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Article

Ferrer House at Rocafort, an Early Case of Design Brise-Soleil for the Mediterranean in Valencia

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Abstract: In 1944 the architect Antonio Gómez Davó designed and built a new house for Mr. Ferrer at Rocafort in the suburbs of Valencia (Spain). In this same year, Europe, America, Russia and even Japan were still at war and Spain was only recovering from its own intestine conflict. Therefore, architectural innovations and influences were scarce as was the circulation of specialized journals on the matter. But in many creations, like the ceramic vaults and the brise-soleil, Le Corbusier himself had declared his profound nostalgia from the Mediterranean, a Sea that he had come to appreciate in his travels to the “orient”. In the case of Gómez Davó, having been born and raised in a prominent family of Valencia he could not remain indifferent to the design features that appeared in the vernacular architecture of the area, specially the type of inclined louvers of Arabic descent, that covered bow-windows and balconies and which have come to be known in Spain as the Majorcan louvers; nowadays even employed by Rafael Moneo for instance at the extension of the Painter Miro Foundation. However, with so many difficult circumstances surrounding him, Gómez Davó could not get to the point of producing a ground breaking design based on solar assumptions for the whole façade of the building, instead when providing an entrance porch apt for spending life, meals and well deserved rest hours outdoors in the pure Mediterranean tradition, he ventured to construct a surprising perforated wall oriented to the South in order to control radiation in winter and provide shade in the summer while affording excellent light and superb conditions of ventilation. By means of our own devised simulation tools we have analyzed the conditions of the house and especially of such innovative brise-soleil at times reminiscent of Alvar Aalto solutions for day-lit roofs, which he was aware intuitively and by his own incipient study of solar geometry, that needed adaptation from so distant latitudes as Finland and Valencia. By outlining such unknown and bold precedent we contribute to revitalize the early and daring pioneers of solar architecture in peripheral Spain and Europe, at the birth of critic regionalism, a fact often disregarded in conventional history of Modern Architecture.

Keywords: Mediterranean outdoor spaces; Brise-Soleil; Le Corbusier; radiative exchange simulations; early solar design in Southern Europe

1. Introduction

Antonio Gómez Davó was an architect educated in the latter wake of Spanish regional modernism (reminiscent of Art Nouveau). In this tendency of precedents, we could perhaps include architects such as Antoni Gaudí, Jujol [1] or the Seville-born Aníbal González. Each one of them resorted frequently to the Orient as a source of inspiration and especially the Mediterranean Levant, to an architectural idiom rich with features of the “arabesque” [2].

In this context of “oriental” architecture [3], sunny weather of the “deserts” was a constant and elements and features that could control the excess of solar radiation were persistent [4]. One of the most important of them is usually represented by the “mashrabiya” مشربية, which derives from the Arabic verb شرب, normally meaning to “drink” [5] as the chamber in which it was placed soon became the coolest place of the house whence honored guests (Figure 1) were invited to take refreshments [6,7]. Another similar element is the well-known Indian “jali”. [8]

Both the mashrabiya and the jali had the necessary function of cooling the adjacent chambers by means of ventilation and evaporation (as they were connected to water conduits, basins or even if the

former was not available ceramic jars) [9,10], but they also were tailored to protect from indiscreet gazes, and in this manner we arrive to the name *jalousie* descending from the Indian term for lattice “*jalis*”.

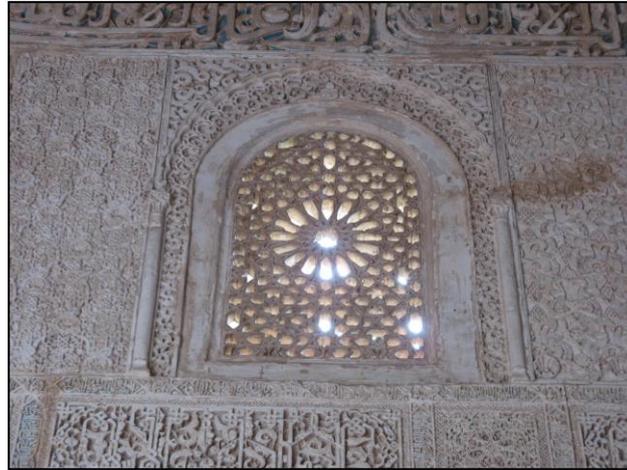


Figure 1. A window with gypsum lattice work in the style of mashrabiya.

In the Mediterranean, whose coastal architecture has maintained a prevalence of Arabic elements, notably in Spain [11], but mostly in Malta and occasionally Southern Italy [12,13], not only the masharabiya (Figure 2) was enhanced; it also evolved to a special kind of louvers which even today are designed as “Majorcan” in Spain and “Persiannes” [14] (from Persia) in France’s Midi.



Figure 2. A typical street mashrabiya.

Le Corbusier, a self-confessed nostalgic of the Mediterranean [15] was well aware of such fact. Therefore, he developed the celebrated brise-soleil along with other Levantine features like the ceramic tile vault that he had known from the Sagrada Familia school buildings (Figure 3) created by Gaudi in Barcelona [16].



Figure 3. The reconstructed Sagrada Família Schools by A. Gaudí.

Gomez Davó was clearly a modern architect who would not hesitate to build using concrete and steel [17] but at the same time, he was sensitive to the idiom of his native homeland of Valencia [18] and naturally he wanted to incorporate when possible some shadow and cooling elements especially in the vicinity of windows and outdoor porches [19].

He had sought the opportunity at various projects, but always failing for one reason or another, until finally in this unassuming project for Mr. Ferrer he could achieve one of his goals. We know for his first sketches [20] that he tried to create a perforated wall with circles (Figures 4–8) much in the manner of Alvar Aalto in the Viipuri library of 1929 but on a vertical plane; The idea of the circles had to be discarded due to mounting costs and other drawbacks like not enough space on the actual lot. In short, the original design was replaced by oblong octagons.



