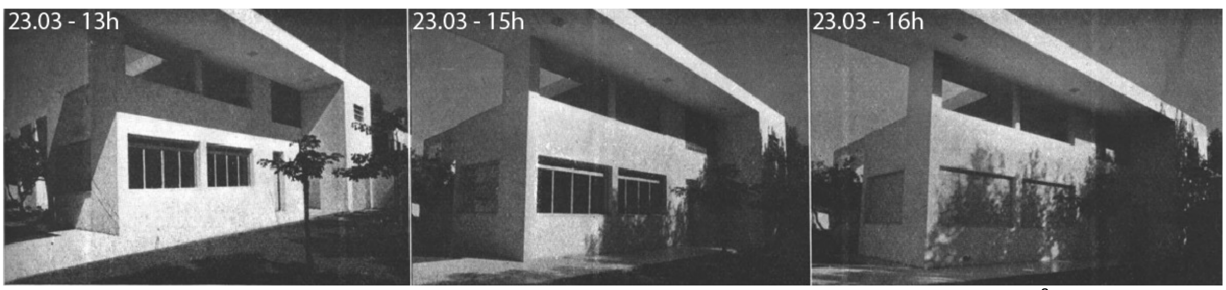

Figure 8. Pictures by Acosta of sun movement in 1939 (source: Nuestra Arquitectura n°122)

Acosta performed shadow studies as a design tool (Figure 7a) and as a post occupancy study. Both the simulations (Figure 7b) and the pictures he took prove that he could exactly predict the position of the sun at a set hour and design with this input in order to regulate the indoor thermal environment. Even if the size of the overhangs varies for the NE and NW orientations, they remain insufficient to serve the front facade. The architect foresaw this deficiency and offset it with tree shadow (Figure 8).

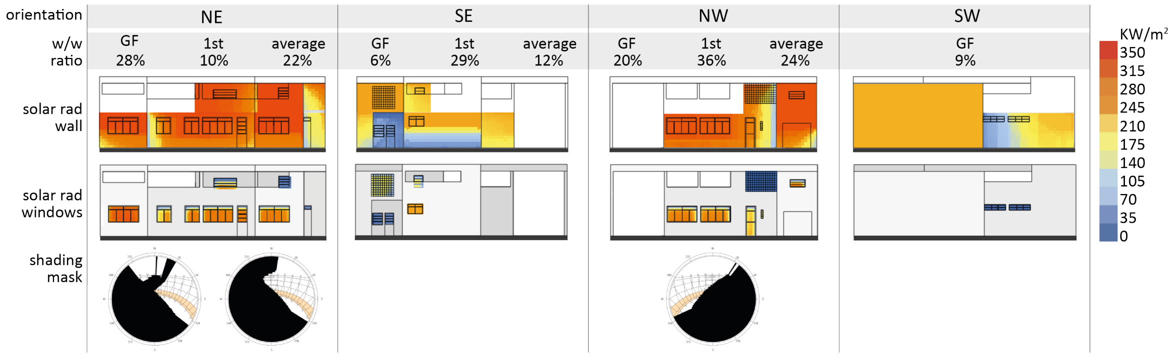

Figure 9. Validation of the solar control of the Helios House in Villa del Parque

As predicted in the previous section, the deviation from due north is greater than 20%, and the shading device leaves an excessive period of overheated hours unprotected. The front facade -NW- lets the sun in all the afternoon during the whole year. Regarding the solar load, results confirm that all the facades remain exposed and the shading system does not reduce significantly the quantity of solar radiation hitting the windows -from 320 to 280 KWh/m^2 , as an average- .

The disposition of the rooms in plan and section, size of openings, adaptive opportunities, and shading are planned in line with solar principles, which is remarkably advanced for the time. Nevertheless, the system of overhangs is applied here as if the orientation was due north, causing to reduce the performance. Acosta fully understood the fundamentals but did not adapt them properly for this orientation.

Case study 2: Rent House in Palermo Chico

This rent house was the only high rise building Acosta completed (1943). The plot was surrounded by large parks that have remained until today, with high potential for views. The typical plan is asymmetrical, T shaped, covering less than 2/3 of the plot.

The entire design optimises conditions for the comfort of the users. The main rooms -living and bedrooms- are located facing NE with very big windows (72% w/w) and very large balconies (2.2m). Maximum adaptive opportunities are provided, having guaranteed the performance with the use of the fixed balcony – "shading slab"-. Rooms are naturally ventilated through sliding panels and an operable upper part in all the openings. Bedrooms are provided with night shutters, and living rooms with a system of operable venetian blinds. Acosta took care of every mean for the users to regulate their thermal environment. He made such an emphasis on these devices that he showed special detailed pictures of them in publications (Figure 10).