Figure 4. View from the South West of Ferrer's house and the perforated wall. Archivesog Gomez Gil.

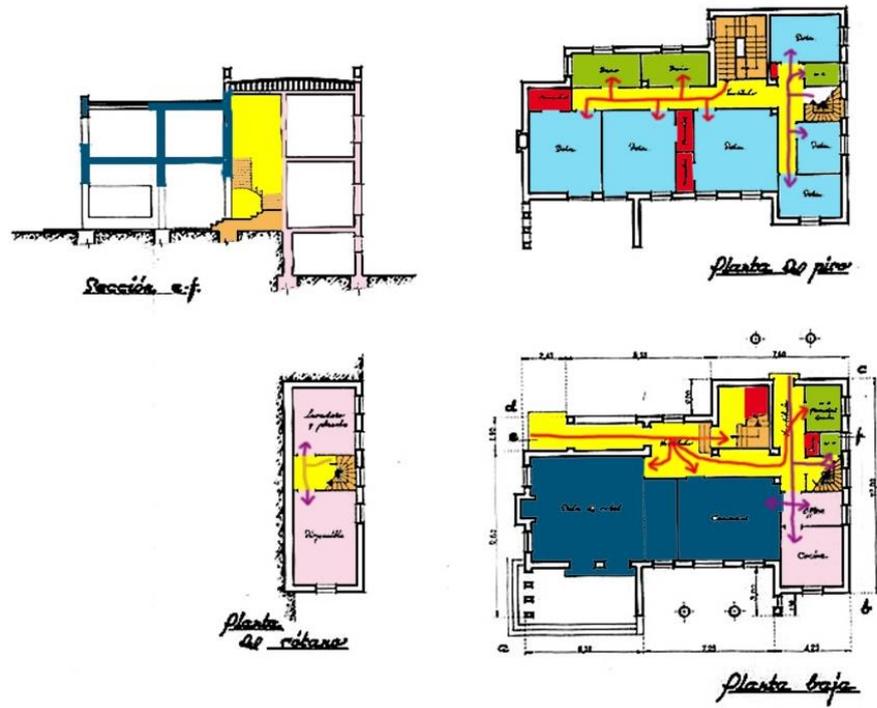


Figure 5. Plans and sections of the Ferrer House. Archives of Gomez Gil.

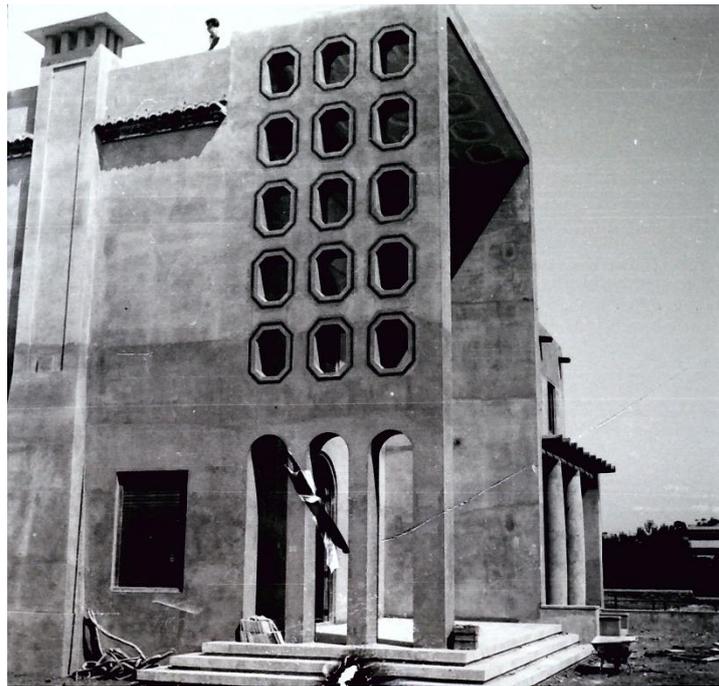


Figure 6. View of the construction process of the Ferrer House. Archives of Gomez Gil.

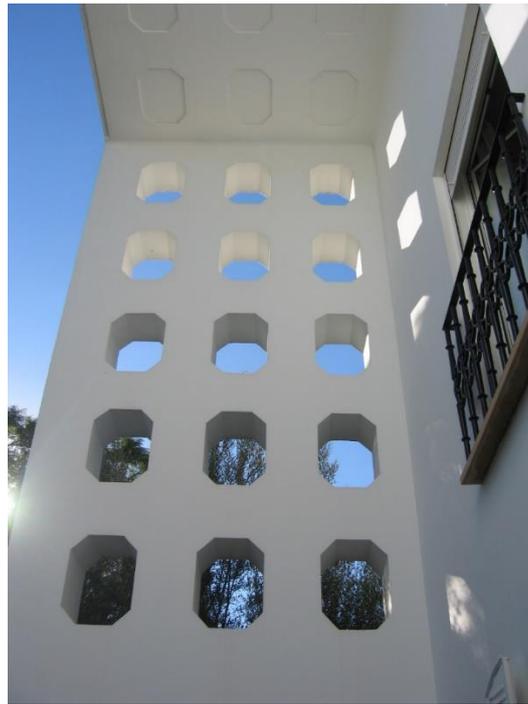


Figure 7. Details of the porch at Ferrer House.



Figure 8. The Sun entering in winter through one of the openings.

In the plans of Figure 5 we can see how he had to opt for a mainly Eastern exposure of the detached house for better views and predominant breezes of the summer. However, he was allowed for more freedom in the entrance porch.

He desired to protect this area from excessive radiation and unwanted winds which could disturb the long hours spent outdoors (Figures 6–8).

The design was optimized to obtain a better climatic performance. In other words, he sought how to achieve satisfactory diffusion of the natural energies available, be they sun, light or wind. [24] The control of solar radiation both in winter and in summer is important pre-requisite in the design of such type of residence but it was altogether uncommon of this period [25,26]. Very few projects let alone some pertaining to the Bauhaus sphere demonstrated concern of the relationship with the environment outside of the selection of the view [27]. Le Corbusier ideas had been generated in the mild climates of Central Europe and had little consideration towards the problems of hot weather which were roughly considered marginal to the space of modernity [28], thus promoting the advent of the International Style [29].

In the case of sunny climates as Easter Spain has, the used of glazed surfaces preconized by the glass-box adepts needs to be reviewed in detail to reduce energy use, since they present a significant repercussion in the cooling demand [30].

Moreover, the handicaps posed by direct sun over the architectural structures are not adequately dealt with conventional software that only takes into account diffuse radiation. A conscious understanding of solar geometry for the current designs is necessary, and with it, adequate tools to compute the paramount contribution of solar radiation gains to the spaces and comfort of the people [31].

2. Materials and Methods

In order to establish the performance of the solar porch we have started by studying the solar movements and the incidence of radiation, around the location of the house with the help of our personally developed software.

Such program is based on the solution of the canonical equation or reciprocity theorem for any possible form (Eq.1):

$$d\phi_{12} = (E_1 - E_2) \cos \theta_1 \cos \theta_2 \frac{dA_1 dA_2}{\pi r_{12}^2} \quad (1)$$

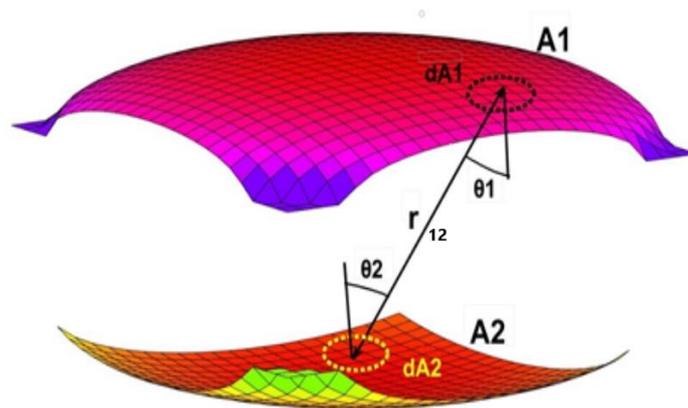


Figure 9. Radiative emissions for a couple of surfaces of any type A1 and A2.

Equation 1 describes the respective quantity of radiative energy by unit area that will impinge on any of the two surfaces concerned E_1 and E_2 . The corresponding incident angles θ_1 and θ_2 which are depicted in the figure represent the tilt to the normal of the distance line that connects two arbitrary points belonging to each surface named r_{12} , both in the equation and in the figure [21].

In order to solve Eq. 1, we need resolve the inner part of the integral, as expressed in Eq. (2) [22].

$$F_{ij} = \frac{1}{A_i} \int_{A_i} \int_{A_j} \cos \theta_i \cos \theta_j \frac{dA_i dA_j}{\pi r_{ij}^2}. \quad (2)$$

The remaining task is to apply Eq. 2 to the particular shapes of the octagon that are found in the lateral wall of the porch, Figure 10.

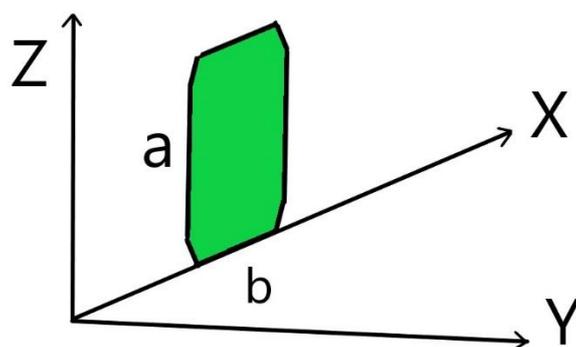


Figure 10. Coordinates of the octagon used for calculations with main sides a and b.

Secondly, we present the solar charts for the precise location which are the basis to proceed with the radiation study (Figures 11 and 12).

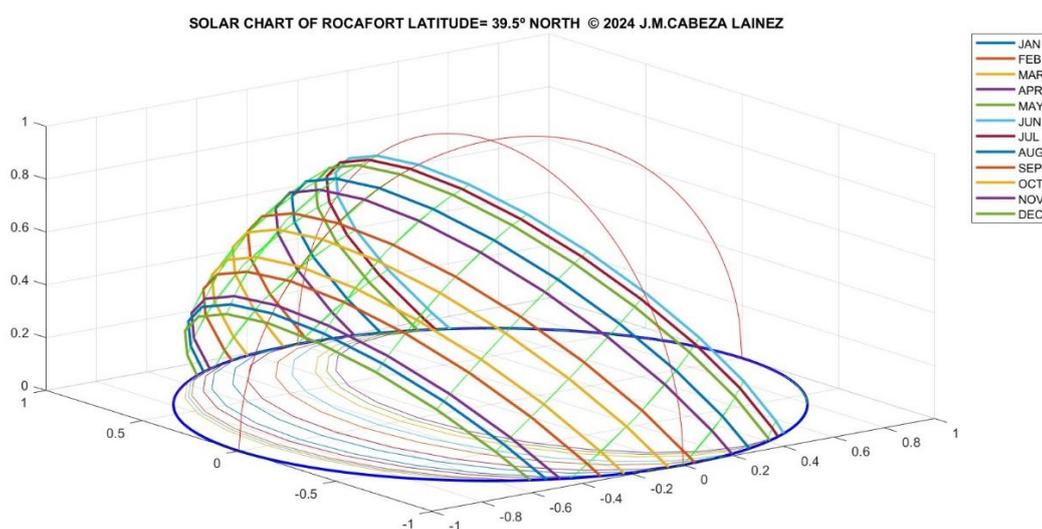


Figure 11. Solar chart for Rocafort where the Ferrer House is located.