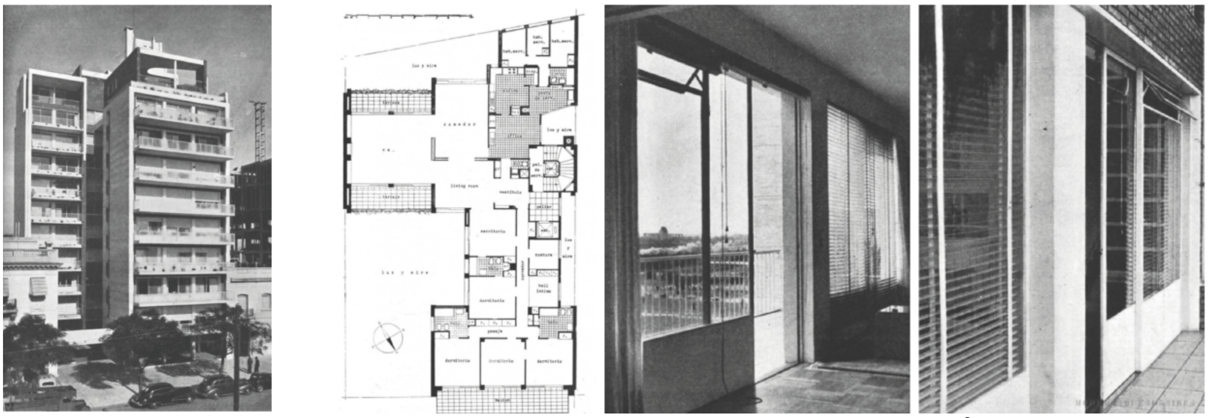

Figure 10. Rent house in Palermo Chico (source: Nuestra Arquitectura n°168)

Secondary rooms are facing SE and located in the centre, protected through the rest of the rooms. All the service functions of the dwelling are located facing SW and NW and sheltering the main rooms from the afternoon sun.

Acosta mentions that if the neighbour construction is built on the whole party wall, it would be a “hygienic and economic catastrophe since the air-and-light yards would become holes, and the rooms would not have any sun nor light”.

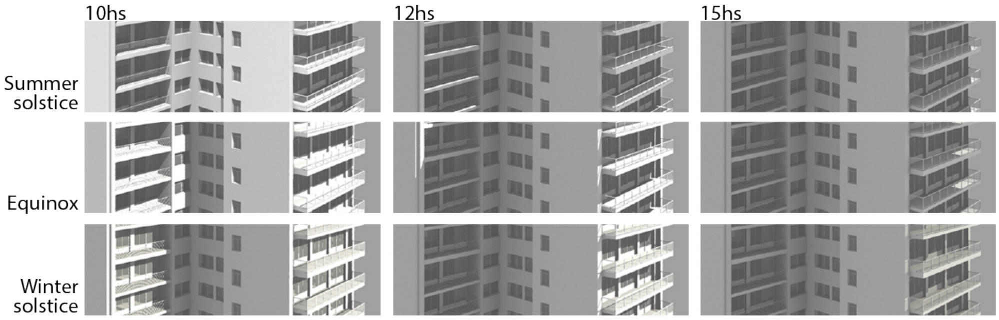

Figure 11. Shadow studies

Shadow studies (Figure 11) prove that the size of the balcony is perfectly calibrated. During the warm period, the sun barely reaches the balcony at all times and spares the window completely, preventing the interior from overheating. During the cold period, the sun reaches both the balcony and the interior, acting as a source of heat gain. At the equinox, the run rays reach the balcony, but not the glazing area, preventing the interior from excessive gains, but creating an enjoyable outdoor space. Results from the solar load analysis (Figure 12) confirm the adequacy of the overhangs for its significant contribution to reducing the amount of solar radiation: from 280 to 80 KWh/m^2. It is to be noted that SW orientation has larger windows than expected -56% w/w-, to enable views to the park.

Figure 12. Solar control assessment

Discussion

Although Acosta's studies of the vernacular architecture of Buenos Aires are highly relevant to learn from its considerations, his most meaningful contribution was to approach climate as a scientific tool that could inform his designs. He developed his theory in the 30's, which is still factual today. All his meteorological studies are useful, and briefly explained to reach a wide audience. The solar studies he carried out are also valid today. The principles of the Helios System for Buenos Aires are accurate and suited as guidelines. Furthermore, the identification of a system of shading devices as the key element design in the mentioned climate is instrumental as a starting point. Both case studies confirm that the application of the system was precise, and encompassing all the aspects of environmental design as we understand it nowadays. However, Acosta utilised the scheme that was intended for due North in rotated angles, as for the Helios House in Villa del Parque, which weakened the performance of the entire system. Comparing the two cases, the high-rise building shows a better performance than the detached house due to a lower deviation angle from due North. The guidelines Acosta provides are most relevant when choice can be made, but fails to explain how to cope with other situations.

Conclusion

Wladimiro Acosta was a pioneer in addressing environmental design scientifically, as he understood all the topics we cover today through the latest scientific research of his time. It is very likely that he was the first to use meteorological science as a mean to inform architecture. The Helios System is well-founded and seems to be a reasonable starting point to design in Buenos Aires, highlighting solar control with overhangs. His suggestions may be of a reduced application in today's urban context, though his thorough studies and principles are still solid and will remain a valid reference for Argentinian architects.

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