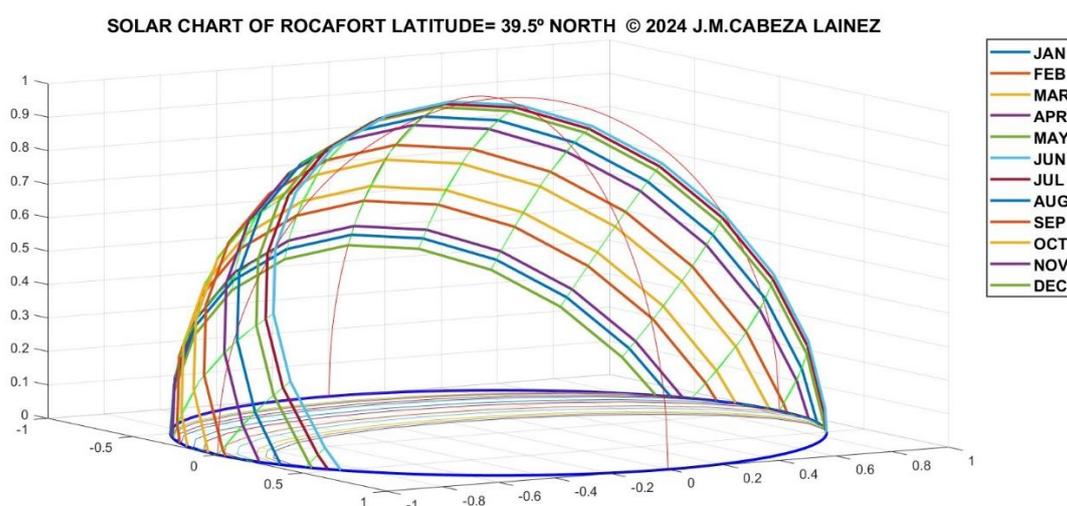


Figure 12. Solar chart for Rocafort. View from the Northeast.

We have to stress out, that in the solar geometry manual of Gómez Davó the latitude of Valencia is set at 38 deg. North, one degree below the real latitude of the area but we do not believe that this minor slight produced a considerable error in the construction details of the porch.

By analyzing in deep our charts, created by computer it is clear that in these latitudes, the solar height in the winter is around 40 degrees, thus facilitating the penetration of the sun by any vertical aperture oriented to the south [24]. However, around the summer solstice this altitude is around 70 degrees and the incidence of the sun would be scarce. That is the main interest of porches with a Southern exposure that the architect used advantageously. The octagonal openings on the perforated wall were carefully dimensioned to permit the passing of the sun and the wind while at the same time maintaining adequate strength as a bearing structure [25].

We have checked with the help of the solar charts (Figures 13 and 14) that we have constructed, comparing with the satellite three-dimensional image (Figure 15) and a scale-model (Figure 16), that overshadowing does not appear at virtually any moment of the year.

This is a necessary aspect to check in winter. On the contrary, during the summer period, less radiation is desirable but we need to maintain acceptable daylighting levels and adequate ventilation [26].

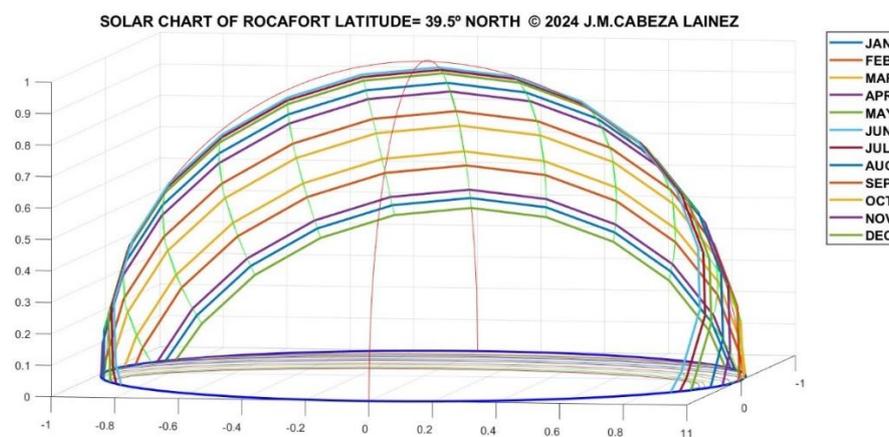


Figure 13. Solar chart from the South- East.

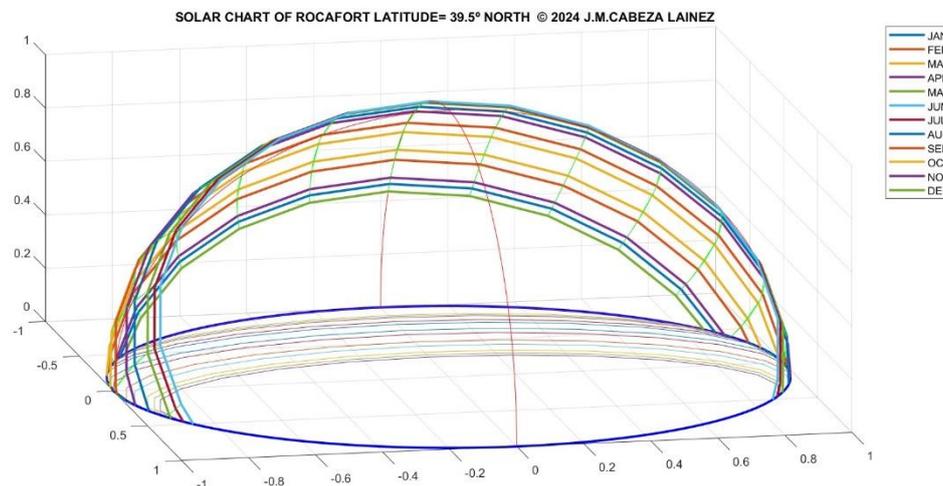


Figure 14. View of the solar movement from the South- East.



Figure 15. The current 3D satellite image of the house.



Figure 16. 3D calculation model.

The complete results of the solar performance are given in Figure 17 for the dates of 1st January, 4th of April, 7th of July and 10th of October, approximately corresponding with the solstices and the equinoxes.

Different hours of the day have been considered to have a more general idea of the overall performance of the sun-porch.

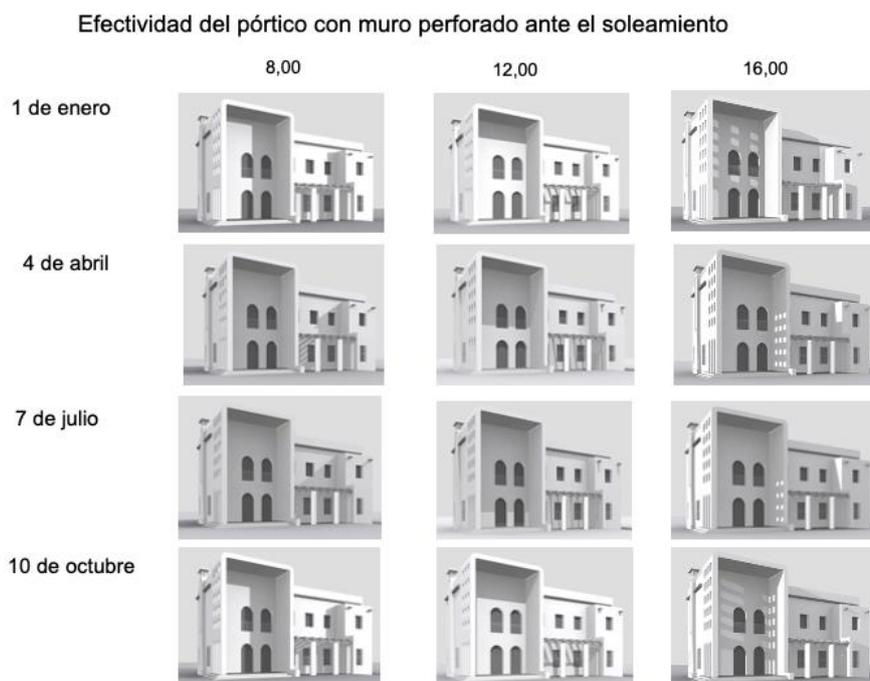


Figure 17. Evolution of sun bathed and shaded areas. At different hours throughout the year.

This solar performance justifies the design employed but it is necessary to check it also under radiation premises as we will do in the following section [27].

3. Results of the Simulation and Discussion

We show below some of the most relevant computer results of the simulations (Figures 18–21). We need to trace the extent of the solar-patches that appear on the façades and on the floor of the porch.

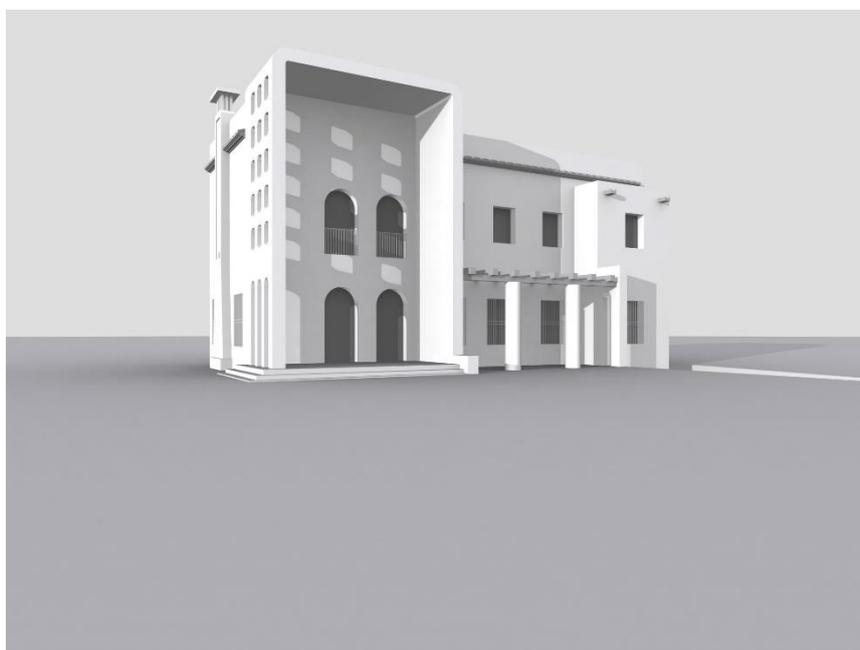


Figure 18. The sun-patches that appear on the wall of the porch in the morning on the first of January.

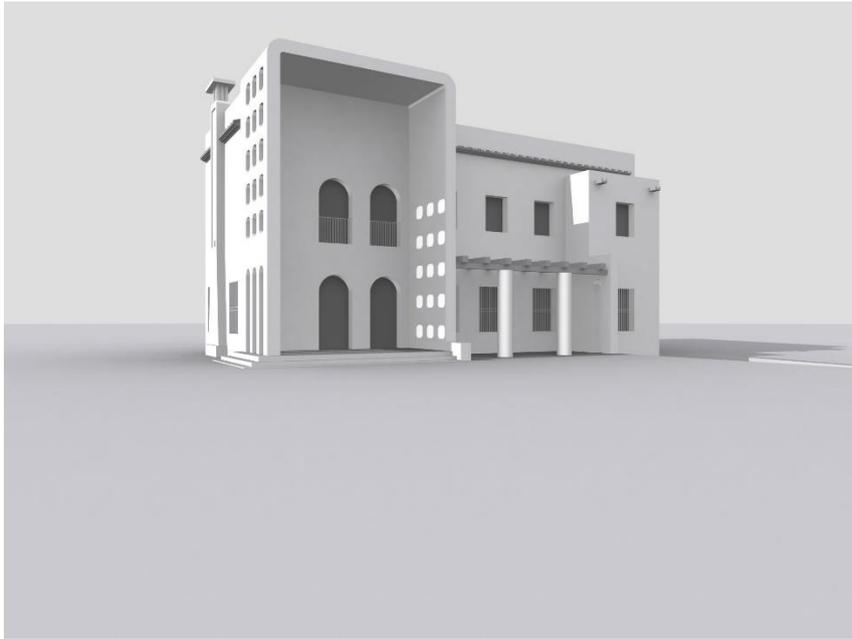


Figure 19. Solar movement under the porch on the 4th of April at midday.

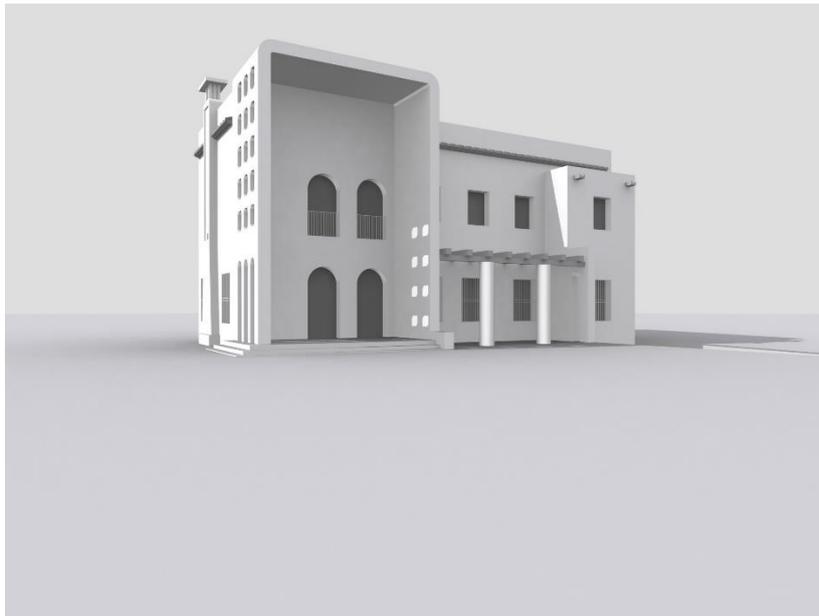


Figure 20. Simulation graph for noon on 7th July.

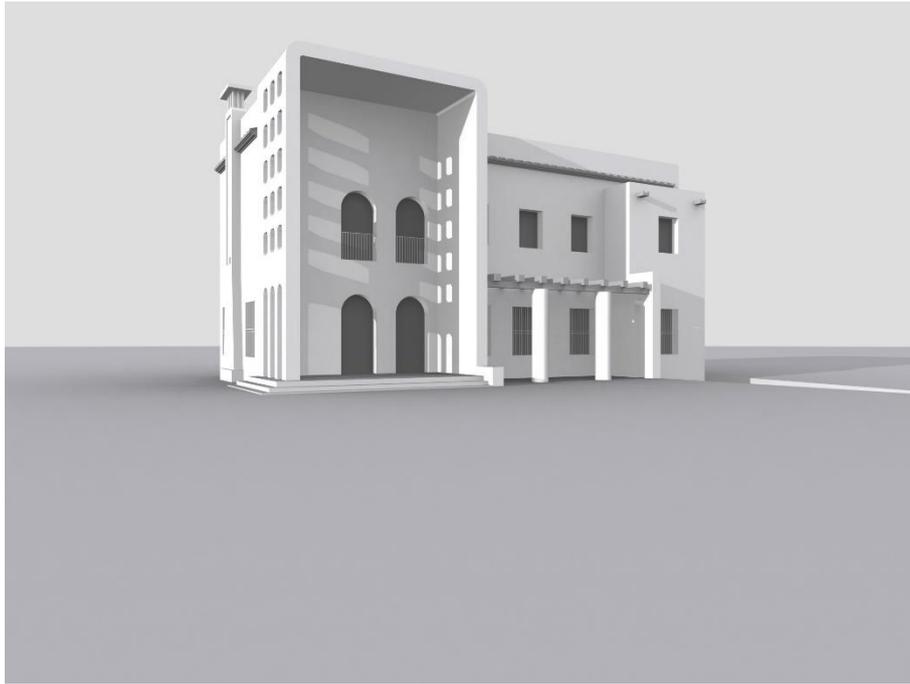


Figure 21. the same graph for around noon at the 10th of October.

We have demonstrated with these simulations that the areas swept by the sun tend to be on a lower height or directly on the floor as the year advances to the summer solstice and in this moment the area illuminated by direct radiation is almost negligible [28].

Based on the former, we have concluded that the design of the solar porch is optimal from the point of view of shading in summer and illuminating in winter [29].

It is necessary now to check the alternatives from the point of view of radiation employing Equations 1 and 2 in the simulation software and remembering the graph in Figure 10. [30]

The type of equation that we would use for the simulation is Eq.3 below with the corresponding amounts determined by the dimensions of the octagon a and b and the dimensions of the porch [31,32]

$$f_{21} = \frac{1}{2\pi} \left(\arctan \frac{x_0}{y} - \arctan \frac{x_0-m}{y} - \frac{y}{\sqrt{a^2+y^2}} \left(\arctan \frac{(m+b)-x_0}{\sqrt{a^2+y^2}} - \arctan \frac{m-x_0}{\sqrt{y^2+a^2}} a \right) \right) +$$

$$\frac{by}{\sqrt{a^2(x_0-m)^2+y^2(a^2+b^2)}} \left[\arctan \frac{a^2+b(b+m-x_0)}{\sqrt{a^2(x_0-m)^2+y^2(a^2+b^2)}} - \arctan \frac{b(m-x_0)}{\sqrt{a^2(x_0-m)^2+y^2(a^2+b^2)}} \right] -$$

$$\left(\frac{my}{\sqrt{a^2x_0^2+y^2(a^2+m^2)}} \left(\arctan \frac{a^2+m^2-x_0m}{\sqrt{a^2x_0^2+y^2(a^2+m^2)}} + \arctan \frac{x_0m}{\sqrt{a^2x_0^2+y^2(a^2+m^2)}} \right) \right) \quad (3)$$

We have introduced both the direct and the diffuse radiation in the simulation Figures 22–24, the general calculations appear in Kwh/m², while the detailed output for winter and summer for the sole porch area appear in W/m².



Figure 22. General Thermograph and radiation analysis of the house in summer.

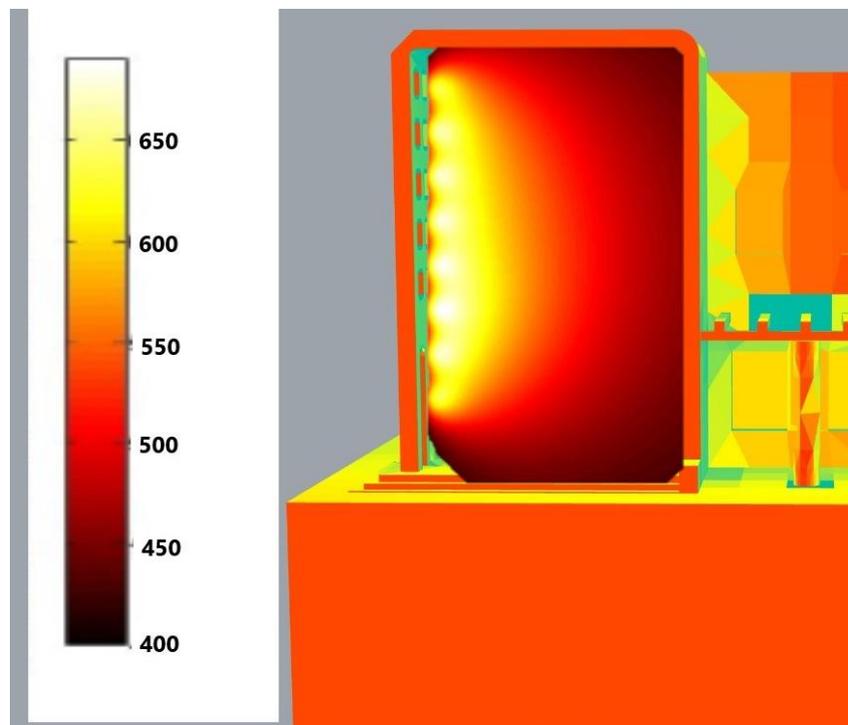


Figure 23. Detail of Radiation Distribution in winter in W/m^2 .

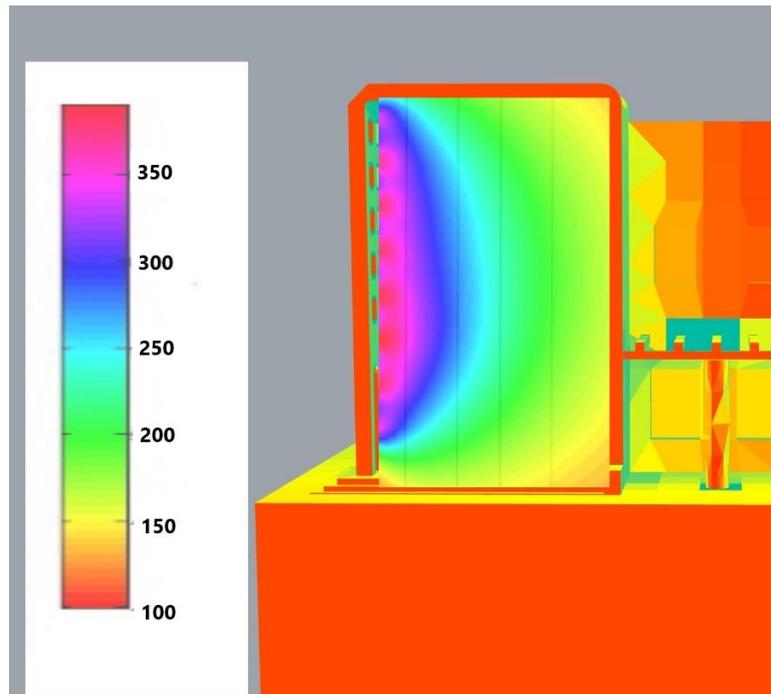


Figure 24. Detail of Radiation Distribution in summer in W/m^2 .

In Figure 23, we can observe that the values in winter range from 600 to 400 W/m^2 , which is an excellent value for this latitude by all standards [33]. In summer, Figure 24 the values are generally reduced between a maximum of 300 W/m^2 and 100. This reveals that the porch is not uncomfortable in the months of June and July by the effects of radiation alone while daylighting is kept at a satisfactory level. The probability of a cloudy sky is of 5% in summer and maybe around 15% in winter [34], therefore the winter values should be balanced with caution as they do not have a 100% occurrence.

Finally, for the general analysis of radiation in Figures 25 and 26, we would notice the mild values achieved in winter from 350 to 100 Kwh/m^2 and slightly more elevated quantities for the case of summer when the intensities of direct radiation are much higher. This is a good index of the level of protection from excessive radiation that the designed elements are able to attain [35].

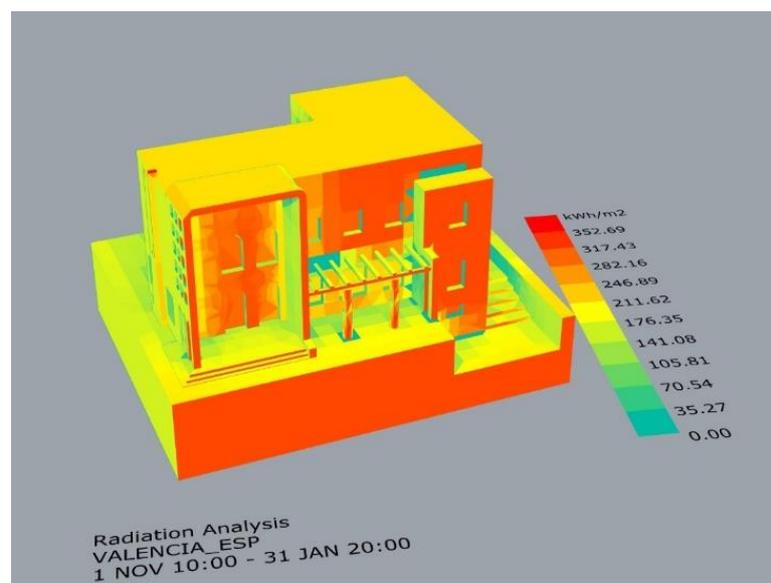


Figure 25. Thermograph of the building in winter.

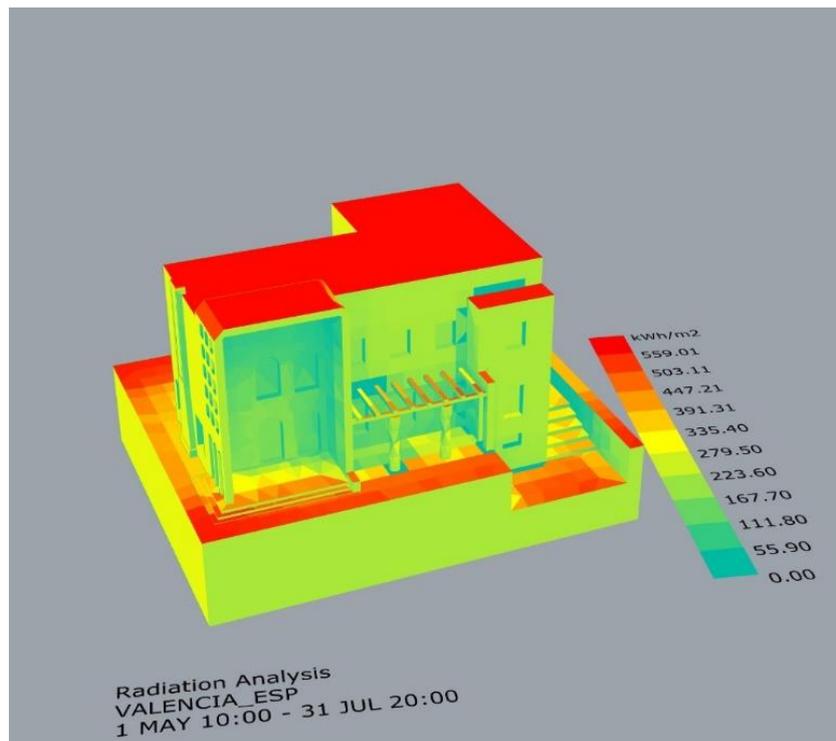


Figure 26. Thermograph of the building in summer.

Further developments and knowledge are expected to be achieved when we apply the CFD analysis with fluent and other specific software to the wind flow around the urban area to discover the contribution of the breezes from the sea to the overall comfort of the outdoor spaces [36] and especially of the porch area

4. Conclusions

The design solutions adopted at the Ferrer House in Valencia constitute an important precedent that is considered to have inaugurated a trend towards critical regionalism in the area and especially in the dedicated production of the architect Gómez Davó. The radiation and solar performance of the building and especially of the entrance porch have been evaluated and assessed with state of the art tools that we have developed specifically for this research. It is regrettable that with the end of the Pacific War, and the imposition of restrictions on Spanish debilitated economy under Francoism, Gómez Davó was forced to discontinue this kind of solutions in favor of a much more restricted type of architecture to say the least. As architecture itself became a sort of emblem for the regime of the epoch. But still we have this important example of an insight that could have been influential for many in the Spanish Levant.

In further advances of the proposed research we would like to add the wind-flow performance of different elements that appear in this house. But generally speaking it has been demonstrated that this design is excellent in the aspects of lighting and protection from solar radiation, we propose even a monitoring campaign to establish the levels of comfort obtained in the surrounding areas of the Ferrer House.

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